Australian Government
Department of Transport and Regional Services

RTA

Queensland Government
Department of Main Roads

TUGUN BYPASS

stewart road to kennedy drive

Environmental Impact Statement

December 2004

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Executive summary

What is the proposal?

The Tugun Bypass is a proposed new motorway between Currumbin in Queensland and Tweed Heads in NSW, and would significantly relieve traffic congestion in the existing road corridor.

The northern limit of the proposed Tugun Bypass would be where the bypass joins the Pacific Motorway at Stewart Road, Currumbin. The route then follows an alignment to the west of the Gold Coast Airport main runway, joining the Pacific Highway on Tweed Heads Bypass just north of Kennedy Drive, Tweed Heads in NSW.

The proposed bypass would be approximately 7 km long, and involve the construction and operation of a four-lane restricted-access motorway with a central median to separate north–south traffic flows at a posted speed of 100 km/h. The median would be wide enough to allow future upgrading to six lanes. Grade-separated interchanges would be provided at Stewart Road in Queensland and at the Tweed Heads Bypass in NSW. These would provide for all traffic movements and provide connections to the local road network. An overpass would also be provided within the Gold Coast Airport to maintain existing access.

At the southern end of the bypass, the proposed alignment crosses an area covered by the obstacle limitation surface (OLS) of the Gold Coast Airport. OLSs ensure a required level of safety for the operation of the airport and no structure is permitted to intrude into this area. A tunnel will be provided to comply with this requirement.

How does the environmental assessment process work?

The environmental assessment of the Tugun Bypass needs to satisfy the requirements of three jurisdictions. The merits of the proposal have been examined and are reported in the environmental impact statement (EIS) and species impact statement (SIS). The Queensland Department of Main Roads has been designated as the proponent for the sections of the proposal in Queensland and a rail roof slab to allow for the future construction of a rail tunnel within the airport. The NSW Roads and Traffic Authority is the proponent for the sections of the bypass in NSW and Commonwealth airport land. Gold Coast Airport Ltd has submitted a Major Development Plan (MDP) for the section of the bypass passing through the airport. The environmental assessment has been conducted in accordance with the NSW Environmental Planning and Assessment Act 1979 and the Commonwealth the Environment Protection and Biodiversity Conservation Act 1999. The EIS also meets the requirements of the Queensland Transport Infrastructure Act 1994. The proposal has also been referred to the Commonwealth government as required by the Environment Protection and Biodiversity Conservation Act 1999. The MDP will meet the requirements of the Airports Act 1996.

The EIS, SIS and MDP have been placed on public exhibition and comments are invited on the proposal, the EIS, SIS and MDP. Following exhibition of the EIS, SIS and MDP, the proposal and all submissions received will be considered and a report prepared providing responses to the issues raised and any additional information that may be relevant. The report will be issued to the various approval authorities for their consideration and assessment. The proposal requires:

- an approval issued by the NSW Minister for Infrastructure, Planning and Natural Resources
- an approval issued by the District Director of Queensland Department of Main Roads

- consent from the Minister for Transport and Regional Services
- a final determination issued by the Commonwealth Minister for the Environment and Heritage.

How was the proposal developed?

An alternative transport corridor between Currumbin and Tweed Heads has been the subject of community discussion and planning for many years. The identification of alternatives to the Gold Coast Highway at Tugun has a history extending back to the closure of the original Gold Coast railway line in 1961.

Conflicting service requirements of the Gold Coast Highway between Tugun and Coolangatta have increased with growing traffic volumes. In the existing strategic road network hierarchy for the area, the Gold Coast Highway provides an urban arterial (and tourist route) along the coastal strip between Helensvale and Coolangatta. Further to the west, the Pacific Motorway provides a regional arterial function between Helensvale and Tugun, carrying longer-distance traffic as part of the interstate highway system. Between Currumbin and Coolangatta, the Pacific Motorway traffic currently converges on the Gold Coast Highway in a corridor east of Gold Coast Airport.

A possible bypass route west of Gold Coast Airport was identified by Queensland and NSW authorities in 1982. Subsequently, the Queensland Department of Main Roads (Main Roads) acquired selected parcels of land in Queensland for road purposes. In 1987, the Tweed Local Environmental Plan (Tweed Shire Council 1987) identified a reserve to be used for a road to bypass Tugun. The former Albert Shire Planning Scheme (Albert Shire Council 1995) identified both a road bypass corridor and an extension of the Gold Coast rail line from Robina to Gold Coast Airport.

In 1998 Queensland Transport commissioned the Southern Gold Coast – Tweed Corridor Study. The aim of the study was to identify potential solutions to the transport issues facing the Southern Gold Coast and Tweed area. Extensive community consultation was conducted as part of the study. The outcome of the study was a strong community preference for a route to the west of the airport.

Following the completion of the Southern Gold Coast – Tweed Corridor Study, Main Roads commissioned a route selection study to further investigate options and recommend a route for a transport corridor in the area around Tugun. The resulting preferred alignment for the proposed transport corridor (called C4) extends from Stewart Road in Currumbin to Kennedy Drive in Tweed Heads, and passes to the west of Gold Coast Airport. This option was adopted by the Queensland government in 2000 for formal environmental impact assessment under a joint process to satisfy the requirements of the Queensland, NSW and Commonwealth governments. The route was also incorporated within the Gold Coast Airport master plan approved by the Commonwealth Government in 2001.

Why is the Tugun Bypass needed?

Significant development has occurred along the coastal strip between the Gold Coast and Tweed Shire in the last 30 years, producing a continuous urban area from north of the Gold Coast to south of Tweed Heads in NSW. This development has been accompanied by increases in traffic demand as the population density roses.

In addition, the Gold Coast Highway also functions as a major cross-border route for interstate traffic, including heavy vehicles. This results in a conflict between providing a fast, efficient highway for interstate traffic, and supplying the high level of access required for the local community. This conflict causes congestion at peak hours, and during holiday periods, and results in delays of up to an hour or more.

A number of indicators of travel efficiency and reliability have been used to determine the condition of the existing road network in the Tugun area, and all show a deteriorating situation that will significantly worsen as the traffic increases. Consequential changes include increases in travel times and a continuing decline of the road network's level of service. Table 1 details the indicators of travel efficiency and reliability.

Table 1: Indicators of travel efficiency and reliability

Intersection performance	Levels of service provide an indication of intersection performance, with level A indicating free-flowing conditions and level F a breakdown of flows. Traffic modelling shows that intersections in the Tugun area will be operating at levels of service from E to F by 2007. This indicates that the traffic issues need immediate resolution.		
Travel speeds	Modelling has shown that average travel speeds along the Gold Coast Highway in 2007 will range from 10 to 66 km/h, while in 2017 they will decrease to a range of 10 to 46 km/h. The slowest speeds will occur during the morning and evening peaks.		
Travel times	Travel times from Stewart Road to Kennedy Drive via the Gold Coast Highway are currently 9 to 12 minutes during the morning and afternoon peaks. Times will increase rapidly without the bypass.		
	Travel times from Stewart Road to Kennedy Drive		
		2002	**2017**
	Morning peak	9–11 min	>30 min
	Evening peak	12 min	>30 min

What other options were considered?

The corridor available to accommodate major road and rail proposals south of Currumbin is narrow with significant natural and artificial constraints. These include Cobaki Broadwater and Gold Coast Airport. Existing and proposed urban development also restricts the number of possibilities available. There are two sets of options available for such a corridor. These are along a route to the west of the airport and along the existing route via the Gold Coast Highway. The latter would involve a major upgrade of the existing corridor in order to provide the required capacity including the introduction of elevated structures. These would result in significant costs along with community and amenity impacts. The other disadvantage is that an upgrade of the existing corridor would not leave any room for further upgrades in the future. Options to the west need to avoid any potential disruption to operations at the airport and minimise impacts on the environment adjacent to Cobaki Broadwater. The C4 option was chosen as it provides the economic and social benefits associated with removing traffic from the existing corridor combined with the lowest level of impacts on the environmental values around the Cobaki Broadwater.

What would the Tugun Bypass look like?

The proposed Tugun Bypass would provide a new seven kilometre road from the Pacific Motorway at Stewart Road to the Tweed Heads Bypass at Kennedy Drive. The bypass would be built to motorway standard with controlled access similar to the Tweed Heads Bypass. Initially,

there would be two lanes in each direction with breakdown shoulders, a wide median and grade-separated interchanges. Two further lanes could be added in the median when justified by demand. This is not expected to be necessary until after 2027.The road would be constructed within a corridor ranging in width from 60 m to 90 m. Additional land would be required at interchanges. The wider sections of the corridor are required to accommodate embankments and interchanges and sufficient space would be provided within the corridor for water quality control measures, noise reduction measures and landscape planting. The design has been developed to achieve as narrow a cross section as possible while maintaining required safety standards. This would minimise impacts on environmentally sensitive areas. The most significant structure on the bypass would be a tunnel required to maintain the protected airspace at the southern end of the main runway at the airport.

How would it relate to Gold Coast Airport?

Approximately 2.0 km of the route of the Tugun Bypass would cross airport land running parallel to the main runway before turning to the east to join the Tweed Heads Bypass north of Kennedy Drive. In order not to intrude into the OLS, the road is depressed below the ground surface entering a tunnel to the south of the runway. The route is located as far to the west as possible while avoiding impacts on the National Estate area and sensitive wetlands adjacent to Cobaki Broadwater. Approximately 13 ha of land would be acquired from the airport for the road. An existing airport access track would be replaced with a bridge to provide access to the area of the airport to the west of the bypass.

How would vehicles, pedestrians and cyclists cross the Tugun Bypass?

Vehicles, pedestrians and cyclists would be able to cross the Tugun Bypass at each of the interchanges along the route. Crossing points would be at the Tweed Heads Bypass in the south and Stewart Road in the north and would ensure that local accessibility is maintained or enhanced.

How would the Tugun Bypass be constructed?

Construction of the Tugun Bypass would be put out to competitive tender. The form of the contract will be a design construct and maintain contract, known as a DCM contract. Under a DCM contract it is the responsibility of the successful tenderer(s) and their contractors to determine the actual means of construction, including scheduling of works and overall timing in accordance with NSW RTA's and Main Roads specifications and contract documents. The most likely equipment to be used during construction would include bulldozers, backhoes, scrapers, excavators, paving machines, concrete trucks, mobile cranes, compactors and compressors, steel drum vibration rollers, rubber/multi-tyred rollers, water trucks and haul trucks. All the contractor's operations, equipment, compounds and material storage areas would be located within the road reserve or in adjacent areas. All sites would be securely fenced. The Tugun Bypass would be built over a period of approximately 24 months. Once opened the contractor would maintain the bypass for a period of ten years.

What are the impacts of the proposal?

Planning and land use

A corridor for the Tugun Bypass is included on the Tweed Heads Local Environmental Plan 2000. However, the route of the proposal has been realigned to minimise environmental impacts and would pass through land zoned predominantly for Special Uses (Airport), Rural and Open Space/Recreation and a small portion of land zoned environmental protection. The Tugun Bypass would not affect any proposals included in local statutory planning documents and would not inhibit development strategies in place in Gold Coast City or Tweed Shire local government areas.

Traffic and transport

Access would be maintained to all existing properties on completion of the proposal. There may however be some short-term disruption to access to some properties in Tweed Heads West adjacent to the road works during construction. There may also be some disruption to traffic, pedestrians and cyclists during construction of the interchange at Tweed Heads Bypass. However on opening, the Tugun Bypass would attract a significant proportion of traffic from the existing route along the Gold Coast Highway thereby alleviating existing traffic-related impacts.

Noise

The Bypass would move the flow of interstate and heavy vehicle traffic from the Gold Coast Highway to a new route to the west. Local traffic would continue to use the Gold Coast Highway corridor. At the northern end of the bypass the route passes close to residential areas not currently affected by noise from traffic. At the southern end residential areas close to the Tweed Heads Bypass are already affected by existing traffic noise, the Tugun Bypass will alter traffic flows and alter the distribution of road noise.

The noise likely to be generated by the bypass and its impacts on surrounding properties has been assessed as part of the assessment process. Noise levels have been predicted from a computer noise model. It has taken account of likely traffic flows, road surfaces, speed, percentage of commercial vehicles and the noise levels at properties either side of the alignment have been calculated. The results of the modelling show that the standards required for noise at properties can be met in most cases by a combination of low noise road surface and noise barriers. This will be further studied during the detailed design phase and the contractor will develop the final configuration of barriers and treatments. In some cases there may be a requirement to implement measures outside the road reserve to ensure standards are met. This will require negotiations between individual landholders , the NSW RTA and Main Roads.

Air quality

Air quality in the Tugun area is good with no exceedances of established health-based criteria for vehicle pollutants. Predictions of future concentrations of the main pollutants indicate that levels are expected to remain well below established air quality guidelines at locations 10 m from the edge of both the existing route and the proposed bypass with the latter in operation. The proposal would result in a 3.5% decrease in emissions of the greenhouse gas carbon dioxide by 2017, however the savings contributed by the bypass are very small when compared with the contributions of the rest of the Gold Coast road network.

The level of dust associated with road construction work can, under worst case meteorological conditions result in short-term dust impacts. Exposed areas would be stabilised as soon as possible and appropriate dust suppression methods would be used to reduce impacts. The majority of the proposed bypass is at some distance from houses and air quality is not expected to be a problem during construction at these locations.

Cultural heritage

Aboriginal people have been present in the northern NSW – south east Queensland region for at least 22,000 years. By approximately 2,500 years ago this area was populated by numerous language groups linked through extensive systems of marital exchange and ceremonial obligation. The first non-indigenous people came to this area in the 1800s and initial activity was focused on the cedar trade.

The area adjacent to the proposed road corridor has experienced a high degree of disturbance and a number of items including a bora ground have been destroyed by previous construction activities. However, important indigenous relics are located in the National Estate area which lies immediately to the west of the proposed alignment adjacent to Cobaki Broadwater. The midden complex within this area is of particular importance comprising intact cultural material in an estuarine site which maintains much of its former environmental context. A small part of the road works would intrude beyond the boundary of the National Estate area affecting some 1,000 square metres. This would be entirely within an area previously disturbed and would not affect the shell midden complex or the fenced vegetated area. No other known sites of indigenous heritage significance would be affected by the proposal and site surveys did not identify any new sites, stone scatters or isolated artefacts. Reports of burials (graves) in this area cannot be discounted. Testing for sub-surface deposits would be undertaken in this area and in three other areas prior to the start of construction. A cultural heritage management plan will be developed in consultation with the Traditional Owners and the various regulatory agencies to deal with any material that might be discovered during the sub-surface testing or during construction.

No sites of European cultural significance were identified along the alignment.

Water quality and flooding

The key surface water feature in the study area is the Cobaki Broadwater to the west of the proposed alignment. In common with all road projects, construction of the Tugun Bypass presents a potential risk to water quality. The primary risk occurs while soils are exposed during earthworks when suspended sediment and associated pollutants can be washed into downstream watercourses. This can cause siltation of waterways and damage to ecosystems. A soil and water management plan would be prepared for the Tugun Bypass indicating guidelines to be followed to address water quality impacts. During operation of the Tugun Bypass, there is the potential for water pollution originating from the road to affect Cobaki Creek and the Broadwater. A system of filter strips and swales along with constructed wetlands will treat run off from the bypass once it is opened.

The primary impact of the Tugun Bypass proposal on the Tweed River floodplain would be the loss of storage capacity resulting from the filling required for the road embankments. Flood modelling has shown that the filling required for the proposal would result in increases in levels of less than 5 mm for up to the 100-year flood event. The magnitude of these impacts would be negligible. Any loss of floodplain storage capacity as a result of the proposal would be insignificant in the context of the Tweed River catchment as a whole and it would have little

effect on the duration of flooding in the area. The primary means of managing the potential impacts of the proposal on flooding is to include the necessary waterway openings across the alignment of the bypass and provide adequate drain rerouting where this is required. These structures would maintain future floods at acceptable levels.

Groundwater

A number of aspects of the tunnel construction have the potential to affect groundwater. These relate to the consequences of lowering the groundwater during construction and the possible obstruction of groundwater movement following the positioning of the tunnel walls within the aquifer. Lowering of the groundwater around the tunnel during its construction has the potential to reduce levels and/or flows to Cobaki Broadwater and its associated wetlands. Dewatering could also allow the intrusion of saline water from the estuary into the adjacent sand aquifer. Groundwater would therefore be pumped across the tunnel obstruction for re-injection into the sand aquifer to maintain groundwater levels at or close to natural conditions during the time it takes to build it. Computer modelling has shown that the operation of injection wells would result in no noticeable change to levels or flows at the nearby wetlands during construction.

Temporary lowering of the water table during construction could result in the oxidation of sulphide materials in the soil. This process generates acid which, on rewatering, could migrate as acidic groundwater. Once built the tunnel would form an impermeable barrier across the groundwater flow path extending up to a depth of 20 m. Mitigation during the operation of the bypass would consist of a network of cross-alignment drains which would equalise groundwater levels on either side of the obstruction. This would allow unhindered groundwater movement, reinstating flows across the barrier provided by the tunnel and its access ramps. Management during both construction and operation would comprise monitoring of water levels and pumped water quality. Additional inspections of the drainage system would be undertaken during operation. In all cases, if monitoring indicates inadequate performance of the measures included in the design, remedial actions would be initiated. These could include increasing the number of injection wells and in-line treatment of the pumped water.

Flora and fauna

The proposed Tugun Bypass spans an area of south-eastern Queensland and north-eastern NSW recognised for its high environmental values. It comprises a biogeographical zone where temperate and sub-tropical regions meet and a large number of flora and fauna species are at the northern or southern limits of their geographical range. The area accommodates significant flora and fauna species and a high diversity of vegetation communities and important mammal, bird, amphibian and bat species. The surveys undertaken for the EIS covered an area of approximately 9 square kilometres. A total of 586 plant species were recorded in the study area together with 247 species of vertebrate fauna, consisting of 179 species of bird, 31 species of mammal, 20 reptile species and 17 amphibians. Notable values of the study area include:

- the occurrence of populations of threatened plant species
- small isolated populations of Common Planigales and Long-nosed Potoroos and significant populations of the Wallum Sedge Frog, Wallum Froglet and the Eastern Long-eared Bat
- a high diversity of vegetation communities
- a high diversity of bird, amphibian and bat species

- the occurrence of habitat for a range of threatened and significant flora and fauna species and important habitat for use by a number of bird species protected under migratory agreements
- proximity to Cobaki Broadwater, an important breeding ground for commercially and recreationally important fish in the Tweed Estuary.

The development of the Tugun Bypass has been guided by the principle of delivering infrastructure while protecting the environment. The original C4 alignment has been altered a number of times to route it away from ecologically sensitive areas. This has included alterations to avoid orchid habitat, changes to avoid Long-nosed Potoroo habitat as much as possible, the design of a launched bridge for Hidden Valley, and changes to minimise impacts on Wallum Sedge Frog breeding ponds.

However, it has not been possible to avoid all impacts on areas of native vegetation and their associated ecosystems and residual impacts would remain. The bypass would result in the removal of around 45 ha of the native vegetation communities. When the route of a new road crosses through areas of native vegetation and important habitat, it creates an effect known as an edge effect. This is degradation of habitat quality that occurs as a result of weed invasion, increased predation, disturbance, and changes in moisture regimes. There will be an additional 26 ha of edge-affected habitat.

To offset the residual impacts a compensatory habitat package has been developed. The package consists of land purchases and management measures. The package has been prepared in recognition of the nationally important ecological values of the area and presents an opportunity to provide the necessary level of management and protection the area deserves.

Overall, the land package combined with the management measures represents a favourable environmental outcome from a local, regional and national perspective for the following reasons:

- it fulfils the size and proximity criteria set out in the draft NSW RTA policy
- it compensates for key habitat that would be lost and edge-affected as a result of the proposal
- it is in close proximity to the impacted area and is directly or indirectly connected to habitat within the Tugun Bypass study area
- it compares favourably with the type and quality of habitat within the Tugun Bypass study area
- it contains a regionally significant Koala population that may be one of the last populations in south and west Tweed
- it contains mature hollow-bearing trees that appear to be a limiting resource in the Tugun Bypass study area
- it forms a strategically located link connecting habitat areas around the Cobaki Broadwater for flora and fauna
- it provides an opportunity for the establishment of a continuous area of land with environmental protection around the Cobaki Broadwater.

Social and economic effects

During construction of the Tugun Bypass there would be temporary, short term impacts on the general amenity of those residents adjacent to the construction works and, more intermittently,

those adjacent to the proposed access routes to the site. Users of surrounding roads and, in some instances, pedestrian networks would also be affected for short but varying periods. Management measures would aim to reduce these impacts as much as possible.

During operation of the Tugun Bypass, the only areas which could be affected by community impacts are those close to the interchange at Tweed Heads Bypass. However, measures included in the proposal would minimise any effects. These would include the provision of pedestrian and cyclist crossing of the bypass and the inclusion of mitigation measures to manage traffic noise. Extensive planting of vegetation in these areas would also minimise the visual changes brought about by the proposal. The removal of a high proportion of through traffic from the existing route through Tugun would result in an improvement in local amenity producing benefits for the community.

Construction of the Tugun Bypass would create both direct and indirect employment benefits for the local and regional economies. Once the proposal is operational, improved accessibility would assist in the stimulation of increased economic activity in the area with broader benefits stemming from the reduced costs of distribution resulting from the journey time savings.

Visual quality and landscape character

The existing visual character of the area along the proposed route of the Tugun Bypass is generally flat and undistinguished except where vegetation frames views to the steeper ground to the west and across the airport to the coast. The construction of the proposal would result in visual change which would be softened over time as the landscape planting included in the proposal matures. A landscape strategy has been developed to mitigate the visual impacts of the proposal using treatments that are consistent and appropriate for the unique location. During detailed design, this plan would be developed further and it will integrate with the concepts being developed for the future upgrade of the Pacific Motorway from Nerang to the border.

Hazard and risk

Potential hazards during operation of the Tugun Bypass include the transport of dangerous goods and the spillage of hazardous chemicals. Proposed water quality measures such as constructed wetlands would prevent hydrocarbons such as oil and petrol from entering local creeks. The transport of certain classes of dangerous goods (explosives and compressed and liquefied gases) through the tunnel pose the greatest risk of major damage and the risk of fatalities in the event of an accident. It is therefore proposed that vehicles carrying these goods are banned from using the bypass. The removal of other classes of dangerous goods from the existing highway through Tugun would result in a substantial reduction in the risk for the community living adjacent to that route. All road lighting for the proposal with the potential to interfere with prescribed airspace at the airport would comply with the requirements of the Airports (Protection of Airspace) Regulations and be approved by the airport operators.

Cumulative impacts

The preparation of the EIS has involved detailed assessment of all environmental issues associated with the study area. The assessment adopted a large study area to ensure that impacts away from the immediate footprint of the proposal were also considered.

The results from the studies provided a framework for assessing the impacts of the proposal and those of associated proposals and activities. At the start of the process, the study area was

known to have a number of high environmental values, particularly those associated with flora and fauna. The studies have confirmed this and have also provided additional data and information. The studies have, therefore, greatly increased knowledge of the environment of the study area.

Other known or proposed activities or developments that could lead to cumulative impacts have been assessed. The building of rail link from Robina to Coolangatta has been assessed and a roof slab included in the proposal so as not to preclude its future construction. The two major residential developments proposed either side of the alignment, close to the NSW–Queensland border, would lead to significant cumulative impacts on the high ecological values of the area if they were to proceed without any mitigation measures. The Tugun Long-nosed Potoroo population would be most at risk from these developments, with or without the bypass proposal. Other proposed activities in the area include the upgrade of the Pacific Motorway from Nerang to the border, the development of commercial precincts at the airport and an extension to the main runway at Gold Coast Airport.

The package of mitigation measures has included a number of commitments to work with surrounding developments to improve the management of conservation issues in the area. This includes agreement between GCAL and the proponents to work together to prepare and implement a vegetation management plan for the southern section of the OLS.

What measures would be used to reduce environmental impacts?

An environmental management plan would be prepared by or on behalf of Main Roads and the NSW RTA to the satisfaction of the relevant approval authorities, by consulting with appropriate government agencies during detailed design and prior to the start of construction works. The environmental management plan would define the procedures to be carried out prior to, during, post-construction and during operation of the Tugun Bypass to manage potential environmental impacts. All the mitigation measures described in the EIS, subsequent environmental safeguards developed during the detailed design stage of the proposal and any conditions imposed by the various approval authorities would be incorporated in the environmental management plan.

The environmental management plan would become the reference document to ensure that the commitments to environmental protection and management in the EIS and subsequent approvals are fully implemented by Main Roads, the NSW RTA and their agents. It would also serve as a framework to confirm the accuracy of impact predictions made in the EIS and to determine the effectiveness of the mitigation measures. This would be done through the preparation and implementation of a monitoring program. The environmental management plan would be prepared to be relevant to all stages of construction.

What are the benefits of the Tugun Bypass?

The construction of the Tugun Bypass would provide an alternative corridor for heavy vehicles and take them away from the residential areas of Tugun and Bilinga. Significant improvements in amenity would result from this, including reduced noise levels, improvements in access and better air quality.

The bypass would also separate interstate traffic from local traffic resulting in lower traffic volumes on the local roads and improved levels of amenity and safety. This would also benefit cyclists and pedestrians. Conflicts between local and through traffic, as is currently the case, would be removed.

Travel times from the border to Stewart Road would be greatly reduced. Modelling of future traffic flows show that significant delays of greater than 30 minutes would be commonplace by 2017 without the bypass; with the bypass, travel times from the border to Stewart Road would be reduced to 5 minutes.

A detailed economic assessment of the Tugun Bypass has been undertaken and the results show the savings to the community are $59 million in avoiding accidents and $1,861 million in reduced travel times. If the bypass were not built, then the $1,920 million in savings becomes the potential cost to the community of not proceeding with the proposal. The cost is also reflected in the continually lower level of service leading to increased frustration among users.

What are the conclusions of the EIS?

The proposed Tugun Bypass would provide one of the missing links in the interstate highway between Brisbane and Sydney and, by separating through and local movement functions, would result in an improvement in both the safety and efficiency of these movements. The proposed Tugun Bypass provides an appropriate balance between social and biophysical factors and would provide substantial road user economic benefits. Management measures have been proposed to ensure that the identified adverse impacts of the proposal can be mitigated and the environment adequately protected.

What are the contents of the EIS?

The EIS contains the following parts:

Part A: Overview and Background (Chapters 1 to 3) includes a preliminary description of the proposal, the determination and approval processes required by the three determining authorities, and a summary of community and stakeholder consultation

Part B: Need for the Proposal and Consideration of Alternatives (Chapters 4 and 5) outlines the need for the Tugun Bypass and the consequences of not constructing the bypass, together with a description of the route selection and concept design processes

Part C: The Tugun Bypass Proposal (Chapters 6 and 7) provides a detailed description of the proposal and the methods proposed for its construction

Part D: Impacts of the Proposed Tugun Bypass on the Physical and Biological Environment (Chapters 8 to 11)

Part E: Impacts of the Proposed Tugun Bypass on the Socioeconomic Environment (Chapters 12 to 16)

Part F: Cumulative Impacts (Chapter 17), includes an assessment of impacts associated with other transport proposals and identified major development proposals. Environmental management and monitoring is discussed in Chapter 18.

Part G: Justification of the Proposal (Chapters 19 and 20) summarises the findings of the impact assessment and provides a justification of the proposal in terms of environmental, social and economic considerations and the principles of ecologically sustainable development.

How can I make a submission?

The draft EIS, SIS and MDP documents will be available for inspection from Monday 13 December 2004 until Monday 14 March 2005 at the following locations. During the period of the public exhibition, copies of the draft EIS and SIS documents will be available for purchase for

$27.50 (printed copy) or $11 (compact disc), at locations marked with a hash (#). Copies of the draft MDP will be also available for purchase for $15 (printed copy) or $5 (compact disc), at locations marked with a hash (#) and a star (*). All prices include GST. Any interested person or organisation is invited, before the closing date specified below, to provide written comments on the proposed activity and draft EIS (including draft EIS Summary Brochure), SIS and MDP documents.

Australian Capital Territory

Department of the Environment and Heritage
John Gorton Building
King Edward Terrace
Parkes ACT

New South Wales

Roads and Traffic Authority (Grafton) #
Pacific Highway Office 21 Prince Street
Mon-Fri, 8:30am – 4:30pm

Roads and Traffic Authority (Sydney) #
Ground floor Centennial Plaza
260 Elizabeth Street Surry Hills
Mon-Fri, 8:30am – 5pm

RTA Motor Registry (Tweed Heads) #
Greenway Drive, Tweeds Heads
Mon – Fri, 9am- 5pm, Sat 8:30am – 12noon

Tweed Shire Council
Civic Centre Tumbulgum Rd
Murwillumbah
Mon, 8:00am – 4.45pm
Tues-Fri, 8:00am – 4:30pm

State Library of New South Wales
Level 7, Reference Library
Macquarie Street
Sydney
Mon – Fri, 9:00am to 9:00pm
Saturday, Sunday 11:00am to 5:00pm

Tweed Heads Branch Public Library
Civic Centre, Brett Street, Tweed Heads
Mon-Thu, 10:00am – 5:00pm
Fri, 10:00am – 7:00pm
Sat, 9:00am - midday

Kingscliff Branch Public Library
Turnock Street Kingscliff
Tues, Thu, Fri, 10:00am – 5:00pm
Wed, 10:00am – 7:00pm
Sat, 9:00am - midday

Murwillumbah Area Public Library
Civic Centre, Tumbulgum Road
Murwillumbah
Mon, Tues, Wed, Fri, 10:00am – 5:00pm
Thu, 10:00am – 8:00pm
Sat, 9:00am - midday

NSW Govt Info Centre (Sydney)
Goodsell Building, Cnr Phillip & Hunter Sts
Mon-Fri, 8:30am-5pm

Nature Conservation Council (Sydney)
Level 5, 362 Kent Street Sydney
Mon-Fri, 9am – 5pm

Department of Infrastructure, Planning and Natural Resources Planning Centre (Sydney)
Henry Deane Building
20 Lee Street, Haymarket
Mon-Fri, 8:45am – 5pm

Queensland

Queensland Department of Main Roads#
36-38 Cotton St Nerang
Mon-Fri, 8:30am – 5:00pm

Queensland Transport#
Spring Hill Office Complex
Ground Floor, 477 Boundary Street Spring Hill
Mon, Tues, Thu, Fri, 8:30am – 4:30pm
Wed, 9:30am – 4:30pm

State Library of Queensland
299 Montague Road
West End
Mon-Thu, 10:00am – 8:00pm
Friday, Saturday, Sunday and Public Holidays, 10:00am – 5:00pm

Elanora Library
The Pines Shopping Centre
K.P. McGrath Drive Elanora
Mon, Tue, Wed, Fri, 9:00am – 6:00pm
Thu, 9:00am – 7:00pm
Sat – 9:00am – 3:00pm

Robina Library
Cnr Robina Town Centre Dr & San Antonio Blvd
Mon, Tue, Wed, Fri, 9:00am – 6:00pm
Thu, 9:00am – 7:00pm
Sat, 9:00am – 3:00pm
Sun, Midday – 4:00pm

Coolangatta Library
Griffith Street, Coolangatta
Mon-Fri, 9:00am – 5:00pm
Sat, 9:00am – midday

Gold Coast Airport * (draft MDP only)
Level 1, Airport Central, 1 Eastern Avenue
Gold Coast Airport, Bilinga
Mon-Fri, 9:00am – 5:00pm

Project staff from the NSW RTA, Queensland Main Roads and Gold Coast Airport Limited will be available to discuss the project and answer questions at the following venues:

Thursday 16 December 2004	Tugun Community Centre 414 Coolangatta Road Tugun	2:00 pm to 7:00 pm
Thursday 16 December 2004	Tweed Shire Council Civic Centre Brett Street Tweed Heads	2:00 pm to 7:00 pm
Saturday 18 December 2004	The Pines Shopping Centre K.P. McGrath Drive Elanora	10:00 am to 2:00 pm
Saturday 18 December 2004	Tweed City Shopping Centre Minjungbal Drive Tweed Heads South	10:00 am to 2:00 pm

Dates for staffed displays after the 18 December 2004will be advised via media advertisements and on the NSW RTA, Main Roads and Gold Coast Airport Limited websites, or by calling the Project Team on (freecall) 1800 209 020.

A draft MDP can be viewed on Gold Coast Airport Limited website at www.goldcoastairport.com. All other documents can be viewed on the NSW RTA website at www.rta.nsw.gov.au and on Main Roads website at www.mainroads.qld.gov.au/tugunbypass.

Persons or organisations wishing to comment on the proposed activity, and the draft EIS and draft SIS are invited to make written representations by letter/fax/e-mail on or before 4:00 pm on Monday 14 March 2004 to:

Project Director
Tugun Bypass Project
Queensland Department of Main Roads
36-38 Cotton Street
PO Box 442, Nerang Qld 4211
Fax No.: (07) 5596 9511
E-mail: SouthCoast@mainroads.qld.gov.au

Written comments on the draft MDP are also invited. They can be made by letter/fax/e-mail on or before 4pm on Monday 14 March 2005 to:

Project Manager
Tugun Bypass Major Development Plan
Gold Coast Airport Limited
Level 1, Airport Central, 1 Eastern Avenue
PO Box 112, Coolangatta QLD 4225
Fax No.: (07) 5536 2838
E-mail: BBidwell@gcal.com.au

All submissions will be treated as public documents unless confidentiality is requested. Where the supplier indicates at the time of supply of information that it should be kept confidential, the NSW RTA and Main Roads will attempt to keep it confidential but there may be legislative or legal justification for the release of the information, for example under the NSW Freedom of Information Act 1989 and/or Queensland Freedom of Information Act 1992 or subpoena or statutory instrument. A list of names of members of the public making written comments upon the draft MDP to Gold Coast Airport and a summary of the comments must accompany the draft MDP when submitted to the Commonwealth Minister for Transport and Regional Services.

For more information please contact: Phil Clutterbuck, Queensland Department of Main Roads Project Director on 07 5596 9500.

Glossary and abbreviations

Abutment	The peripheral part of a structure that directly receives a load.
Acid sulphate soils (ASS)	Naturally acid clays, mud and other sediments usually found in swamps and estuaries. They may become extremely acidic when drained and exposed to oxygen, and may produce acidic leachate and run-off which can pollute receiving waters and liberate toxins. ASS are classified as materials which are above the groundwater, are undergoing oxidation and have a pH of less than 4.0.
Afflux	Extent of increased water levels upstream of a constriction in flow caused by a bridge channel or culvert.
Airshed	Lower atmosphere within a defined geographic region.
Alignment	A detailed geometric layout, in plan and profile, following a general route.
Alluvial soil	Juvenile soils formed by deposition from still or moving water. Little pedological development beyond some accumulation of organic matter at the surface.
Alluvium	Unconsolidated deposit of gravel, sand or mud formed by water flowing in identifiable channels. Commonly well sorted and stratified.
Ambient	The background level at a specified location, being a composite of all sources. Examples include noise and air pollutants.
Amenity	The degree of pleasantness of an area or place.
Annual average daily traffic (AADT)	Annual Average Daily Traffic volume representing the total traffic in both directions at each location, calculated from mechanically obtained axle counts.
Anthropogenic	Caused or influenced by the activities of humans.
ANZECC	Australian and New Zealand Environment and Conservation Council
Aquifer	A soil or rock layer or group of layers that is sufficiently saturated and permeable to yield significant quantities of water.
Arboreal	To live in, or be connected with, trees.
Archaeological site	A site is defined as any material evidence of past Aboriginal activity that remains within a context or place that can be reliably related to that activity.
Argillite	A compact rock, derived from mudstone or shale.

Artefact	An object, normally portable, made or modified by human hands.
Asphalt or asphaltic concrete	A dense, continuously graded mixture of coarse and fine aggregates, mineral filler and bitumen usually produced hot in a mixing plant.
Attenuation	The reduction in sound pressure level magnitude during transmission (around a barrier or over a distance outdoors). (Unit: dB, dBA)
Average daily traffic	Average daily traffic based on survey counts and not adjusted as for AADT.
Average recurrence interval (ARI)	Average or expected period between exceedance of a flood.
Background noise level	The ambient sound pressure level in the absence of the sound under investigation exceeded for 90% of the measurement period. Normally equated to the average minimum A-weighted sound pressure level. Symbol L_{A90} (unit: dBA).
Batter	The side slope of walls, embankments and cuttings or the degree of such slope, usually expressed as a ratio of horizontal distance to one vertical height.
Bedrock	The unweathered rock that lies below loose surface deposits of soil and alluvium.
Benefit Cost Ratio	The ratio of the present value of benefits to the present value of costs of a project.
Berm	A ledge formed at the top, bottom, or intermediate level of an earth slope.
Biological diversity	The variety of all life forms, comprising genetic diversity (within species), species diversity and ecosystem diversity.
Bored pile	A long, heavy steel or reinforced concrete post inserted vertically into the ground by drilling to support a load.
Borehole	A hole produced in the ground by drilling or driving.
BP	Before present as applied to the dating of Aboriginal items.
Bund wall	A wall erected to prevent the escape of stored liquids into the environment.
CAMBA	China-Australia Migratory Bird Agreement.
Canopy	The uppermost layer of foliage formed by the crowns of trees.
Capital costs	Initial one-off outlays required to establish, construct or equip an investment project.

Carbon monoxide	A colourless, odourless, poisonous gas which reduces the oxygen-carrying capacity of blood.
Carriageway	The portion of a road or bridge used by vehicles (inclusive of shoulders and auxiliary lanes).
Coffee rock	Is a locally used term for a weakly to strongly cemented brown to black coloured fine to medium sand or silty sand. It is formed by the downward leaching of organic matter which is flocculated at the level of an often fluctuating groundwater table. It occurs as discontinuous horizons of variable strength and thickness.
Concentration	On release, emissions are transported and diluted resulting in a volume of pollutant (in the case of traffic) per volume of ambient air. Measured in parts per million or micrograms per cubic metre. Ambient air quality goals are expressed in terms of concentrations.
Concept design	Initial functional layout of a concept, such as a road or road system, to provide a level of understanding to later establish detailed design parameters.
Contaminated	A condition or state which represents or potentially represents an adverse health or environmental impact because of the presence of potentially hazardous substances.
Culvert	One or more adjacent, enclosed channels for conveying a stream below road formation level.
Cumulative impact	The sum effect on the environment resulting from the successive effects of several different impacts.
Cut-and-cover	A method of tunnel construction whereby the structure is built in an open excavation and subsequently covered.
Cut batters	The side slopes of cuttings.
dBA	Decibels using the 'A' weighted scale, measured according to the frequency of the human ear.
Decibel	A scale unit used in the comparison of powers and levels of sound energy. The number of decibels is ten times the logarithm to the base of ten of the ratio of the powers. (Unit: dB).
Depauperate	Falling short of full natural development.
Design speed	A nominal speed used for the design of geometric features of the road, such as curves.
Discharge/Flow velocity	The rate at which liquid flows.
Discount factor	Rate of interest used to discount future values and reduce them to present rate value.

Disjunct	Separate.
Drawdown	The localised lowering of groundwater levels as a result of water extraction.
Dredging	Removal of solid material from the bottom of a body of water using equipment such as a scoop or suction pipe.
Dual carriageway	A highway or road with separated carriageways for traffic travelling in opposite directions.
Earthworks	The process of extracting, moving and depositing earth during construction.
Earthwork balance	Comparison of the volume of material derived from the proposal as a result of cuts and the volume of material required as fill. Ideally these should be the same.
Ecologically sustainable development	Using, conserving and enhancing the community's resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be increased.
Ecosystem	A functional unit of energy transfer and nutrient cycling in a given place such as a forest or estuary; it includes all the relationships within the biotic community and between the biotic components of the system.
Ecotone	A region of transition between two plant communities, characterised by a transition between either the floristic components of the communities or the structures of the communities.
Embankment	A mound or bank of earth or stone formed to support a roadway, serve as a protective barrier, or the like.
Emission	Release of a substance from a source. In the case of air pollutants, the rate of emission is measured in grams per second.
Energy dissipation	Decreasing the velocity of discharge by the use of various engineering and naturally occurring impediments.
Erosion	The natural process where wind or water detaches a soil particle and provides energy to move the particle.
Excavation	The act or process of digging out earth during construction.
Fauna	The animal population.
Fill batters	The side slopes of material placed in an embankment; the degree of such slope is expressed as a ratio of x horizontal to one vertical.

Floodplain	Large flat area of alluvium adjacent to a watercourse, characterised by frequent active erosion and aggregation by channelled and overbank stream flow.
Flora	Plants that make up the vegetation of a site.
Floristic	Refers to the species composition of a plant community.
Frequency	Similar to pitch of a musical note in sound pressure fluctuations of cycles per second (or Hertz). Most sounds contain a composite of frequencies of varying sound pressure levels in the range of 20 Hertz to 20,000 Hertz. (Symbol of unit: Hz).
Grade separation	The separation of a road, rail or other traffic so that crossing movements, which would otherwise conflict, are at different elevations.
Gradient	The degree of ascending or descending with a uniform slope.
Greenhouse effect/global warming	The heating of the atmosphere by the absorption of infrared energy remitted by the Earth as it receives energy from the Sun.
Greywacke	Coarse-grained sandstone that consists of poorly sorted angular to subangular grains of quartz and feldspar, with a variety of dark rock and mineral fragments, embedded in a compact clayey matrix having the general composition of slate.
Ground vibration	Representing the combined speed of ground oscillation at a point from a source of vibration such as a blast or piece of mobile plant (Unit: mm/s, m/s).
Groundwater	All waters occurring below the land surface. The upper surface of the soils saturated by groundwater in any particular area is called the water table.
Habitat	The place where an organism lives; habitats are measurable and can be described by their flora and physical components.
Headstock	Bearing supporting the main elements of a structure.
Hydraulic gradient	Difference in pressure (rate of change per unit distance of flow) measured at a specific point and in a given direction.
Hydrocarbon	Class of compounds containing only hydrogen and carbon. Examples include methane (CH_4) and benzene (C_6H_6).
Hydrology	The study of rainfall and surface water run-off processes.
IAS	Impact Assessment Study; a requirement for project approvals in Queensland
Indurated	Hardness as applied to soils that have hardened under the influence of ground conditions.

In situ	In original place or location
Interbedded	Layers or bands of sedimentary rock of different grain size such as sands, silts and clays.
Interchange	A grade separation of two or more roads with one or more interconnecting carriageways or ramps.
Introduced species	Plants and animals not native to Australia and known or thought to have been brought in by humans.
Invert	The level at the lowest point of a drain, culvert, pipe or channel.
Invertebrate	An animal without a backbone or spinal column.
ISO 14001	International standard relating to the format and preparation of environmental management systems.
Isolated find	A single stone artefact, not located within a rock shelter, and which occurs without any associated evidence of Aboriginal occupation within a specified radius.
JAMBA	Japan-Australia Migratory Bird Agreement.
Leachate	A liquid resulting from percolation through or contact with waste material.
Lens	Geologic deposit or body bounded by at least one curved, converging surface, giving it a lens like appearance.
Level of service	A qualitative measure describing operational conditions within a traffic stream and their perception by motorists and/or passengers.
Local road	A road or street used primarily for access to abutting properties.
Longitudinal section	The section drawn along the length of the route.
Median	A strip of road not normally intended for use by traffic, which separates carriageways for traffic in opposite directions.
Metapopulation	A population comprising several local sub populations spatially separated but linked by migrants.
Midden	Open accumulation of shells, food refuse and sometimes stone tools.
Mode share	The proportion of use of each main travel mode.
mol H^+/tonne	A measure of hydrogen gas per tonne in terms of its molar mass.
mr/hour	Radiation dose of one-thousandth of a rad per hour.
NATA	National Association of Testing Authorities Australia

National Estate	Places defined and registered under the Australian *Heritage Commission Act 1975* as having aesthetic, historic, scientific, or social significance or other special value for present and future generations.
Net present value	The present value of benefits less the present value of costs.
Nitrogen dioxide (NO_2)	A respiratory irritant formed by the oxidation of nitric acid.
Obstacle limitation surface (OLS)	Definition of the volume of airspace near an airport which should remain free from obstacles that may endanger aircraft in visual operations or during the final phase of an instrument flight. It is not the intention to restrict all obstacles but to ensure that their impacts on aircraft operations are examined and their presence accounted for.
Ozone	A secondary air pollutant which is an indicator of photochemical smog. It is formed by chemical reaction involving oxides of nitrogen and reactive compounds under the influence of sunlight.
PANS-OPS Surface	Similar to the obstacle limitation surface but relating to instrument procedures. As a result, the PANS-OPS surface cannot be penetrated by an obstacle under any circumstances. Defined surfaces are protected by the *Airports (Protection of Airspace) Regulations.*
Particulates	Dust and other fine particles.
Pavement	The portion of a carriageway above the subgrade (generally natural material) for the support of, and to form a running surface for, vehicular traffic.
pH	A measure of the degree of acidity or alkalinity expressed on a logarithmic scale of 1-14, on which 1 is most acid, 7 is neutral and 14 is most basic (alkaline).
Piezometer	A dedicated bore for measuring groundwater levels.
Point Load Index Strength test	Method of determining rock strength by crushing core samples in a specialised test apparatus.
Portal	Entry and/or exit of a tunnel.
Present value	Cumulative value of a number of future economic costs or benefits reduced to a current valuation taking into account the fact that future calls on resources have less value than their current equivalent because a smaller volume of current resources appropriately expended today could generate the required volume of resources at future dates.

Public transport mode	A mode of transport for carrying large numbers of the public, such as bus or train.
Quaternary sediments	Sediments deposited during the geological period of time from the present to two million years ago.
Raptor	Predatory animal, usually referring to birds.
Receptor	An environmental modelling term used to describe a map reference point where the impact is predicted. A sensitive receptor would be a home, work place, school or other place where people spend time. An elevated receptor is a point above ground level.
Rehabilitation	The restoration of a landscape and especially the vegetation following its disturbance.
Remnant vegetation	Native vegetation remaining after widespread clearing has taken place.
Residual	A substance or quantity that remains after a process has been completed.
Road corridor/reservation	The strip of land along which a road is to be constructed.
Sediment	Material of varying sizes that has been or is being moved from its site of origin by the action of wind, water or gravity.
Sedimentation basin	An area where run-off is ponded to allow sediment to be deposited. The longer the period that the run-off is held, the smaller the size of the sediment deposited. Such basins have to be cleaned regularly.
State Environmental Planning Policy Number 14 (SEPP 14)	Policy prepared under the *Environmental Planning and Assessment Act 1979* for the protection of identified coastal wetlands in NSW.
Shoulder	The portion of the carriageway beyond the traffic lanes adjacent to, and flush with the surface of the pavement.
Site compound	Area enclosing construction machinery, stockpiles and site offices, usually adjacent to construction sites.
Soil	That part of the upper weathered layer of the earth's crust that can support plant growth. Any naturally occurring loose or soft deposit forming part of the earth's crust and resulting from weathering or breakdown of rock formation or from the decay of vegetation.
Stockpile	Temporarily stored spoil/waste material.

Standard Penetration Test	A standard split spoon sampler, about 50 mm in diameter, is driven into the ground by blows from a drop hammer weighing 64 kilograms and falling 0.76 m. The sampler is driven 0.15 m into the soil at the bottom of a borehole, and the number of blows (N) required to drive it a further 0.3 m is then recorded. Although the test is entirely empirical, considerable experience with its use has enabled a reasonably reliable correlation to be established between the N value and certain soil properties.
Stone artefact	Fragment of a stone (used by Aborigines) which generally possesses one or more of the following characteristics: positive or negative ring crack, distinct positive or negative bulb of force, definite eraillure scare in a position beneath a platform or definite remnants of flake scars.
Stormwater	Rainwater which runs off urban and agricultural catchments, following rain events. This untreated water is carried in stormwater channels and discharges into creeks, rivers, lakes, harbours and oceans.
Sulphuric acid	A corrosive acid made from sulphur dioxide. Sulphuric acid can form from the oxidation of iron sulphides in soils.
Total suspended solids	A common measure used to determine suspended solid concentrations in a waterbody and expressed in terms of mass per unit of volume (eg milligrams per litre).
Travel demand	The number of potential trips generated by the population in a specific area for all purposes. This can be further divided into the type of trip (for example, work, recreation, commercial) and mode (for example, private car, public transport).
Treatment train	An expression used to the describe the sequence of systems used to treat surface water run off from a road.
Turbidity	A measure of light penetration through a water column containing particles of matter in suspension.
Unsuitable material	Material derived from the proposal of a quality not suitable for reuse as fill as part of the construction. It may be suitable for use in associated features such as landscape or acoustic mounds.
Velocity	The rate of speed or motion.
VHF Omini-range (VOR)	Navigational beacon used to assist aircraft to locate the airport and assist with landing during bad weather conditions.
Volume to capacity ratio	The ratio of the volume of traffic travelling on a mid block section of road in a specific period to the capacity of that mid block section during that period.

Water body	The collective name for all forms of static and active water features (rivers, creeks, streams, lakes and estuaries).
Weathering	Gradual wearing down of a natural or man made feature by the weather.
Wetland	Land either permanently or temporarily covered by water. These areas are usually characterised by vegetation of a moist soil or aquatic type.
1 in 100 year flood level	Refers to the flood which occurs, on average, once every 100 years. Also known as the 100 year Average Recurrence Interval of a flood. These events are of a random nature. It is possible for there to be two 100 year floods in successive years; similarly the 100 year flood may not occur for 200 years and the 100 year flood may not be the largest flood in the last 100 years.

Part A – Introduction and background

1. What is the Tugun Bypass?

1.1 Introduction

The existing road network linking the Pacific Motorway and the Gold Coast Highway in south-east Queensland with the Tweed Heads Bypass in northern NSW is currently operating at or near capacity. Traffic flows during peak periods exceed the capacity of the road network, resulting in delays. The congestion worsens significantly during holiday periods, when delays of an hour or more are common.

This part of the road network is the main route used by traffic travelling between NSW and Queensland, including heavy vehicles. This results in a conflict between the need for an efficient and fast cross-border route, and the need to provide a high level of access for the local community.

1.1.1 Overview of the proposal

The Tugun Bypass is a proposed new motorway between Currumbin in Queensland and Tweed Heads in NSW, and would significantly relieve traffic congestion in the existing road corridor.

The northern limit of the proposed Tugun Bypass would be where the bypass joins the Pacific Motorway at Stewart Road, Currumbin. The route then follows an alignment to the west of the Gold Coast Airport main runway, joining the Pacific Highway on the Tweed Heads Bypass just north of Kennedy Drive, Tweed Heads in NSW. Figure 1.1 shows the route of the proposed bypass.

The proposed bypass would be approximately 7 km long, and involve the construction and operation of a four-lane restricted-access motorway with a central median to separate north–south traffic flows at a posed speed of 100 km/h. The median would be wide enough to allow future upgrading to six lanes. Grade-separated interchanges would be provided at Stewart Road in Queensland and at the Tweed Heads Bypass in NSW. These would provide for all traffic movements and provide connections to the local road network. An overpass would also be provided within the Gold Coast Airport to maintain existing access.

At the southern end of the bypass, the proposed alignment crosses an area covered by the obstacle limitation surface (OLS) of the Gold Coast Airport. Obstacle limitation surfaces ensure a required level of safety for the operation of the airport and no structure is permitted to intrude into this area. A tunnel will be provided to comply with this requirement.

1.2 Background to the proposal

1.2.1 History of the proposed Tugun Bypass

An alternative transport corridor between Currumbin and Tweed Heads has been the subject of community discussion and planning for many years. The identification of alternatives to the Gold Coast Highway at Tugun has a history extending back to the closure of the original Gold Coast railway line in 1961.

Figure 1.1 **Proposed Tugun Bypass**

Conflicting service requirements of the Gold Coast Highway between Tugun and Coolangatta have increased with growing traffic volumes. In the existing strategic road network hierarchy for the area, the Gold Coast Highway provides an urban arterial (and tourist route) along the coastal strip between Helensvale and Coolangatta. Further to the west, the Pacific Motorway provides a regional arterial function between Helensvale and Tugun, carrying longer-distance traffic as part of the interstate highway system. Between Currumbin and Coolangatta, the Pacific Motorway traffic currently converges on the Gold Coast Highway in a corridor east of Gold Coast Airport.

A possible bypass route west of Gold Coast Airport was identified by Queensland and NSW authorities in 1982. Subsequently, the Queensland Department of Main Roads (Main Roads) acquired selected parcels of land in Queensland for road purposes. In 1987, the Tweed *Local Environmental Plan* (Tweed Shire Council 1987) identified a reserve to be used for a road to bypass Tugun. The former *Albert Shire Planning Scheme* (Albert Shire Council 1995) identified both a road bypass corridor and an extension of the Gold Coast rail line from Robina to Gold Coast Airport.

In 1998 Queensland Transport commissioned the *Southern Gold Coast – Tweed Corridor Study*. The aim of the study was to identify potential solutions to the transport issues facing the Southern Gold Coast and Tweed area. Extensive community consultation was conducted as part of the study. The outcome of the study was a strong community preference for a route to the west of the airport.

Following the completion of the *Southern Gold Coast – Tweed Corridor Study*, Main Roads commissioned a route selection study to further investigate options and recommend a route for a transport corridor in the area around Tugun. The resulting preferred alignment for the proposed transport corridor (called C4) extends from Stewart Road in Currumbin to Kennedy Drive in Tweed Heads, and passes to the west of Gold Coast Airport. This option was adopted by the Queensland government in 2000 for formal environmental impact assessment under a joint process to satisfy the requirements of the Queensland, NSW and Commonwealth governments. The route was also incorporated within the Gold Coast Airport master plan approved by the Commonwealth government in 2001.

These studies are summarised in Chapter 4.

1.2.2 Relationship to the Pacific Motorway and NSW Pacific Highway Upgrading Program

The Pacific Highway between Hexham, NSW and the Queensland border is currently being upgraded as part of a joint commitment between the NSW and Commonwealth governments. The upgrades, which are scheduled over a 10-year period, would benefit the people of NSW by:

- eliminating current accident 'black spots'
- reducing the journey time between Hexham and the Queensland border by 60 to 90 minutes
- reducing vehicle operating costs
- improving the regional and inter-regional function of the road corridor as the key transport spine on the north coast
- supporting regional economic development and tourism.

The program has committed $2.2 billion (from July 1996) to improvements. A number of upgrading projects have been completed and planning is well advanced for upgrading further significant sections of the highway in northern NSW to four-lane dual carriageway standard.

The Pacific Highway is the main road transport corridor on the north coast of NSW and the major link between Sydney, Brisbane and the Gold Coast. The highway carries high traffic volumes, particularly during holiday periods. The Pacific Motorway provides for interstate traffic movements to Brisbane and destinations further north, as well as providing an important inter-urban link between the Gold Coast and Brisbane.

The Pacific Motorway currently joins the Gold Coast Highway at Tugun. The section of common alignment has been developed as a major urban road with divided carriageways and service roads. It also has an important local access function, with 10 at-grade intersections over a length of about 3.5 km, four of which are signalised.

In recent years, the route to the north of the study area, between Logan and Nerang, has been upgraded to full motorway standard. This 43 km Pacific Motorway Project was opened to traffic in late 2000.

In 2004 the Commonwealth Department of Transport and Regional Services issued its *AusLink White Paper*. The White Paper sets out a number of national objectives for future land transport investment and recognises the Tugun Bypass as a priority for improvement in the national road network. The proposal is consistent with the required standards for future highways.

1.2.3 Relationship to the Robina to Coolangatta rail extension

The rail line would be part of the Coolangatta extension proposed by Queensland Transport and includes a station at Tugun and a southern terminus at the Gold Coast Airport. In Queensland the government has acquired the land necessary to provide a transport corridor. The corridor would provide the land necessary for construction of the bypass and preserve space for the future development of the rail link. The future rail line has also been recognised in the Gold Coast Airport Final Master Plan with identification of a possible corridor generally adjacent to the road proposal. Approximately 400m of rail corridor would need to be acquired in NSW to complete the link. The impacts of a future rail corridor are considered in the cumulative impacts section of this EIS.

1.2.4 Proponents for the proposal

The route of the bypass crosses land in Queensland and NSW and includes Commonwealth land in Gold Coast Airport. Approval for the proposal is required from three different jurisdictions.

To comply with the various approval processes in each jurisdiction, different sections of the proposal have different proponents. The Queensland Department of Main Roads is the proponent for the section of the bypass within Queensland and the rail roof slab within the airport while the NSW Roads and Traffic Authority (NSW RTA) is the proponent for sections of the bypass within NSW. Gold Coast Airport Limited is not a proponent for the project but has submitted a major development plan for the section within Commonwealth Airport Land. It is currently intended that day to day operations would be managed with agreement of the NSW RTA by Main Roads through the latter's Traffic Management Centre at Nerang. This is both due to costs and limitations in telecommunication technology and the impact that incidents on the proposed bypass would have on the road network in the south Gold Coast area.

1.2.5 Objectives of the Tugun Bypass

The proposed bypass aims to satisfy two primary objectives and to have regard for the possible future development of a rail line. The two objectives are:

- to provide an efficient, high-speed link for freight and other regional and interstate traffic between Queensland and NSW
- to separate heavy vehicles and other interstate traffic from local and tourist traffic in the Tugun area.

1.2.6 The purpose of the EIS

The purpose of the EIS is to seek approval for the proposal under the following legislation:

- Commonwealth Environment Protection and Biodiversity Conservation Act 1999
- NSW Environmental Planning and Assessment Act 1979
- Queensland Transport Infrastructure Act 1994.

Approval is also required under the Commonwealth *Airports Act 1996*, which requires the preparation of a major development plan. This has also been prepared and is to be displayed concurrently with this EIS. A species impact statement (SIS) has also been prepared to meet the requirements of the NSW *Threatened Species Conservation Act 1995*.

1.2.7 The proposal examined in the EIS

The proposal examined in the EIS is the C4 route for the Tugun Bypass. The EIS also assesses the impacts of accommodation works for a possible future rail tunnel under the Gold Coast Airport runway. Those works are physically separate from the proposed bypass but it is intended that they be undertaken at the same time as the construction of the bypass as it will not be possible to construct the slab once the runway extension is built. The accommodation works are necessary to allow for the future construction of the railway described in Chapter 17. Main Roads is the proponent for the accommodation works.

The Robina to Coolangatta rail extension does not otherwise form part of the works proposed in this EIS. The proposal consists of a preferred alignment located in an assessment corridor which is 1 km wide on either side of the alignment.

The proposed bypass would be located on the preferred alignment (Option C4) within the 2km study area that forms the basis of the detailed assessment in this EIS.

1.2.8 Related study documentation

A number of assessments of various components of both the road and rail proposals have been completed and, in some cases, exhibited over the past few years.

An environmental impact assessment (EIA) for the section of the Tugun Bypass between Currumbin and a point just north of Boyd Street was exhibited in November 2002, and subsequently approved by the Queensland government. Approvals for the Queensland section of the bypass are still required from the Commonwealth Minister for Environment and Heritage under the *Environment Protection and Biodiversity Conservation Act 1999*.

The proposal was submitted to the Commonwealth government for approval by the Minister for the Environment and Heritage under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* in 2004. An Impact Assessment Study (IAS) was prepared by Queensland Transport in 2003 for one section of the proposed rail link from Robina to Gold Coast Airport. The section, from Robina to Elanora (Part A), was exhibited in March 2003.

The second part (Part B) of the IAS will address the timing and staging of the proposed rail extension south of Elanora and is expected to be completed in 2005.

1.3 Approach to the assessment of environmental impacts

1.3.1 Approach to the environmental impact assessment

The environmental impact assessment seeks to ensure that all relevant environmental matters are considered and that community and interest groups are involved. The process provides for stakeholders to convey their views on the proposal to the relevant government approval agencies for consideration. An environmental impact statement (EIS) is produced which summarises the findings of the environmental impact assessment. The EIS quantifies and assesses potential impacts and documents the benefits of the proposal. It also outlines the types of environmental management measures proposed to reduce impacts and discusses opportunities created by the proposal that could realise benefits. The information in the EIS includes proposed future monitoring of the environmental performance of the proposal.

1.3.2 Objectives of the EIS

The specific objectives of this EIS are to:

- comply with Commonwealth, NSW and Queensland statutory requirements for the C4 route
- assess the strategic impacts of the proposal on the land use and transport systems of the area
- assess individual and cumulative impacts on the environment
- propose mitigation measures where practical
- determine whether the proposal is justified in terms of the principles of ecologically sustainable development
- establish the basis for subsequent environmental management of construction and operation if the proposal proceeds.

1.3.3 Content of the EIS

This EIS has been produced to meet the requirements of the NSW *Environmental Planning and Assessment Act 1979*, the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*, and the Queensland *Transport Infrastructure Act 1994*. Both the Director-General of the NSW Department of Infrastructure Planning and Natural Resources and the Commonwealth Minister for Environment and Heritage have defined the key issues and prepared guidelines that must be considered in the EIS. These are included in Appendix A of this EIS.

The studies for the Tugun Bypass environmental impact assessment commenced in 2000. In the subsequent four years the results of the various studies have been used to refine the concept design of the proposal. Further studies were also commissioned to ensure that all aspects of the various environmental issues were fully understood. The long time period of the assessment has meant that the content of some of the earlier reports has been superseded by newer work. Changes to the design of the bypass have also been introduced to take account of these studies.

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

1.3.4 Integration of regulations, guidelines and policies across all jurisdictions.

The development of the concept design for the proposal has had to consider the differing requirements of laws and regulations of three different jurisdictions. As well as the statutory requirements the design has had to consider the design guidelines of the NSW RTA and Main Roads. A policy was adopted that if a conflict between jurisdictions arose then highest standard would apply. This has meant that the concept design would be in compliance with all jurisdictions.

1.3.5 Integrating the principles of ecologically sustainable development

The NSW RTA is committed to ensuring that major road proposals are consistent with the principles of ecologically sustainable development (ESD) and that sufficient and unambiguous scientific information is provided in its environmental impact assessments to allow the performance of proposals to be assessed against the adopted principles.

The requirements for addressing ESD in NSW environmental assessments are documented in Schedule 2 of the NSW Environmental Planning and Assessment Regulation 2000. This legislation outlines four interrelated principles:

- the precautionary principle: if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation
- intergenerational equity: the present generation should ensure that the health, diversity and productivity of the environment are maintained or enhanced for the benefit of future generations
- conservation of biological diversity and ecological integrity: this is a fundamental consideration
- improved valuation, pricing and incentive mechanisms: environmental factors should be included in the valuation of assets and services.

Ecological sustainability has been considered at all stages of the proposal, including the development of the proposal, during the detailed environmental impact assessments, and in preparing the main volume of the EIS. Such consideration has included both short-term and long-term economic, environmental, social and equity issues, as set out in Table 1.1.

Table 1.1: Integration of the principles of ecologically sustainable development in the EIS

ESD Principle	Inclusion in EIS
Precautionary principle	• Scope and methodologies used for environmental assessments derived from detailed consultation with authorities, the community and other stakeholders, as described in Technical Paper 1. • Potential threats of serious or irreversible damage identified and assessed in detail, as described in Chapters 8 to 16. • Detailed assessment of strategic alternatives to the Tugun Bypass proposal, as described in Chapter 5. • Detailed assessment of the risk-weighted consequences of various options for the design of the Tugun Bypass, as described in Chapter 5. • Identification and management of potential hazards and risks, as described in Chapter 11. • Measures identified to mitigate environmental impacts, as described in Chapters 8 to 16. • Monitoring and auditing of the environmental outcomes predicted in the EIS would be undertaken, as described in Chapter 18.
Intergenerational equity	• Community consultation strategy implemented, as described in Chapter 3 and Technical Paper 1, to identify community concerns and values. • Assessment of potential biophysical impacts of the proposal, as described in Chapters 8, 9 and 10, including identification of appropriate mitigation measures. • Assessment of the potential social impacts of the proposal undertaken, as described in Chapter 13 and Technical Paper 15, with specific reference to community concerns and values. • Identification of potential health-related impacts, as described in Chapter 13 and Technical Paper 15. • Monitoring and auditing of the environmental outcomes predicted in the EIS would be undertaken, as described in Chapter 18.
Conservation of biological diversity and ecological integrity	• Identification of potential water quality impacts and appropriate management measures, as described in Chapter 8 and Technical Paper 8. • Identification of the potential impacts on species and vegetation communities of local, regional and state significance, as described in Chapter 10 and Technical Paper 12.
Improved valuation, pricing and incentive mechanisms	• Community values identified, as described in Chapter 3 and Technical Paper 15. • Identification of costs and benefits as part of the economic analysis described in Chapter 19. • Local and regional cumulative impact assessments undertaken, as described in Chapter 17.

The EIS also provides a summary of ESD matters at the end of each section that deals with impact assessment and mitigation measures (Parts D and E). These summaries use the first three of the four inter-related principles of sustainable development. The fourth principle, improved valuation, pricing and incentive mechanisms, is discussed in Chapter 20. The assessment criteria are presented in Table 1.2.

Table 1.2: Assessment criteria for ecologically sustainable development

Precautionary principle	Intergenerational equity	Conservation of biological diversity
Threats of serious or irreversible damage do not exist.	The health, diversity and productivity of the environment are enhanced for the benefit of future generations; no depreciation or degradation in the use of renewable and non-renewable resources is predicted.	No loss of genetic, species or ecosystem diversity that could result in diminished ecological integrity or viability is predicted.
Some threats of serious or irreversible damage may exist; future consequences are predictable; and means of mitigating damage are clearly available.	There are threats to the health, diversity and productivity of the environment that could result in a degraded resource for future generations, but mitigation measures are available. The depletion of non-renewable resources can be prevented by the use of renewable substitutes.	Loss of genetic, species or ecosystem diversity is such that resulting ecological integrity or viability is sustainable, and loss is reversible, provided means of mitigation are implemented.
Uncertainty over threats of serious or irreversible damage exist; future consequences are not predictable; and mitigation measures are not viable.	There is serious and permanent degradation to the health, diversity and productivity of the environment. The rate of depreciation or degradation of renewable and non-renewable resources is not sustainable.	Loss of genetic, species or ecosystem diversity is such that ecological integrity or viability is unsustainable.

The preparation of the EIS itself contributes to ensuring that the development and operation of the proposed bypass would comply with the principles of ecologically sustainable development. The EIS provides detailed information about the proposal and allows public discussion on whether it should proceed, and if so, subject to what mitigation measures and conditions of approval to limit environmental impacts.

1.3.6 Structure of the EIS

The EIS consists of a number of documents, which include the main environmental assessment, the species impact statement, and the technical papers. Volume One comprises the main environmental assessment of the proposal. This assessment is supported by 16 technical papers, which provide detailed information on background data, assessment methods, and the results of the specialist studies.

Volume One of the EIS contains eight parts:

Part A: Overview and Background (Chapters 1 to 3) includes a preliminary description of the proposal, the determination and approval processes required by the three determining authorities, and a summary of community and stakeholder consultation

Part B: Need for the Proposal and Consideration of Alternatives (Chapters 4 and 5) outlines the need for the Tugun Bypass and the consequences of not constructing the bypass, together with a description of the route selection and concept design processes

Part C: The Tugun Bypass Proposal (Chapters 6 and 7) provides a detailed description of the proposal and the methods proposed for its construction

Part D: Impacts of the Proposed Tugun Bypass on the Physical and Biological Environment (Chapters 8 to 11)

Part E: Impacts of the Proposed Tugun Bypass on the Socioeconomic Environment (Chapters 12 to 16)

Part F: Cumulative Impacts (Chapter 17), includes an assessment of impacts associated with other transport proposals and identified major development proposals. Environmental management and monitoring is discussed in Chapter 18.

Part G: Justification of the Proposal (Chapters 19 and 20) summarises the findings of the impact assessment and provides a justification of the proposal in terms of environmental, social and economic considerations and the principles of ecologically sustainable development.

The appendices to Volume One are as follows:

- requirements of the Director-General of the Department of Infrastructure, Planning and Natural Resources
- checklist of key issues addressed in the EIS
- Environmental Planning and Assessment Regulation 2000 Certificate
- summary of issues raised during community and stakeholder consultation
- list of properties affected by the proposal
- list of members of study team
- environmental record of the proponents.

The SIS consists of two volumes and should be read in conjunction with the EIS.

The technical papers are provided in five accompanying volumes. They give more detail to support the material described in Volume One and the SIS.

The assessment process for the proposal has been ongoing since early 2000. A number of the technical studies were completed in the earlier stages of the process, and the results were used to refine the design of the proposal. Some additional studies have also been commissioned, therefore, if there are any inconsistencies between the material in the technical papers and the main EIS, the material in the EIS should be considered to prevail.

The remaining volumes of the EIS are as follows:

Volume Two:

- Technical Paper 1 — Community Consultation
- Technical Paper 2 — Engineering Design

Volume Three:

- Technical Paper 3 — Traffic and Transport
- Technical Paper 4 — Geotechnical Assessment
- Technical Paper 5 — Acid Sulfate Soil Management
- Technical Paper 6 — Contaminated Land

Volume Four:

- Technical Paper 7 — Flooding and Hydrological Assessment
- Technical Paper 8 — Surface Water Quality Assessment

- Technical Paper 9 — Groundwater
- Technical Paper 10 — Noise and Vibration
- Technical Paper 11 — Air Quality Assessment

Volume Five:

- Technical Paper 12 — Flora and Fauna Assessment

Volume Six:

- Technical Paper 13 — Urban Design, Landscape and Visual Assessment
- Technical Paper 14 — Cultural Heritage Assessment
- Technical Paper 15 — Land Use Planning and Socioeconomic Assessment
- Technical Paper 16 — Hazard and Risk

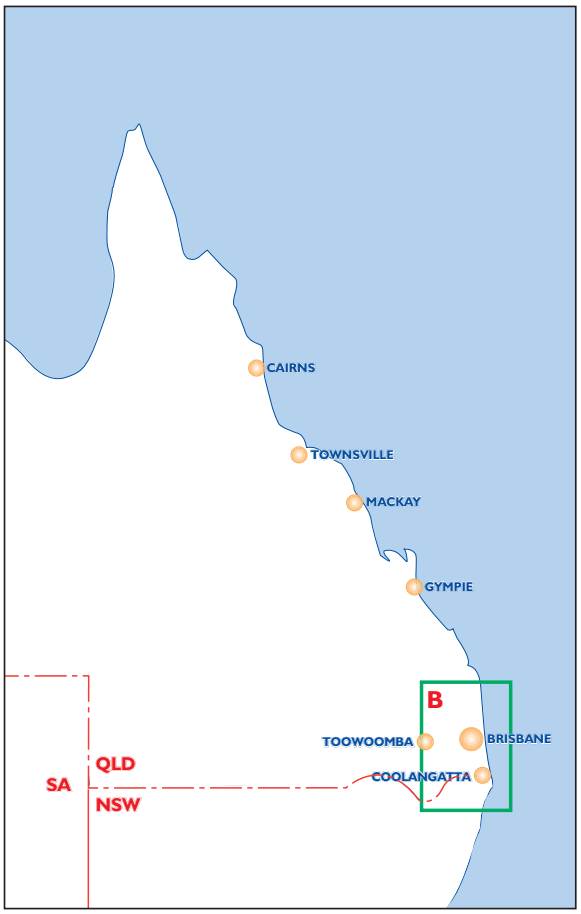
1.3.7 Definition of study areas

The following terms are used in the EIS to describe areas relevant to the assessment:

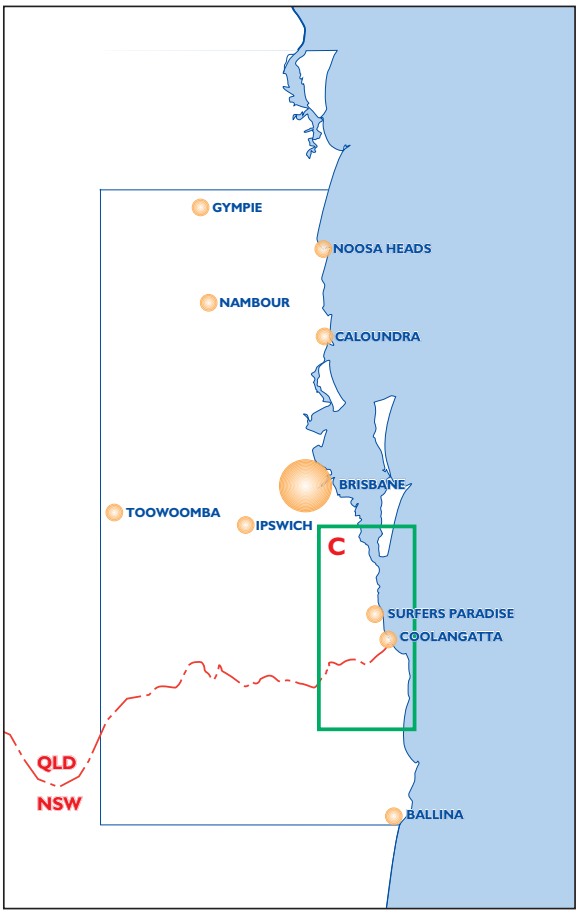
- **South-east Queensland —** (including part of Tweed Shire) is the region incorporating the section of Queensland north to Gympie, west to Ipswich and south to Tweed Heads
- **Gold Coast – Tweed —** this region incorporates Gold Coast City and Tweed Shire local government areas
- **Gold Coast City Council Transport Plan Study Area** — this includes Gold Coast City and part of Tweed Shire
- **Tugun** — the local area from Stewart Road to Kennedy Drive, incorporating Currumbin, Currumbin Waters, Tugun Heights, Bilinga and Coolangatta
- **local assessment areas** — the areas defined as relevant to the particular assessment.

The study area adopted for the environmental impact assessment consists of a corridor 1 km wide either side of the proposed alignment.

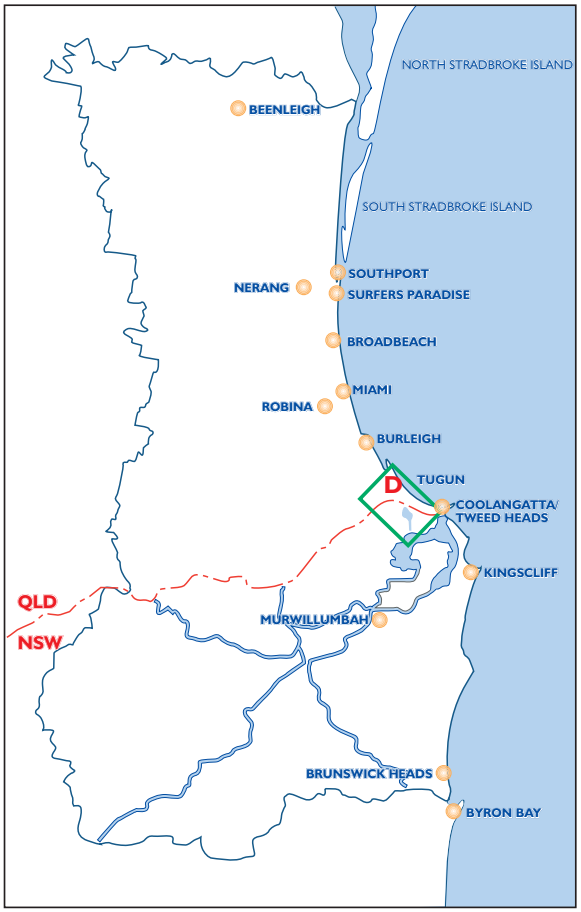
These are shown on Figure 1.2.



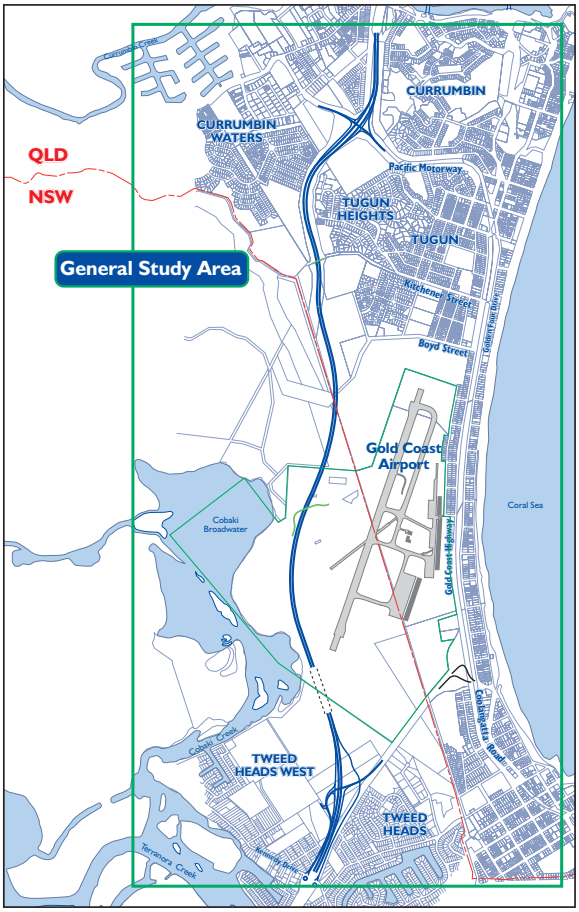
A. Queensland



B. South East Queensland



C. Gold Coast / Tweed Region



D. Study Area - Proposed Tugun Bypass

- Proposed Tugun Bypass
- Gold Coast Airport Boundary
- Queensland/NSW Border
- Proposed Access Bridges
- Tunnel

Figure 1.2 **Study Areas Used in Tugun Bypass EIS**

2. The approvals process for the proposal

This chapter summarises the processes that need to be followed to obtain statutory approvals for the construction of the Tugun Bypass. As the proposed route alignment is located partly within Queensland and partly within NSW, and crosses through land owned by the Commonwealth (Gold Coast Airport), requirements under Queensland, NSW and Commonwealth law apply to the project.

2.1 The proponents

The proponents for the each section of the Tugun Bypass alignment are:

- Main Roads for the section situated in Queensland and for the separate railway accommodation works within NSW on the Airport land (as described in Chapter 6
- the NSW RTA for the section within NSW, including the airport land owned by the Commonwealth (other than the railway accommodation works).

2.2 Environmental assessment legislative requirements

2.2.1 Commonwealth

The Tugun Bypass proposal is subject to the requirements of Commonwealth legislation and approval processes. The relevant legislation is the *Airports Act 1996*, the *Environment Protection and Biodiversity Conservation Act 1999*, and the regulations to those Acts. The *Native Title Act 1993* and *Aboriginal and Torres Strait Islander Heritage Protection Act 1984* are also potentially relevant.

The *Environment Protection and Biodiversity Conservation Act 1999* commenced on 16 July 2000. The environmental approval process established by this legislation, as it applies to the proposed Tugun Bypass, is illustrated in Figure 2.1. The definition of environment under the Act includes:

"*a) ecosystems and their constituent parts, including people and communities; and*

(b) natural and physical resources; and

(c) the qualities and characteristics of locations, places and areas; and

(d) heritage values of places; and

(e) the social, economic and cultural aspects of a thing mentioned in paragraph (a), (b) or (c)."

The Act requires that approval must be obtained from the Commonwealth Minister for the Environment and Heritage for actions (excluding the granting of government authorisations or funding) which have, may have or are likely to have, a significant impact on a matter of national environmental significance. Matters of national environmental significance fall into the following categories:

- World Heritage properties

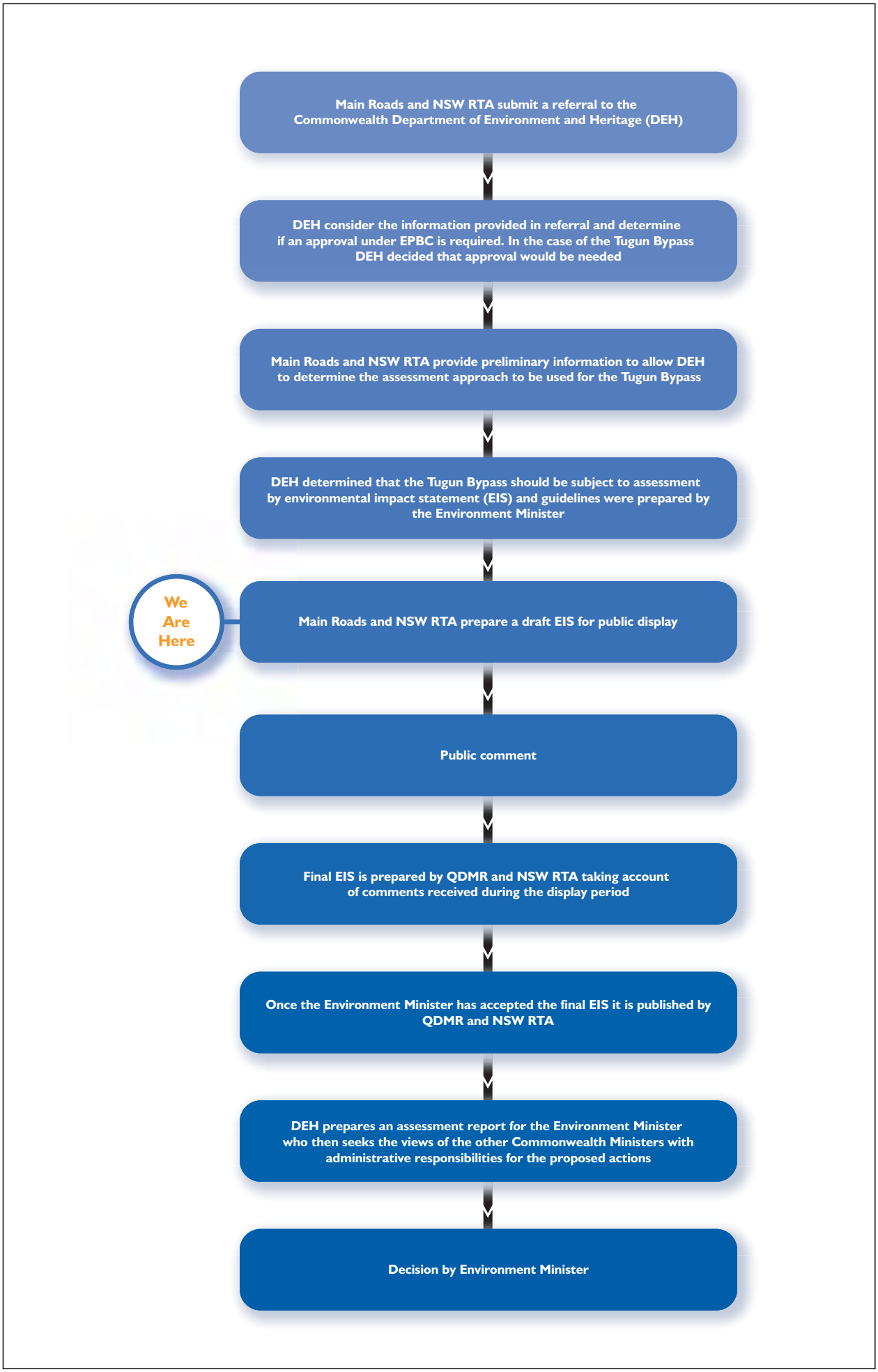


Figure 2.1 **Approvals Process - Environment Protection and Biodiversity Conservation Act 1999**

- RAMSAR wetlands
- threatened species and communities listed under the *Environment Protection and Biodiversity Conservation Act 1999*
- migratory species listed under the *Environment Protection and Biodiversity Conservation Act 1999*
- nuclear actions, including uranium mining
- the Commonwealth marine environment
- National heritage places.

The Act also requires approval from the Commonwealth Minister for the Environment and Heritage for any action by:

- a Commonwealth agency that is likely to have a significant impact on the environment; or
- any person on Commonwealth land that is likely to have a significant impact on the environment (including impacts outside of Commonwealth land); or
- any person outside of Commonwealth land that is likely to have a significant impact on the environment on Commonwealth land.

Approval requirements under the *Environment Protection and Biodiversity Conservation Act 1999* apply irrespective of any approvals obtained under State law.

Referral of controlled action

A person proposing to take an action that the person thinks may require approval under the *Environment Protection and Biodiversity Conservation Act 1999* (i.e. a controlled action) is required to refer the action to the Commonwealth Minister for the Environment and Heritage. The Minister then determines whether the action requires approval and, if so, under which provisions of the *Environment Protection and Biodiversity Conservation Act 1999*.

NSW RTA and Main Roads have referred the Tugun Bypass proposal to the Minister, as separate proponents for those parts of the action to be undertaken in their respective States, and the Minister has determined the action requires approval under the following provisions of the *Environment Protection and Biodiversity Conservation Act 1999*:

- Sections 18 and 18A (Listed threatened species and ecological communities)
- Sections 26 and 27A (Protection of the environment from actions involving Commonwealth land).

Environmental impact statement

The Minister has determined that the proposal must be the subject of an environmental impact statement and this document has been prepared to meet that requirement.

The Minister has issued guidelines concerning the content of the EIS, a copy of which is in Appendix A, and they have been used in the preparation of this document. NSW RTA and Main Roads, as the designated proponents, must publish a draft version of the EIS, invite public comments on the draft, consider those comments in finalising the EIS and provide the Minister with both the final EIS and the public comments.

The Minister will then determine whether or not to grant approval for the action and, if so, on what conditions.

Airports Act 1996

It is proposed to construct the Tugun Bypass before the transfer of title of the section currently within the Gold Coast Airport from the Commonwealth to NSW RTA or Main Roads. Accordingly, the requirements of the *Airports Act 1996* will apply to the Tugun Bypass project during the construction of the Tugun Bypass.

Master Plan

The future development of Gold Coast Airport is subject to the *Airports Act 1996*. The Act contains provisions that require Gold Coast Airport Ltd to develop a master plan for the airport.

One of the key features of the Final Master Plan for the Gold Coast Airport is the provision of a road/rail corridor through the western and southern sectors of the site generally consistent with the proposed alignment for the Tugun Bypass.

Major Development Plan

The construction of the Tugun Bypass through the Gold Coast Airport would be classified as a major airport development under the *Airports Act 1996*, being development carried out at an airport site that is likely to have a significant environmental impact. The proposal may also fall within that classification on the basis that it affects an area identified as environmentally significant in the environment strategy for the Gold Coast Airport. The Draft Airport Environment Strategy 2004 indicates environmentally significant areas are located within the alignment of the proposed Tugun Bypass.

Accordingly Gold Coast Airport Pty Ltd, as airport lessee, may not permit the construction of the Tugun Bypass on airport land other than in accordance with a major development plan prepared and approved by the Minister for Transport and Regional Services under the *Airports Act*. A major development plan must set out certain information outlined in section 91 of the *Airports Act 1996*, including the following:

- the airport-lessee's objectives for the development
- the extent to which the proposal will fulfil the future needs of civil aviation and other uses of the airport
- a detailed outline of the development
- the extent to which the development could affect the noise exposure levels at the airport
- the airport-lessee's assessment of the environmental impacts that might reasonably be expected to be associated with the development
- the airport-lessee's plans for dealing with those environmental impacts (including plans for ameliorating or preventing environmental impacts).

A major development plan must be placed on public exhibition as a draft before being submitted to the Minister for Transport and Regional Services for approval. A draft major development plan has been prepared and it is proposed that it be placed on public exhibition for 90 days at the same time as the EIS.

Section 160 of the *Environment Protection and Biodiversity Conservation Act 1999* requires that the Minister for Transport and Regional Services obtain and consider advice from the Minister of Environment and Heritage in any decision relating to the adoption or implementation of a major development plan. The Minister for the Environment and Heritage has decided that the environmental impacts of the major development plan must be assessed by an environmental impact statement. This document has also been written to meet that requirement.

Figure 2.2 illustrates the steps in the approval of a major development plan.

The Tugun Bypass would also require approval as a building activity from the airport building controller before the airport lessee could permit its construction. Approval may only be granted if the proposed works are consistent with the Final Master Plan for the Airport and the major development plan in relation to the Bypass.

Native Title Act 1993 (Commonwealth)

Native title is the communal, group or individual rights and interests of the indigenous people of Australia in relation to their traditional land or waters, as recognised by the common law of Australia and the *Native Title Act 1993*. Native title will only exist in relation to a particular area of land if the indigenous people in question have maintained a continuing connection to their traditional land or waters and their native title rights and interests have not been extinguished by a grant of tenure or use of land by the Crown or a third party.

Native title was first recognised in Australian law by the High Court's decision in *Mabo v Queensland (No.2)* (1992) 175 CLR 1. The recognition, protection and extinguishment of native title rights and interests are governed by the *Native Title Act 1993*, which came into force on 1 January 1994. The States and Territories have also enacted their own legislation to implement the scheme of the *Native Title Act 1993*.

The *Native Title Act 1993* protects native title from invalid interference by prescribing a regime governing acts that occur on land and waters after 1 January 1994 that affect native title (described as 'future acts'). An act 'affects' native title (and is therefore a 'future act') if it is wholly or partly inconsistent with the continued existence, enjoyment or exercise of native title rights and interests. If an act is a 'future act' and does not comply with the *Native Title Act 1993*, it will be invalid in so far as it affects native title. The future act regime of the *Native Title Act 1993* does not apply to acts in relation to land where native title has been extinguished.

As of November 2004, there were no native title determination applications, determination of native title or Registered Indigenous Land Use Agreements for the Tugun Bypass area. The proponents will determine the extent to which the requirements under the future act regime are applicable at the time of acquisition of the land.

Aboriginal and Torres Strait Islander Heritage Protection Act 1984 (Commonwealth)

The *Aboriginal and Torres Strait Islander Heritage Protection Act 1984* is the principal legislation for the preservation and protection of areas and objects of particular significance to Indigenous people at the Commonwealth level. The *Aboriginal and Torres Strait Islander Heritage Protection Act 1984* applies to all States and Territories, and operates in addition to State legislation.

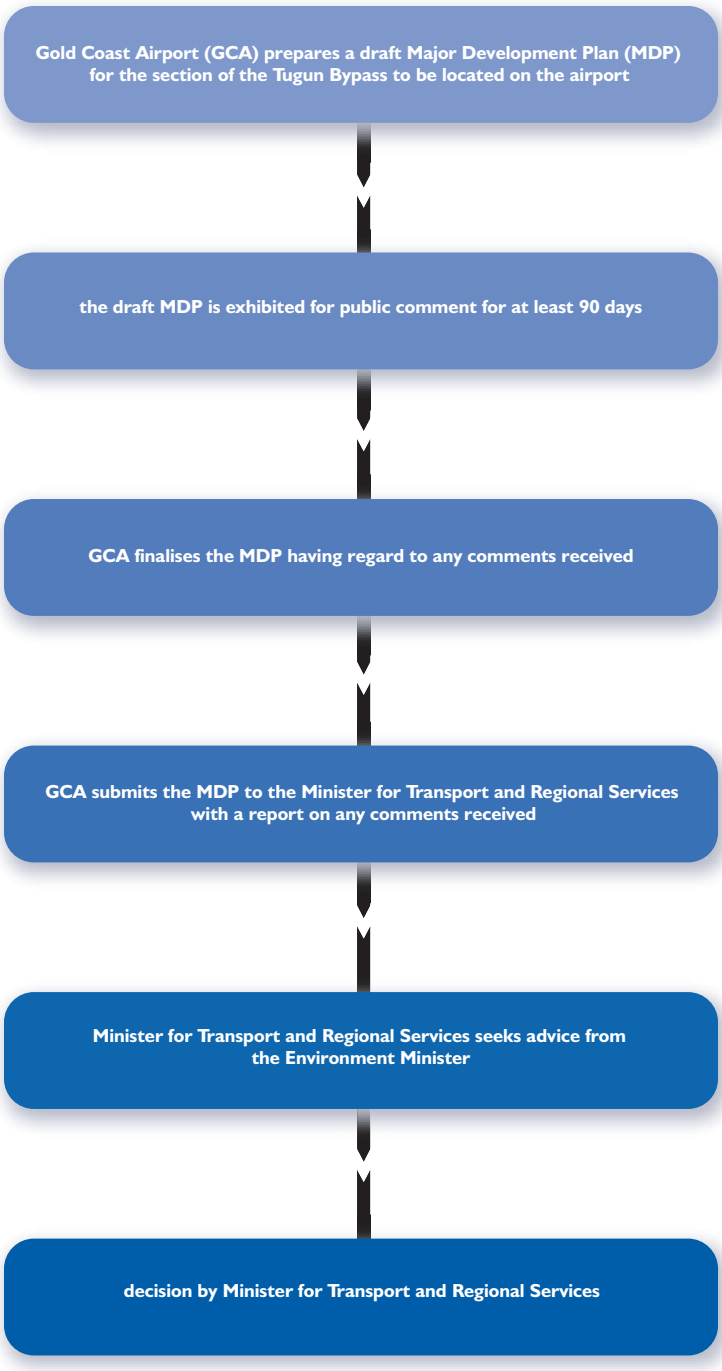


Figure 2.2 **Approvals Process - Airports Act 1996**

The *Aboriginal and Torres Strait Islander Heritage Protection 1984* provides for the protection of 'significant Aboriginal areas' and 'significant Aboriginal objects'. A 'significant Aboriginal area' is defined in the *Aboriginal and Torres Strait Islander Heritage Protection 1984* to mean an area of particular significance to Aboriginals in accordance with Aboriginal tradition. A 'significant Aboriginal object' is defined to mean an object (including Aboriginal remains) of particular significance to Aboriginals in accordance with Aboriginal tradition.

An Aboriginal area and an Aboriginal object will only receive protection where the Minister makes a declaration under the *Aboriginal and Torres Strait Islander Heritage Protection 1984* in relation to the area or object. The Minister is able to make an 'emergency declaration' in relation to 'significant Aboriginal areas' that are under serious and immediate threat pursuant to section 9 of the *Aboriginal and Torres Strait Islander Heritage Protection 1984*. A declaration under section 9 may only have effect for a period not exceeding 30 days and may be extended by the Minister to a maximum of 60 days in total. The Minister is also able to make a 'final' declaration under section 10 where satisfied that the area or object or class of objects is significant and is under threat of injury or desecration. A declaration pursuant to section 10 of the *Aboriginal and Torres Strait Islander Heritage Protection 1984* has effect for as long as is specified in the declaration and may be expressed to be a permanent declaration.

The *Aboriginal and Torres Strait Islander Heritage Protection 1984* contains offence provisions for contravening a declaration. There is no 'permit' process under the *Aboriginal and Torres Strait Islander Heritage Protection 1984* for carrying out activities in areas subject to declarations under the Act - if an area is subject to a declaration made pursuant to the *Aboriginal and Torres Strait Islander Heritage Protection Act 1984*, no activity may be conducted in contravention of that declaration.

2.2.2 NSW

Environmental Planning and Assessment Act 1979

The *Environmental Planning and Assessment Act 1979* controls development in NSW. Environmental planning instruments under the *Environmental Planning and Assessment Act 1979* impose restrictions on the types of development that may be carried out on land to which an environmental planning instrument applies. Primarily those restrictions are imposed through the creation of land use zones although the operation of some environmental planning instruments is not confined to a particular zone or area. Environmental planning instruments commonly provide that particular types of development are prohibited, require development consent or may be carried out without development consent. The Tugun Bypass proposal constitutes development for the purpose of the *Environmental Planning and Assessment Act 1979*.

Part 5 of the *Environmental Planning and Assessment Act 1979* applies to certain types of development that may be carried out without development consent. It prescribes an environmental assessment process for such development, which includes the preparation of an environmental impact statement where the activity is likely to significantly affect the environment or threatened species, populations, ecological communities or their habitats.

Environmental Planning Instruments

Environmental planning instruments have statutory force under the *Environmental Planning and Assessment Act 1979*. There are three main types of environmental planning instruments:

- State Environmental Planning Policies (SEPPs)

- Regional Environmental Plans
- Local Environmental Plans.

Environmental planning instruments relevant to the Tugun Bypass proposal are briefly described below.

Tweed Local Environmental Plan

The *Tweed Local Environmental Plan 2000* regulates development within the Tweed Local Government Area. The consent authority for the purposes of the *Tweed Local Environmental Plan 2000* is Tweed Shire Council. The *Tweed Local Environmental Plan 2000* establishes zones which place restrictions on the types of development which may be carried out. In each zone, certain types of development are:

- permissible with consent
- permissible without consent
- prohibited.

The consent authority may grant development consent under the *Tweed Local Environmental Plan 2000* (other than development specified in Item 3 of the Table to clause 11) only if:

- it is satisfied that the development is consistent with the primary objective of the zone within which it is located
- it has considered those other aims and objectives of this plan that are relevant to the development
- it is satisfied that the development would not have an unacceptable cumulative impact on the community, locality or catchment that will be affected by its being carried out or on the area of Tweed as a whole.

The proposed Tugun Bypass would pass through land included in the following zones:

- Rural 1(a)
- Open Space 6(a)
- Special Use 5(a)
- Environmental Protection (wetlands and littoral rainforests) 7(a).

Rural Zone 1(a)

The primary objectives of the Rural zone are to enable the ecologically sustainable development of land that is suitable primarily for agricultural or natural resource utilisation purposes and to protect rural character and amenity.

Within the Rural 1(a) Zone, roads are permissible with development consent.

Open Space Zone 6(a)

The primary objective of the Open Space zone is to identify existing public land, and land that is proposed to be acquired for public ownership, to satisfy the open space and recreation needs of local residents and visitors to the area of Tweed and to enable its development to encourage or assist their recreational use and enjoyment of the land.

Within the Open Space 6(a) Zone, roads are permissible without development consent.

Special Uses Zone 5(a)

The primary objective of the Special Use zone is to identify land that is developed or is proposed to be developed, generally by public bodies, for community facilities and services, roads, railways and public utilities.

Within the Special Uses 5(a) Zone, roads are permissible without development consent.

The Gold Coast Airport is within the Special Uses Zone. That Zone also includes a road corridor along a formerly proposed alignment for the Tugun Bypass. That alignment is further west than the current proposal, although there is a small area of overlap at the southern end of the current alignment.

Environmental Protection (Wetlands and Littoral Rainforests) Zone 7(a)

The primary objective of the Environmental Protection (Wetlands and Littoral Rainforests) 7(a) Zone is to identify, protect and conserve significant wetlands and littoral rainforests, and prohibit development which could destroy or damage a wetland or littoral rainforest ecosystem.

In this zone, roads (along with earth works and works for drainage and landfill) are only permissible with development consent where, pursuant to clause 8(2), the applicant demonstrates to the satisfaction of the consent authority that:

- the development is necessary for any one of the following reasons:
  - it needs to be in the locality in which it is proposed to be carried out due to the nature, function or service catchment of the development
  - it meets an identified urgent community need
  - it comprises a major employment generator.
- there is no other appropriate site on which the development is permitted with consent (other than as advertised development) in reasonable proximity
- the development will be generally consistent with the scale and character of existing and future lawful development in the immediate area
- the development would be consistent with the aims of this plan and at least one of the objectives of the zone within which it is proposed to be located.

The proposed Tugun Bypass enters the Environmental Protection (Wetlands and Littoral Rainforest) 7(a) Zone at Boyd Street, which is located at the north western perimeter of Gold Coast Airport.

Other provisions of the *Tweed Local Environmental Plan 2000* that are potentially relevant to the Project include:

- Clause 15 – availability of essential services
- Clause 17 – social impact assessment
- Part 4 – subdivision
- Part 5 – roads

- Part 7 – hazards and buffers
- Part 8 – heritage.

North Coast Regional Environmental Plan

The North Coast Regional Environmental Plan applies to Northern NSW, including the Tweed Local Government Area.

The aims and objectives of the North Coast Regional Environmental Plan must be taken into consideration by:

- a consent authority when determining an application for development consent for the carrying out of development on or in relation to land within the region
- the Minister or a public authority when determining whether or not to grant concurrence to the granting of such a consent.

Part 5 of the North Coast Regional Environmental Plan concerns regional transport and infrastructure. The objectives of the North Coast Regional Environmental Plan with regard to regional infrastructure are to:

- safeguard the role and efficiency of the main roads system of the region, particularly by recognising the importance of primary arterial roads, and
- facilitate maintenance and improvement of transport in the region.

Part 3 of the North Coast Regional Environmental Plan concerns conservation and the environment. It includes objectives relating to:

- protecting areas of natural vegetation and wildlife and providing corridors between significant areas;
- protecting the scenic quality of the region;
- protecting the water quality of the coastal environment;
- minimising changes to coastal processes resulting from development;
- encouraging retention of natural areas and regeneration of already degraded areas.

SEPP 4 – Development Without Consent and Miscellaneous Exempt and Complying Development

SEPP 4 provides that certain development, which would otherwise be permissible with development consent, may be undertaken without development consent. Clause 11C of SEPP 4 extends that exemption from the requirement for development consent to roadwork on a classified road or proposed classified road. The Tugun Bypass is a proposed classified road. However, there are a number of limitations on the application of clause 11C, including that it does not apply where development for the purpose of roads is prohibited under the relevant environmental planning instruments.

SEPP 14 – Coastal Wetlands

SEPP 14 aims to ensure that coastal wetlands are preserved and protected in the environmental and economic interests of the State.

Various wetlands are listed under SEPP 14. The following activities may only be carried out on that land with development consent from the local council and the concurrence of the Director-General of the Department of Infrastructure, Planning and Natural Resources:

- land clearance
- construction of a levee
- drainage
- filling.

Such development is designated development under the *Environmental Planning and Assessment Act 1979* and therefore requires the preparation of an environmental impact statement.

SEPP 14 Wetland Number 5(a) fringes the north-eastern shores of Cobaki Creek and is adjacent to Gold Coast Airport. The proposed alignment for the Tugun Bypass crosses a small area of the wetland in the north-eastern corner where a buffer of casuarinas is located.

SEPP 44 – Koala habitat protection

The stated aim of SEPP 44 is to encourage the proper conservation and management of areas of natural vegetation that provide habitat for koalas, to ensure a permanent free-living population over their present range and reverse the current trend of koala population decline, by:

- requiring the preparation of management plans before development consent can be granted in relation to areas of some koala habitat;
- encouraging the identification of areas of core koala habitat; and
- encouraging the inclusion of areas of core koala habitat in environmental protection zones.

SEPP 44 applies to development applications for land within the Tweed Shire that has an area of more than 1 ha. Accordingly it would apply to a development application for the Tugun Bypass.

Under SEPP 44 a council must satisfy itself whether the land to which the development application relates is potential koala habitat. If it is, then the council must satisfy itself whether the land is core koala habitat. Development consent may only be granted for development on core koala habitat if a plan of management has been prepared in accordance with Part 3 of SEPP 44.

In the study area for the Tugun Bypass proposal, vegetation types have been identified as potential koala habitat areas but extensive field work has failed to reveal any evidence of use of the area by koalas.

SEPP 71 – Coastal protection

SEPP 71 imposes various restrictions and requirements in relation to development within the coastal zone, as defined under the *Coastal Protection Act 1979* (NSW). In particular it:

- specifies certain matters that must be taken into account in determining a development application to carry out development on land within the coastal zone; and
- provides that development consent may not be granted to development which will impede public access to the coastal foreshore, permit a system of non-reticulated effluent disposal that will negatively impact on water quality within various types of coastal water bodies

(including coastal lakes listed in Schedule 1 of SEPP 71) or involve the discharge of untreated stormwater into such water bodies.

The proposal would affect land within 100m of a coastal lake listed in Schedule 1 of SEPP 71.

SEPP 63 – Major transport projects

SEPP 63 provides that certain major transport projects and ancillary activities (such as obtaining extractive material for construction work and removing vegetation) may be carried out without development consent. SEPP 63 applies to the extent of any inconsistency between it and another EPI. Where SEPP 63 applies, the relevant major transport project is assessed under Part 5 of the *Environmental Planning and Assessment Act 1979*.

The NSW RTA has requested that the NSW Minister for Infrastructure, Planning and Natural Resources amend SEPP 63 so that it also applies to the Tugun Bypass proposal. If that occurs, then requirements for development consent or any categorisation as prohibitedions development that would otherwise apply to the Tugun Bypass proposal under the environmental planning instruments discussed above will no longer apply. The Tugun Bypass would be required to be assessed under Part 5 of the *Environmental Planning and Assessment Act 1979*.

The discussion below concerning the requirements for assessment documents and the approvals process under the *Environmental Planning and Assessment Act 1979* assumes the Tugun Bypass proposal is assessed under Part 5 of the *Environmental Planning and Assessment Act 1979*.

Requirement for an EIS

Under Part 5 of the *Environmental Planning and Assessment Act 1979*, the NSW RTA is both the proponent and a determining authority in relation to the part of the Tugun Bypass that would be constructed in NSW.

As a determining authority, the NSW RTA is required under section 111 of the *Environmental Planning and Assessment Act 1979* to examine and take into account all matters affecting or likely to affect the environment by reason of the construction and operation of the Tugun Bypass. Section 112 provides that a determining authority must consider an EIS in relation to an activity, before deciding whether to carry it out or approve it, if the activity is likely to significantly affect the environment or threatened species, populations, ecological communities or their habitats. The Tugun Bypass is likely to have such a significant effect and accordingly this EIS has been prepared.

The *Environmental Planning and Assessment Act 1979* and the *Environmental Planning and Assessment Regulation 2000* set out requirements in relation to the form and content of an EIS. One requirement is that the EIS include matters referred to in applicable guidelines published by Department of Infrastructure, Planning and Natural Resources, which in this case are the EIS Guidelines for Roads and Related Facilities. Another is that the person responsible for preparing the EIS consult with the Director-General of the Department of Infrastructure, Planning and Natural Resources and, in completing the EIS, have regard to the Director-General's requirements concerning its form and content. A copy of the Director-General's requirements for this EIS is in Appendix A.

Requirement for an SIS

Section 112 of the *Environmental Planning and Assessment Act 1979* provides that, where an activity is likely to significantly affect threatened species, populations, ecological communities or their habitats, a determining authority must not carry out or approve the activity unless a species impact statement has been prepared. It is likely that the Tugun Bypass proposal will significantly affect threatened species and accordingly a SIS has been prepared which forms part of this EIS. The requirements concerning the preparation of a SIS are set out in Division 2 of Part 6 of the *Threatened Species Conservation Act 1995*. Similarly to an EIS, a person preparing a SIS must consult with the Director-General of the Department of Environment and Conservation and comply with any requirements of the Director-General concerning the form and content of the SIS. Such requirements have been obtained in relation to the SIS for the Tugun Bypass proposal and Appendix A of the SIS contains a copy of those requirements.

Approvals process under the *Environmental Planning and Assessment Act 1979*

The approval process under Part 5 of the *Environmental Planning and Assessment Act 1979* involves exhibition of the EIS and SIS, a requirement for the concurrence of the Director-General of Department of Environment and Conservation, a requirement for approval from the NSW Minister for Infrastructure, Planning and Natural Resources and a decision by the NSW RTA on whether to proceed with the Project. The process is summarised in Figure 2.3.

- prepare EIS and SIS
- exhibit EIS and SIS and invite public comment
- NSW RTA considers EIS, SIS and public submissions and sends a copy of all submissions to the Director-General of the Department of Infrastructure, Planning and Natural Resources
- if the NSW RTA wishes to proceed with the proposal, the NSW RTA seeks the concurrence of the Director-General of the Department of Environment and Conservation
- Director-General of the Department of Environment and Conservation considers the SIS, any representations made on it during the public exhibition period and the other matters set out in section 112D of the *Environmental Planning and Assessment Act 1979*
- Director-General of the Department of Environment and Conservation makes a decision on whether to grant concurrence and informs NSW RTA
- NSW RTA seeks approval from the Minister for Planning under Division 4 of Part 5;
- Director-General of Department of Infrastructure, Planning and Natural Resources reports to the Minister on the assessment of the proposed activity;
- Minister for Planning consults with the Minister for Roads;
- Minister for Planning determines whether to grant approval and, if so, on what conditions
- if approval is granted, NSW RTA considers approval and determines whether to proceed with the proposal.

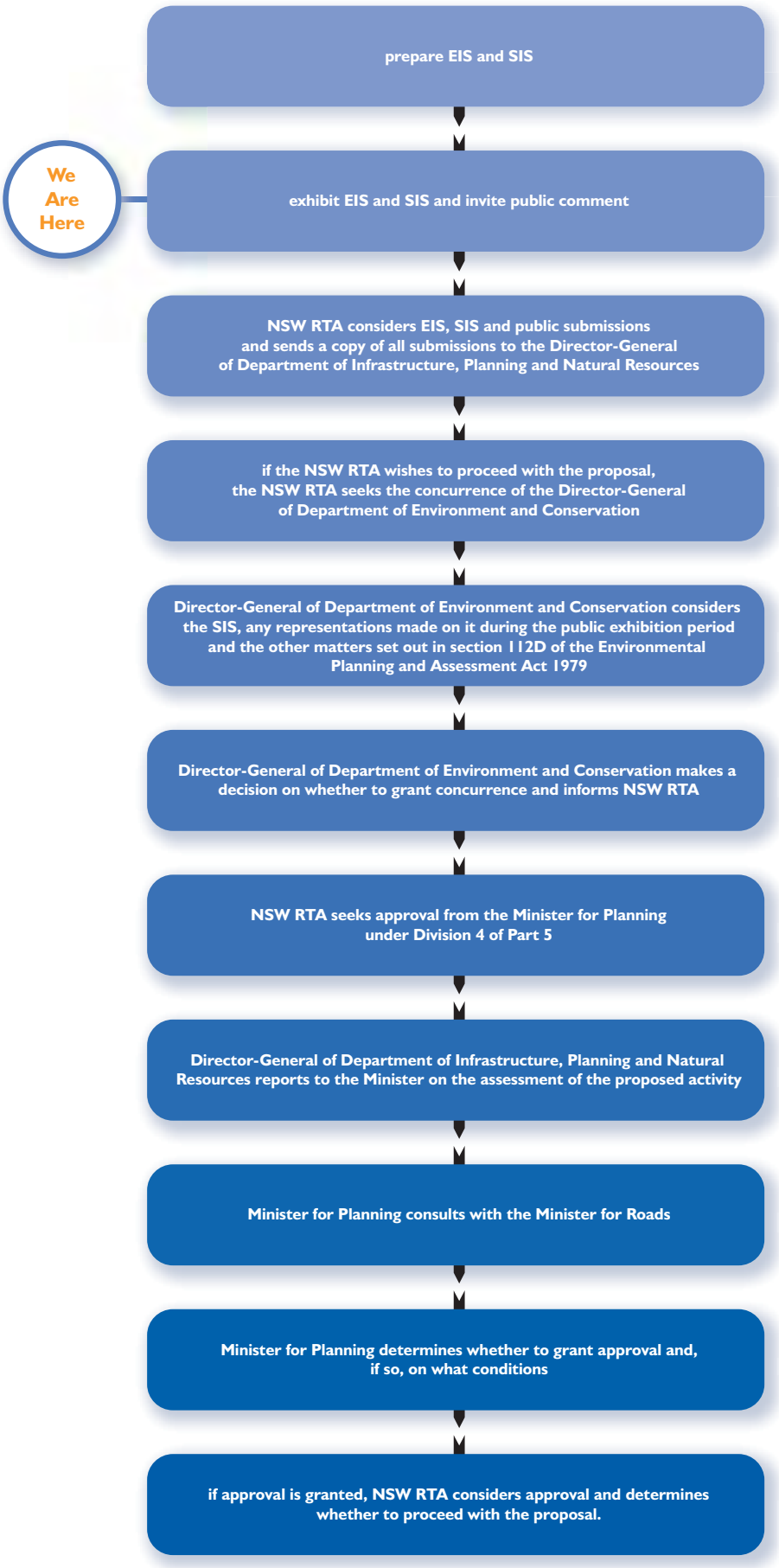


Figure 2.3 **Approvals Process - NSW Environmental Planning and Assessment Act 1979**

Other NSW Approvals

The following approvals will or may also be required for the Tugun Bypass proposal:

Rivers and Foreshores Improvement Act 1948

A Part 3A permit will be required under this Act for the removal of material and excavation within 40 m of the top of the bank of a river, lake, coastal lake or lagoon, or anything which detrimentally affects the flow of such watercourses. The term 'river' is broadly defined in the Act to include any stream of water, whether perennial or intermittent, flowing in a natural channel, or in a natural channel artificially improved, or in an artificial channel which has changed the course of the stream of water.

Water Act 1912

Approval under the Water Act would be required for any water supply works, any works draining the flood or other waters of a river or lake, or the construction of an earthwork, embankment or levee within a floodplain.

Water Management Act 2000

This Act includes a new approval regime which will replace the approval requirements in the *Rivers and Foreshores Improvement Act* and *Water Act*. However that regime has not yet commenced for areas of NSW that are not the subject of a water sharing plan. There is currently no such plan for the project area.

National Parks and Wildlife Act 1974 (NSW)

The principle legislation for the protection and management of Aboriginal cultural heritage in NSW is the *National Parks and Wildlife Act 1974*. The *National Parks and Wildlife Act 1974* is administered by the NSW Department of Environment and Conservation.

The *National Parks and Wildlife Act 1974* provides for the protection of 'Aboriginal objects' and 'Aboriginal places'. An 'Aboriginal object' is defined as any deposit, object or material evidence (not being a handicraft made for sale) relating to the Aboriginal habitation of NSW, including Aboriginal remains. An 'Aboriginal place' is an area declared by the Minister to be or to have been of special significance with respect to Aboriginal culture.

There are two relevant offence provisions in the *National Parks and Wildlife Act 1974*. Section 86 relevantly provides that a person is guilty of an offence if, except in accordance with a permit issued under section 87, they disturb or move any Aboriginal objects. Section 90 of the *National Parks and Wildlife Act 1974* provides that a person who, except in accordance with a consent from the Director-General of the National Parks and Wildlife Service, knowingly destroys, defaces or damages, or knowingly causes or permits the destruction or defacement of or damage to, an Aboriginal object or Aboriginal place is guilty of an offence. This requirement will be relevant to the extent that the proposal might involve works that disturb the heritage place listed on the Register of the National Estate.

The Department of Environment and Conservation maintains an 'Aboriginal Sites Register'. However, there is no requirement that an Aboriginal object be registered before it is protected under the *National Parks and Wildlife Act 1974*.

Aboriginal Land Rights Act 1983 (NSW)

The *Aboriginal Land Rights Act 1983* contains a statutory lands rights scheme which provides a mechanism for the transfer of 'claimable Crown land' to Aboriginal Land Councils established under the Act.

'Claimable Crown land' is defined in the *Aboriginal Land Rights Act 1983* to be Crown lands which, at the time a claim is made for the relevant land:

- are able to be lawfully sold or leased, or are reserved or dedicated for any purpose, under the *Crown Lands Consolidation Act 1913* or the *Western Lands Act 1901*
- are not lawfully used or occupied
- do not comprise lands which, in the opinion of a Crown Lands Minister, are needed or are likely to be needed as residential lands
- are not needed, nor likely to be needed, for an essential public purpose
- do not comprise lands that are the subject of an application for a determination of native title (other than a non-claimant application that is an unopposed application) that has been registered in accordance with the *Native Title Act 1993*
- do not comprise lands that are the subject of an approved determination of native title (within the meaning of the *Native Title Act 1993*) (other than an approved determination that no native title exists in the lands).

Provided that the claimed land is 'claimable Crown land' at the date a claim is lodged, the Minister is required to transfer the land to the claimant Aboriginal Land Council.

Claimants do not have to prove any traditional connection or affiliation with the claimed land in order to make a claim under the *Aboriginal Land Rights Act 1983*.

The *Aboriginal Land Rights Act 1983* also contains provisions restricting the dealing with and transfer of land vested in Aboriginal Land Councils under the *Aboriginal Land Rights Act 1983*.

An Aboriginal Land Claim (Number 3093) has been registered on behalf of the Tweed Byron Local Aboriginal Land Council. The section of the claim over the Boyd Street road reserve was refused in 1992 on the grounds that it was needed for an essential public purpose. The remainder of the claim (including DP755740-56, DP 755740-57, two sections of DP 755740-58 and DP755740-321) is still to be determined.

Protection of the Environment Operations Act 1997

An environment protection licence must be obtained from the NSW Environment Protection Authority for activities listed in Schedule 1 of that Act.

One such activity is 'Freeway or tollway construction'. However the Tugun Bypass proposal does not meet the definition of that activity because the section of the road within NSW will be less than 5 km long.

Other types of activities that require an NSW Environment Protection Authority licence include:

- bitumen pre-mix or hot-mix industries:

  - with an intended production capacity of more than 150 tonnes per day or 30,000 tonnes per year;
  - where the activity is specific to the Tugun Bypass project, operates for more than 1 year.
- extractive industries:
  - including storing or stockpiling for re-use more than 30,000m^3 of extractive material per year.
- *cement works* that have an intended production capacity of more than 150 tonnes per day or 30,000 tonnes per year in bulk of cement, fly ash, powdered lime or any other similar dry cement products.

Whether the construction of the Tugun Bypass requires an NSW Environment Protection Authority licence will depend on the location (i.e. within NSW or Queensland), duration and capacity of the types of construction works that are listed in Schedule 1. Those matters will be determined when the detailed design of the works and construction program is undertaken.

Local Government Act 1993

Section 68 of this Act imposes an approval requirement for various activities, including the installation of temporary structures on land, carrying out sewerage or stormwater drainage works and certain actions involving the disposal of effluent. Such approvals are likely to be required for the construction phase of the project. The approval body will be Tweed Shire Council.

2.2.3 Queensland

Transport Planning and Coordination Act 1994

The general objectives of the *Transport Planning and Coordination Act 1994* are to coordinate transport in a way that provides economic and social benefits. They are broad objectives that are supplemented by more detailed objectives within the Transport Infrastructure Act 1994 and four other acts concerning transport services.

Under the *Transport Planning and Coordination Act 1994* the Chief Executive is required to develop for the Minister's approval a Transport Coordination Plan. The Tugun Bypass is identified in the Departments roads implementation program which gives effect to the Transport Coordination Plan through a process set out in the *Transport Infrastructure Act 1994*.

In the development of this coordination plan the Chief Executive has taken into account the Government's environmental policies. This EIS considers in further detail the environmental impacts associated with the proposed Tugun having regard to the environmental legislative framework in Queensland.

Transport Infrastructure Act 1994

One of the key objectives of the *Transport Infrastructure Act 1994* is the establishment of a regime that allows for and encourages effective integrated planning and efficient management of a system of transport infrastructure. In particular, this includes a regime under which a system of roads of national and state significance can be effectively planned and managed.

The Queensland section of the Tugun Bypass would be constructed, maintained and operated under Section 29 of the *Transport Infrastructure Act 1994*.

Environmental Protection Act 1994

The *Environmental Protection Act 1994* is the legislative basis for the protection of the environment in Queensland. Environmental authority is required under the Environmental Protection Act for all environmentally relevant activities prescribed by the Environmental Protection Regulations 1998. A number of environmentally relevant activities are likely to be undertaken as part of the construction. An application to an environmental authority would require details of the plans for impact management, stormwater management, waste minimisation, hazardous substances and environmental monitoring.

A material change of use of premises for an environmentally relevant activity under the *Environmental Protection Regulation 1998* requires a development under the *Integrated Planning Act 1997* unless a code of environmental compliance has been made for it under regulation. A registration certificate for environmentally relevant activities is also required under the *Environmental Protection Act 1994.*

The proponents would obtain the necessary approvals for the proposal from the Queensland Environmental Protection Agency and/or Gold Coast City Council.

Integrated Planning Act 1997

The level of assessment for development under the *Integrated Planning Act 1997* is set out in Schedules 8 and 9 of the Act and the relevant local government planning scheme. Any proposed development involving a material change of use, operational works, building works, reconfiguring a lot, or plumbing and drainage works must comply with the provisions of the Act.

The level of assessment for any proposed activity is set down in the local planning scheme. The local planning scheme covering the Queensland portion of the proposed Tugun Bypass is the *Gold Coast City Council Planning Scheme – Our Living City* (Gold Coast City Council 2003).

The level of assessment required for a proposed development may be:

- exempt development — which does not require approval
- self-assessable development — which must comply with relevant codes but does not require an application to council
- code-assessable development — which is assessed against the relevant codes
- impact-assessable development — which must be publicly notified, and assessed against the relevant codes and the potential impacts of the proposal.

Under the new planning scheme, road works, ancillary works and encroachments constructed by the State government and the declaration or opening of a State controlled road, as defined in the Transport Infrastructure Act 1994 and the Transport Infrastructure (State Controlled Roads) Regulation 1994, are identified as exempt development. As the proposed Tugun Bypass would be constructed on behalf of Main Roads, which is authorised under the Transport Infrastructure Act 1994 to undertake works, no development application is required to be submitted to the Gold Coast Council for approval under the Council's planning scheme of the road work, ancillary works and encroachments associated with the bypass.

The Integrated Planning Act provides some exemptions from the local planning scheme. Exempt development is operational works carried out by, or on behalf of, a public-sector entity authorised under state law to carry out the works. As the proposed Tugun Bypass would be constructed on behalf of Main Roads, which is authorised under the Transport Infrastructure Act to undertake the works, an approval for operational works would not be required.

The Integrated Planning Act also requires a development permit for clearing native vegetation unless subject to an exemption. The "specified activity" exemption includes, in relation to a State-controlled road, 'road works carried out on a State-controlled road and ancillary works and encroachments carried out under section 50 of the Transport Infrastructure Act'. Most, if not all, the clearing of native vegetation associated with the Tugun Bypass will fall within this exemption.

Also, approvals may be required under the Integrated Planning Act for various auxiliary construction works.

2.3 Cooperative assessment process

The approvals process for the Tugun Bypass proposal is complex as it requires approvals from a number of different jurisdictions. In July 2004 the various approval authorities agreed to a cooperative assessment process in order to run the various approval processes concurrently. It was agreed to utilise combined elements where possible and to ensure that any conditions of approval are consistent. The key outcomes of the agreement were:

- Joint EIS guidelines to be produced that represent the Director-General's requirements issued under the NSW *Environmental Planning and Assessment Act 1979* and the EIS guidelines issued by the Commonwealth Minister for Environment under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.
- A joint display period to be adopted for the display of the EIS, the SIS and the major development plan.
- Liaison between the Commonwealth Department of Environment and Heritage, the Commonwealth Department of Transport and Regional Services, the NSW Department of Infrastructure, Planning and Natural Resources and the Queensland Department of Main Roads.

2.4 Other approval processes

2.4.1 Additional approval processes required to proceed with the proposal

Should the proposal proceed, Main Roads or its contractors would need to obtain relevant approvals and licences generally aimed at monitoring the performance of the proposal both during its construction and operation. These are detailed in Table 2.1.

Table 2.1: Approvals required under Commonwealth and state legislation for the construction and operation of the proposed bypass

Legislation	Approval/permit required	Consent authority
Commonwealth		
Environmental Protection and Biodiversity Conservation Act 1999	A permit is required under the Environmental Protection and Biodiversity Conservation Act to take, kill, injure, move, trade or keep a member of a listed threatened species or ecological community in a Commonwealth area. The relocation of some species on the airport will therefore require a permit.	Minister for Environment and Heritage
Airports Act 1996	Assuming no change of title prior to construction: • the project must be the subject of a major development plan approved under the Airports Act; • approval must be obtained for any building activities (including roads, railways, tunnels and fences).	Minister for Transport Airport Building Controller, Airport Environment Officer
NSW		
Environmental Planning and Assessment Act 1979	Approval under Division 4 of Part 5	Minister for Planning
Rivers and Foreshores Improvement Act 1948	Part 3A permit for the removal of material or excavation within 40 m of the top of the bank of a river, lake, coastal lake or lagoon, or anything which detrimentally affects the flow of such watercourses.	Department of Infrastructure, Planning and Natural Resources
Water Act 1912	Approval for: • water supply works; • works draining the flood or other waters of a river or lake; or • the construction of an earthwork, embankment or levee within a floodplain.	Department of Infrastructure, Planning and Natural Resources
Protection of the Environment Operations Act 1997	An environmental protection licence may be required for the construction of the Tugun Bypass if the project involves an activity listed in Schedule 1 of the Protection of the Environment Operations Act 1997 (such as 'Bitumen pre-mix or hot-mix industries' or 'extractive industries'). The proposal does not constitute 'Freeway or tollway construction'.	Environment Protection Authority
Local Government Act 1993	Approvals for temporary site buildings and effluent disposal during the construction phase.	Tweed Shire Council
National Parks and Wildlife Act 1974	Consent to destroy, deface or disturb any Aboriginal objects or places.	Director-General of National Parks and Wildlife Service
	Consent to disturb or move an Aboriginal object.	Director-General of National Parks and Wildlife Service

Legislation	Approval/permit required	Consent authority
Queensland		
Integrated Planning Act 1997	A development permit is required for the making of a material change of use of premises for an environmentally relevant activity for which a code of environmental compliance has not been made under the Environmental Protection Regulation 1998. Environmentally relevant activities are listed under the Environmental Protection Regulation 1998. A registration certificate is also required under the Environmental Protection Act for environmentally relevant activities	Gold Coast City Council and/or Environmental Protection Agency
Environmental Protection Act 1994	Under Section 118ZZF approval is required for the removal of contaminated soil from sites listed on the Contaminated Land Register or Environmental Management Register (unless done under a remediation notice).	Environmental Protection Agency
	Under Section 39 a licence is required to conduct environmentally relevant activities. Environmentally relevant activities likely to be required for the proposal include: • ERA 7: Storage of chemicals • ERA 11: Storage of petroleum products • ERA 20: Extracting rock or other material • ERA 22: Screening materials — screening, washing, crushing, grinding, milling, sizing or separating material extracted from the earth or by dredging • ERA 62: Concrete batching for works (including mobile works) having a design capacity of more than 100 tonnes per year.	Environmental Protection Agency
Aboriginal Cultural Heritage Act	The Act requires that a person who carries out an activity must take all reasonable and practicable measures to ensure the activity does not harm Aboriginal cultural heritage. A cultural heritage management plan is to be prepared in consultation with the Traditional Owners for the Tugun Bypass prior to construction work commencing.. Any works affecting a place of aboriginal cultural heritage significance may require approval to remove or relocate artefacts or other evidence of indigenous cultural heritage	
Nature Conservation Act 1994	A permit, licence or authority may be required to take, use or keep a protected animal or plant. Chapter 3 of the Nature Conservation Regulation 1994 provides for licences, permits or other authorities that may be granted	Environmental Protection Agency
Agricultural Chemical Distribution Control Act 1966	Under Section 36 a licence is required for certain weed-spraying operations.	Department of Primary Industries, Animal and Plant Health Service.
Gold Coast Council Planning Scheme – Our Living City 2003	Development approval is required for a material change of use for a public utility to allow road construction to proceed in the Special Facilities (Local Government and Sanitary Purposes) zone.	Gold Coast City Council

2.5 Preparing a representations report

Following the exhibition of the EIS, the SIS and the major development plan all submissions from the public and other stakeholders will be reviewed and a representations report will be prepared. The report will consider:

- the EIS and SIS
- the major development plan
- all representations and responses to the issues raised
- any new information relating to the proposal
- a summary of mitigation measures and other commitments should the proposal proceed
- any other matters required under Clause 243 of the Environmental Planning and Assessment Regulation 2000.

The report will be sent to all the relevant approval authorities who will then decide if the proposal should proceed. The planning design and decision process allows for input from public authorities and the community. Assessment of representations made in response to the exhibition of the EIS, SIS and major development plan is an integral part of the approval process and can result in modifications and improvements to the design of the proposal. Should the project be approved the proponents would continue to involve relevant agencies and the local community in the detailed design of the proposal and during the construction period.

3. Community and stakeholder consultation

3.1 The consultation program

Consultation with the community and other stakeholders has been an important part of the environmental impact assessment process for the Tugun Bypass. This chapter presents the consultation processes undertaken with the community, authorities and other key stakeholders before and during the preparation of the EIS, and discusses the issues raised during these processes. Greater detail on the consultation processes and their results can be found in Technical Paper 1.

3.1.1 Objectives of the program

A Public Consultation and Community Development Plan, developed in May 2000, outlined the public consultation and community involvement process for the Tugun Bypass. The plan addressed the requirements of the *Public Consultation Policy, Standards and Guidelines* (Main Roads 1999c) and was consistent with the *Community Involvement Practice Notes and Resource Manual* (NSW RTA 1998).

The key objectives of the community and stakeholder consultation plan were to inform the community about the proposal, and to provide the local and broader community with opportunities to provide input into the EIS. The plan was also developed to incorporate the requirements of advisory and government bodies, and to keep them informed on the progress of the EIS.

The broad objectives of the consultation program were to:

- conduct an open and transparent public consultation and community involvement process
- ensure that community feedback is included in the decision-making process
- ensure that opportunities for community input are maximised.
- The plan was revised and renamed the *Tugun Bypass Engagement Strategy* in June 2004. This revision acknowledges the changes that have occurred in the community over the past two years.

3.2 Community and stakeholder consultation prior to the EIS

3.2.1 Consultation during the route selection phase

A number of strategic planning and route selection studies were undertaken before selection of the preferred route. These studies incorporated community and stakeholder consultation activities, the key outcomes of which are summarised below.

Southern Gold Coast – Tweed Corridor Study

The *Southern Gold Coast – Tweed Corridor Study* was undertaken from June 1997 to June 1998, and included community consultation to identify community attitudes and issues associated with transport options.

The key public views and preferences stated during the study included:

- preference for a road bypassing Tugun to the west of the airport
- objections to the routes to the east of the airport
- frustration that no decision had been made
- preference for the bypass to be routed to the east of the airport to avoid potential impacts on the environmental areas and on Aboriginal sites, and access issues from Kennedy Drive.

A finding of the community consultation was that 83% of respondents to the route selection process were in favour of the C options to the west of the airport.

Following the *Southern Gold Coast – Tweed Corridor Study*, Queensland Transport informed the community of the Queensland government's decision on the outcomes of the study, and defined the next stage of the study.

Pacific Highway at Tugun — Route Selection Report

Main Roads commissioned the *Pacific Highway at Tugun — Route Selection Report* in 1999. The route selection investigations included consultation with local government (Tweed Shire Council and Gold Coast City Council); agencies from the NSW, Queensland and Commonwealth governments; Aboriginal organisations in NSW and Queensland; and local community groups. A major consultation and route selection activity was the two-day value management workshop. The key finding of this workshop was to confirm the C4 option as the preferred alignment.

3.3 Consultation with the community during the EIS

The community consultation process for the Tugun Bypass EIS began in May 2000. This section outlines the key tools used and the activities undertaken to inform the community and stakeholders of the study, and to obtain and integrate their input into the decision-making process. The issues raised to date are also outlined in Section 3.5.

The components of the community and stakeholder consultation program are shown in Figure 3.1.

3.3.1 Community information tools

The community information tools used to raise awareness about the proposed Tugun Bypass, to provide project updates, and to encourage the community to contact the study team to discuss their issues and concerns, are summarised in Table 3.1.

Submissions made by the community were accepted in the form of faxes, emails and other written submissions at any time during the project development.

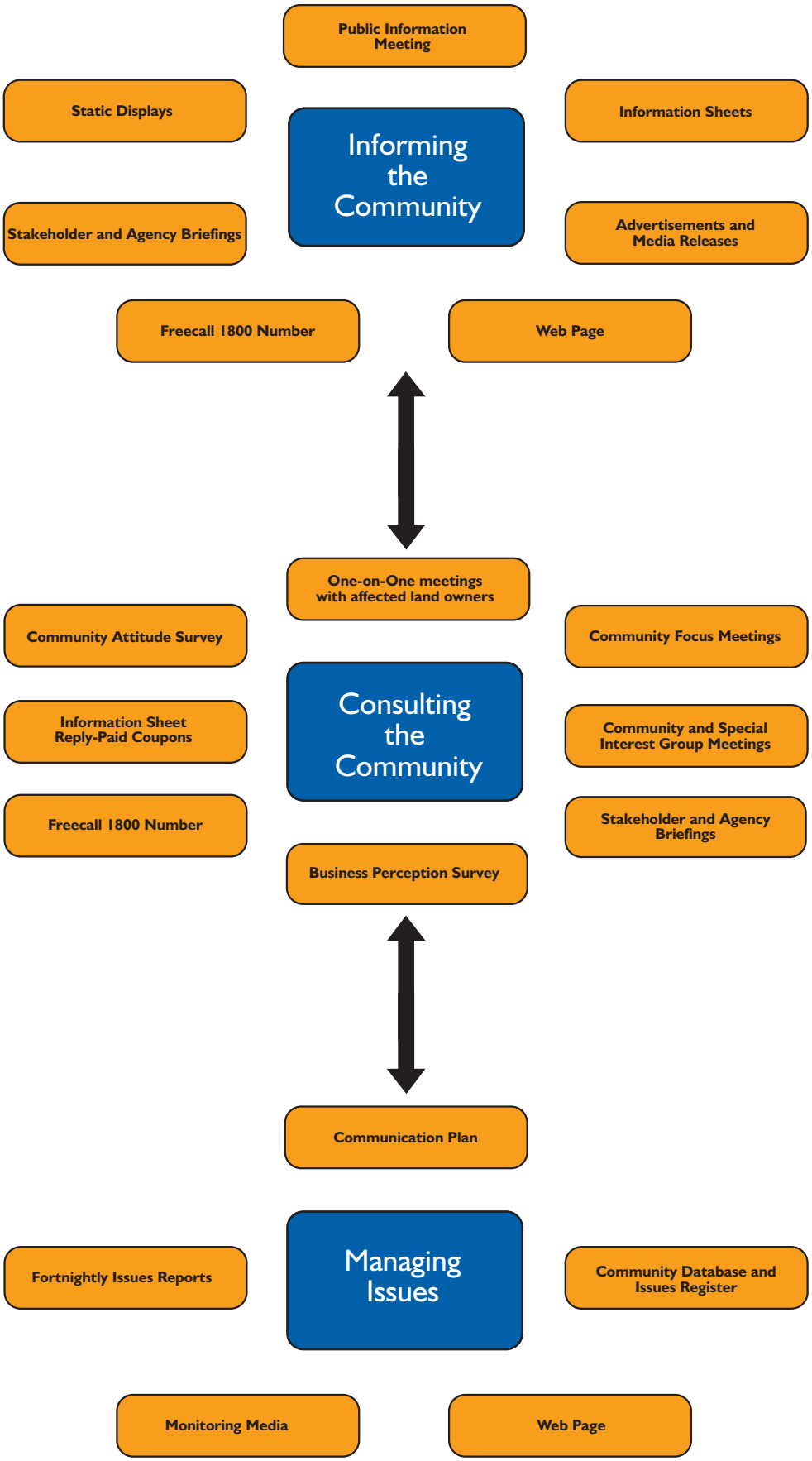


Figure 3.1 **Community and Stakeholder Consultation Program**

Table 3.1: Tugun Bypass community information tools

Community Information Tool	Date	Summary
Public information meeting	August 2000	• Held at the Tugun Progress Hall, to provide information to the broader community.
Staffed and static displays		
Robina to Tugun IAS	April 2000 and October 2000	• Held at The Pines Shopping Centre, Robina Library, Tugun Village Community Centre and government agencies. • Included information on the Tugun Bypass EIS.
Stage 1 Environmental Impact Assessment (EIA)	November and December 2002	• Held at libraries, Tweed Shire Council, Main Roads Nerang, community centres and schools. • Information shelter established at Rotary Park. • Stage 1 EIA documents were available for viewing.
Stewart Road interchange	November and December 2003	• Plan of the new interchange design was displayed at The Pines Shopping Centre, Main Roads Nerang, Elanora Library and three electorate offices.
Gold Coast Show and Brisbane Exhibition	August 2002 and August 2004	• Display material related to the Tugun Bypass was included in the Main Roads stand.
Community cabinet meeting	October 2000	• A staffed display was held at the Queensland government's community cabinet meeting at Tugun.
Community information line and issues register	Established May 2000	• 1800 Freecall telephone information established. • Database developed to record community issues. • Mailing list created to keep respondents informed of the study's progress.
Stakeholder briefings	On going	• Provided project updates to key stakeholders, elected representatives, property owners, environment and community interest groups, and transport and construction industry representatives.
Information sheets		
Information Sheet 1 (including reply-paid coupon)	August 2000	• Distributed to 5,550 Queensland and 2,000 NSW residents and businesses; 295 reply-paid coupons received. • Provided general information on the project, study process and timeframe, opportunity to join a mailing list and contact details to encourage community input.
Information Sheet 2	November 2000	• Provided a project update, including a summary of study results, issues raised by the community, the study process and timeframe, and project contact details.
Information Sheet 3	February 2001	• Provided an update on environmental studies to date, information on the refined alignment, answers to commonly asked questions, and contact details.
Information Sheet 4	September 2001	• Provided a summary of project progress, description of the EIS and SIS processes, list of community and special interest groups involved, and project contact details.
Information Sheet 5	November 2002	• Provided details of the staged approvals process, display locations for the section of the bypass between Stewart Road and Boyd Street, plans and details of the preferred route, and information on how to make a submission.
Information Sheet 6	October 2004	• Provided a project update, including details of the preferred (C4) route, map, timeline and project contact details to 30,000 houses and businesses on the Southern Gold Coast and Northern Tweed.
Website and email facility	Ongoing	• Information on the project was attached to the Main Roads and consultant's website.

Community Information Tool	Date	Summary
		• NSW RTA website included a link to the Main Roads website. • Main Roads website was promoted on display posters, newsletters and advertisements, and an email address was created for the project.
Media releases	Ongoing	• Ministerial media releases have been issued periodically to announce key project milestones.
Media monitoring	Ongoing	• Local and Brisbane media were monitored to ensure the study team were aware of emergent issues.

3.3.2 Community consultation activities

Throughout the EIS process, the project team met with key stakeholders, including elected representatives, local councils, property owners, special interest groups and the general community, to discuss project progress, and issues and concerns relating to the proposal. The 1800 freecall number and email enquiry service have been maintained by Main Roads. The latest information sheet was issued in October 2004 (see Table 3.1).

Table 3.2 summarises the key community consultation activities undertaken. Communication tools discussed in Section 3.3.1 were generally made available to all identified stakeholders.

Table 3.2: Community consultation activities

Stakeholder group	Consultation activity
Federal, state and local elected representatives	• Meetings with elected representatives that enabled them to provide input and obtain information on the project.
Local councils	• Meetings with Gold Coast City Council and Tweed Shire Council to discuss design requirements and issues of concern.
Potentially affected property owners	• Meetings to advise of potential impacts on individual properties, including Gold Coast Airport Limited and private landowners. • Opportunity to discuss design and property access options.
Community and special interest groups	• Meetings held with community, environment and special interest groups. • Discussed issues specifically relating to impacts on the local community and environment. • Involvement in the Community Focus Group. • Tugun Progress Association hosted a meeting in June 2002 to present the community's views on the bypass. The meeting was attended by State and Federal members from both NSW and Queensland. • A community attitude survey was conducted in January 2001, targeting local residents and businesses. The short survey was designed to determine community awareness of, and attitude to, the project. • A business perceptions survey was conducted in February 2001 with 28 owners/managers in the study area. The survey obtained views on potential impacts to business as a result of the development.

3.3.3 Community focus group

A community focus group was convened to represent the wider community. The group was made up of representatives from 15 key community and special interest groups within the Tugun region. A list of the members of the community focus group can be found in Technical Paper 1. These groups were invited to take part because of the input they could provide to the

knowledge of local, economic, social, cultural and environmental impacts of the proposed Tugun Bypass.

The community focus group has met six times. The meetings covered the following issues:

- first meeting: a forum to discuss the study process and to introduce the study team
- second meeting: an update on study progress and an opportunity to gather information to help refine the preferred option
- third meeting: a further update on progress
- fourth meeting: allowed the focus group to view the refined alignment during a bus tour and to address issues of concern. The tour included Tugun Heights, Hidden Valley, Tugun Landfill, Gold Coast Airport and Kennedy Drive.
- fifth meeting: an update on the studies undertaken, the revised timetable and the approval process
- sixth meeting: discussion of a wide range of issues of current community concern.

3.4 Consultation with authorities

Queensland, NSW and Commonwealth government agencies have been involved in the consultation process since the start of the project. Meetings with authorities and key stakeholders have been held regularly throughout the EIS process. A summary of the consultation is provided below.

3.4.1 Planning focus meeting

A planning focus meeting was held in June 2000 to provide an opportunity to introduce Commonwealth, Queensland and NSW government agencies to the project and to raise any issues or concerns. The meeting was attended by representatives from 15 government agencies. (A detailed list is provided in Technical Paper 1.)

3.4.2 Meetings with local councils and individual agency consultation

Separate meetings were held with representatives of the Gold Coast City Council and Tweed Shire Council to discuss the project. The meetings discussed design requirements and issues of concern, and provided briefings on the progress of the project. The meetings are ongoing. Meetings also took place with technical staff from both councils to incorporate local council requirements within the design.

In addition to ongoing meetings, a number of agencies were provided with regular information about the project throughout the study. A detailed list of agencies consulted during the project is provided in 1.

The methods used to provide information to agencies included a combination of:

- regular information sheets (including final drafts for comment)
- updates on the community focus meetings
- monthly reports to Queensland Transport, Queensland Rail, NSW National Parks and Wildlife Service, and NSW Department of Infrastructure, Planning and Natural Resources.

Meetings will continue to be held with the community and all stakeholders and relevant authorities throughout the approval process.

3.5 Overview of issues raised during community and stakeholder consultation

This section outlines the findings of the community and stakeholder consultation process. These findings were drawn from the comments received throughout the process, as outlined in Sections 3.3 and 3.4. This includes the outcomes of the Planning Focus Meeting.

3.5.1 Key community and stakeholder issues

A table providing a summary of issues raised by the community and stakeholders, and the sections of the EIS which address these issues, is included in Appendix D.

Many different environmental concerns were raised by individuals and community groups. The main issues were as follows:

- location of the route alignment, particularly near the Cobaki Broadwater area
- impacts on flora and fauna, mainly endangered species
- impacts resulting from tunnel construction
- noise and amenity issues
- timing of construction, approvals process and funding
- property acquisition
- disturbance to the Tugun Landfill.

Route alignment and development adjacent to the Cobaki Broadwater area raised both environmental and cultural heritage concerns. There were also concerns that leachate from the Tugun Landfill could affect the wetland.

The community focus group raised issues regarding the impacts of tunnelling along the proposed route, including the construction and operation of the tunnel, safety, vegetation loss, impacts on groundwater and surface water, and impacts on rare and threatened species. Members of the group also raised questions about why a species impact statement (SIS) was needed, and what this involved.

Noise was an issue of interest. A number of references were made to increased noise levels along the Gold Coast Highway resulting from increased numbers of heavy vehicle following the opening of the Chinderah to Yelgun Freeway. There was a desire for the bypass to be constructed to alleviate these impacts. Effects on resident amenity, such as visual impacts and the provision of facilities for cyclists, were also raised by the community focus group.

The timing of construction was also a broader community issue, reinforced by participants at the public information and community focus group meetings, who consistently questioned the delay in commencing, and the length of the approvals process. These community members indicated that they would like to see the proposed Tugun Bypass as a priority for funding and construction. The main feedback received by Main Roads during public displays was 'When is the Tugun Bypass going to be built?'

Specific issues relating to the design of the bypass were also raised, particularly regarding the design of the route around the Tugun Landfill, the location of interchanges along the alignment, and the connection of interchanges to local roads.

Property acquisition was a major concern to those directly affected by the proposal.

Most contact from members of the wider community consisted of requests for information sheets and requests for inclusion on the mailing list for the study. Community members who contacted the study team were keen to be kept informed of study progress. Enquiries were also received from developers and contractors, and community members considering buying property in the area.

3.5.2 Key agency issues

Comments received from key government agencies and regulators indicated support for the proposed Tugun Bypass, and their willingness to cooperate with other Commonwealth, Queensland and NSW government agencies.

The main issues raised by the government agencies during the consultation process were:

- the decision to split the approvals process for the project into two stages (this decision has since been reversed)
- differences between the NSW, Queensland and Commonwealth legislation and standards
- implications of the bypass encroaching on the Tugun Landfill
- natural environment issues.

The decision to split the project and apply for separate approvals for two stages of the bypass was a major issue, due to the implications of a disjointed assessment of potential environmental impacts. This decision has since been reversed, and the total alignment has been assessed within the EIS.

Differences between NSW, Queensland and Commonwealth legislation and standards were a concern to some agencies, predominantly due to the disparate approval processes and requirements.

The environmental implications of the bypass encroaching on the Tugun Landfill were also raised, particularly with regard to water quality.

Design and construction were a key matter among various agencies, especially the timing of construction, design and construction methods for the tunnel, potential effects on groundwater flows, use of excavated material, design and capacity of the interchanges, and extractive industry requirements.

The integration of the bypass proposal with the airport master plan, and the implications of this integration for the development of the bypass, were also raised.

Issues regarding the acquisition of properties were raised, particularly in relation to social impacts on residents.

Other issues included air quality, requirements for compensatory habitat, endangered species conservation, management of acid sulfate soils, noise attenuation, impacts on flora and fauna, provision for fauna movement, and protection of significant environmental areas.

Issues raised by the key agencies have been addressed in the relevant sections during preparation of the EIS.

3.6 Conclusions

Overall, the feedback from the community consultation program indicated general support for the proposed Tugun Bypass. Consultation undertaken since 1997 on the preferred route alignment suggests that a majority of the community prefer the C alignments, west of the Gold Coast Airport. Concerns with regard to the project were mainly related to perceived delays, the timing of construction and the approvals process.

Feedback from the community tended to indicate an interest in being kept informed of the progress of the project, rather than expressing any concerns, opinions or suggestions. However, some respondents did express specific concerns and these were mainly related to environmental impacts, as outlined in Section 3.5.1.

Comments received from key government agencies and regulators focused on issues relating to the design requirements for the alignment, and impacts on the environment.

Issues raised during the consultation process were used in the refinement of the alignment and the identification of mitigation strategies. The issues raised have been addressed in relevant parts of the EIS. The potential social impacts of the bypass are discussed in Chapter 13 and Technical Paper 15.

Part B – Need for the proposal and consideration of alternatives

4. Need for the bypass

4.1 Introduction

The purpose of this chapter is to:

- outline the national and regional planning and transport strategies that support an alternative road corridor to the existing Gold Coast Highway
- define the existing situation that generates the need to build a bypass at Tugun.

4.2 Background

As mentioned previously, an alternative transport corridor between Currumbin and Tweed Heads has been the subject of community discussion and Main Roads planning for more than 30 years. Main Roads identified the future need for an alternative corridor to the Gold Coast Highway in the mid-1960s. The Queensland and NSW governments, in 1982, jointly identified a possible bypass route west of the Gold Coast Airport, and Main Roads acquired part of the land in Queensland for the road corridor. The need for a bypass of Tugun and Bilinga has compounded over recent time with increases in traffic volumes along the Gold Coast Highway/Pacific Highway and with increasing population and density of the southern Gold Coast region.

4.3 National and regional planning and transport strategies supporting the proposal

Transport and land use planning for south-east Queensland and northern NSW are controlled by the Queensland and NSW governments. However, there is national involvement for certain projects, such as the proposed Tugun Bypass.

The following documents, as detailed in Technical Paper 3, establish the transport and land use planning context for the proposed Tugun Bypass at national, state and regional levels:

- *AusLink White Paper* (Commonwealth Department of Transport and Regional Services, 2004)
- South East Queensland Regional Framework for Growth Management (Queensland government 1998)
- Integrated Regional Transport Plan for South East Queensland (Queensland Transport 1997a)
- Transport 2007 — An Action Plan for South East Queensland (Queensland Transport 2001a)
- South East Queensland Freight Study (Queensland Transport 1996)
- Southern Gold Coast – Tweed Corridor Study — Land Use and Transport Study (Queensland Transport 1998b)
- North Coast Regional Environmental Plan (NSW Department of Planning 1988)
- North Coast Urban Development Strategy (NSW Department of Planning 1995b)

- Northern Rivers Regional Strategy, Final Report of Phase One (NOREDO, NOROCO and NSW Department of Planning 1998)
- North Coast Road Strategy (NSW RTA 1992)
- Upgrading the Pacific Highway: Ten Year Pacific Highway Reconstruction Program (NSW RTA 1997).

The key documents are summarised below.

4.3.1 AusLink White Paper

The *AusLink White Paper* was released by the Commonwealth Department of Transport and Regional Services in 2004. The White Paper sets out a number of national objectives for future land transport investment over the 5-year period, 2004 to 2009.

The White Paper identifies a number of strategic directions to improve long-term infrastructure and to guide its investment priorities under the National Land Transport Plan. Included in the directions is a commitment that the Commonwealth government will improve the capacity and performance of the vitally important eastern seaboard north–south interstate corridors by upgrading critical road and rail links.

The White Paper recognises that interstate corridors are critical for national, state and regional economic and social development, trade, security and connectivity, and that these corridors comprise Australia's major national freight and passenger arteries.

The White Paper identifies the Tugun Bypass as a priority for improvement in the National Network, and commits $120 million towards its construction.

4.3.2 South-east Queensland strategies

A number of documents, including the *South East Queensland Regional Framework for Growth Management, Integrated Regional Transport Plan for South East Queensland* and Transport 2007, provide overall strategy and action plans for south-east Queensland. The strategic planning opportunities and plans discussed in these documents include the construction of the proposed Tugun Bypass.

The *South East Queensland Freight Study* identified that freight traffic at Tugun includes significant movements across the border with NSW. A priority was set in the study to continue to support projects that provide incremental freight transport benefits and satisfy other transport outcomes. One of the actions listed as being able to achieve such benefits was a Gold Coast Airport bypass.

4.3.3 NSW Pacific Highway Upgrading Program

The NSW Pacific Highway Upgrading Program is being managed by the NSW RTA. The program aims to improve the existing Pacific Highway as the principal north–south coastal route from Hexham to Tweed Heads, as set out in the *North Coast Road Strategy*.

Increased funding was made available by the NSW and Commonwealth governments from 1996 to 2006 to undertake upgrading works along the Pacific Highway under the program. Its objective is to provide a higher standard road and a safer, more efficient highway link to the

Queensland border. It also aims to reduce travel time by 60 to 90 minutes from Hexham to Tweed Heads, and maximise the percentage of dual carriageway-standard highway.

Although the Pacific Highway is already dual carriageway between the Queensland border and Yelgun, the Tugun Bypass would become part of the upgraded Pacific Highway, and provide an improved connection with Queensland's highway system.

4.4 Local planning and transport strategies

4.4.1 Gold Coast City Council

A number of Gold Coast City Council planning scheme documents are relevant to planning and transport strategies in the local area. These are summarised below:

- The *Gold Coast City Council Planning Scheme — Our Living City* sets out Gold Coast City Council's preferred policies and strategies for the development of the local government area.
- The *Gold Coast City Transport Plan – Transport Master Plan 1999 to 2030* (Gold Coast City Council 1998b) was prepared within the framework established by the Integrated Regional Transport Plan. As a 30-year transport master plan, it documents strategies and actions to address the travel demand challenges facing the city. The proposed Tugun Bypass was identified as a key transport opportunity within this document, as was the downgrading in function of the Gold Coast Highway and the provision of a line-haul public transport corridor along the Gold Coast Highway.
- The Activity Centre Strategy, prepared by Gold Coast City Council in 1998, focuses on Council's urban development policy and the preferred location of employment. Coolangatta and Tweed Heads together are identified as a regional centre providing a range of services and facilities required by the combined communities on both sides of the Queensland–NSW border.
- The *Gold Coast Bicycle Network Strategy*, adopted by Gold Coast City Council in 1996, recommended a city-wide network of on- and off-road bikeways, and provided a set of policy and program recommendations directed at all levels of government, the community and the private sector.

4.4.2 Tweed Shire Council

Tweed Shire Council's planning scheme documents relating to planning and transport strategies in the local area include the following:

- The Tweed Shire Strategic Plan (2000+), produced in 1997, provides broad directions for future planning in the Tweed designed to address issues specific to the area.
- The *Lower Tweed River Transportation Study* (Tweed Shire Council 1997) is part of the Tweed Shire Road Network Strategy. This considers new road connections in the vicinity of the proposed Tugun Bypass, and includes an interchange at Boyd Street.
- The *Tweed Bicycle Plan,* adopted by Tweed Shire Council in 1995, recommends a strategic bicycle network for the shire and a detailed local area network for Tweed Heads. It also focuses on the provision of signed on-road routes to encourage longer-distance bicycle touring through the Tweed Valley and between coastal communities.

4.5 Existing situation creating the need for a bypass

4.5.1 Traffic

Significant development has occurred along the coastal strip between the Gold Coast and Tweed Shire in the last 30 years, producing a continuous urban area from north of the Gold Coast to south of Tweed Heads in NSW. This development has been accompanied by increases in traffic demand as the population and density rises.

In addition, the Gold Coast Highway also functions as a major cross-border route for interstate traffic, including heavy vehicles. This results in a conflict between providing a fast, efficient highway for interstate traffic, and supplying the high level of access required for the local community. This conflict causes congestion at peak hours, and during holiday periods, and results in delays of up to an hour or more.

A number of indicators of travel efficiency and reliability have been used to determine the condition of the existing road network in the Tugun area, and all show a deteriorating situation that will significantly worsen as the traffic increases. Consequential changes include increases in travel times and a continuing decline of the road network's level of service. Table 4.1 details the indicators of travel efficiency and reliability.

Table 4.1: Indicators of travel efficiency and reliability

Intersection performance	Levels of service provide an indication of intersection performance, with level A indicating free-flowing conditions and level F a breakdown of flows. Traffic modelling shows that intersections in the Tugun area will be operating at levels of service from E to F by 2007. This indicates that the traffic issues need immediate resolution.		
Travel speeds	Modelling has shown that average travel speeds along the Gold Coast Highway in 2007 will range from 10 to 66 km/h, while in 2017 they will decrease to a range of 10 to 46 km/h. The slowest speeds will occur during the morning and evening peaks.		
Travel times	Travel times from Stewart Road to Kennedy Drive via the Gold Coast Highway are currently 9 to 12 minutes during the morning and afternoon peaks. Times will increase rapidly without the bypass.		
	Travel times from Stewart Road to Kennedy Drive		
		2002	2017
	Morning peak	9–11 min	>30 min
	Evening peak	12 min	>30 min

4.5.2 Population growth and employment

The population of the Gold Coast – Tweed Heads region is forecast to increase to around 620,000 by 2011. This is expected to lead to a 60% increase in travel demand along the Gold Coast Highway at Tugun: from the current average of 72,000 vehicles per weekday to 120,000 by 2017. Without the bypass, all this traffic would have to use the existing route along the Gold Coast Highway and Tweed Heads Bypass.

The Gold Coast is an important employment centre in south-east Queensland and is expected to account for 121,000 jobs by 2011, or 20% of the total expected employment growth in this area. The major employment node on the southern Gold Coast is Coolangatta, and most employment growth in the next 10 years is expected to be in Tweed Heads, Coolangatta and around Elanora. Employment growth would be hindered by a non-functioning road network. Population

growth in the areas to the south and west of Coolangatta, and the possible failure to achieve complementary growth in jobs in those areas, may result in the demand for local trips growing at a rate that is much faster than the growth in the resident population of the area.

4.5.3 Safety

In total, 286 accidents were recorded on the section of road between the Pacific Motorway and the Tweed Heads Bypass from the period 1994 to 2004. Injury rates are higher than for a typical four-lane divided road, reflecting the high traffic volumes, a large number of uncontrolled access points, and the difference in speed expectations of through-traffic and local traffic.

There are also areas where pedestrian and cycle movements conflict with traffic on the highway. These cross-movements are generally associated with trips between residential areas of Tugun to the west of the Gold Coast Highway and the shops and beaches to the east.

4.5.4 Amenity of the area

The Gold Coast Highway runs through the middle of the Tugun and Bilinga communities. The movement along this corridor of 72,000 vehicles per day (including B-doubles and other heavy vehicles) significantly affects the amenity of the area. The most significant effect is the severance of the residential areas to the west from amenity areas, such as the shops and beaches in the east. This means that residents are faced with a barrier formed by four lanes of traffic when they are trying to reach the amenity areas.

Road traffic noise levels (daytime and night-time) along the Gold Coast Highway and the Tweed Heads Bypass currently exceed the respective Queensland and NSW road traffic authorities acceptable noise criterion levels. As traffic volumes and the percentage of heavy vehicles increase along the Gold Coast Highway and the Tweed Heads Bypass, road traffic noise levels will also increase. The night-time noise levels will increase significantly with the increase in heavy vehicles during off-peak travel times.

4.6 Conclusion

There are numerous national, regional, and local planning studies and strategies that have identified the need to improve the existing situation along the Gold Coast Highway and the Tweed Heads Bypass in the Tugun and Bilinga area.

In summary, traffic on the existing Pacific Motorway/Gold Coast Highway, and Tweed Heads Bypass are subjected to the following unsatisfactory conditions that result in a reduced amenity for residents, tourists, and businesses in the Tugun and Bilinga area:

- excessive traffic volumes causing travel time delays and increasing driver frustration
- increasing population growth and density compounding the existing traffic situation
- increased safety concerns for motorists, pedestrians and cyclists
- a significant reduction in amenity for the area through reduced accessibility and increases in road traffic noise.

5. Why Option C4 is preferred

This chapter describes the route selection process that resulted in the selection of option C4 as the preferred route to be the subject of formal environmental impact assessment. The details of this chapter draws heavily from two previous studies, namely, the *Southern Gold Coast – Tweed Corridor Study* and *Pacific Highway at Tugun Route Selection Report*.

5.1 Overview of the route selection process

The selection of Option C4 has a long and complex history. Environmental and engineering investigations have been undertaken in association with community consultation over the past six years to provide the background to the selection of C4 and this EIS.

Figure 5.1 illustrates the history of the selection of C4 and the completion of the EIS for C4. Figure 5.1 contains the history from 1997, when the first detailed engineering, environmental and community consultation studies were commissioned to find a solution to the transport issues facing the southern Gold Coast and Tweed areas. The following sections of this chapter are also referenced in Figure 5.1 to aid comprehension of the history of the project.

Prior to the *Southern Gold Coast – Tweed Corridor Study* in 1998, the need for an alternative road corridor for the Tugun area was identified as long ago as the early 1980s. At that time Main Roads purchased land in Queensland to preserve a road corridor to the west of the existing Gold Coast Highway. In NSW, Tweed Shire Council included a corridor in its *Local Environmental Plan*.

5.2 Southern Gold Coast – Tweed Corridor Study (1998)

5.2.1 Background

Queensland Transport commissioned the *Southern Gold Coast - Tweed Corridor Study* following the Integrated Regional Transport Plan. The investigation included broad transport planning, engineering and environmental studies to identify potential solutions to the transport issues facing the southern Gold Coast and Tweed area. The study also included community consultation over three phases to identify community attitudes and issues associated with transport options, including the Tugun Bypass and the extension of the Gold Coast rail line to Gold Coast Airport. Three broad corridor options (A, B and C) were identified through a comprehensive consultation process, details of which follow. The Study was guided by a Steering Committee with representation of the NSW Department of Urban Affairs and Planning as well as a Reference Group with representation of the NSW RTA and NSW Department of Urban Affairs and Planning.

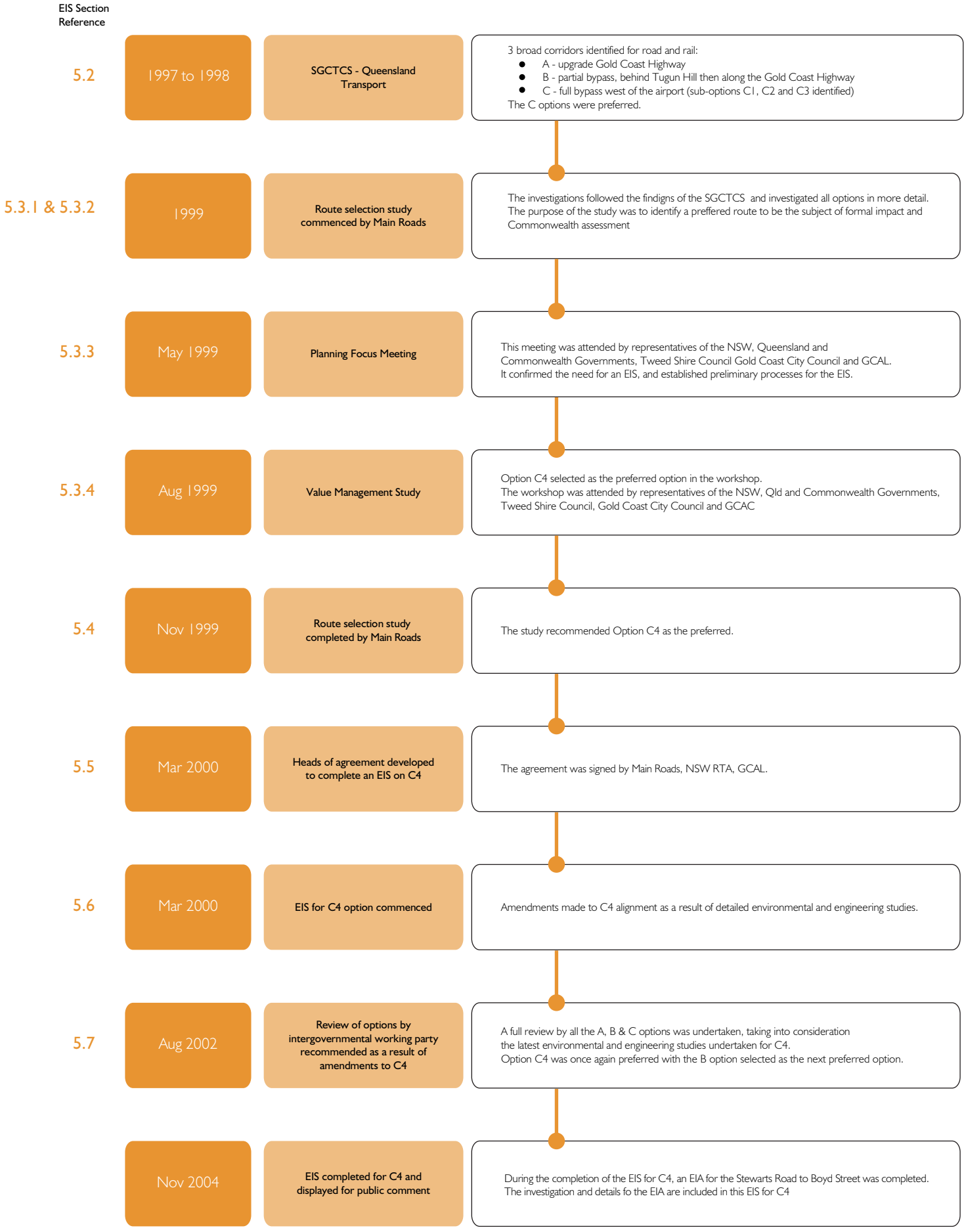


Figure 5.1 **Tugun Bypass - Route Selection and EIS History**

5.2.2 Community consultation phases

Phase 1 – Community information phase

The first stage focussed on the provision of community information and provided guidance to the local community in identifying regional transport and land use needs.

Phase 2 – Community meetings

The second phase consisted of community meetings and inputs to the development and evaluation of corridor options for a bypass.

Phase 3 – Community feedback

The third phase comprised the assessment of community responses. The *Corridor Options Discussion Paper* was also released during this phase. This outlined three potential route corridors, which are shown on Figure 5.2. The options were:

- Option A — upgrade of the existing Pacific Motorway – Gold Coast Highway alignment with two sub-options A1 and A2
- Option B — partial bypass running along the western side of Tugun Hill to near Boyd Street and eastwards to join the Gold Coast Highway with three sub-options B1, B2 and B3
- Option C — full bypass of the Gold Coast Highway with three sub-options C1, C2 and C3. C1 was located to the west of Gold Coast Airport. C2 was largely within the airport boundary, crossing the line of the airport runway just beyond its southern end. C3 crossed the existing airport runway approximately midway along its current alignment.

Community consultation activities included:

- the distribution of a newsletter with a 'tear off' questionnaire to allow for feedback on the *Corridor Options Discussion Paper*
- information days throughout the area
- continuing media announcements and displays of study outputs.

Discussion paper

Over 460 copies of the discussion paper were distributed to the community and 140 comment forms were received in reply. The feedback showed:

- strong support for Options C1, C2 and C3 to the west of the airport
- opposition to eastern options along the coastal strip in the Tugun and Bilinga areas, due to concerns over potential isolation of properties
- preference for a road tunnel through Tugun Hill
- concerns that the eastern options would not be compatible with the need to separate the local road network from the interstate network.

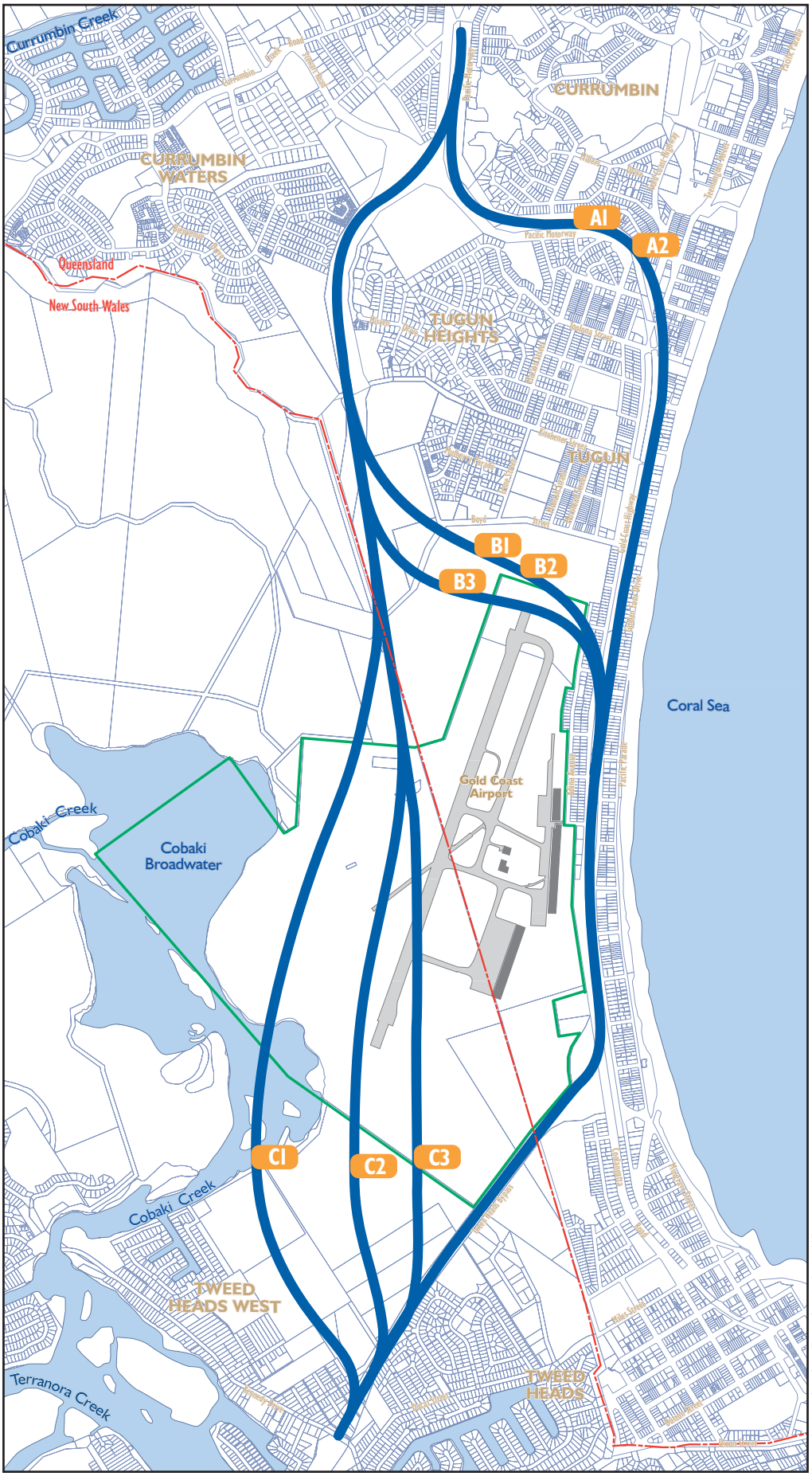


Figure 5.2 **Tugun Road Alignment Options**

Newsletter questionnaire

The newsletter was distributed to over 50,000 households. 1,105 responses were received with the following results:

- Option A – 80 responses in support
- Option B – 70 responses in support
- Option C – 909 responses in support.

Forty respondents did not express a preference. The results showed 83% of the respondents in favour of the C options to the west of the airport.

Submissions

Submissions were invited throughout the study. Thirty submissions were received covering a wide range of opinions and issues. Issues included:

- preference for a Tugun road bypass to the west of the airport
- objections to routes to the east of the airport
- expressions of frustration that no decision had been made
- preference for the bypass to be routed to the east of the airport to avoid potential impacts on environmental areas, Aboriginal sites and access issues from Kennedy Drive.

A newsletter was distributed detailing the process, indicating that Option C was the community's preference and setting out the next stages in the development of the proposal.

5.3 Pacific Highway at Tugun, Route Selection Study

5.3.1 Proposal objectives

Following the completion of the *Southern Gold Coast – Tweed Corridor Study*, Main Roads commissioned further environmental and engineering studies of the corridors identified in this study. The development and evaluation of the options was undertaken on the basis of a number of objectives for the project:

- the provision of a road corridor to separate interstate freight and other movements from local and tourist traffic along the coastal area
- 100 km/h posted speed in conformity with the adjacent sections of the Pacific Motorway/Highway
- support for public transport opportunities on the Gold Coast such as dedicated bus lanes and the provision of light rail
- preservation of a rail corridor to Coolangatta
- improved safety for pedestrians and cyclists between the Gold Coast and Tweed Heads
- reduced travel times for interstate traffic
- reduced accident and severity rates.

5.3.2 Engineering and environmental investigations

Two principal sets of options were available for a transport corridor through the study area, plus a number of hybrids that shared features with each of the main options. These options are shown on Figure 5.2. Preliminary engineering design work and environmental studies were undertaken for each of the options resulting in three potential solutions with various sub-options. Preliminary cost estimates for each of the options were also calculated. The options resulting from this work were:

- Option A — upgrade of the existing Pacific Motorway – Gold Coast Highway alignment with two sub-options A1 and A2
- Option B — partial bypass running along the western side of Tugun Hill to near Boyd Street and eastwards to join the Gold Coast Highway with three sub-options B1, B2 and B3
- Option C — full bypass of the Gold Coast Highway with three sub-options C1, C2 and C3. C1 was located to the west of Gold Coast Airport. C2 was largely within the airport boundary, crossing the line of the airport runway just beyond its southern end. C3 crossed the existing airport runway approximately midway along its current alignment.

The process undertaken to identify the preferred options considered both the road and rail alignments. The C3 option was discarded at this stage due to the major impacts it would have on the airport. A new option called C4 was introduced at this time that was a hybrid of options C1 and C2. The A1 option was also discarded as it became impractical to consider the large number of elevated structures that would be required.

5.3.3 Planning focus meeting

The process of investigation for the route selection study was confirmed at a planning focus meeting held in May 1999. This meeting was attended by agency representatives from Queensland, NSW RTA and the Commonwealth, as well as representatives from Gold Coast City Council, Tweed Shire Council, and Gold Coast Airport Limited.

5.3.4 Value management study

Following completion of the engineering and environmental investigations a Value Management Workshop was undertaken. The workshop was attended by representatives from the following agencies:

- Tweed Shire Council
- Gold Coast City Council
- Commonwealth Department of Transport and Regional Services
- Environment Australia (Commonwealth)
- NSW RTA
- Main Roads
- NSW National Parks and Wildlife Service
- NSW Department of Land and Water Conservation
- NSW Environment Protection Authority

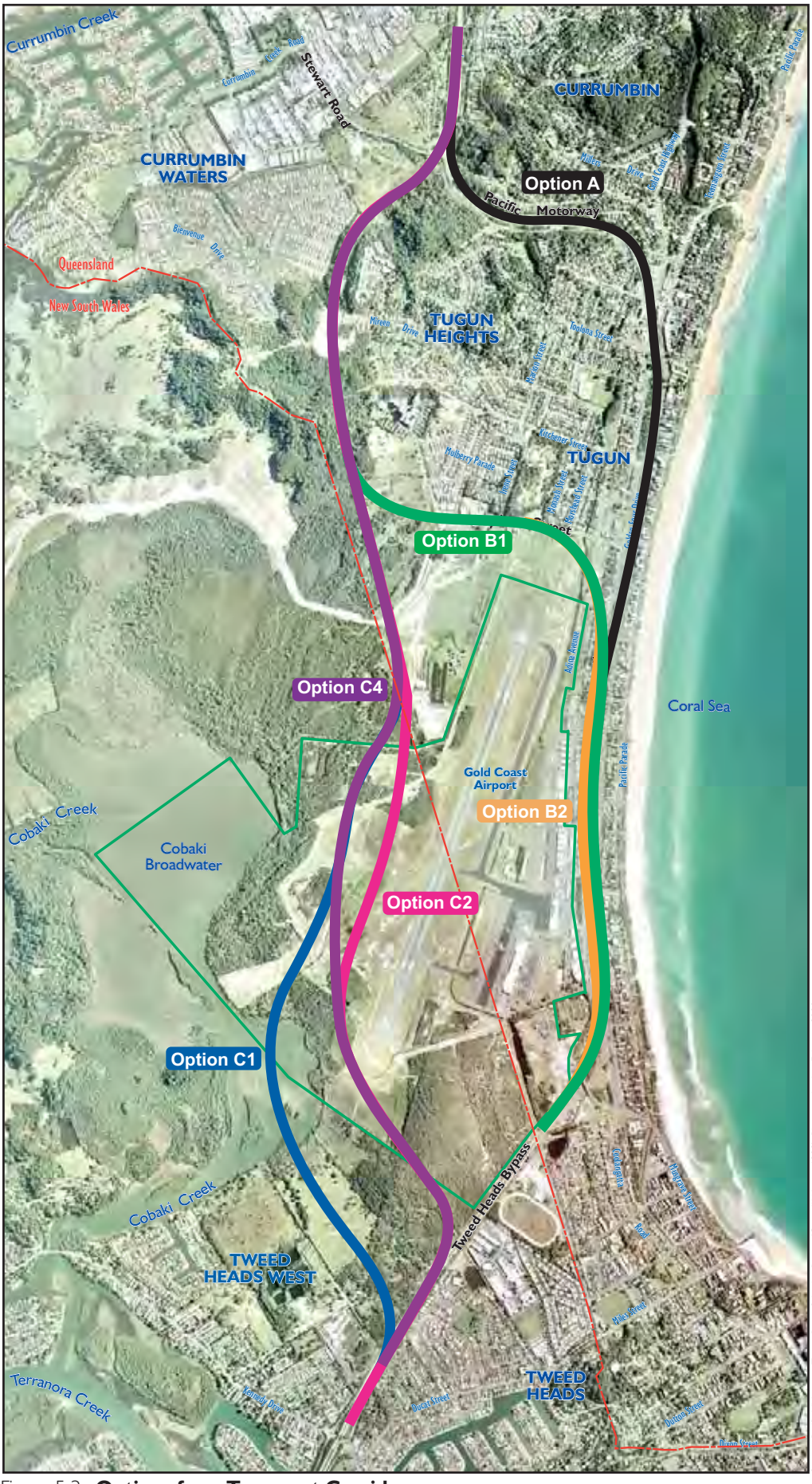


Figure 5.3 **Options for a Transport Corridor**

- NSW Department of Urban Affairs and Planning
- Queensland Transport
- Queensland Environmental Protection Agency
- Gold Coast Airport Limited
- Connell Wagner.

The objectives of the workshop were:

- to agree a list of options for the transport corridor
- to agree a list of evaluation criteria to discriminate between the options
- to agree weightings relevant to the evaluation criteria and the range of sensitivity testing on those weightings
- to rank the options in terms of preference
- to refine the top ranked option to accommodate suggested improvements.

The workshop considered three possible route corridors and six sub-options – A, B1, B2, C1, C2 and C4. The options considered by the value management study are shown on Figure 5.3. The do nothing option was also considered. These are described on the basis of the options included in the Route Selection Study (Main Roads 1999b) and are summarised in Table 5.1.

Table 5.1: Characteristics of the road alignment options

Option	Principal Characteristics
A	Alignment
	• The only option where road and rail would be located in different corridors. There is insufficient space to accommodate the rail line in parallel with the road from Stewart Road to the intersection with Gold Coast Highway and maintain acceptable horizontal radii. Alternatively, major earthworks, tunnelling and land acquisition would be necessary.
	• Horizontal radii along the existing Pacific Motorway alignment north of Tugun Hill would limit posted speed to 80 km/h. Alternatively, additional earthworks and land acquisition would be required.
	• Longitudinal profile of the existing highway would be lowered by a maximum of 2.5 m. North of Boyd Street, the service roads (Golden Four Drive and Coolangatta Road) would be widened to two lanes northbound and two lanes southbound respectively, to accommodate local traffic. South of Boyd Street, the highway would be widened to six lanes with the existing service roads performing their current function.
	• Southbound traffic on the Gold Coast Highway would join via parallel access roads to a large roundabout at Boyd Street. There would be no right-hand turn from the north as at present.
	Interchanges
	• Grade-separated interchange at Stewart Road replacing the existing traffic lights.
	• Large grade-separated interchange at Boyd Street. The highway would be elevated above the roundabout at this location.
	• Major upgrade of the Kirra–Bilinga interchange to accommodate local movements and revised access arrangements at Gold Coast Airport.
	Traffic
	• Design speed would be restricted to 80 km/h on the northern section around Tugun Hill, with a consequent impact on transport efficiency.

Option	Principal Characteristics
	Constructability
	• The whole route would have to be built while maintaining existing traffic movement on the highway, leading to congestion and delays.
	• Traffic management would cause disruption during construction, with subsequent effects on costs.
B1	Alignment
	• Road and rail line would share the same corridor. The road alignment is 400 m longer than Option A.
	• Horizontal radii where the alignment curves to the east adjacent to Boyd Street are likely to limit posted speed to 90 km/h.
	• Vertical alignment would be below the natural ground level where the road passes to the north of the airport. This would avoid the obstacle limitation surface at the northern end of the runway. As a result, it may be necessary to lower the Gold Coast Highway to achieve the necessary vertical clearance to the elevated bypass.
	• An initial four-lane configuration would be provided north of Boyd Street. The cross-section and configuration to the south would be similar to that for Option A.
	• Boyd Street would be extended to an intersection with Gold Coast Highway.
	• Ramps would be provided to allow access to and from the Gold Coast Highway adjacent to the north-east corner of the airport.
	Interchanges
	• Major grade-separated interchange at Stewart Road replacing the existing traffic lights.
	• Grade-separated dumb-bell configuration to provide an interchange between Boyd Street and the bypass is proposed adjacent to Tugun Landfill.
	• The Kirra–Bilinga interchange would be the same as for Option A.
	Traffic
	• The 90 km/h posted speed through the Boyd Street area would have some impact on transport efficiency.
	Constructability
	• That section of the route to the south of Boyd Street would have to be built while maintaining existing traffic movement on the highway, leading to congestion and delays.
	• Traffic management would cause disruption during construction with subsequent effects on costs.
B2	Alignment
	• Option B2 would share the same alignment as B1 from Stewart Road to Boyd Street. It would then curve through the north-east corridor of the airport to follow an alignment to the west of the Gold Coast Highway forming a new corridor.
	• Maximum design speed of 90 km/h could be achieved in the vicinity of Boyd Street.
	• Once clear of the obstacle limitation surface at the northern end of the runway, the road alignment would rise to ground level to run parallel to this Gold Coast Highway.
	• Connections between the Gold Coast Highway and the bypass would require overpasses for both northbound and southbound traffic.
	• Configuration of the road cross-section would be similar to that of Option B1.
	Interchanges
	• Interchanges would be similar to those proposed for Option B1.
	Traffic
	• The 90 km/h posted speed through the Boyd Street area would have some impact on transport efficiency.
	Constructability
	• That section of the route to the south of Boyd Street would have to be built while maintaining existing traffic movement on the highway, leading to congestion and delays.
	• Traffic management would cause disruption during construction with subsequent effects on costs.

Option	Principal Characteristics
C1	Alignment
	• Road and rail line would share the same corridor. The road option is marginally longer than Option C4.
	• Option C1 would share the same alignment as Option B as far as Boyd Street, and a similar alignment to C4 until adjacent to the National Estate area. It would then curves to the west to provide sufficient space to pass to the south of the airport runway and join the Tweed Heads Bypass adjacent to Honeysuckle Street, Tweed Heads West.
	• Approximately 800 m of the route would be located on a bridge structure passing over part of Cobaki Broadwater and its accompanying wetlands.
	• Immediately to the south of the wetlands, the vertical alignment would either fall to avoid penetrating the obstacle limitation surface at the southern end of the runway. Any lowered section would require extensive flood protection.
	• Horizontal radii would restrict design speed to 90 km/h in the area from the Cobaki Broadwater bridge to Tweed Heads Bypass.
	Interchanges
	• A standard diamond configuration with traffic light control would be provided at Stewart Road.
	• The Tweed Heads Bypass interchange would incorporate a full diamond, grade-separated configuration with two signalised intersections at-grade allowing traffic from both directions on the Tweed Heads Bypass to connect to the Tugun Bypass.
	• Existing eastern ramps at Kennedy Drive would be replaced by a two-lane service road.
	• The Kirra Bilinga interchange would be similar to Options A and B.
	Traffic
	• The 90 km/h posted speed in the southern section of the route would have some impact on transport efficiency.
	Constructability
	• Construction would be difficult in the environmentally sensitive areas of Cobaki Broadwater and close to the runway where restrictions would apply.
C2	Alignment
	• Road and rail line would share the same corridor.
	• Option C2 shares the same alignment as Options B and C1 as far as Boyd Street then diverges to the west to run parallel to the existing runway at Gold Cost Airport without infringement of the obstacle limitation surface before curving to the east to pass under the obstacle limitation surface at the southern end of the runway in a tunnel. It would then join the Tweed Heads Bypass some 200 m to the north of the interchange included in Option C1.
	• Horizontal and vertical alignment would achieve a design speed of 100 km/h.
	Interchanges
	• All interchanges would be of similar configuration to those included in Option C1. The Tweed Heads Bypass interchange would be located approximately 200 m further north.
	Traffic
	• The alignment would allow a design speed of 100 km/h along the full length of the option.
	Constructability
	• Construction would be difficult close to the operating runway and in particular in relation to the cover and cut tunnel located in the proximity of the runway threshold where restrictions would apply.
C4	Alignment
	• Road and rail line would share the same corridor.
	• Option C4 shares the same alignment as Options B, C1 and C2 as far as Boyd Street and a similar alignment as C1 until adjacent to the National Estate area. It would then curve to the east to pass under the obstacle limitation surface at the southern end of the runway in a tunnel following the same alignment as Option C2.
	• Horizontal and vertical radii would achieve a design speed of 100 km/h.

Option	Principal Characteristics
	Interchanges
	• All interchanges would be of a similar configuration to those included in Options C1 and C2.
	Traffic
	• The alignment would allow a posted speed of 100 km/h to be achieved along the full length of the option.
	Constructability
	• Construction would be difficult, particularly in relation to the cut and cover tunnel located close to the runway where restrictions would apply.

The workshop was held over two days. The first day was dedicated to providing the participants with the results of the previous community consultation (see Chapter 3), engineering design work and environmental studies and the second to assessing each of the options and arriving at a preferred option.

Initial assessment criteria

The workshop participants identified a set of criteria to analyse each option. A long list of 21 was generated initially; then reduced to seven. A definition of each was agreed. The final assessment criteria selected are listed in Table 5.2.

Table 5.2: Agreed assessment criteria and definitions

Evaluation Criteria	Definition
Impacts on the natural environment	Loss/fragmentation/degradation of habitat
Social impact	Loss of houses, community facilities and lifestyle
Local land use planning	Land use potential/future mix
Airport impact	Degree to which airport operations are restricted
Transport efficiency	To meet local and regional transport needs for the long-term
Visual impact	Prominence of cuttings, structures, noise walls etc
Safety	The accident potential for all road users (loss of life)

Table 5.3: Matrix of Paired Comparisons

	Assessment Criteria	Natural Environmental Impact	Social Impacts	Local Land Use Planning	Airport Impacts	Transport Efficiency	Visual Impact	Safety	Frequency	Weighting
A	Natural environmental impact		A	A	A	A	A	G	5	24
B	Social impact			B	B	E	B	G	3	14
C	Local land use planning				D	E	C	G	1	5
D	Airport impact					E	D	G	2	10
E	Transport efficiency						E	G	4	20
F	Visual impact							G	0	0
G	Safety								6	27
	Weighting Factor								**21**	**100**

Note 1: This matrix has been amended slightly to aid understanding.
2: Frequency is the number of times that the criterion is preferred over the paired alternative.
3: Weighting is derived by normalising the frequency to 100.
4: Visual impacts, with a frequency of zero, were not considered further.

Source: Main Roads 1999b

A standard process of comparing each criterion and establishing their ranking was adopted. A weighting for each criterion was developed. Table 5.3 shows the matrix of paired comparisons produced at the workshop. A consensual approach was used to determine their relative significance.

As visual impact had a frequency on the matrix of zero, it was deleted from the evaluation criteria.

The outcome of the evaluation of options by all the stakeholder representatives at the workshop was that C4 was the highest ranking option. Sensitivity testing of the evaluation matrix following the selection of option C4 confirmed this option as the highest ranked option. Chapters 10 and 11 from the Pacific Highway at Tugun Route Selection Report are presented as Appendix E.

5.4 Conclusion of the Route Selection Study

The conclusions of the route selection report were as follows:

- traffic modelling has predicted strong growth in the traffic volumes on the existing Gold Coast Highway/Pacific Highway corridor at Tugun
- traffic movements are expected to increase from a current level of 47,000 vehicles per day to 70,000 vehicles per day within the next ten years
- congestion delays and poor level of safety on the existing corridor can be expected to worsen over time as traffic volumes increase
- the level of service on the Tugun section of the Pacific Highway route can be expected to significantly degrade, particularly compared to other sectors of the route to the north and south of Tugun where significant upgrading is both planned and under construction to improve traffic conditions on the Pacific Highway between Sydney and Brisbane
- there is a demonstrated need to increase capacity, reduce delays and increase road safety in the Tugun area for both local and regional traffic
- a full range of options have been examined including railway corridor options. All options previously examined in the *Southern Gold Coast – Tweed Corridor Study* have been re-examined in greater detail. A new option (Option B2) recommended by Tweed Shire Council has also been evaluated
- preliminary investigations have been undertaken of the environmental, social and economic impacts of the options. Further investigations will be necessary as part of the detailed impact assessment of the project.
- the evaluation of options and selection of a preferred option was undertaken in a Value Management Workshop involving representatives from organisations and agencies at the Commonwealth, State and Local government levels in both NSW and Queensland.
- the outcome of the Value Management Workshop was the Option C4 was the highest ranking option in terms of the agreed evaluation criteria and the weightings assigned by the workshop participants to those criteria
- a set of recommendations were made by workshop participants for the refinement of Option C4 to minimise environmental impacts.

It was recommended that Option C4 be adopted by the Commonwealth, NSW and Queensland governments as the preferred option for the route of the Pacific Motorway/Highway at Tugun.

Further, it was recommended that formal impact assessment of the C4 option commence under a joint process to satisfy the impact assessment requirements of the Commonwealth, NSW and Queensland.

A 'do nothing' option for the existing Gold Coast Highway and local road network would normally be considered during a route selection process. The levels of congestion and delays that are currently experienced indicate a deteriorating situation that will significantly worsen with increases in traffic in the next few years. The 'do nothing' option has not been considered further as the current situation already fails to deliver the necessary level of service and further declines would not be acceptable to the community.

5.5 Impacts of options on matters protected

It is a requirement of the EPBC regulations that an EIS should provide to the extent reasonably practicable a comparative description of the impacts of each alternative on the matters protected by the controlling provisions for the action. The Value Management Workshop was completed in 1999, the year before the regulations commenced and therefore the requirements were not considered during the original workshop. The remainder of this section undertakes a retrospective assessment of the various options on matters protected. The assessment is based on the original concepts for each of the options as assessed at the Value Management Workshop and not the refinements made in the intervening years. The majority of the data relating to matters protected was obtained from studies and surveys conducted after the value Management Workshop.

The A option followed the existing road corridor from the Pacific Motorway to the Tweed Heads Bypass. As this option would have overlain the existing corridor it is unlikely that it would have had any impacts on the natural environment and the matters protected.

The B options followed a new corridor along their northern section. This route, shared with the C options, would have passed through Hidden Valley. The B options would therefore have had an impact on those plants in the valley listed as matters protected. These are *Cryptocarya foetida, Syzygium morei, Macadamia tetraphylla.* A roost site for the Grey-headed Flying Fox, *Pteropus poliocephalus* is also found in Hidden Valley. South of Hidden Valley the B options followed a route to the north of the airport to rejoin the Gold Coast Highway near Boyd Street. South of Boyd Street the B options followed the existing road corridor and so would have been unlikely to have any impacts on the natural environment and matters protected along this section.

The C options followed a new route to the west of the Gold Coast Airport. They shared the northern section of the route with the B options and so had the same impacts on Hidden Valley. South of Hidden Valley the C options passed close to areas of known habitat for the Long-nosed Potoroo *Potorous tridactylus*, passed through habitat for the Swamp Orchid *Phaius Australis* and the Wallum Sedge Frog *Litoria olongburensis*.

The C4 option was subject to considerable refinement from its original configuration to avoid or minimise impacts on matters protected and a comprehensive compensatory habitat package developed to offset any residual impacts.

5.6 EIS for C4 commenced

Following the adoption of C4 as the preferred option by the Queensland government in 1999 and the Heads of Agreement, detailed environmental studies were commissioned and the initial

engineering design work refined. The development of the EIS was guided by a Major Stakeholder Group with representatives of QDMR, RTA, GCAL and Queensland Transport. The results of the various environmental studies are presented in the technical papers accompanying the EIS.

The results of the various studies identified a number of areas of ecological importance. Changes to the alignment were made to avoid or minimise impacts on these areas. These included:

- refining the alignment through Hidden Valley from the original concept of importing fill to the development of a launched bridge design to minimise the impact on regionally significant plants and ecosystems
- alterations of the alignment to avoid populations of Swamp Orchids
- optimising the alignment to reduce the impact of the road corridor on habitat for the Wallum Froglet, Wallum Sedge Frog and Long-nosed Potoroo.
- optimising the alignment to reduce the impact of the road corridor on habitat for the Wallum Froglet, Wallum Sedge Frog and Long-nosed Potoroo.

5.7 Review by Intergovernmental Working Party

A working party, made up of senior representatives of the Commonwealth, NSW and Queensland governments was formed in August 2002. Representatives from the NSW RTA, Main Roads and the Commonwealth Department of Transport and Regional Services provided inputs to the working party. The Terms of Reference (TOR) of the working party was to facilitate the resolution of complex planning and environmental approvals and gain common agreement on the scope, cost, timing and related funding arrangements for the Tugun Bypass proposal. Technical and financial subgroups were formed as part of this review.

The working party noted that while the scope of Option C4 had undergone considerable refinement since the route selection process in 1999, comparable refinement of the rejected options had not been undertaken. The working party felt that the lack of refinement could lead to the view that the options assessment process was biased towards the western options. In order to address this, the working party undertook a review of the options, concentrating on the following areas:

- the need for elevated roadway over long sections of the eastern options
- the cross section of the elevated roadway
- reported alignment restrictions on the northern end of Option A
- the need for Option B to affect such a large area of the Tugun Landfill
- the number of grade-separated intersections proposed on these options.

The working party adopted a phased approach to the review of options. The first stage determined the better of the eastern routes by comparing the A options to the B options. A number of revised or refined options were also considered where appropriate.

The A route options

The A route options involve the upgrade of the existing Pacific Motorway–Gold Coast Highway corridor. The following options were considered:

A1: Six-lane at-grade widening (eventually widened to eight lanes) with 80km/h posted speed limit. All interchanges would be grade-separated. This option has a limited life of 10 to 15 years when congestion would again reach current levels. (Cost $215 million).

A2: Separate six-lane elevated roadway south of the Pacific Motorway–Gold Coast Highway intersection, constructed above the at-grade Gold Coast Highway, with 80km/h posted speed limit north along the Tugun Hill section, rising to 100 km/h to the south. All interchanges would be grade-separated. (Cost $590 million).

A3: A new alignment developed to meet the primary objectives of the proposal (100km/h, grade-separated interchanges and a separate corridor for through-traffic). This alignment included a highway corridor alongside the Gold Coast corridor from Boyd Street to the south. (Cost $650 million).

A4: A revised alignment to achieve 90km/h along the Tugun Hill section and 4 km of elevated road to carry through-traffic over the Gold Coast Highway south of Tooloona Street. All interchanges grade-separated. (Cost $500 million).

A tunnel option along that section of the route from the Pacific Motorway–Gold Coast Highway intersection to the Tweed Heads Bypass was also investigated in 2003. This was however not considered further due to excessive cost. ($485 million).

Rail options along the A alignment

It is not possible to identify a viable alignment for a rail corridor along the northern section of the A route due to the terrain and the constricted nature of the available route.

The B route options

All the B route options can be considered to be partial bypasses as they follow a new corridor in the northern section of the route before joining the Gold Coast Highway, just south of Boyd Street. The following B options were considered:

B1: Four-lane partial bypass (eventually widened to six lanes) joining the Gold Coast Highway north of the airport, followed by six-lane at-grade widening of the highway from Boyd Street (eventually widened to 10 lanes) with 100 km/h north of Boyd Street, 80 km/h south and grade-separated interchanges. (Cost $280 million).

B2: Four-lane partial bypass (eventually widened to six lanes) joining the Gold Coast Highway to the north of the airport and a separate six-lane elevated roadway south from Boyd Street above the at-grade Gold Coast Highway. The option incorporated a 100 km/h speed limit and grade-separated interchanges. (Cost $520 million).

B3: Similar to B2 but with the through-lanes along the Gold Coast Highway, south from Boyd Street within a separate corridor, alongside the highway. The option incorporated a 100 km/h speed limit and grade-separated interchanges. (Similar to the B2 alignment in the Route Selection Report (Main Roads 1999b). (Cost $360 million).

B4: Similar to the other B options to the north of Boyd Street, but included a new corridor inside the airport boundary to the west of Adina Avenue, announced in February 2004. (Cost $440 million).

An alignment for the rail line can be provided adjacent to any of the B road options. (Rail options along B alignments are not adjacent for all B's east of airport)

A diagrammatic cross-section of the elevated portion of the route is shown on Figure 5.4.

Comparison of the A and B options

The working party met in September 2002 following the assessment undertaken by the technical sub-group and recommended that the A options were not considered further.

Reasons for eliminating the A options were:

- high costs of achieving an 80 km/h alignment with higher costs for 100 km/h
- lack of separation of through and local traffic
- the need for extensive above ground or below ground structures
- noise, visual and pollution impacts on the residents of Tugun and Bilinga
- continued severance of the Tugun and Bilinga communities
- no provision for rail along the northern section of the route
- no opportunity for future upgrades.

The technical sub-group then undertook the comparison of the B and C route options using B1 and B3 as the two viable options in the comparison.

The C route options

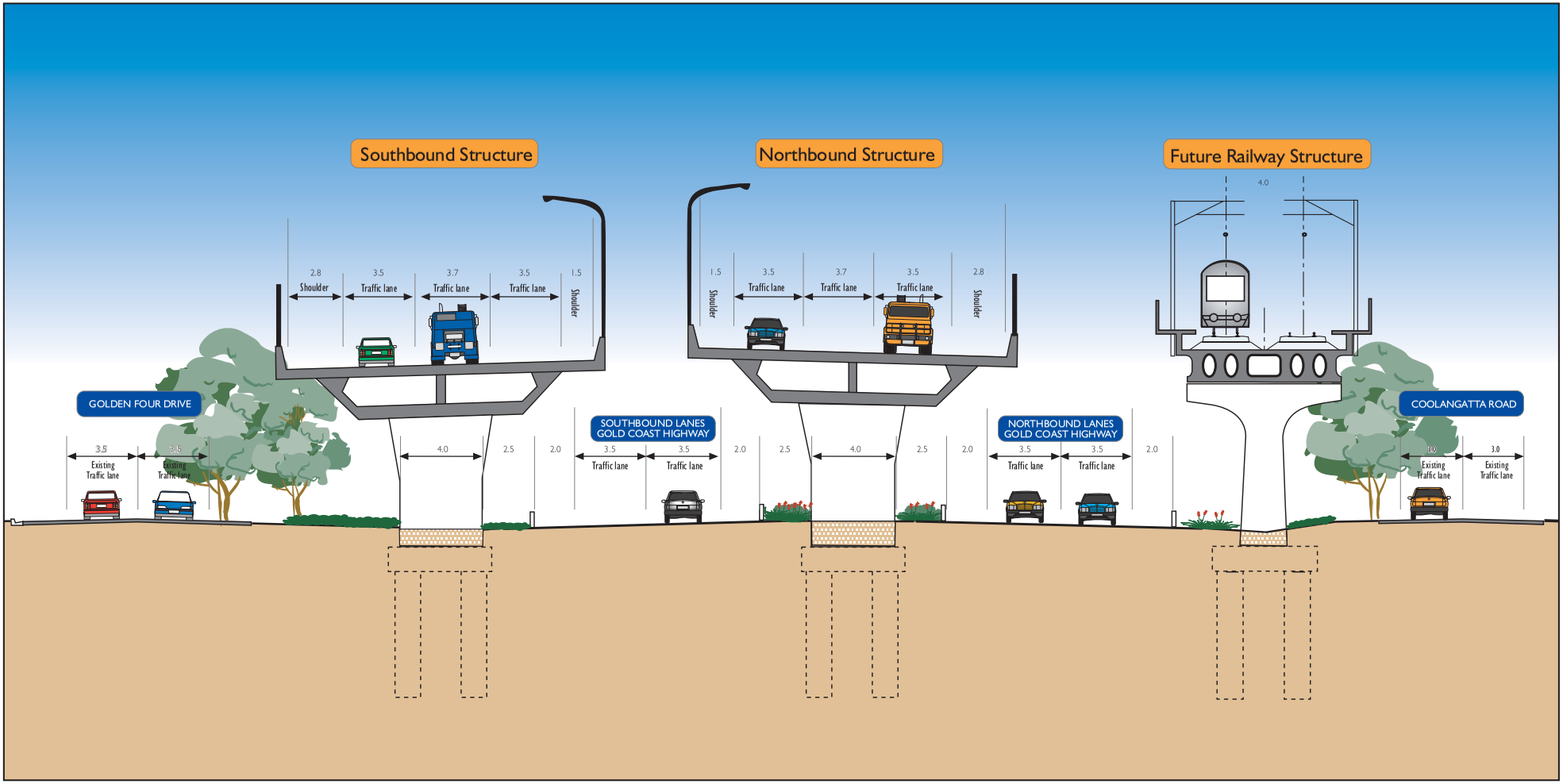
The C route options all comprised a full bypass of the Gold Coast Highway. Each would provide four lanes initially, subsequently widened to six lanes accommodating traffic at 100 km/h. Interchanges would be grade-separated. Option C3 included in the Route Selection Report (Main Roads 1999b) involved a driven tunnel under the existing runway at Gold Coast Airport but was subsequently discarded due to excessive costs. The following C options were considered:

C1: Located as far to the west as possible without affecting the National Estate area and lowland rainforest areas adjacent to Cobaki Broadwater. A bridge would be necessary over a section of the Broadwater to allow the alignment to remain at-grade beyond the proposed southern extension of the airport runway. (Cost $370 million).

C2: The alignment was located as close as possible to the existing runway without infringement of the obstacle limitation surface along its length. A tunnel beneath the obstacle limitation surface at the southern end of the runway would be required. (Cost $340 million).

C4: Option C4 was a hybrid of Options C1 and C2 which maximised opportunities to develop the western commercial precinct identified in the master plan for the airport and aligned to minimise direct effects on sensitive areas along the route. A tunnel at the southern end of the runway would be required in common with Option C2. (Cost $340 million).

The technical sub-group reported to the working party in October 2002 indicating that Options B1, B3 and C4 were considered to be viable.



Not to scale

Figure 5.4 **Existing Highway Upgrade Option Typical Cross Section (looking south)**

Option C1 was rejected due to its intrusion on Cobaki Broadwater and the impact on Tweed Heads West Sewage Treatment Works and adjoining properties. Option C2 was not considered to be acceptable due to its impacts on the airport.

Comparison of the B and C options

The remaining options (B1, B3 and C4) differed mainly in relation to costs and their impacts on the human and natural environments. The selection of the C4 alignment was based on the following considerations:

- Option B1 would be limited to 80 km/h to the south of Boyd Street
- Option B1 provided no opportunity for future upgrade for conditions beyond a 20-year horizon
- Option B3 costs would be higher than Option C4
- Option B3 would require the acquisition and demolition of more than 150 houses and businesses
- community severance issues would affect both B options in the area south of Boyd Street
- extensive community support existed for a western route.

Based on these considerations, the working party endorsed the decision to proceed with obtaining planning and environmental approvals for the preferred C4 option for the Tugun Bypass.

It was also recommended that the B options would be retained as 'fall back' options should approval not be obtained for the proposed C4 route.

Comparison of B4 and C4 options

In early 2004 the Queensland Government considered a new B option, called the B4 option. This option followed the northern sections of the other B options until south of Boyd Street where it entered a new corridor inside the boundary of the Gold Coast Airport to the western side of Adina Avenue. . It included grade separated interchanges at Stewart Road and the entrance to the Gold Coast Airport and an overpass at Boyd Street.

The major constraint for all the B options is how to fit the bypass beneath the existing OLS for the Gold Coast Airport. The B4 option would need the existing runway moved south to allow the OLS to be moved. In addition to the constraints posed by the OLS the B4 option significantly affected community facilities and the sporting fields at the northern end of the airport. These facilities included the Gold Coast Council depot, the GECKO recycling facility, the Tugun Soccer Club, the Tugun Leagues Club and football field, the skate park and the Betty Diamond Park.

The B4 option would require the demolition of 14 residences, however this is the smallest number of all the B options. The impacts on commercial properties would also be significant, particularly commercial properties within the Gold Coast Airport. 35 businesses, which include the general aviation and maintenance facilities would need to be relocated.

The level of social impacts associated with the B4 option would be considerable with the Tugun and Bilinga communities being subject to significant increases in noise, reduced visual amenity combined with community severance and isolation.

Once built the B4 option would not be able to be further upgraded to meet future demand, making it a short term solution only.

The C4 option has a number of significant benefits when compared with B4. The impacts on the communities of Tugun and Bilinga are removed and are replaced by a number of significant benefits. The construction of the Tugun Bypass would provide an alternative corridor for heavy vehicles and take them away from the residential areas of Tugun and Bilinga. The bypass would also separate interstate traffic from local traffic resulting in lower traffic volumes on the local roads and improved levels of amenity and safety. This would also benefit cyclists and pedestrians. Conflicts between local and through traffic, as is currently the case, would be removed. There would also be significant improvements in amenity, including reduced noise levels and improvements in access.

The C4 option has a higher level of impacts on the natural environment when compared with the B4 option. However the refinement of the alignment and the provision of mitigation measures combined with a compensatory habitat package provide a balance between the significant social and community benefits and the needs of the natural environment. The B4 and C4 options are shown on Figure 5.5.

5.8 Conclusion

Each set of alignment options have different social, economic and environmental considerations. This section summarises the different considerations for each set of alignments.

The A options follow the route of the existing Gold Coast Highway. The social impacts of developing the A options would be significant with the introduction of significant above or below ground structures. This would lead to an increased level of community severance for the communities of Tugun and Bilinga separating the majority of the community from the beaches and the coastal strip. The visual impacts of major above-ground structures would also be significant.

The impacts on the natural environment would not be significant as the A route options follow the existing highway corridor. However there would be increased noise levels on residential areas either side of the corridor as a result of increasing traffic. Any below ground option would have to contend with the high groundwater levels found throughout the coastal plain at Tugun and Bilinga.

The costs of the various A options are the highest of all the options and would not have space for future upgrades. They therefore have the highest economic impacts and do not present good value.

The B options follow a new corridor for the northern half of their alignments before reverting back to the existing corridor. The B options have significant social impacts, with the various options resulting in the destruction of community facilities such as soccer fields and sports clubs. The various B options would also require a number of residential properties to be demolished with up to 150 properties required for the B3 option.

The impacts on the natural environment are greater for the B options than for the A routes. The northern section of the corridor would require the bridging of Hidden Valley which contains a high density of rare and threatened plant species. The southern section of the road would follow the existing Gold Coast Highway corridor and so would lead to increased impacts from road noise on the communities along this section. The northern section would pass through residential areas not currently affected by road noise and would therefore increase the number of residential properties impacted.

Figure 5.5 **B4 and C4 Options**

The B options are less costly than the A route options but do not provide any opportunities for future upgrades and some options would be limited to 80km/h south of Boyd Street, so limiting their efficiency. In economic terms they present better value than the A options but they have limited life and high social costs.

The C options remove the negative impacts from the communities of Tugun and Bilinga and provide a number of significant benefits. These include improved levels of amenity and safety as the interstate traffic will be removed from the coastal corridor.

The significant social benefits are balanced against the C options having the largest impact on the natural environment. The C4 option was chosen as the option with the least impact on the environmental values surrounding the Cobaki Broadwater. Other C options were discarded as their level of impact on the natural environment was too high. The environmental impacts associated with the C4 option have been reduced by the alteration of the alignment to avoid areas of high environmental value.

The cost of the C4 option is approximately equivalent to the median cost for the B options but has the significant advantage that it can be upgraded to accommodate six lanes in the future.

Part C – The Tugun Bypass proposal

6. Description of the proposal

6.1 Introduction

The description of the proposed Tugun Bypass contained in this chapter is based on a concept developed as part of the design development process. The proposal is described more fully in Technical Paper 2. The description in this chapter provides the general location, alignment and configuration of major elements of the proposal.

Detailed design would be completed by the design and construction management (DCM) contractor if the proposal is approved, further developing all aspects of the concept design as outlined in the EIS. This final design would take into account the concept design and general issues raised within the EIS during the exhibition period and conditions imposed by approval authorities, as well as the results of further investigations. Consequently, it is possible that the details of the final proposal may vary from the description provided in this chapter. The concept design and construction methods proposed in this and the following section as a solution to the project objectives and constraints may also be varied by the DCM contractor within the limits of any conditions imposed and the design constraints, principles and standards detailed in this section.

6.2 General description of the proposal

The Tugun Bypass involves the development of a new road that would connect the Stewart Road interchange in Currumbin to Kennedy Drive in Tweed Heads.

The proposal is for a motorway-standard road, approximately 7 km in length, which traverses the hills and valleys west of the John Flynn Hospital and Medical Centre, the rural and generally undeveloped Gold Coast hinterland, and Gold Coast Airport. The road would be a four-lane divided carriageway with the capacity to be expanded to six lanes, and incorporating a tunnel to carry it under the obstacle limitation surface associated with the proposed extension to the main runway of Gold Coast Airport. The width of the road corridor would vary along the route to accommodate embankments and cuttings, and allow sufficient space for sedimentation basins to treat motorway run-off prior to discharge into local waterways, noise-reduction measures (including walls and mounds) and landscaping. Additional land would be required at interchanges and to incorporate service roads that would form part of the Tweed Heads Bypass and Kennedy Drive intersections. The upgrading to six lanes would occur within the existing footprint.

The horizontal alignment of the road has been designed for a posted speed of 100 km/h, and to address the numerous constraints along the route. The vertical alignment would be steeper in the north and flat in the southern section except for the descents and ascents associated with the road tunnel below the runway of Gold Coast Airport.

Access to the southern section of the new road would be provided at a grade-separated interchange on the Tweed Heads Bypass. This interchange would include a bridge and ramps to provide appropriate connections for traffic using the adjacent roads (including Kennedy Drive) and the bypass. Access to the northern section would be via the Stewart Road interchange.

In addition to the four lanes of traffic with space to expand to six, the typical cross-section of the carriageways would allow for a shoulder for emergency vehicles and vehicle breakdown, and sufficient space for the necessary services, safety systems and environmental controls.

The preferred alignment for the Tugun Bypass is shown in Figures 6.1a to 6.1e. More detail is included later in this chapter, and a detailed description of the concept design is included in Technical Paper 2.

Photograph taken February 2000

0 250 Metres

Road carriageway

Road cutting

Road embankment

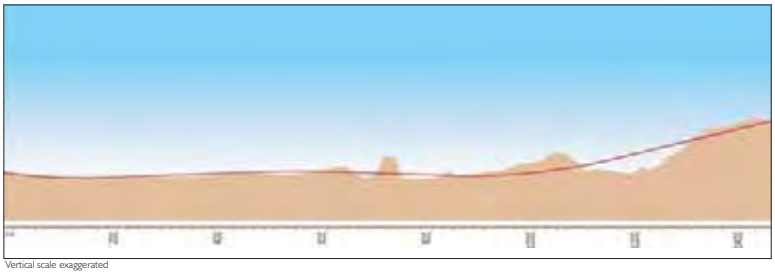
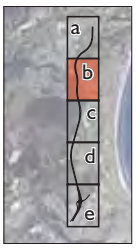


Figure 6.1a **Proposed Alignment Tugun Bypass**



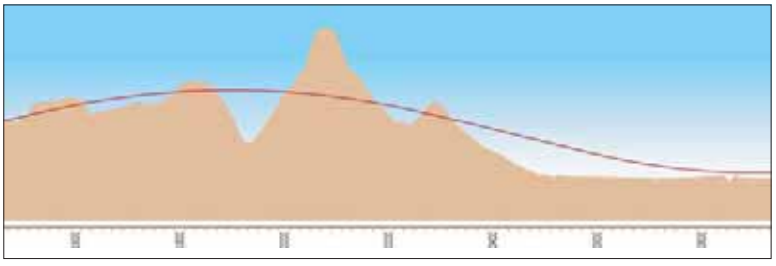
Photograph taken February 2000

0 250 Metres

Road carriageway

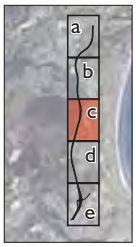
Road cutting

Road embankment



Vertical scale exaggerated

Figure 6.1b **Proposed Alignment Tugun Bypass**



Photograph taken February 2000

0 250 Metres

Road carriageway

Road cutting

Road embankment

Airport Boundary

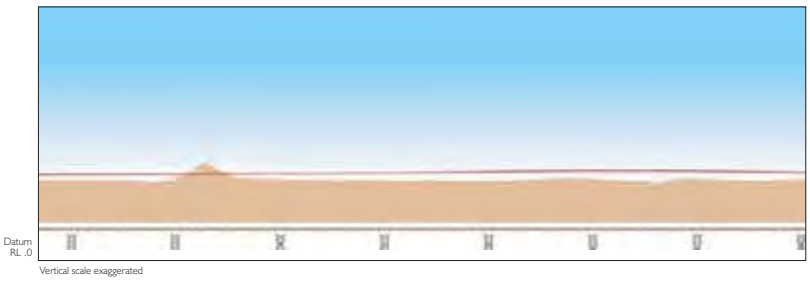


Figure 6.1c **Proposed Alignment Tugun Bypass**

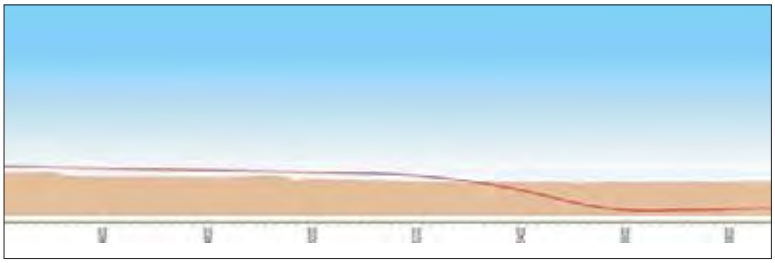
Photograph taken February 2000

0 250
Metres

Road carriageway

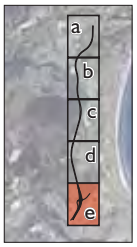
Road cutting

Road embankment



Vertical scale exaggerated

Figure 6.1d **Proposed Alignment Tugun Bypass**

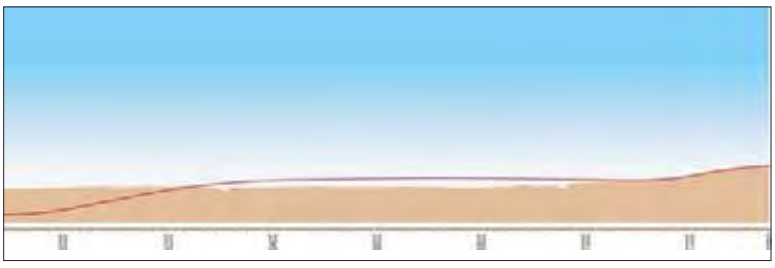


0 250
Metres

Road carriageway

Road cutting

Road embankment



Vertical scale exaggerated

Figure 6.1e **Proposed Alignment Tugun Bypass**

6.3 Design context and constraints

The Pacific Motorway/Highway (including the Tweed Heads Bypass) is the primary road connection between south-east Queensland and northern NSW. The Gold Coast Highway, between the Pacific Motorway and the Tweed Heads Bypass, is currently required to accommodate a range of traffic functions, including through-traffic movements and local cross-movements.

This mix of functions and road-user expectations results in reduced safety and efficiency of traffic movement. The Tugun Bypass would address these concerns by:

- providing the missing link in the high speed interstate highway between Stewart Road and Tweed Heads Bypass
- separating through and local movement functions to improve both the safety and efficiency of these movements.

The design constraints may be categorised into two key areas:

- those related to the natural environment through which the proposal would pass
- those resulting from human impacts on the area, including major structures and facilities, and sources of potential contamination.

6.3.1 Site description and route alignment

The topography of the proposed alignment comprises steep hills and ridges north of Boyd Street, becoming generally flat from Boyd Street to Kennedy Drive, with low-lying wetland and bush areas. Areas to the west of the proposed bypass comprise a large estuary made up of a complex of creeks and lakes, known as Cobaki Broadwater, all forming part of the Tweed River system. In the north-west, there is an area of botanical significance known locally as 'Hidden Valley'.

Developed areas occur to the north of the alignment, with residences both to the east and west. The John Flynn Hospital and Medical Centre is located to the east of the alignment, north of Boyd Street. South of Boyd Street, areas to the east are owned by Gold Coast City Council and the airport, with a narrow band of residential and tourist-related development adjacent to the Gold Coast Highway.

Soil cover to the north comprises residual soils while south of Boyd Street soils are predominantly alluvial, and comprise loose and medium-dense silty sands with intervening lenses of cemented sands, known as 'coffee rock', at depths of up to 14 m. Sandmining in parts of the area has disturbed the natural sediments and altered the original topography. Potential acid sulfate soils exist within the alluvial sands, south of Boyd Street.

To the south, recent sediments form an unconfined aquifer above impervious basement rock, which occurs approximately 40 m below the surface. Aquifer conditions are not uniform owing to the presence of lenses of cemented sand.

Groundwater recharge is from infiltration of rainfall. The combination of recharge and topography forms a groundwater mound roughly in line with the airport runway. This results in groundwater movement towards Coolangatta Creek in the north and east, and Cobaki Broadwater in the south-west. However, groundwater gradients are low and movement is slow.

Groundwater quality has been affected by landfill operations just south of Boyd Street and could have been affected by a number of other influences, including sandmining. In most areas, groundwater in the sand aquifer is fresh.

The corridor of the proposed bypass is located in an area of high floristic diversity deriving from a combination of landform, soil and climate. This wide variety of habitat types has probably resulted in the high diversity of fauna in the area, particularly frogs, reptiles and raptors. The area also provides habitat for a number of migrating bird species. A number of terrestrial and freshwater fauna species found in the area are at the limit of their distributional range.

6.3.2 Design constraints

The key constraints that have been identified during the project, and have been incorporated in the final concept design, are summarised in Table 6.1.

Table 6.1: Design constraints

Principle	Comment
Ground and subsurface conditions	The topography north of Boyd Street comprises steep hills and ridges, with elevation ranging from 6–51 m AHD (Australian Height Datum). The area south of Boyd Street to the Tweed Heads Bypass has a high water table and is subject to occasional (infrequent) flooding. A high probability of acid sulfate soils occurring within the alignment has been identified. Groundwater movement is slow and generally towards Cobaki Broadwater.
Flora and fauna	The area to the north of the John Flynn Hospital and Medical Centre, known locally as Hidden Valley, contains regionally significant vegetation and habitat. The area to the west and south-west of the main runway at Gold Coast Airport contains varied and diverse habitat with a large number of flora and fauna species. Important native vegetation communities and their associated habitats are also found here, and these include mangroves and wetlands.
Potential sources of contamination	Sources of contamination are likely to be present in the area, with the most significant being the Tugun Landfill. A small portion of the landfill would be affected, requiring management measures to contain leachate and disposal of waste material.
Existing major structures/facilities	The John Flynn Hospital and Medical Centre is north of Boyd Street, and has an influence on the alignment owing to the topography and road geometry. The location of the Gold Coast Airport runway, and associated obstacle limitation surface, has a major influence on the design of the proposal, requiring the construction of a tunnel and approaches, with a total length of 1 km. The obstacle limitation surface is shown in Figure 6.2.
Future rail alignment	The proposed future Robina to Coolangatta rail link would be in tunnel when passing under Hidden Valley. The physical limitations of the proposed rail corridor and the geometric controls required mean that any movement of the alignment to the west has significant implications for the Hidden Valley rail tunnel. Each 10 m the alignment moves to the west from the current C4 alignment requires the road grade to be raised and the rail tunnel to be extended by approximately 15-20m. As the rail costs approximately $75,000 per metre each 10 metre change adds approximately $1.2 to 1.5 million to the cost of the rail tunnel. The additional cost is much greater than the value of the reduced land requirement.

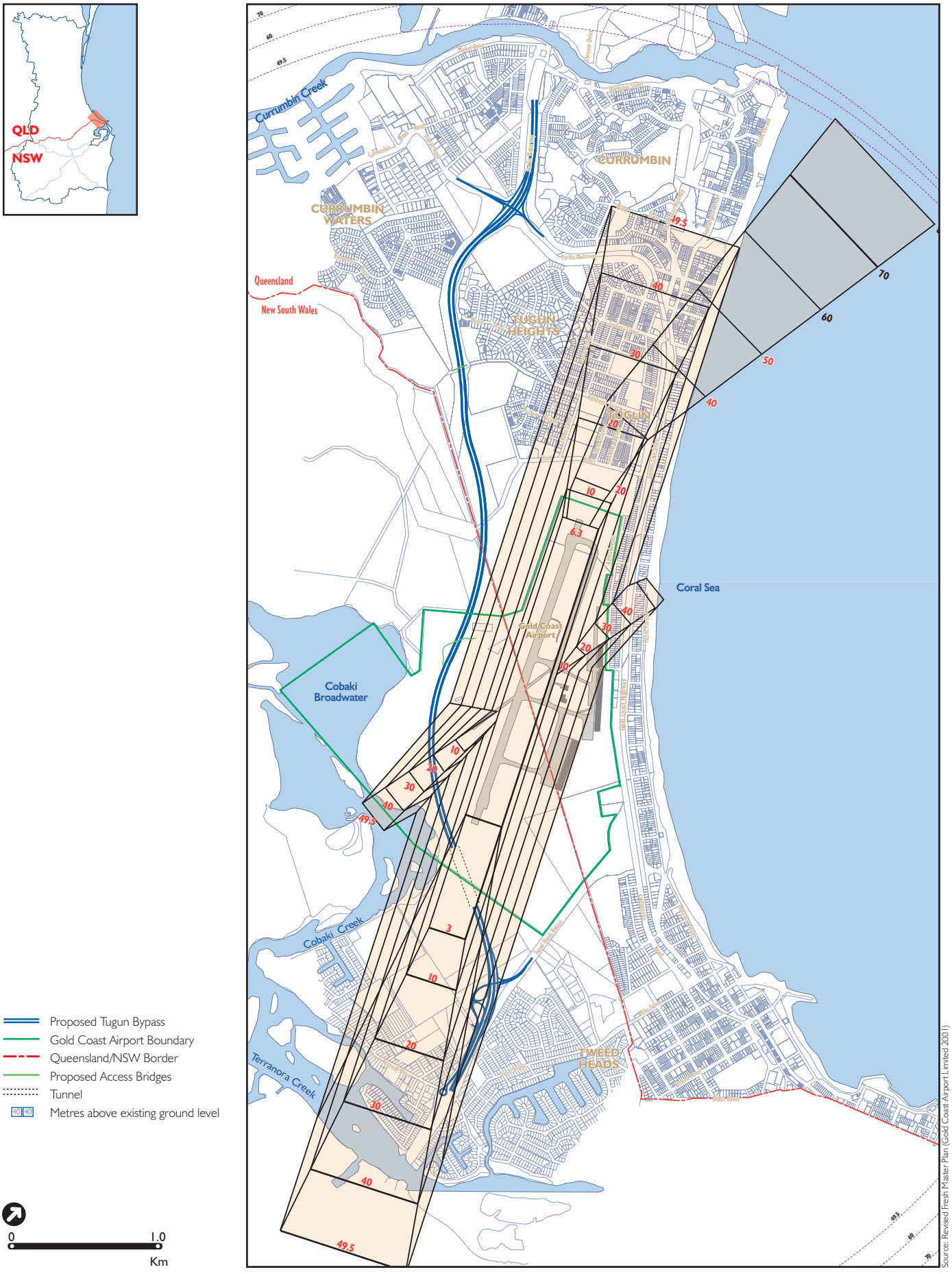


Figure 6.2 **Inner Obstacle Limitation Surface at Gold Coast Airport**

6.4 Design principles

A concept design strategy was developed for the proposal. The primary aim of the strategy was to develop landscape and urban design treatments currently required to integrate the proposal with the landscape and reduce its visual impact.

These guidelines provide the basis for a more detailed concept plan, including urban and landscape design works to be implemented as part of the proposal. These are discussed in further detail in Chapter 16 and Technical Paper 13, with the key principles summarised in Table 6.2.

Table 6.2: Urban design principles

Principle	Comment
Integration of the highway	The new highway would be integrated as far as possible with the surrounding landscape.
Local character	A new highway can have both positive and negative changes on the local character of the region. Design principles would be applied to reinforce positive aspects of the local area.
Traveller experience	'Traveller experience' refers to what travellers perceive as they drive through a particular area, and other benefits such as opportunities to stop for services. Design principles to improve traveller experience would be applied.
Local amenity	Design principles would be applied, where practicable, to minimise undesirable impacts on the local amenity, such as visual and noise impacts.
Road-safety considerations	Road-safety issues include considering any relevant guidelines and providing necessary set-backs for trees and road furniture.
Environmental values	The Tugun visual catchment includes large tracts of native vegetation adjacent to Cobaki Broadwater and within the Gold Coast Airport, as well as an area of native vegetation forest near the John Flynn Hospital and Medical Centre. Design principles relating to the maintenance and improvement of environmental values would be applied.

The overall concept design principles used to develop the proposal were:

- improving the capacity and efficiency of the transport corridor between Currumbin and Tweed Heads
- placing a high priority on the transport needs of the public
- maintaining vistas, and respecting the visibility and character of the topography and landscape in the design of the proposal and its associated structures, including the placement of trees, lighting, signage and street furniture
- similarly creating new driving vistas, and respecting the visibility and character of the topography and landscape in the design of the proposal and its associated structures, including the placement of trees, lighting, signage and street furniture
- creating a consistent image relative to the local context in the design of portals and associated elements such as gantries, signs and railings
- enhancing surrounding areas and ameliorating the unnatural features of the various structures included in the proposal
- not limiting the potential future rail corridor.

In 2004 the NSW RTA produced the *Draft Pacific Highway Urban Design Framework* which sets out urban design guidelines for the Pacific Highway from Hexham to Tweed Heads. The framework provides an overarching urban design vision which can be summarised as:

"A sweeping green highway, providing panoramic views to the Great Dividing Range and the forests, farmland and coastline of the Pacific Ocean. The route punctuated by the presence of distinctive settlements, rivers, mountains and bridges."

The framework also sets out six urban design objectives to help achieve this vision. Table 6.3 sets out the six objectives and details how the design strategy for the Tugun Bypass meets these objectives.

Table 6.3: Integration of the draft NSW RTA urban design framework

	Objective	Comment
1	Provide a flowing road alignment that is responsive and integrated with the landscape	This objective relates to designing a highway that responds to landform and patterns of land use. The landscape through which the highway passes is relatively flat so there is no need to curve the alignment in response to topography. Even so, the highway does have a slight curving nature in response to the need to create an intersection with the Tweed Heads Bypass section to the south, and connect through the hill to the north. This design is a less contrasting one than a straight road section would be. The roadway is proposed to be constructed on a raised embankment of a maximum of approximately 2.7m high due to existing soil and flooding conditions. This embankment means that the highway is above the natural surface level, which is less desirable from an urban design view than one at ground level that would be less visible and result in less change to the existing landscape. However, the low nature of the embankment means that the road height would be reasonably integrated into the landscape. The highway responds to land use patterns by not severing communities or major vegetation areas.
2	Provide a well-vegetated, natural road reserve	Planting of native species has been proposed where possible along the highway. The use of trees has been limited due to restrictions associated with tree heights in the vicinity of the airport. As far as practical this objective has been addressed.
3	Provide an enjoyable interesting highway	Travellers would experience a variety of landscapes along this short section of highway which would well satisfy this objective. This would include having some views over the coastal areas to the east, views across the airport and the experience of entering and leaving the tunnel. Landscape works have been kept low adjacent to the airport to maximise distant views to the coast. The tunnel would also serve as a distinct approach to the state borders.
4	Respect the communities and towns along the road	This objective is more applicable to settlements in regional areas. It relates to using opportunities to increase amenity and minimise severance (through physical and psychological connectivity). The proposal has sought to achieve this objective where relevant by minimising and mitigating against visual amenity and noise impacts. There would, however, be a loss of some visual amenity to nearby existing and future residents around the southern interchange and northern residential areas. Some longer views of these residents would be severed by the construction of required noise barriers and proposed landscape works. The number affected is relatively small and planned landscape works should allow for new views of closer vegetation, thus reducing potential impact. Physical severance from the Cobaki wetland to the west would occur due to the highway location between this wetland and residential areas to the east. However, in terms of an ecological management perspective this is seen as a very positive outcome as better and controlled management of this important natural asset due to restricted public access.

	Objective	Comment
5	Provide consistency-with-variety in road elements	This objective relates to ensuring there is good design and compatibility with road elements such as bridges, barriers and landscape works. In this regard the following recommendations should be included in the EIS: • Bridges – within the EIS the proposed bridges at the Tweed Heads Bypass interchange and nearby bypass are recommended to be of visually consistent design. They should also visually relate to the other bridges along this section of the highway (from at least the Tweed River to the motorway to the north). • Landscape – the framework advocates locally distinctive trees at key locations. Some feature trees and shrubs are proposed in the design at the Tweed Heads Bypass interchange which compliments this objective. • Barriers – if wire rope or floppy top safety fencing is to be used it should be of a dark colour, consistent with the framework. Some discussion related to the design of noise barriers, which in the EIS differ from recommendations made in the Framework, is provided below.
6	Provide a simplified and unobtrusive road design	This objective relates to the detailed design of road elements such as signs, bridges, tunnels and other structures and ensuring clutter is minimised. Recommendations that should be included at this stage, as presented in the Urban Design Framework, include: • Signage – should be kept below the skyline, minimised, kept off overbridges. • Earthworks – the edges of the proposed embankments at the southern interchange and past the airport should be "feathered" at their junction with the existing landform (i.e. a smooth transition rather than a sharp one). Some difference to the framework, however, is suggested in terms of noise barriers, as in this document they are recommended to be simple and monochromatic. The EIS also recommended including landscape screening to the rear (i.e. the view of nearby residents) and road side of some required noise barriers. This is consistent with the framework which suggests such measures be included.

The following sections contain a detailed description of the proposal. With the exception of the design principles and the criteria that provide the basis for the proposal, all these features could be subject to some change during the detailed design stage as the proposal is refined further.

6.5 Design standards

Commonwealth and state road authorities publish guidelines that allow designers to translate requirements such as design speed and reasonable levels of safety into specific characteristics. The engineering concept for the Tugun Bypass was developed using the following documents as guidelines:

- Road Planning and Design Manual (Main Roads 2001)
- Road Design Guide (NSW RTA 1988)
- Grade Separated Interchanges —A Design Guide (AUSTROADS 1984)
- Rural Road Design — Guide to the Geometric Design of Rural Roads (AUSTROADS 2003).

The most stringent standards would be adopted for the Tugun Bypass. These requirements and the concept design principles as outlined in the previous sections provided the basis for the concept design and the development of a detailed design to be undertaken if the proposal proceeds.

The relevant requirements influencing the concept design are summarised in Table 6.4.

Table 6.4: Road geometry design criteria

Feature	Parameter
Lanes	Six-lane proposal, four lanes initially To be upgraded when demand requires
Posted speed	100 km/h
Minimum desirable radius of horizontal curves	1,200 m
Absolute minimum radius of horizontal curves	600 m
Stopping site distance (level grade)	210 m
Desirable maximum gradient	3.0%
Absolute maximum gradient	5.0%
Design vehicle	B-Double
Flood protection	Minimum 1-in-100-year flood event
Median details	Minimum 10.1 metre wide central median Two 0.5-metre-wide shoulders (minimum) Vegetated median 9.1-metre-wide
Lane width (minimum)	3.5 m (minimum)
Shoulders (outer)	3 m
Bridge and tunnel clearances (minimum)	5.3 m (minimum)
Tunnel lane width	3.5 m

Design criteria for the road are described in more detail in Technical Paper 2.

6.6 Urban and landscape design

6.6.1 Urban and landscape design strategy

The concept urban and landscape design strategy is shown in Figure 6.3. This identifies the key elements that were used to develop the more detailed Urban and Landscape Design Concept Plan, which is fully detailed within Technical Paper 13.

These plans provide a balance between the desire for attractive landscaping and the need for functional aspects such as noise barriers, setbacks from the highway, and the airport obstacle limitation surface. The urban and landscape design plan for the Tugun Bypass will be in accord with the strategy being developed for the upgrade of the Pacific Motorway from Nerang to the border. A summary of the main features is provided below.

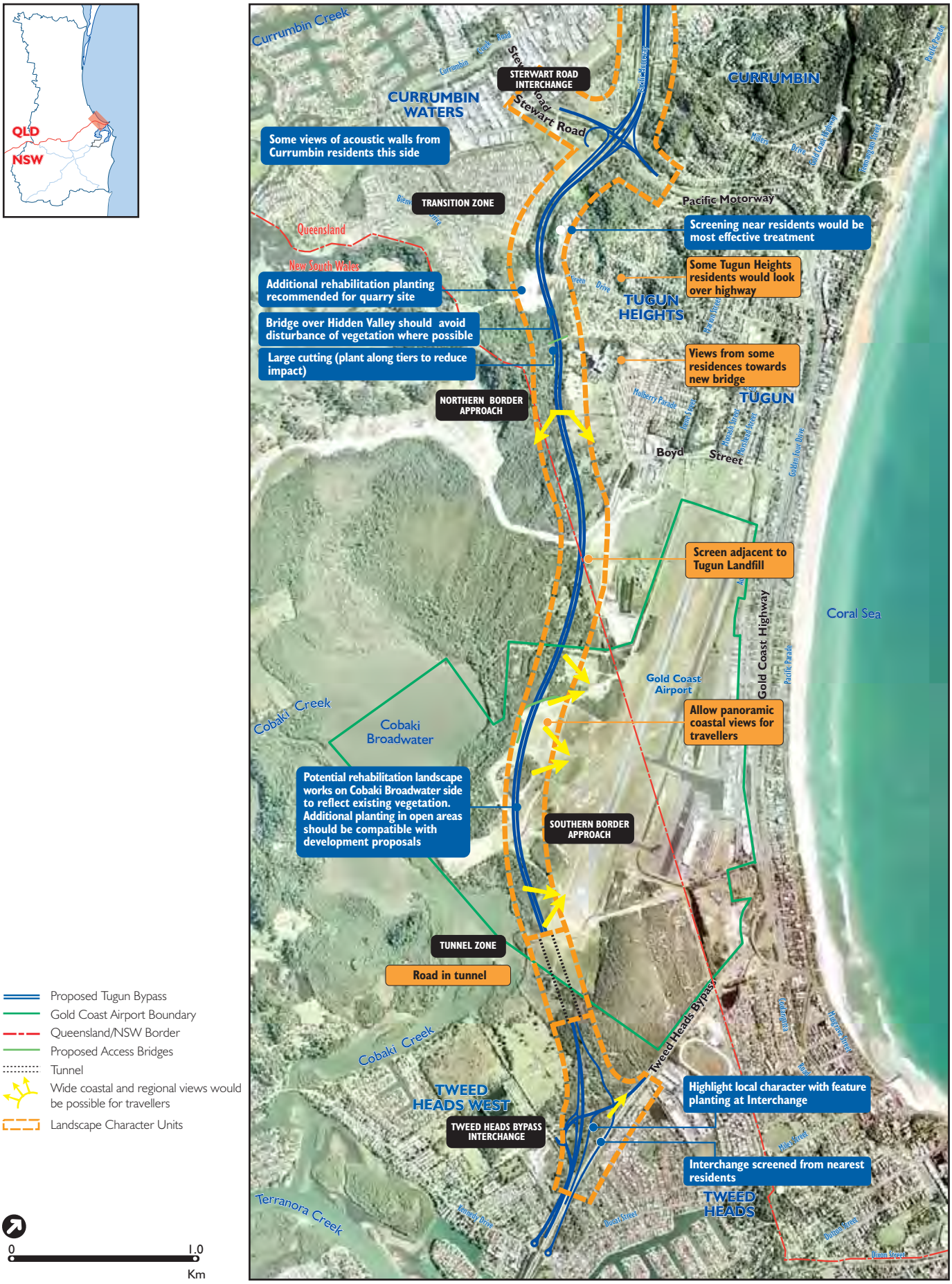


Figure 6.3 **Urban and Landscape Design Strategy**

6.6.2 Landscape treatments

A number of landscape treatments are proposed along the Tugun Bypass. Native plant species would be used for these treatments. Plant species would be defined during the detailed design phase. Plants within and around Gold Coast Airport must meet the airport's specifications for limiting bird attraction.

The main landscape treatments identified on the Urban and Landscape Design Concept Plan are based on the existing landscape and vegetation types adjacent to the proposed bypass, and are as follows:

- forest plantings to the north of Boyd Street, where local forest areas occur. These would consist of tall trees and shrubs designed to closely resemble the surrounding vegetation
- low forest plantings in medians and other places where minimum setback distances are required. These would consist of native shrubs and groundcovers
- coastal heath plantings consisting of low shrubs and groundcovers with the main objective to maintain plant heights low enough to allow attractive traveller views towards the coast
- woodland plantings proposed to the south of Boyd Street where the bypass would be adjacent to existing woodland. These would be designed to replicate the existing woodland vegetation and strengthen the edge alongside the Cobaki Broadwater. Low woodland plantings are proposed where safe set-backs are required
- feature planting at the Tweed Heads Bypass interchange to highlight its role as a gateway to Coolangatta.

A landscape concept plan for the Tweed Heads Bypass interchange is shown in Figure 6.4.

6.6.3 Visual and headlight screening

The location of screen planting and noise barriers along the highway boundaries would form a visual and headlight screen along some sections. Central median shrub planting would also achieve this at some locations. However, it is suggested that places where coastal views are particularly important, such as past the airport, it is more appropriate to permit open panoramic views.

6.6.4 Urban elements

Urban elements along the proposed Tugun Bypass would be highlighted, where possible, to achieve a balance between landscaping and the need for functional aspects, such as noise barriers. A summary of the main elements is provided below.

Noise barriers

A number of noise barrier sections would be necessary for the Tugun Bypass. Noise attenuation is important, but can have negative visual impacts. To minimise this, the impacts of the noise walls would be managed through design and plantings sympathetic to the surrounding landscape.

Not to Scale

Figure 6.4 **Landscape Concept Plan for Tweed Heads Bypass Interchange**

Bridges

Bridges are a very important element of the overall urban design of a highway. They can be used to highlight landmark or gateway sites, and reflect aspects of the surroundings.

The bridges included in the project provide an opportunity to create designs that highlight the social importance of their location close to the border.

Interchanges

Landscape concept designs for the Tweed Heads Bypass interchange are included in Figure 6.4. The interchange would include a mixture of treatments, such as feature planting.

Road tunnel

Tunnels provide an opportunity to create a sense of entering and exiting different spaces, and they can be used to highlight the traveller's experience, as well as reinforcing the context of the landscape that the traveller is about to see. In this case, the road tunnel would be used as an integral component of the southern section of the bypass, and one that highlights the bypass as a transition between two states.

Erosion control

Erosion control would be necessary on any steep fill embankments and on road excavation that leave a cut surface. These embankments would require treatment to ensure stability. Where planting is proposed on banks that are steeper than two horizontal to one vertical, prior to landscaping, the banks would be stabilised by erosion-control matting and covered with mulch to improve their final appearance.

6.6.5 Safety and design considerations

Any planned urban and landscape design works would need to satisfy the relevant road safety guidelines. For example, a setback of approximately 13 m is required for trees and other roadside hazards along the highway, unless protected by safety barriers.

Other valuable information on aspects to consider during the detailed design phase is included in *Beyond the Pavement* (NSW RTA 1999) and the *Roads Landscape Manual* (Main Roads 1997a). Both the NSW RTA and Main Roads would be consulted over any changes to relevant guidelines prior to the finalising of the detailed design.

6.7 Detailed project description

Detailed design would only be undertaken if the project is approved. The following is a description of the major elements of the concept design. The final design would be completed by the DCM contractor for the project. It may vary from this description in order to allow for issues raised during the public display period, conditions imposed as part of the project approval or technical issues relating to constructability or the outcome of further investigations.

6.7.1 Carriageway design details

The typical cross-section of the carriageways would allow for:

- four lanes of traffic initially, with provision for an additional two lanes
- a 3-metre-wide outer shoulder along the proposed road corridor to operate as an emergency vehicle and vehicle breakdown lane
- sufficient space within the road corridor to accommodate appropriate services, landscaping, noise-reduction measures, water-quality-control measures, fencing and other environmental mitigation works.

The bypass design details are summarised in Table 6.5 and shown in Figure 6.5 as typical cross-sections. Figure 6.5 represents the typical arrangement of the road where it is constructed either on an embankment or in a cutting.

Table 6.5: Bypass design details

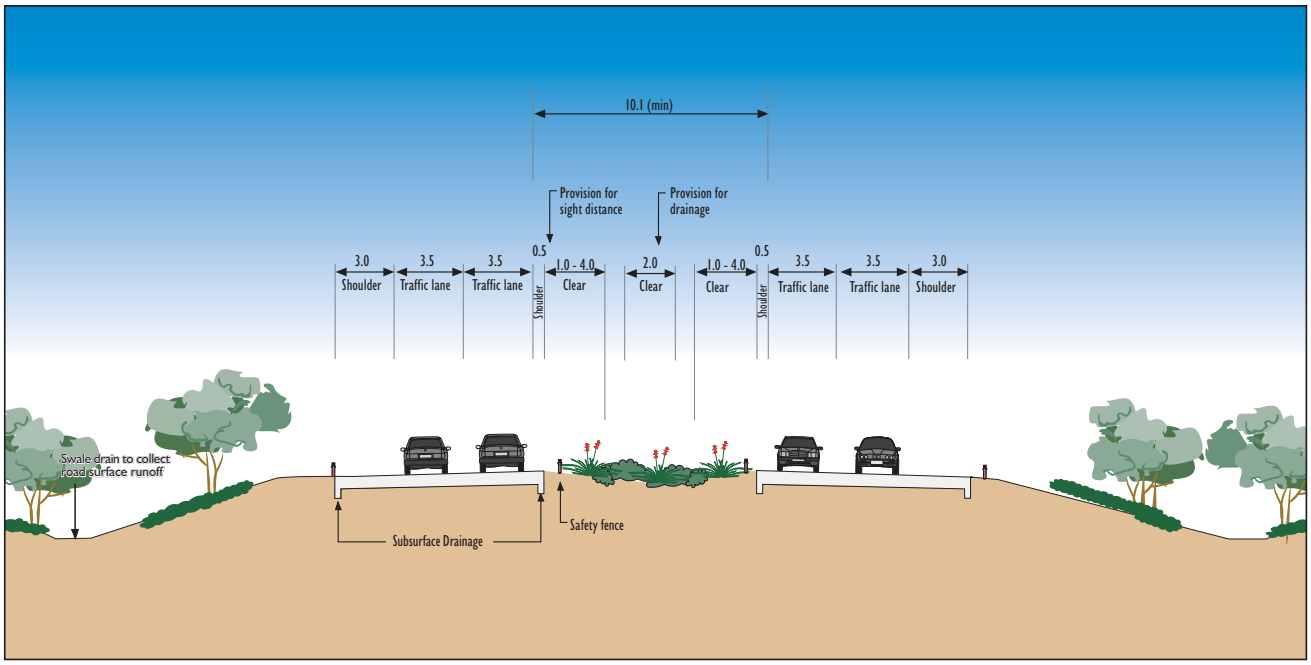
Feature	Details
Four-lane bypass	Two carriageways 3.5-metre-wide inner and outer lanes 3-metre-wide outer shoulder 10.1-metre-wide median (minimum) Roadside verges, wire rope and other safety barriers to minimise environmental disturbance
Future six-lane bypass	Utilise the median area reserved under the four-lane scenario 3.5-metre-wide inner and outer lanes 3.7-metre-wide central lane 2.7-metre-wide median (minimum), with a 0.7-metre-wide central concrete barrier
Entry and exit ramps	4-metre-wide lanes for single-lane ramps 3.5-metre-wide lanes for two-lane ramps
Tunnel	Reductions in shoulder widths are proposed for the tunnel and approaches. These are discussed in detail in Technical Paper 2

Planning for transit lanes for the ultimate six-lane bypass is discussed in Technical Papers 2 and 3. The need for transit lanes is marginal and, owing to the constraints affecting corridor width, it is not proposed to allow for transit lane buffers and wide inner shoulders. The adoption of standard lane and shoulder widths would not, however, preclude the introduction of transit lane operation in the future if required.

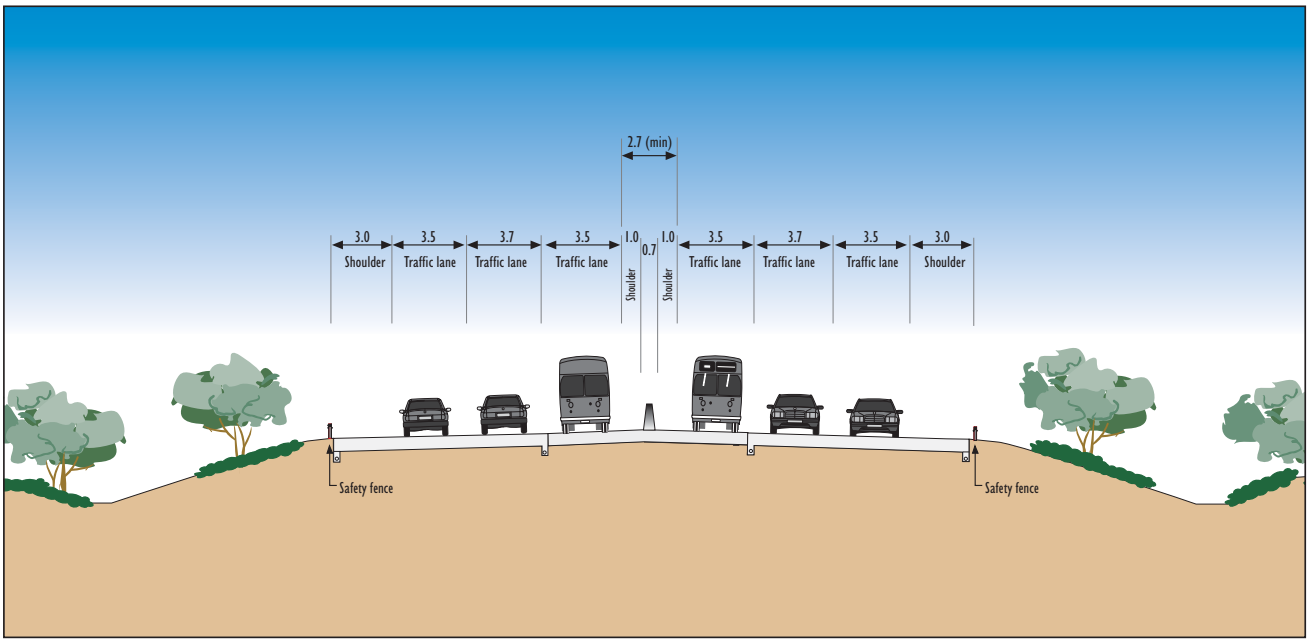
The alignment of the proposal contains horizontal curves ranging between 620 m and 1,700 m radii. Grades proposed are generally flat, apart from the tunnel approaches where grades of approximately 4% are included over short lengths.

6.7.2 Road pavement

Decisions on pavement type would be based on a whole-of-life comparison undertaken during the detailed design stage. Heavy duty, low maintenance pavements, with a nominal design life of 40 years would be adopted on the bypass. Flexible pavements, with a nominal life of 20 years, would be provided on interchange ramps, intersections and connecting local roads. Additional proposed pavement details include open-graded asphalt surfacing (where required) for the bypass, Tweed Heads Bypass interchange, and the tunnel approach ramps to reduce noise.



Typical Four Lane Cross Section



Future Widening to Six Lanes

Figure 6.5 **Typical Bypass Cross Sections**

6.7.3 Interchanges

Interchanges and intersections would be designed in accordance with both the *Road Planning and Design Manual* and the NSW *Road Design Guide*. The design vehicle to be used for design of intersections is a B-double.

The concept design for the proposed bypass includes an interchange at the Tweed Heads Bypass. The proposed bypass would integrate with the Stewart Road interchange currently under construction.

The Tugun Bypass proposal also includes changes to the configuration of the existing Kennedy Drive interchange.

Tweed Heads Bypass

An interchange is proposed to connect to the Tweed Heads Bypass. This would incorporate a modified diamond grade-separated interchange with two signalised intersections at grade, and allow for traffic travelling north and south to connect to the Tweed Heads Bypass. The configuration of the interchange is shown in Figure 6.6.

The existing north facing ramps of the Kennedy Drive interchange would be replaced by two, service roads. These service roads would connect between the realigned north-eastern section of the Tweed Heads Bypass and the Kennedy Drive roundabouts.

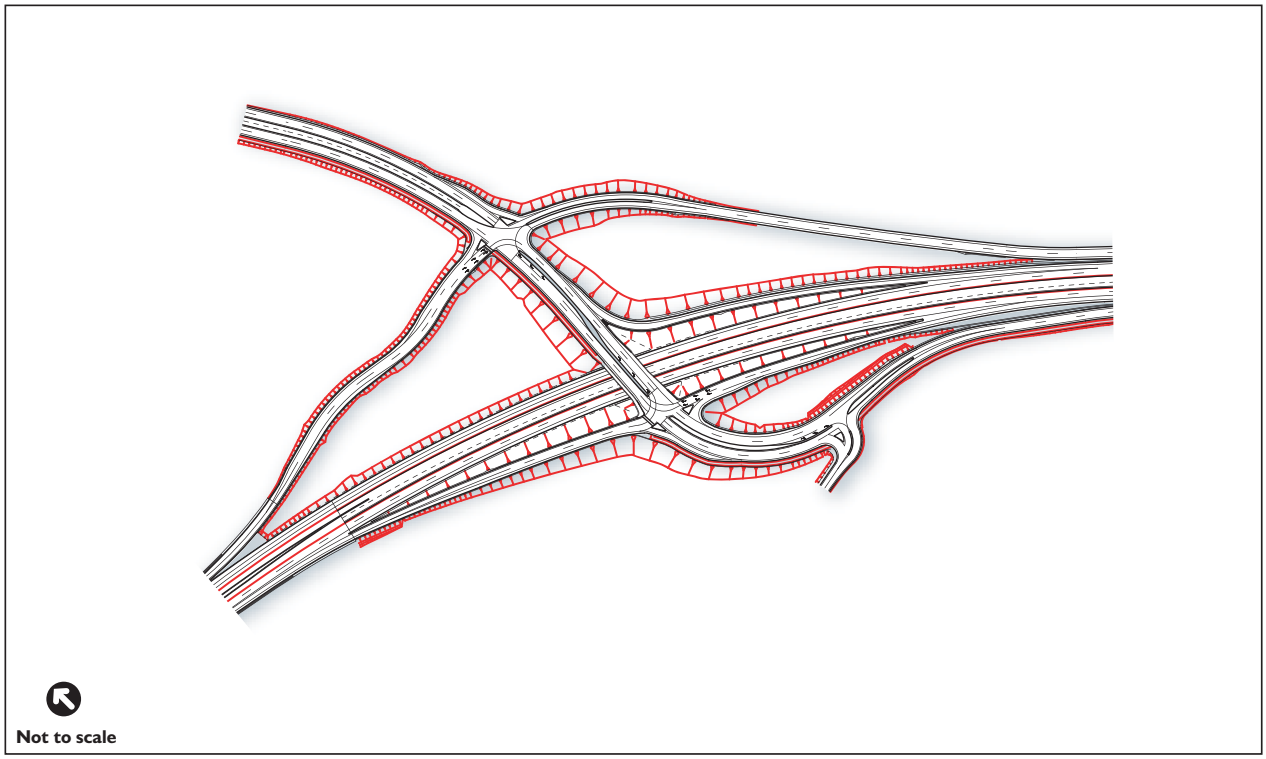
Provision for access to existing properties on Parkes Drive has been incorporated at the western intersection, where a new service road would be constructed. A short section of the existing Tweed Heads Bypass would no longer be required. The road surface would be removed and the area rehabilitated.

Kennedy Drive

The existing north-facing ramps at the interchange of the Tweed Heads Bypass and Kennedy Drive would be replaced by a two-lane service road on each side of the Tweed Heads Bypass. These two service roads would connect at the existing dog-bone roundabouts on Kennedy Drive and at the new Tweed Heads Bypass interchange. The existing dog-bone roundabout on Kennedy Drive would require breaks in the island to create two full roundabouts on both sides of the Tweed Heads Bypass.

Access to/from the north to/onto the Tweed Heads Bypass, or the Tugun Bypass from Kennedy Drive would be via either of the two new service roads that connect to the new interchange of the Tweed Heads Bypass and Tugun Bypass, then via the new north-facing ramps that connect to the Tugun Bypass or the connection back to the Tweed Heads Bypass. The Kennedy Drive intersection is shown on Figure 6.7.

Tweed Heads Bypass Interchange Artist Impression Looking South



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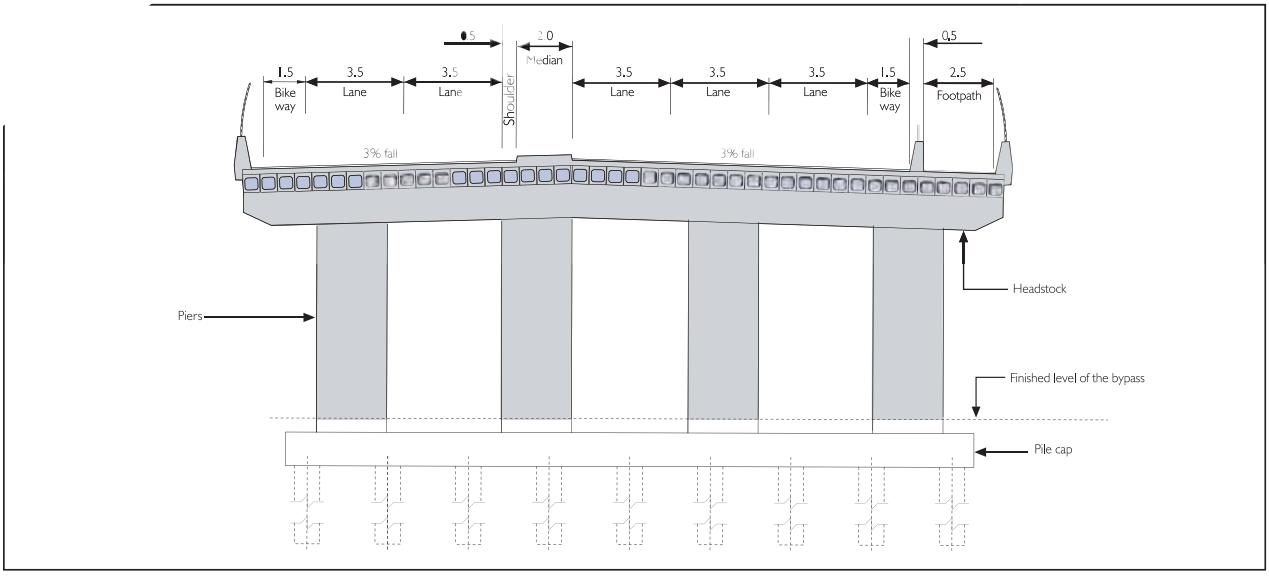
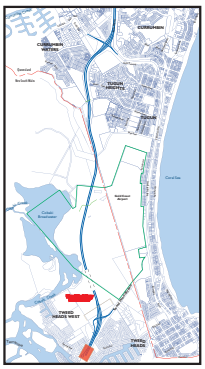
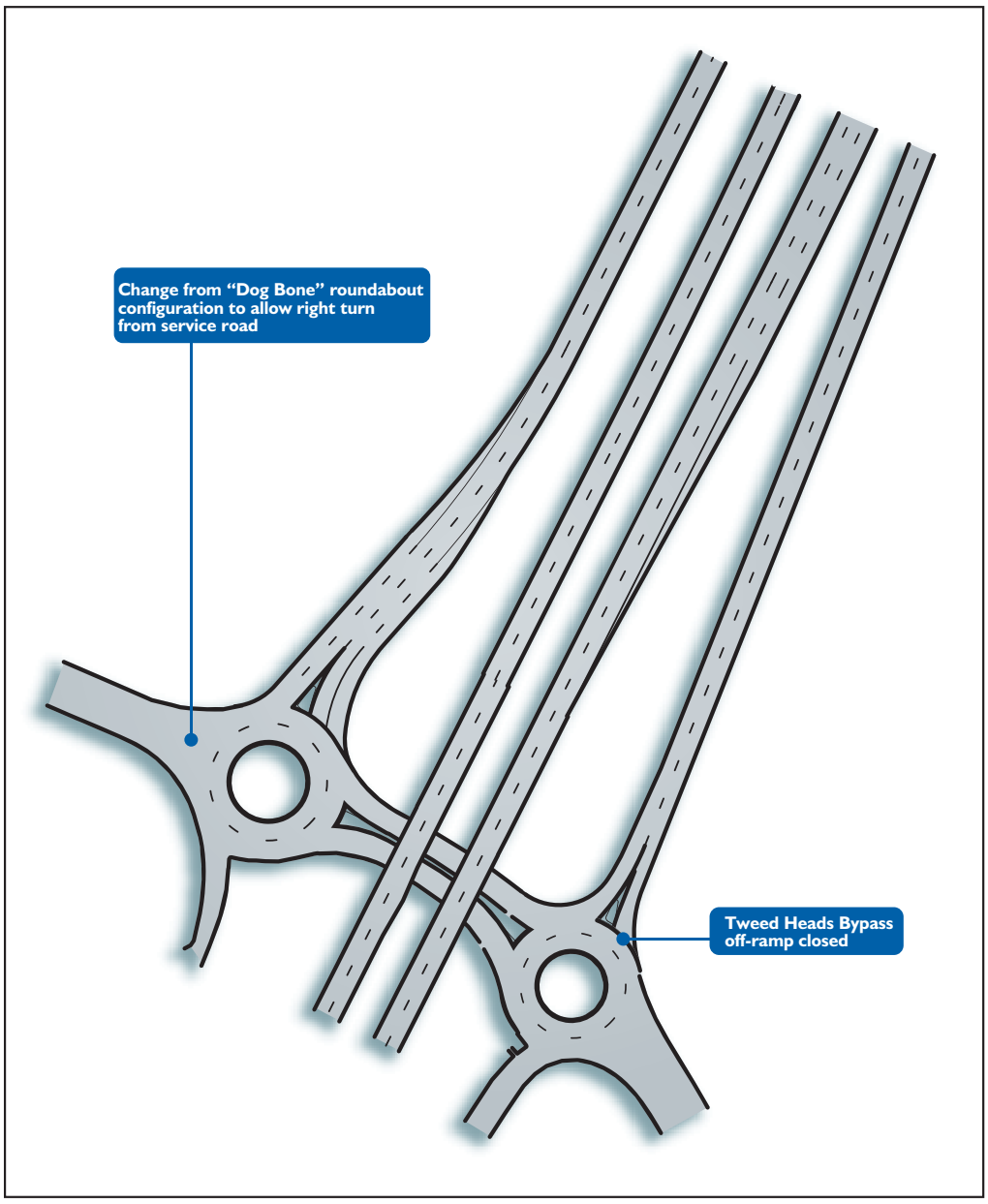
Interchange Layout



Bridge Cross-section

Figure 6.6 **Tweed Heads Bypass Interchange Layout and Bridge Cross-section**





Proposed Road Closure

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Figure 6.7 **Kennedy Drive Intersection and Service Road**

6.7.4 Provision for cyclists and pedestrians

There is no provision for cyclists and pedestrians on the proposed Tugun Bypass. The cross-section of the tunnel and its approaches has been kept to a minimum to reduce costs and minimise environmental impacts. In addition, a high-speed environment, a confined space, and steep gradients on the approaches mean that this is an unsafe environment for cyclists. Alternative routes are available along the Gold Coast Highway, its service roads and Pacific Parade. These are expected to become more attractive to cyclists following the initial reduction in traffic occurring as a result of the opening of the bypass. The separation of cyclists and traffic accords with the NSW RTA's *NSW Bicycle Guidelines*. One of the major aims of the guidelines is to reduce encounters between cyclists and high volumes of fast moving traffic and the best practice method of achieving this is by separation.

The guidelines also state that intersections should be designed to explicitly include bicycles as well as other road users. Special intersections that include a path for cyclists are a major element of integrated network design.

The Tweed Heads Bypass interchange and Stewart Road interchange would be designed to accommodate cyclists and pedestrians. The design would comprise a 1.5-metre-wide bicycle lane on each side of the roadway, and a 2.5-metre-wide shared pedestrian and bicycle footpath outside the northern barrier. This arrangement is shown in Figure 6.8.

The shared footpaths included in the interchanges at both ends of the proposal, Stewart Road and Tweed Heads Bypass, would provide links to existing cycleways adjacent to the Pacific Motorway at Currumbin and on Kennedy Drive and Ducat Street, Tweed Heads, respectively. A footpath (pedestrian/cyclist) would be provided along the western side of the western service road from Tweed Heads Bypass interchange to Kennedy Drive. Both new service roads would have a 2 m shoulder on both sides of the carriageway that would also cater for cyclists.

6.7.5 Road closures and access changes

The proposal would affect a number of existing at-grade public roads or private access routes.

The bypass would sever an access road, which runs from Admiral Crescent, along the northern boundary of the John Flynn Hospital and Medical Centre. The access road is for two properties west of the proposed alignment. In order to ensure that access to these properties is maintained at all times a new access bridge will be constructed prior to the removal of the existing access road.

A private access road on Commonwealth Airport Land leased by Gold Coast Airport Limited would be severed by the proposal. This access would be reinstated with the provision of an overpass bridge as part of the proposal. An alternative access route would be established during the period of bridge construction. The bridge structure is discussed in more detail in Section 6.6.6.

The footprint required for the bypass would involve the acquisition of a section of Parkes Drive adjacent to the Boyd's Bay Garden World Nursery in Tweed Heads West. This would sever access to a number of properties, including land used by the Tweed Heads Pony and Hack Club. It is proposed to construct a new service road between Tweed Heads Bypass interchange and Kennedy Drive to ensure that access is maintained prior to the removal of the section of Parkes Drive. This is shown in Figures 6.6 and 6.7.

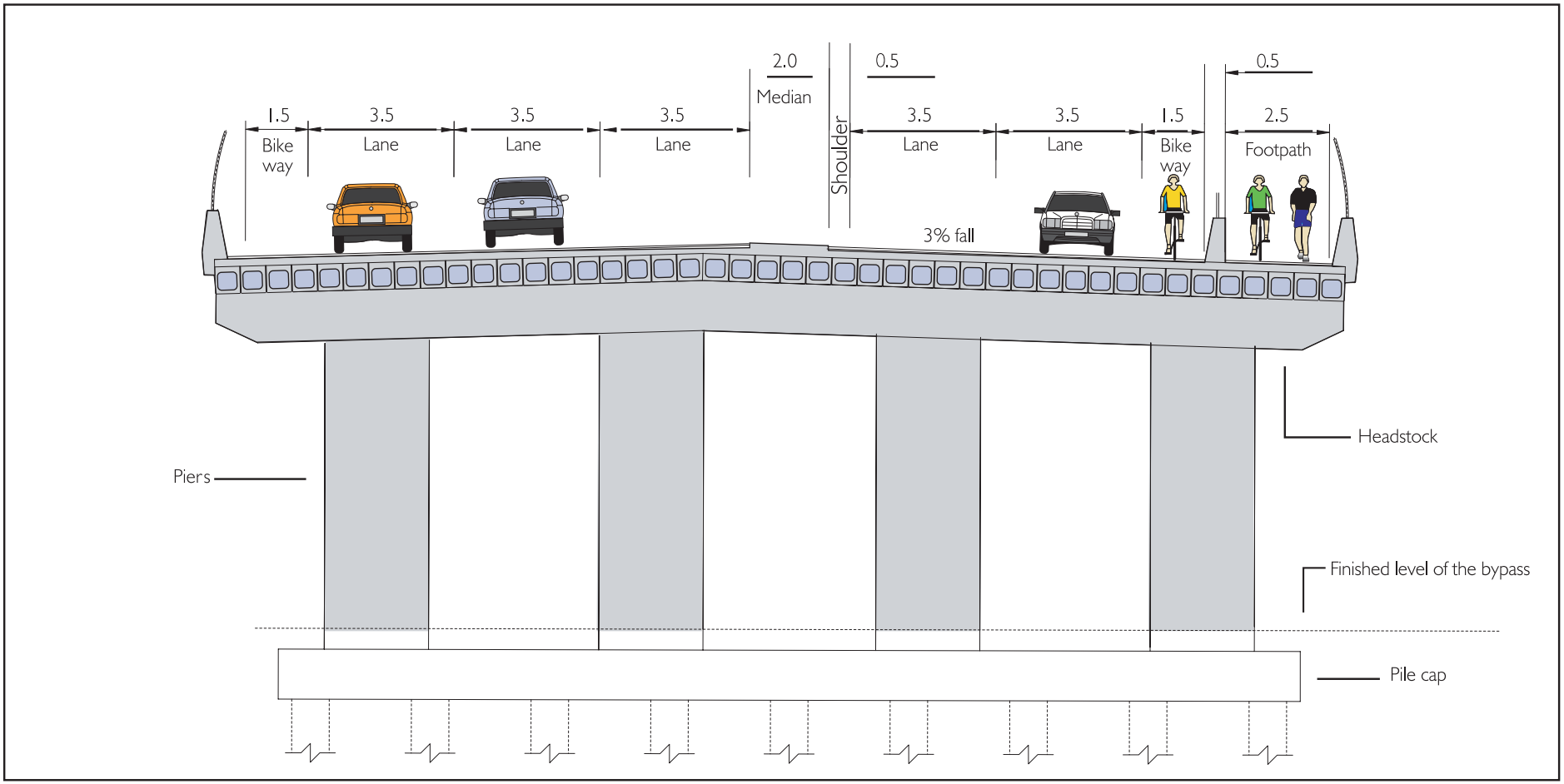


Figure 6.8 **Provision of Pedestrian and Cycle Access at Tweed Heads Bypass Interchange**

The proposed route for the bypass also crosses an existing temporary access track leading from Boyd Street to the site of the future Cobaki Lakes development, located to the west. No bridge is included in this proposal. However, this proposal does not preclude others from constructing a bridge at this location in the future to reinstate access to the development site. The proposed development site would still be accessible via Piggabeen Road in Tweed Heads.

6.7.6 Bridges

The construction of five bridges is proposed as part of the Tugun Bypass. The bridges would be constructed in the following locations: twin motorway bridges over Hidden Valley; a property access bridge adjacent to the John Flynn Hospital and Medical Centre; to provide access to the environmental precinct of Gold Coast Airport Limited to the west of the alignment; and at the Tweed Heads Bypass interchange.

Details of the five proposed bridges are summarised in Table 6.6. Engineering detail is provided in Technical Paper 2.

Bridges and other structures are likely to be prominent visual elements in the proposed road corridor landscape. However, such structures can be used to give character to an area. Careful attention would be given to the appearance and type of structure during detailed design to enable it to be integrated into the surrounding landscape.

The design of the bridges would seek to achieve the following:

- integration of the structure with the surrounding landform
- visual continuity
- use of texture and pattern as embellishments that help integrate the structures with the surrounding environment
- provision of visual interest to reduce the monotony of the continuous highway
- maintenance of the overall character and prominence of the major structures by including secondary elements, such as parapets and railings of appropriate and consistent design (subject to relevant standards)
- consistency in the scale of the individual elements of the associated structures.

Table 6.6: Key features of proposed bridge structures

Bridge	Details and key features
Hidden Valley bridges	Required to minimise surface disturbance owing to environmental significance of the area. Would be a minimum of 100 m long, with no more than three spans, with prestressed concrete deck units, concrete deck slab and asphalt wearing surface. Initial construction to provide two northbound and southbound lanes of traffic, with adequate foundations, piers and headstocks for future widening. Concept design of the proposed Hidden Valley bridge and construction shown on Figure 6.9. Disturbance to vegetation would be kept to a minimum by using a launching truss for construction of the bridge decks.

Bridge	Details and key features
Property access bridge adjacent to John Flynn Hospital and Medical Centre	Required to connect properties on the western side of the proposed bypass. Would be a minimum of 120 m long, with no more than four spans, with prestressed concrete deck units and concrete deck slab. A high-level bridge, located 22 m above the proposed bypass. Bridge width would be sufficient for one-way traffic (suitable for the small volume of traffic).
Gold Coast Airport access bridge	Required to provide the airport with access to the western side of the proposed bypass. This overpass would not be connected to the proposed bypass. Would consist of a minimum of two spans with prestressed concrete deck units, concrete deck slab and asphalt wearing surface, and suitable for one way traffic.
Tweed Heads Bypass interchange bridge	The Tweed Heads Bypass interchange bridge would consist of two spans with prestressed concrete deck units with, concrete deck slab and asphalt wearing surface. A pedestrian footpath would be provided on the northern side of the bridge, and a bicycle lane provided on each side of the roadway. The general arrangement of the interchange and a cross-section of the bridge are shown on Figure 6.6.

Bridge piers and abutments are visually intrusive elements and need careful detailing. In designing these structures, consideration would be given to vantage points and views from the road.

Road tunnel at Gold Coast Airport

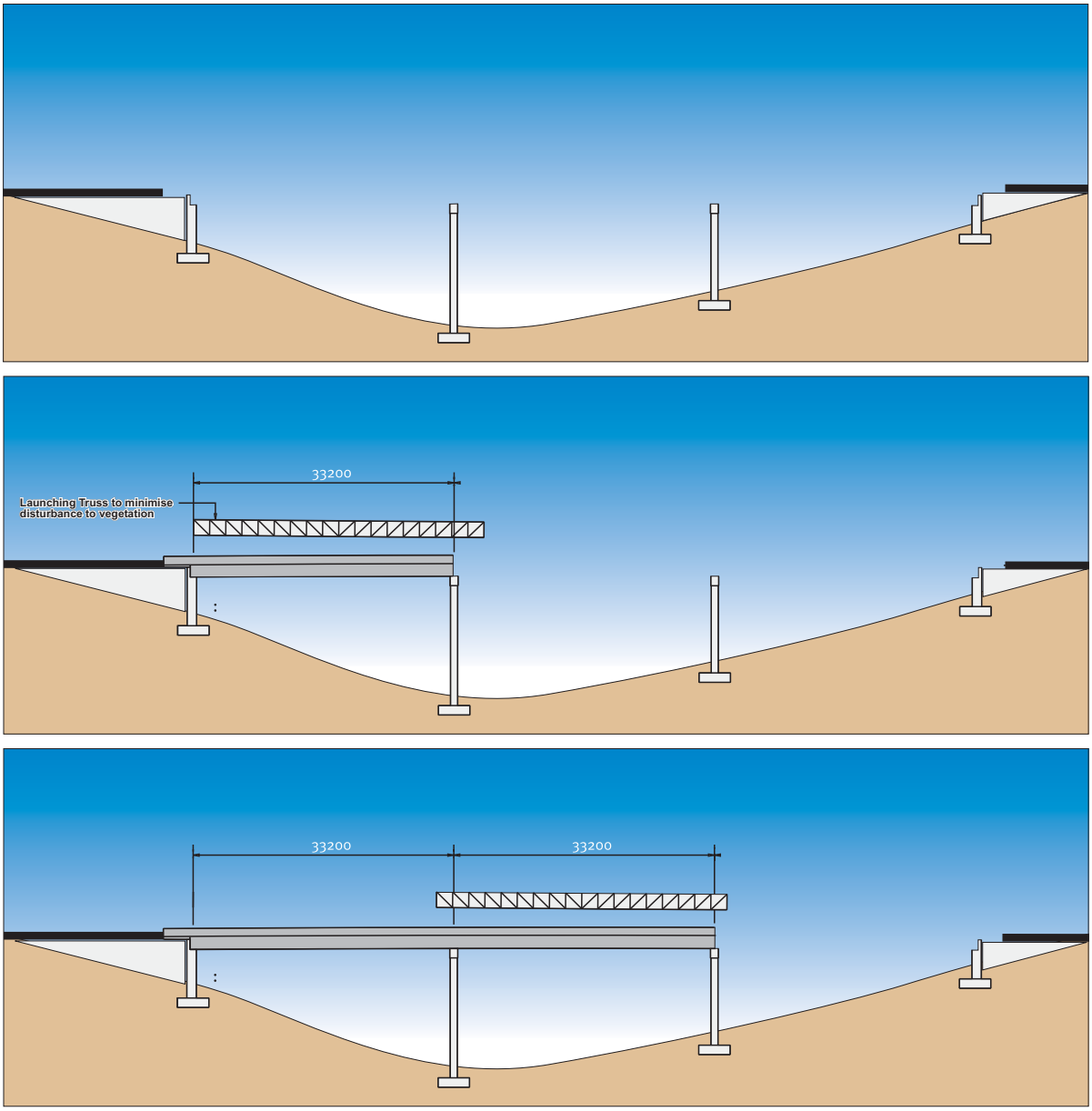
The road tunnel within Gold Coast Airport is a major feature of the Tugun Bypass proposal. The tunnel would carry the road beneath the proposed extension of the Gold Coast Airport main runway and the existing and future obstacle limitation surfaces. Based on the present design and the proposed alignment, the tunnel would be up to 400 m long, with approach ramps at each end. Figure 6.10 shows a view of the bypass looking south, immediately north of the tunnel approaches and Figure 6.11 shows a view of the northern portal.

Figure 6.12 shows a typical cross-section of the proposed road tunnel at Gold Coast Airport.

The primary objective of the tunnel concept design is to satisfy the following requirements while minimising costs:

- maintain a narrow construction corridor
- minimise groundwater drawdown
- minimise tunnel length and depth
- minimise disruption to airport operations.

The tunnel, which would be constructed using a cover-and-cut technique, consists of a shallow twin-tube structure extending under the proposed future runway and taxiway alignments. Because of road alignment and environmental constraints, the tunnel crosses the runway alignment at a considerable angle. In addition to the tunnel proper, sections of the approaches would be constructed below natural ground level to keep carriageway profiles suitable for the 100 km/h posted speed through the tunnel in its initial four-lane configuration.



Hidden Valley Concept Design and Construction Sequence

Artist Impression Hidden Valley

Figure 6.9 **Hidden Valley Bridge Concept Design**

Figure 6.10 **View along the Tugun Bypass looking South across Gold Coast Airport**

Figure 6.11 **View of the Northern Portal of the Tugun Bypass Road Tunnel**

The control of groundwater, and the hydrostatic forces that it would impose on the tunnel and approach structures, are a major issue addressed in its design. The floors and walls of the tunnel must form an impervious barrier to groundwater and need to be heavily reinforced to resist ground and hydrostatic forces. The high water table would impose buoyancy forces on the tunnel and these would be resisted by a combination of tunnel weight, skin friction on the walls, and piles. Some minor seepage would be expected, and would be dealt with by a small seepage-control pump.

Diaphragm walls are proposed as a major component of the tunnel. These are reinforced concrete walls constructed below ground level in a trench. The walls are used as an excavation support and foundation element. The walls also act as groundwater cut-offs to allow the tunnel to be excavated in safety. The tunnel roof would be cast on top of the walls enclosing the tunnel section, and the ground between the walls and under the tunnel roof would then be excavated, and the tunnel floor progressively cast, to form the completed tunnel and approaches.

Construction sequencing would be important and is discussed in more detail in Chapter 7.

The tunnel would incorporate a ventilation system to dilute vehicle emissions, and control smoke and heated gases during fire emergencies. The tunnel would be fitted with sensors that detect harmful contaminants such as carbon monoxide, nitrogen oxide and particulates.

A longitudinal ventilation system is proposed for the road tunnel. This would add to the movement of air through the tunnel to the portals that is normally caused by traffic movement, but would have sufficient additional capacity to operate independently in emergency situations. It would comprise high velocity, fully reversible jet fans mounted beneath the roof of the tunnel at regular intervals.

Computer modelling of ventilation for the control of smoke and heat would be undertaken during the detailed design phase to determine the type, size and location of the fan units. Alternatives to longitudinal ventilation would also be considered.

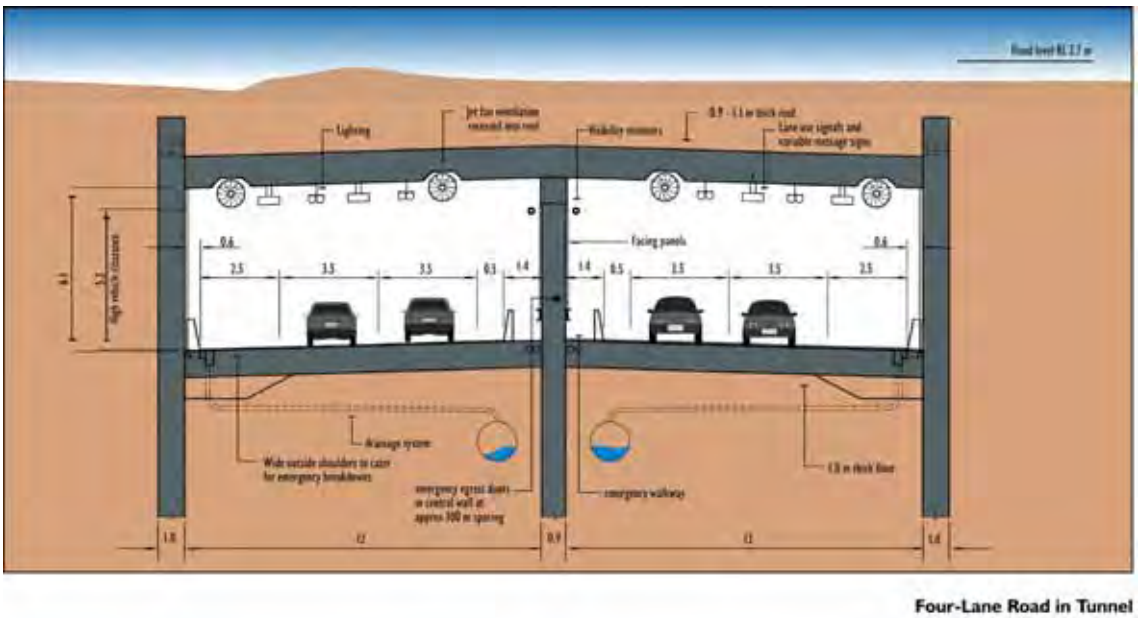


Figure 6.12: Typical cross-section of the Tugun Bypass road tunnel

6.7.7 Flood protection

The highest recorded floods in this area last century were 2.1 m (1954) and 1.3 m (1974).

The most significant causes of high flood levels in the Tweed estuary are elevated ocean levels resulting from high tides, cyclonic storm surges and future sea-level rise as a result of greenhouse effects. River flooding alone would not result in equivalent flood levels in the estuary because of the large spreading and storage available in the lower Tweed floodplain.

Table 6.7 sets out predicted flood levels at the road tunnel proposed for the airport.

Table 6.7: Predicted flood levels at the road tunnel

Average recurrence interval	Ocean level (m)	Combined ocean and flood Level (m)	
		2000 (+0.1m)	2070 (+0.1 +0.3m greenhouse)
1 in 100 year	2.05	2.15	2.45
1 in 200 year	2.30	2.40	2.70
1 in 500 year	2.50	2.60	2.90

Source: Derived from the CSIRO reports prepared for Gold Coast City Council 1998 and 2000 and WBM Oceanics.

Flood walls 2.7 m in height are proposed for the tunnel approaches to protect against rare flood events and future sea level rise resulting from greenhouse effects. Further detail is provided in Technical Paper 7. This level (2.7 m) coincides with the currently 1-in-100-year flood level adopted by Tweed Shire Council for this area. Consequently it is anticipated that the 2.7 m levels are very conservative and will in fact provide:

- 1-in-500-year immunity now
- 1-in-200-year immunity in 2070

It is understood that the Tweed Shire Council flood study is currently under review, and that levels will be revised consistent with the CSIRO reports adopted by Gold Coast City Council.

Ample warning time would be available to close traffic and evacuate the tunnel in extreme events. The height of the flood walls could also be increased due to future long-term sea level rises if necessary.

6.7.8 Earthworks, drainage and water quality

The southern section of the proposal would involve the construction of the road above ground level to allow for 1-in-100-year ARI flood immunity. This would involve the construction of embankments along the majority of the route. These embankments/batters would be constructed at a gradient of two horizontal to one vertical. Where it is not necessary to elevate the road to any significant extent, embankments would be constructed at a gradient of four horizontal to one vertical.

Embankment material would be partially obtained from excavations within the alignment of the proposal. As some materials may be unsuitable for use in construction, additional fill would be required. This is discussed further in Chapter 7.

Provision has been made in the design to maintain existing surface and groundwater hydrology. Construction of the road would include reinstating or diverting existing surface

drainage through channels and culverts, and installing underground drains to allow for groundwater flows across the alignment.

Several culverts would be constructed to accommodate minor waterway crossings along the proposed alignment. The culverts have the following functions:

- allowing the passage of environmental base flows and run-off from local rainfall events (flow in the downstream direction)
- facilitating the passage of flows from the Tweed River floodplain to allow the use of storage upstream from the bypass (flow in the upstream direction).

The local run-off event governs the size of the culverts. A list of the waterway crossings proposed for the bypass is available in Technical Paper 2. Their locations are shown on Figure 6.13.

A system of drains, channels and ponds is proposed to mitigate the potential impacts of road surface run-off, and ensure the level of contaminants meets relevant guidelines for discharge into wetlands and watercourses. Sedimentation basins would also be designed to contain spills of hazardous materials. The final locations and types of sedimentation basins would be selected by taking into account geotechnical, hydraulic, soil conservation, groundwater quality and other environment factors. Suitable access would be provided to ensure that necessary maintenance activities can be undertaken.

As the proposed bypass is in the vicinity of Cobaki Broadwater, which contains a number of wetlands protected under NSW State Environmental Planning Policy No. 14 — Coastal Wetlands, particular attention has been given in the concept design to environmental measures that would be implemented to meet NSW Department of Environment and Conservation guidelines for run-off discharge.

Sedimentation basins would be designed in accordance with *Managing Urban Stormwater: Soils and Construction* (NSW Landcom 2004), and taking into account the high groundwater table and permeability of the soils.

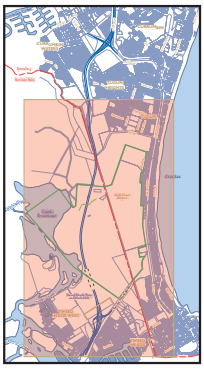
6.7.9 Highway fencing

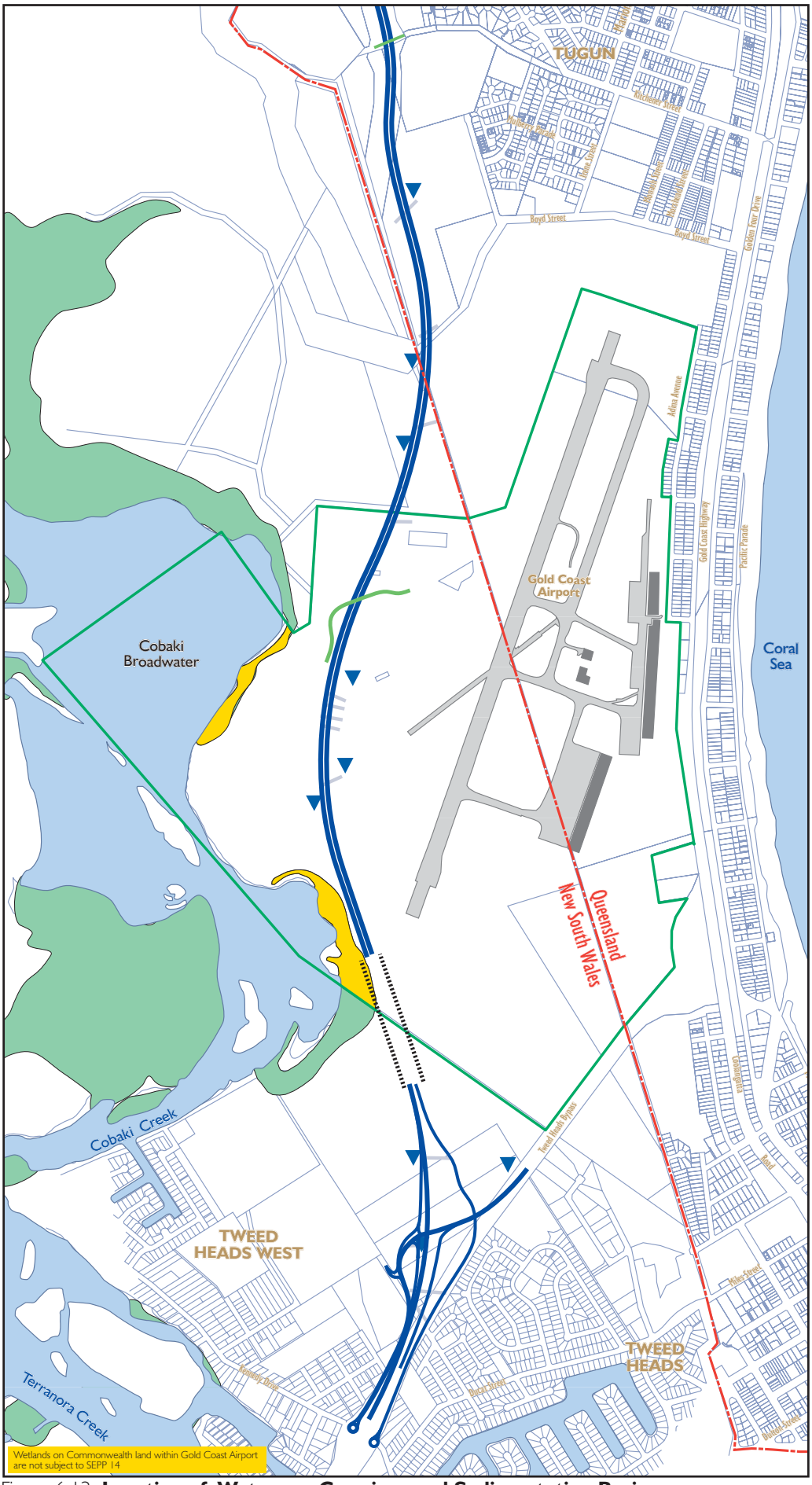
Suitable fencing would be included along the length of the proposed route to separate both humans and animals from the proposed bypass.

In areas near fauna corridors, exclusion fencing would be installed to prevent animals from entering the road reserve, and to reduce the incidence of road kills. In some areas, a fence would be erected to prevent frogs from entering the road corridor and to direct them into an appropriate underpass.

In all other areas of the proposal, a 1.8-metre-high fence would be installed to limit human access. In all cases, if an adjoining property fence is disturbed or realigned, it would be replaced by an equivalent.

The Commonwealth Department of Transport and Regional Services require that security fencing is provided around the airport for safety and security reasons. The bypass alignment crosses existing airport security fencing at several locations. Adjustments to security fencing would therefore be made.





Proposed Tugun Bypass
Gold Coast Airport Boundary
Queensland/NSW Border
Proposed Access Bridges
Tunnel
Proposed Sedimentation Basins
Proposed Road Culverts
SEPP 14 Wetlands
Continuation of Wetland Boundary

0 500
m

Figure 6.13 **Location of Waterway Crossings and Sedimentation Basins**

6.7.10 Provision for fauna habitat and movement

The design of the proposed bypass incorporates fauna underpasses beneath the road. Frog underpasses are proposed to allow the Wallum Sedge Frog and Wallum Froglet to gain access to habitat on both sides of the road. In addition, ponds are proposed to replace lost breeding habitat. The location of fauna movement corridors and frog ponds, and the need for design features to provide habitat and facilitate safe fauna movement are provided in Chapter 10.

6.7.11 Median treatments and emergency cross-overs

Carriageways along the length of the proposed bypass would be separated initially by a central median. The width of the central median is generally 10.1 m (minimum) between edge lines, 9.1 m of which is vegetated. The median would be depressed and landscaped to assist drainage and minimise headlight glare and maintenance.

Median treatments aim to minimise the crossing of the median by vehicles, thereby preventing unsafe U-turns. However, it is important in all cases to provide sufficient access points for maintenance and emergency vehicles. Suitable median crossing facilities will be located every 3 to 5 km, but not within 3 km of interchanges. As the overall length of the bypass is 7 km, cross-over facilities would be provided.

6.7.12 Signs and road lighting

Traffic signposting, including direction, information, regulatory and advisory signs would be installed along the proposed road corridor. These signs would be reflective to be more easily seen at night. Electronic signs would also be installed at suitable locations.

Lighting would be installed at all interchange ramps and intersections and in the tunnel, although it would not extend along the remainder of the proposed corridor. This would be designed to limit lateral light and thereby reduce potential impacts on the surrounding residential areas and particularly to comply with provisions of the *Airports Act 1996* and Civil Aviation Regulations and ensure that the safety of air navigation in prescribed airspace around Gold Coast Airport is not adversely affected.

Emergency telephones would be provided at appropriate intervals along the route.

6.7.13 Management of road and tunnel operation

There are a range of management activities associated with the operational phase of the proposed road. These include:

- maintenance of the infrastructure assets
- traffic management during incidents
- monitoring of tunnel systems (e.g. cameras, lighting, movement sensors, fire suppression systems).

It is currently intended that day to day operations would be managed with agreement of the NSW RTA by Main Roads through the latter's Traffic Management Centre at Nerang. This is both due to costs and limitations in telecommunication technology and the impact that

incidents on the proposed bypass would have on the road network in the south Gold Coast area.

Safety and emergency

The proposed geometric design of the tunnel, variable speed restriction and speed advisory signs would promote operational safety.

In addition, fire and life safety systems would be installed to coordinate the various subsystems that would detect, alert and manage emergency situations in the tunnel. The essential components of the system are summarised in Table 6.8.

An emergency response plan would be prepared to formalise and coordinate all systems and emergency procedures. The plan would be developed in conjunction with the operations control centre and emergency services.

In the event of an incident the intelligent transport system will stop vehicles entering the tunnel and divert traffic along alternative routes.

Table 6.8: Summary of fire and life safety systems

Component	Comments
Detection	Closed-circuit television cameras, linked to an operations control centre, would be used for the primary detection of fires. Roadway loop detectors would be used to alert operations staff of stationary traffic and potential problems. Roof-mounted linear heat detectors would be installed as a secondary protection system.
Alarm	The alarm system would activate sound alarms within the tunnel, transmit alarms to the operations control centre and the emergency response authorities, and (subject to operator checks) automatically activate appropriate ventilation. The alarm system would be activated manually or automatically through detection systems.
Communications	Communication systems within the Tugun Bypass tunnel would include closed-circuit cameras, mobile phone coverage within the tunnel, emergency telephones, variable message signs, lighting and signage of emergency pathways, doors and other facilities, and public address and radio re-broadcast facilities.
Emergency exit and personnel evacuation	A solid fire-rated central wall would be required to separate each carriageway within the tunnel. In the event of an incident requiring evacuation, motorists would be evacuated from one tunnel into the other via emergency pathways and access doors. The spacing of the emergency access doors would be determined through consultation with the NSW Fire Brigade. Personnel evacuation procedures would be developed and documented in the emergency response plan.
Smoke control	In the event of a fire, emergency ventilation would be activated to minimise the spread of smoke and to maintain safe pathways for evacuation.
Fire-suppression systems	Decisions on fire-suppression systems would be made in association with emergency services authorities. Approved systems, including all emergency operations procedures, would be documented in the emergency response plan.

Central supervisory control and monitoring

The Main Roads Traffic Management Centre at Nerang would be used to monitor and control all operational and safety systems for the tunnel, including:

- ventilation
- fire detection and protection

- tunnel air quality
- traffic
- drainage and pump station
- the substation and power distribution.

Power and lighting

The electricity supply system provides power for the operation of the ventilation system, fire and life safety systems, and other tunnel facilities. Power supply to tunnel facilities and detection systems is vital to maintain safety at all times, especially in the event of an emergency. It is, therefore, important that the power supply and distribution system are reliable and maintainable.

Three independent power sources would be provided. Two of these would be from high-voltage mains from different parts of the electricity supply grid. The third source would be a diesel generator automatically started in the event of failure of the other sources. The generator would require sufficient capacity to drive essential components of the systems. An uninterruptible power supply facility, which stores power for use when other sources fail, would also be considered.

Lighting would be designed to reduce the difference between levels of luminance inside and outside the tunnel to allow the driver's eye to react to the tunnel environment. The intensity of lights within the tunnel would therefore be adjusted in accordance with the level of external luminance registered by light sensors. Approximately one-tenth of the lights within the tunnels would be served by an uninterruptible power supply.

Energy efficient lighting and management systems would be incorporated into the final design wherever possible.

6.7.14 Ancillary items

A number of additional, temporary facilities would be required during construction and form part of the project. These include:

- construction compounds
- storage and laydown areas
- concrete and asphalt batch plants
- temporary access points and haul routes for construction materials (including select and general fill, gravel, aggregate and sand)
- stockpiles for bulk materials including construction materials, and temporary storage of unsuitable fill and topsoil.

A number of preferred locations have been identified for some of these facilities, but specific requirements and final locations would depend on the way in which the DCM contractor wishes to organise site activities. Several construction compounds and storage areas would be required along the length of the project. An asphalt batch plant and the main construction compound could be located at the Tugun Landfill subject to Gold Coast City Council approval. An old quarry site at Tugun Heights, airport land, and areas at the Stewart Road and Tweed Head Bypass interchanges would provide other suitable sites for ancillary items and activities. The principal access points for the construction site would be Stewart Road for the northern

construction site, and Boyd Street and the Tweed Heads Bypass for the southern construction site.

These facilities would be closed once the bypass is complete, and the areas rehabilitated as necessary. Provision for these facilities is discussed in more detail in Chapter 7.

6.7.15 Rail tunnel accommodation works

It is proposed that a slab would be constructed for the proposed runway/taxiway connection. The works would be physically separate from all the bypass works including the tunnel. This will provide provision for a future rail tunnel to be constructed underneath the slab without disruption to airport operations. It will be constructed below the runway extension and so would not have any additional environmental impacts.

6.7.16 Changes to airport infrastructure

The proposed bypass would penetrate the existing obstacle limitation surface of the cross-runway and would therefore necessitate the decommissioning of the cross-runway at Gold Coast Airport. This runway would be closed when bypass construction begins.

The primary on-airport navigational aid is the VHF Omni-range (VOR). This facility is a navigational beacon used to assist aircraft to locate the airport and assist with landing in bad weather. The existing structure is situated 250 m north-west of the western end of the cross-runway and will have to be replaced by a doppler VOR due to possible interference by traffic to the existing facility. This would occur prior to the start of the construction and will be undertaken by Air Services Australia.

7. How the road would be built

The proposed Tugun Bypass would be designed, constructed and maintained by the selected contractor using the design, construct and maintain delivery system, the contractor would be required to complete the works in accordance with contractual requirements, relevant standards and conditions of approval for the project. Main Roads and NSW RTA would be responsible for project management of the works, including approval of all designs, and inspecting, monitoring and auditing all works performed by the contractor to ensure compliance with all contractual and other requirements.

The construction of the proposed bypass would involve a number of construction processes. These issues and the construction activities that are constrained by them or that would be needed to address them, are outlined in the following section, along with landscape components of the proposal.

The EIS forms the first stage in the development of the bypass, and the concept design described in Chapter 6 would be subject to refinement and change during later stages. The final methods of construction would be determined by the contractor, taking account of the conditions of approval and the detailed design process and would be outlined in the Construction Environmental Management Plan.

7.1 Construction issues

The construction techniques used to build the bypass would take account of the environmental issues identified within the study area; these are detailed in parts D and E of this EIS. Listed below is a summary of the key environmental issues that would affect construction processes:

- flora and fauna — the study area contains important flora and fauna, so the footprint of the works would be minimised and strict environmental controls maintained
- Hidden Valley — an area containing a high density of rare and endangered plant species, so requiring minimal disturbance
- groundwater — groundwater levels in the southern half of the study area are close to the surface, and may be affected by, the construction of the tunnel. There is the potential for contaminated groundwater in the vicinity of the Tugun Landfill
- acid sulfate soils — found in the southern half of the study area and have the potential to pollute surface waters if not handled correctly
- residential areas — the northern and southern ends of the proposal area are close to residential areas; impacts on these areas would be minimised
- airport operations — the alignment crosses the airport close to take off and landing areas; construction of the bypass must not affect airport operations or the safety of aircraft
- local traffic — the construction of the bypass would require the movement of materials and people; traffic from construction activities must not result in congestion or safety issues on local roads
- Aboriginal heritage — there are areas of significance to Aboriginal heritage along the project alignment that must be respected and protected
- Material would need to be imported as there is insufficient suitable material on site

- water quality — the project adjoins wetland areas of significance that must be protected from potential impacts on water quality during construction.

7.2 Construction activities

The following sections include descriptions of construction methods and sequences that could be utilised during construction of the proposed Tugun Bypass. These methods and sequences represent one feasible and practical approach to the construction of the bypass that addresses the construction issues detailed. They could be amended during the detailed design phase to comply with the project approval conditions, or to achieve a more efficient solution to the project objectives.

7.2.1 Construction methods

This section describes the likely construction methods that could be employed by the DCM contractor for various aspects of the project, and any controls that would need to be incorporated in the activity to meet relevant performance standards and the commitments contained in this EIS. The methods proposed would be expected to ensure that the likely project approval conditions would be met, but the contractor might need to modify these methods once the conditions are known.

Highway

Construction of the proposed highway would involve the following activities:

- mapping to confirm boundaries and define the location of sensitive areas
- installing environmental safeguards to protect sensitive areas along the alignment
- establishing on-site compounds with access roads to the major elements of the project — generally access can be provided along the alignment itself, but there would be some need to provide external access roads owing to property and environmental constraints
- collection of native seed for future tube stock planting
- clearing and grubbing vegetation, and mulching/recycling material for reuse on the project
- stripping topsoil and placing it into stockpiles for reuse
- adapting the techniques required for earthworks according to geotechnical conditions (the principal material available would be silty sands from the tunnel excavation).

As the material in the southern section of the project has shown signs of potential acid sulfate deposits, special techniques would be required to treat this material before compaction in road embankments. This is discussed in Chapter 8, while geotechnical conditions are described in Technical Paper 4, and the management of acid sulfate soil in Technical Paper 5.

Bridges

A total of five bridges would be constructed for the project. These structures would be refined during detailed design to achieve the most economic solution. A detailed construction sequence for each bridge can be found in Technical Paper 2.

Design and construction methods for the twin bridges over Hidden Valley would be particularly important to minimise the impact on this sensitive area.

7.2.2 Construction schedule and workforce

The construction of the Tugun Bypass would take place over approximately 24 months. This time frame would require that several sections of the work would have to proceed simultaneously. This would be determined at the detailed design and construction planning stage. An indicative construction program is shown in Figure 7.1. It is not possible to give an accurate indication of the time it will take to construct the various components of the proposal as this will be determined by the contractor during the detailed design phase. Therefore it is not possible to provide an indication of the possible timeframe of impacts on surrounding residential areas during the construction period. The contractor would be required to conduct community consultation with affected communities to inform them of timing and progress.

The workforce for this scenario would comprise a contractor providing design and construction management, and a number of subcontractors. It is estimated that the construction management team would involve engineering, technical and administration support staff.

Various sections of the project would require specialist construction crews. These would include equipment and plant operators, formsetters, steel fixers, concreters, labourers, tradespersons and truck drivers. It is estimated that an on-site workforce of up to 200 people would be engaged during the construction period. The project would also require additional specialist support for geotechnical investigations, detailed design, and environmental monitoring.

The inclusion of workers to carry out such activities as the supply of material, and waste collection and removal, could expand the total project workforce over the construction period.

7.2.3 Construction hours

Standard construction hours for the proposed bypass would seek to keep disturbance of residents and businesses to a minimum.

Construction hours may vary along the alignment according to the restrictions imposed by the operations of Gold Coast Airport and the guidelines and protocols that apply in NSW and Queensland. Standard construction hours would normally be limited to 7:00 am to 6:00 pm from Monday to Friday, and 8:00 am to 12:00 pm on Saturday. If any activity needs to be undertaken outside work hours local residents would be consulted about the timing and duration prior to work commencing.

The construction of the tunnel would require excavations and other work at the southern end of the runway. The works could intrude into the obstacle limitation surface of the airport and this work would be limited to the airport's curfew period of 11:00 pm to 6:00 am.

In such cases, satisfactory environmental controls would be implemented to minimise impacts.

Balance of earthworks

Ideally, the balancing of earthworks would result in the volume of earth and rock excavated for cutting being equal to the volume of fill required for embankments and associated works. On this project. Additional measures would be investigated during the design phase to minimise the volume of general fill.

The current earthwork balance for the concept design is set out in Table 7.1.

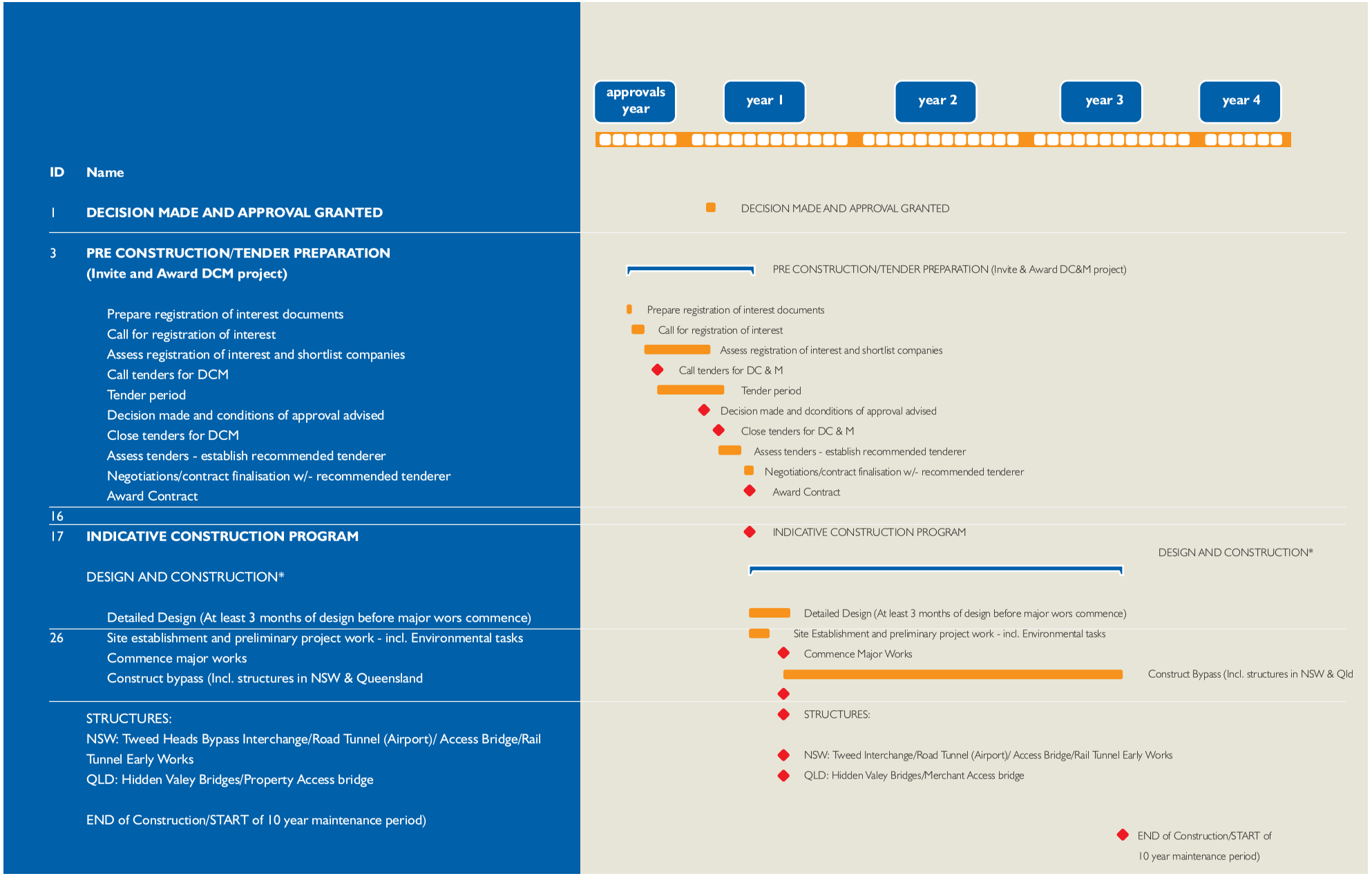


Figure 7.1 **Tugun Bypass Possible Construction Program**

Table 7.1: Earthworks summary

Location	Cut (m^3)	Fill (m^3)	Unsuitable (m^3) (estimate)
Bypass — north Boyd Street	263,000	240,000	35,000
Bypass — south Boyd Street	6,500	170,000	65,000
Airport road tunnel	240,000	20,000	–
Tweed Heads Bypass interchange	15,500	200,000	10,000
	525,000	630,000	110,000
Others			
Stormwater culverts	4,000		
Totals	529,000	630,000	110,000
Total fill required (includes unsuitable)		740,000	
Balance (additional fill required)		211,000	

7.2.4 Construction traffic, haul routes and temporary access arrangements

Traffic would be generated by the construction workforce, visitors and general deliveries. This traffic would include heavy vehicles delivering equipment and material such as piles for bridges, gravel and aggregates for pavement construction and any additional fill material not available from the site. Traffic management measures, to ensure safe passage of vehicles around the site, would be put in place by the construction contractor.

The primary entrance to the main northern construction site would be via Stewart Road. The primary entrance to the main southern construction site would be via Boyd Street and the Tweed Heads Bypass. These entrances would be used by trucks transporting excavated material into and out of the sites. Access to public roads and properties would be maintained throughout the construction works. Where existing access is to be severed alternative access arrangements will be put in place prior to the severance.

7.2.5 Potential construction material sources

Embankment material would be obtained from excavations along the alignment of the proposed bypass. Sources of external fill are discussed below.

Select fill

An estimated 40,500 m^3 of select fill is required below the final pavement layers. It is assumed that all fill would be imported to site from quarry sources. However, any available and suitable material found on site during construction would be used, thereby reducing the amount of imported fill required.

Other materials

Gravels, aggregates, sands and general fill would be required throughout the construction period. These materials may be used for local roads, drainage structures, pavement materials, bedding sands, and erosion protection. Table 7.2 indicates the quantity of imported material required.

It is assumed that none of these materials apart from general fill would be generated from within the project, and that they would need to be obtained from external sources. Suitable sources of material have been identified, as set out in Table 7.3. However, Table 7.3 is only indicative and actual sources used would be determine during detailed design.

Table 7.2: Major imported material requirements

Works	Imported materials	Quantity
Airport tunnel	Sand	67,000 t
	Aggregate	92,000 t
	Cement	38,000 t
	Reinforcing steel	8,500 t
Bridges and other structures	Concrete	4,500 m^3
	Reinforcing steel	700 t
	Deck units	270 units
Pavements	Base (crushed rock)	70,000 m^3
	Asphalt	144,000 t
Earthworks	General fill	211,000 m^3
	Select fill	40,500 m^3

Table 7.3: Possible Sources of imported material

Material	Possible source	Location	Approximate distance (km)
General fill (CBR >3%)	Boral Quarry	West Burleigh	10
Select fill (CBR >15%)	CSR or Pioneer Quarries	Ormeau	50
Sand	Boral CSR or Hymix	Burleigh Tweed Heads	10 8
Aggregate	Hymix Quarry	Nerang	20
Cement	QCL	Yatala	60
Concrete (bridges etc.)	Boral CSR or Hymix	Burleigh Tweed Heads	10 8
Base and sub-base	Hymix Quarry	Nerang	20
Asphalt	Boral or Aztec	Andrews	15
Concrete pipes and concrete box culverts	Pioneer CSR Humes Rocla	West Burleigh Gold Coast Gailes	10 30 100
Bridge deck units and piles	Various suppliers	Brisbane and Wacol	100
Reinforcing steel	Neumann Steel Smorgon ARC	Currumbin Tweed Heads	10 8
Guardrail	Roadtek	Brisbane	100
Wire rope safety fence	Road and Construction Supplies	Gold Coast	20
Concrete barrier units	Various suppliers	Brisbane and Wacol	100
Other fencing	Various suppliers	Gold Coast	20

7.2.6 Potential for sterilising mineral resources

When roads are constructed, there is the potential for any mineral resources below the development to become sterilised, since the resources can no longer be accessed. Sandmining and quarrying have already been carried out in the study area, and nor would the proposal affect the viability of existing extractive mineral resources in the area.

7.2.7 Auxiliary facilities

The contractor would require several temporary areas for a range of construction-related activities. These temporary areas would be used for construction compounds, batch plant sites, and storage facilities for material and equipment.

The equipment used would depend on the contractor's requirements, final design elements and work method chosen. The approach taken has been to identify potential sites that could be used for construction activities, to assess likely impacts, and determine mitigation measures.

Identification of suitable areas has been based on typical requirements for similar projects in Queensland and NSW, combined with identified environmental constraints in the area.

A description of the equipment and facilities required for each construction activity is provided below, followed by a summary table of preferred locations for each activity site.

Construction compounds

The construction contractor would require several construction compounds along the proposed bypass alignment. Compounds ensure the safety and security of demountable offices, ablutions, car parking, workshops, storage of material and equipment, and servicing and repair facilities. Any waste generated in the compounds would be contained within the compound boundaries. Waste which could not be reused or recycled would be removed at regular intervals to a licensed waste disposal depot. Each compound would be fenced and lit at night for security and protection.

Asphalt batch plants

The proposed bypass project would include a full-depth asphalt pavement. A total of up to 20,000 m^3 of asphalt would be required over a 12-month period, and it is most likely that on-site batch plants would be used.

The purpose of an asphalt plant is to receive bitumen, aggregate, sand and other material, mix these together, and to batch and load asphalt into trucks.

These facilities could be situated at the Tugun Landfill, subject to Gold Coast City Council's approval.

Concrete batch plants

It is possible that concrete batch plants would also be required to supply the needs of the project, depending on the construction program and capacity in other local concrete batch plants.

The concrete batch plants would receive and mix aggregate, cement, sand and other materials, and batch load these into concrete trucks.

If required, these facilities could be situated with the asphalt batch plants at the Tugun Landfill, subject to Gold Coast City Council's approval.

Topsoil stockpile areas

Approximately 80,000 m^3 of topsoil would need to be stockpiled on-site. This topsoil would be stored in temporary locations for reuse during landscaping work along the proposed bypass. General and select fill, and other material such as unsuitable timber, mulch and rocks may also need to be stockpiled during the project.

Spoil management

The current earthwork calculations assume that approximately 110,000 m^3 of material not suitable for general fill would be generated. This would require disposal, and replacement with suitable fill material.

Landscaping proposals have identified some areas where batter slopes could be flattened within the road reserve to integrate the proposal more effectively into the surrounding terrain. Unsuitable material could also be placed in mounds to help noise mitigation. These would be identified during detailed design.

The contractor would be required to protect all stockpiles of erodible material against erosion by temporary seeding or mulching, together with the provision of other standard erosion control measures. Natural topsoil would require environmental monitoring and reuse control. Topsoil management measures would be detailed in the Construction Environmental Management Plan and should be developed in parallel with the mapping of the affected areas.

Selection criteria for auxiliary construction facilities

The following criteria have been used to identify potential sites for construction compounds and temporary batching facilities. Such sites should be:

- central to a substantial portion of the works
- located with ready access to the local road network
- within the road reserve or in areas where this type of land use is permitted
- separated from the nearest residence by at least 200 m, or in a location where it can be demonstrated that no adverse impact would occur at the nearest residence
- not located within 100 m of any drain that discharges into the wetland, or mitigation measures that are provided
- located in excess of 100 m from a designated wetland (NSW State Environmental Planning Policy No. 14)
- of low conservation significance for flora and fauna
- sufficiently large to allow effective operation of the plant
- located above an appropriate flood level
- on relatively level ground
- selected so that the use of construction facilities does not affect land use of adjacent properties.

Summary of suitable locations

A range of potential sites for compounds, batch plants, topsoil stockpiles and other material stockpile areas has been selected, according to the above criteria. The preferred location for these sites are listed in Table 7.4 and shown on Figure 7.2.

Table 7.4: Preferred location for potential auxiliary construction sites

Site location	Comments/purpose	Activity
Stewart Road	Area adjacent to interchange	Works and bridge compound
Old quarry site (Tugun Heights)	Stockpile site	Temporary stockpiles
Old quarry site (Tugun Heights)	Hidden Valley bridges	Bridge compound
Tugun Landfill	Main compound and batch plants	Project Administration Centre, batch plants and main compound
Airport land/NSW Crown land within the footprint	Road tunnel works	Tunnel compound
Tweed Heads Bypass	Interchange	Bridge compound

Management of auxiliary facilities

It would be the contractor's responsibility to apply for, and have approved, temporary facilities that meet all requirements of noise, dust, storage, environment and waste management.

All work undertaken on temporary sites would be subject to satisfying site-specific environmental criteria, implementing mitigation measures, and meeting local authority requirements.

Temporary facilities would be for the exclusive use of the proposed bypass project, and would be removed on completion of the project. Once the facilities are no longer required, the sites would be restored to acceptable conditions, as agreed with the land owner.

Examples of management actions to be undertaken at auxiliary facilities are listed in Table 7.5.

Table 7.5: Management of auxiliary facilities

Auxiliary facility	Management action
Construction compounds	Fuel and chemical storage would be in accordance with environmental requirements.
Stockpiles	The contractor would be required to protect all stockpiles of erodible material against erosion by temporary seeding or mulching, together with the provision of other standard erosion control measures. Natural topsoil would require environmental monitoring and reuse control. Topsoil management measures would be detailed in the Construction Environmental Management Plan and should be developed in parallel with the mapping of the affected areas.
Unsuitable material disposal areas	Potential acid sulfate soil not treated in the embankment would either be buried below the water table, or treated before being stockpiled as unsuitable material in the landscape mounds.

Figure 7.2 **Preferred Locations for Auxilliary Facilities**

7.2.8 Waste minimisation and management

A number of processes throughout the construction and operation of the proposed Tugun Bypass would generate waste. Such processes would include the clearing of vegetation, excavation of earth, demolition of existing infrastructure, and the construction of the bypass. Potential sources of waste are listed in Table 7.6.

Specific requirements for waste minimisation and management during the construction and operation of the proposed bypass would be set out in the Construction Environmental Management Plan. The plan would specify waste management measures to be followed during the construction period by the contractor as a condition of the contract. Relevant state and Commonwealth government policy and strategy documents would need to be considered when identifying the measures to be incorporated in the Construction Environmental Management Plan. Source documents would include but not be limited to:

- *Waste Reduction and Purchasing Policy*
- *Waste Avoidance and Resource Recovery Strategy 2003.*

This plan would also propose that the contractor be required to reuse material, wherever possible, and incorporate recycling programs as appropriate. In line with NSW RTA QA Specification G36 contractors would be required to purchase and use recycled content materials where cost and performance competitive, or at least the environmental equivalent of the non-recycled alternative. The cost-competitiveness of a product or material would be assessed on a project lifestyle basis, considering issues such as impacts on construction practices, future maintenance and disposal requirements.

Measures for waste minimisation and management fall within the three categories of reduce, reuse and recycle.

Reduce

The reduction of waste generated by the proposal would involve:

- balancing of earthworks (as far as possible), thereby minimising the import of extra fill
- ensuring that existing roads adjacent to the proposal would, where possible, remain intact, to reduce the need for additional paving materials
- encouraging and educating employees to reduce waste wherever possible.

Reuse

The reuse of waste products during construction would include:

- chipping and mulching vegetation cleared for road construction purposes, and reusing it as an organic base for revegetation
- ensuring that topsoil, stripped before the earthworks phase of the construction period, is free of weeds and then stockpiled for reuse
- reusing topsoil as part of a landscape strategy, using appropriate management techniques
- placing selected vegetation around environmentally significant areas
- ensuring that any soil unsuitable for use in road embankments is used in mounding for noise mitigation, where practical.

Recycle

Recycling waste created during construction of the proposal would involve:

- provision of on-site rubbish-sorting facilities by the contractor, and recycling wastepaper, metals, glass and waste oils
- collecting and delivering disused or damaged concrete kerbs, medians, asphalt and similar material to crushing and recycling plants, where feasible.

Table 7.6: Potential sources of waste

Process	Waste
Construction	
Clearing	Vegetation, fencing materials, dumped materials
Demolition	Building materials, concrete, timber
Excavation	Fuel/oil spills, excess soil
Construction	Concrete, oil/fuel, timber formwork, packaging material, cut-off and scrap metal, on-site litter, site sewage and effluent
Operation	
Light and heavy vehicles	Rubber, oil/fuel, plastics, litter

7.2.9 Energy expenditure and saving

The implementation of the proposal would result in the consumption of energy during both construction and operation of the Tugun Bypass, and would also result in potential energy savings as a consequence of improvement in travel conditions following construction. Construction activities resulting in energy consumption would include:

- procurement and transport of raw materials
- demolition of existing structures and clearing of vegetation
- excavation and construction of the bypass
- removal and transport of excavated material
- operation of electronic signage and lighting during and after construction.

Vehicles and equipment involved during the construction phase would consume a large volume of fuel. On the basis of fuel consumption on recent road projects, fuel consumption for this proposal could be expected to be in the order of 1 million litres. Energy would also be required in the fabrication of pre-cast structures such as bridgework components and culverts.

Electricity consumption on site is expected to be minor, as it would be limited to that at the site offices connected to the local power grid.

Following construction of the proposal, energy requirements would be limited to those for electrical systems in the tunnel, lighting and electronic signage, periodic maintenance, and occasional pavement repair. Low-maintenance landscape planting would be used, where appropriate, to minimise the need for grass cutting.

Significant energy savings would result from reduced travel times, travel distances and congestion once the Tugun Bypass is completed and fully operational.

7.3 Landscape components and management

7.3.1 Plant supply

Plants at an advanced stage of growth would be used in the landscaping of interchange sites, due to the high profile of these locations. Seeds and /or seedlings would be used in areas where mass planting is required, such as next to existing vegetation. Direct seeding (e.g. hydro-mulching) would be considered for mass-planted areas to complement other plantings.

A local nursery would be engaged at the start of the construction phase to collect the seed of locally endemic species and propagate plants for the proposal. It would be preferable to collect seed from areas close to the site for all native species to be planted as seedlings. It should be noted that comprehensive seed collection would take approximately 12 months, with most seed being collected during spring and summer. Some collection of seed has already occurred and the seed stored by Main Roads.

7.3.2 Planting

Areas for planting and seeding would be fully prepared, free of weeds, and with existing soil reused as extensively as possible. Soil used for planting, including both site soil and any imported topsoil, would be tested for quality before use. Any additives recommended to ensure optimal plant growth would be specified and included. It is expected that a slow-release fertiliser and a soil-saturation aid would be used to improve tree growth rates, if appropriate, and that tree guards would be used to protect plants as necessary.

7.3.3 Maintenance

A 12-month maintenance program would be undertaken for all landscape works, and would include watering, weeding, pruning, mowing and replacement of any failed plants. If necessary, the program would be continued until the landscaping is fully established.

Following this initial establishment period, only minor annual maintenance and weed control would be required, this would form part of the 10 year maintenance program under the DCM contract.

7.3.4 Protection of existing vegetation

Existing trees and other vegetation would be retained close to the highway, and would require protection during construction. A Flora and Fauna Management Plan would be prepared to address vegetation protection issues in construction. Protection measures would include installing temporary fencing to at least beyond the radius of the tree canopy (where possible), and minimising vehicle movements and preventing stockpiling within this vegetation zone. The personnel involved in construction would be thoroughly briefed on the importance and techniques of tree protection before any works.

Road construction within tree canopy lines, or alteration of local drainage patterns near trees can kill vegetation, including mature trees, due to factors such as root removal, soil compaction, filling over tree roots, or changed groundwater conditions. Vegetation protection considerations, both during the design phase and construction, would be specified in the vegetation management plan.

The area known as Hidden Valley includes a high density of rare and endangered plant species and requires minimal disturbance. The area would be spanned by twin motorway bridges, minimising the footprint of the highway where it crosses this area. One possible method of construction for the bridges would be the use of a launching truss for the bridge deck. This would minimise the need for activity on the ground and the level of disturbance to vegetation.

7.3.5 Soil management

Any topsoil stripped from the site during construction should be stored in a way that includes vegetative cover for stabilisation during storage, and protection from traffic. Any soil imported to the site should be from an approved source.

Part D – Impacts of the proposed Tugun Bypass on the physical and biological environment

8. Geology, soils and water

8.1 Introduction

This chapter describes the ground and groundwater conditions of the study area, and provides detail on contaminated land, acid sulfate soils, flooding and water quality. The geology and groundwater in the study area were important factors in developing the concept design and in planning the tunnel. An understanding of the soils and geology was important in developing the erosion control and sedimentation measures as part of the study on water quality. A series of technical papers support this chapter.

8.2 Geology and soils

The geology of an area is the basis of the formation of its soils and landforms. A detailed study of the geology, soils and other geotechnical features was undertaken for the proposed Tugun Bypass.

8.2.1 Approach and methodology

The geotechnical investigations included:

- field mapping in the vicinity of the centre line of the proposed Tugun Bypass
- drilling boreholes to obtain soil samples for laboratory testing, and core samples of the bedrock
- excavating test pits to examine subgrade conditions and obtain bulk samples for laboratory testing
- surveying along low-lying areas to assess the likely presence of potential or actual acid sulfate soils
- installing groundwater piezometers for groundwater sampling and level monitoring.

A geotechnical model was developed based on the conditions encountered during the fieldwork. This provided a subsurface profile at each location, with appropriate design parameters assigned to each stratum correlated with the results of the laboratory tests and the data derived from the field tests. The model provided a framework for undertaking the geotechnical assessment of:

- excavation conditions
- stability of fills
- tunnel construction
- embankment construction
- settlement analysis of highway embankments over deep alluvial soils.

The investigations also included analysis of soil erosion potential, confirmed the occurrence of potential acid sulfate soils, mainly along the southern section of the route, and identified a number of areas where soil contamination might be present. Details of the geotechnical investigations and assessment of the results are included in Technical Paper 4, and issues

relating to the management of acid sulfate soils and contaminated land are included in Technical Papers 5 and 6, respectively.

8.2.2 Existing environment

Topography

The study area for the proposed Tugun Bypass spans the Queensland–NSW border at the northern end of the Macpherson Ranges, traversing the flatter coastal areas to the east of the range. The topography of the study area can be divided into two sections, with a hilly area to the north, descending rapidly to a flat southern section at the John Flynn Hospital and Medical Centre.

The topography of the northern section comprises steep hills and ridges where slopes of 35% are common. Elevation ranges from 6 to 51 m Australian Height Datum (AHD). Most of the slopes are vegetated with native trees and dense undergrowth. Previous quarrying immediately south-west of Tugun Heights has resulted in the total removal of vegetation.

The topography of the southern section is flat, with ground levels ranging from 1.5 to 4 m AHD. Sandmining over parts of the area has disturbed the original sediments and altered the natural topography. The result of natural and anthropogenic sediment deposition and reworking is a low-lying, flat, sand-covered plain, bordered by the Cobaki Broadwater to the west. East of Gold Coast Airport, a beach ridge frontal dune, undisturbed by mining but covered by urban development, gives way to beaches and the ocean.

Regional geology

The topography of the study area reflects the underlying geology. The steep hills and ridges of the northern section are underlaid by rocks of the Neranleigh–Fernvale Group of Devonian to Carboniferous Age. This geological unit primarily comprises interbedded fine-to medium-grained, grey-brown greywacke and argillite.

The flat southern section consists of quaternary sediments, including river gravels, alluvium, sand and clay. The recent beach and estuarine sediments covering most of the southern section were found to extend to a depth of approximately 25 m. Deposits interpreted as residual soil above bedrock are found below these sediments. This measurement was situated at the edge of the sedimentary sequence, suggesting that sand cover over much of the area could be greater than 25 m.

The regional geology of the study area is shown in Figure 8.1.

Soils

The subsurface profile along the northern section of the alignment generally comprises thin residual soil overlying the bedrock. A localised area of fill was recorded within the low-lying natural drainage channel that runs across the open area immediately south of Stewart Road. The fill comprises gravely, silty sand and clay, and has been used to form a road embankment. In other parts of the undeveloped area, alluvial sediments overlie the bedrock.

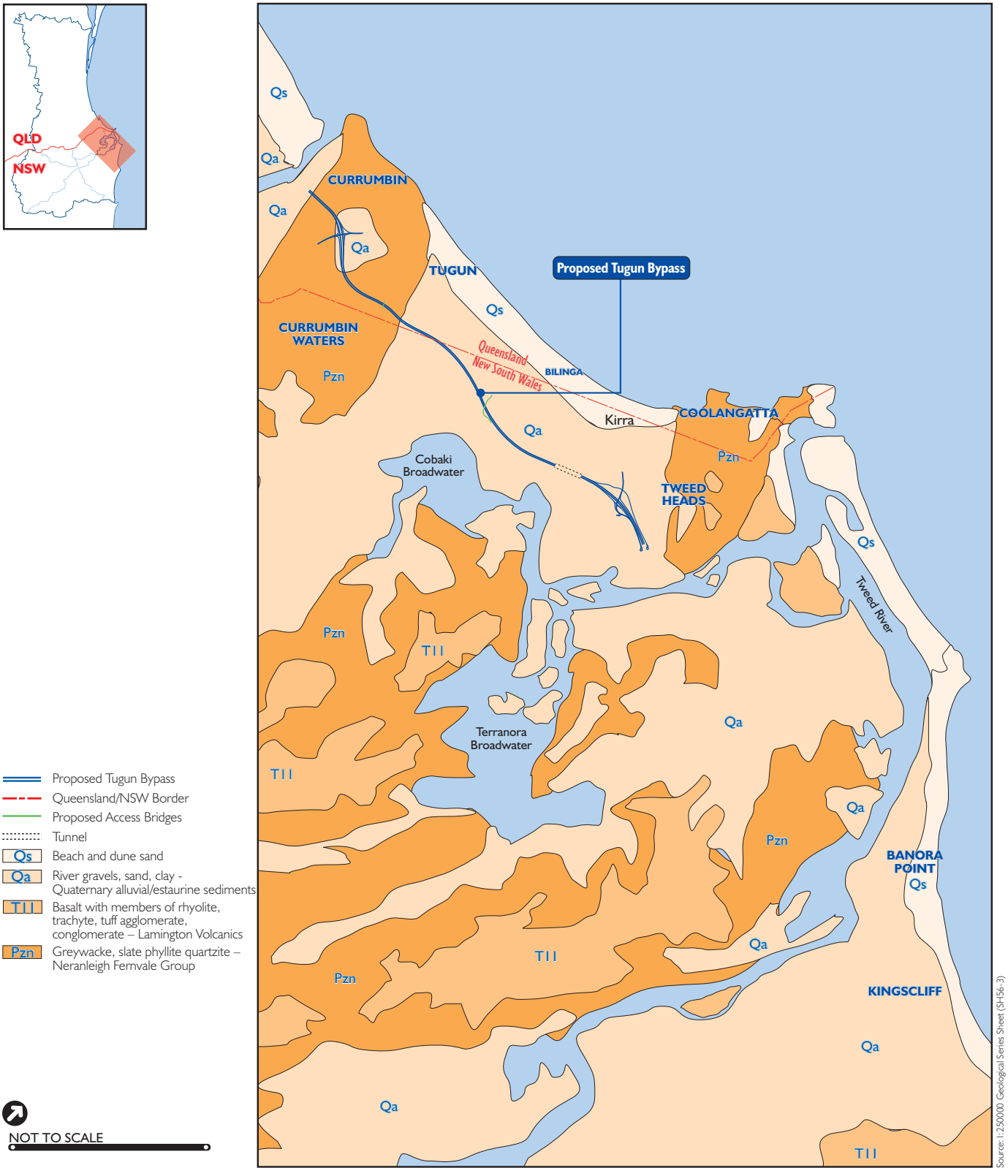


Figure 8.1 **Regional Geology**

The subsurface profile along the southern section of the alignment generally comprises loose to medium-dense quartz sands that extend to depths greater than the level of investigation (6 to 15 m). In some areas, this sand has been lightly cemented by organic material to form layers of indurated cemented sand, locally referred to as 'coffee-rock'. Stiff alluvial clays and residual clays also occur, but they are sparsely distributed. Fill containing gravely sands and sand also occurs in a number of locations throughout the area.

Erosion potential

Erosion is most likely to occur on the steeper slopes of the northern section of the alignment. However, there is also limited potential for it to occur around excavations and drainage lines in the lower, relatively flat areas. Tests on the alluvial clay soils along the northern section of the alignment indicated that the erosion potential of this soil type can be considered to be low.

The erosion potential of sandy soils is primarily related to grain size, the lie of the land and the discharge flow velocity onto the surface. The medium to fine sand found along the proposed alignment is likely to be highly erodible under concentrated flow because of the force that such flow exerts on the sand particles.

Potential acid sulfate soils

'Acid sulfate soils' is the common name given to sediments and soils containing iron sulfides which, when exposed to oxygen and then re-wetted, generate acidic run-off. Natural processes formed the majority of acid sulfate sediments in the Holocene geological period (in the last 10,000 years). Formation conditions require the presence of iron-rich sediments, sulfate (usually from seawater), removal of reaction products such as bicarbonate, the presence of sulfate-reducing bacteria, and a plentiful supply of organic matter. These specific conditions usually limit the occurrence of these soils to low-lying parts of coastal floodplains, rivers and creeks.

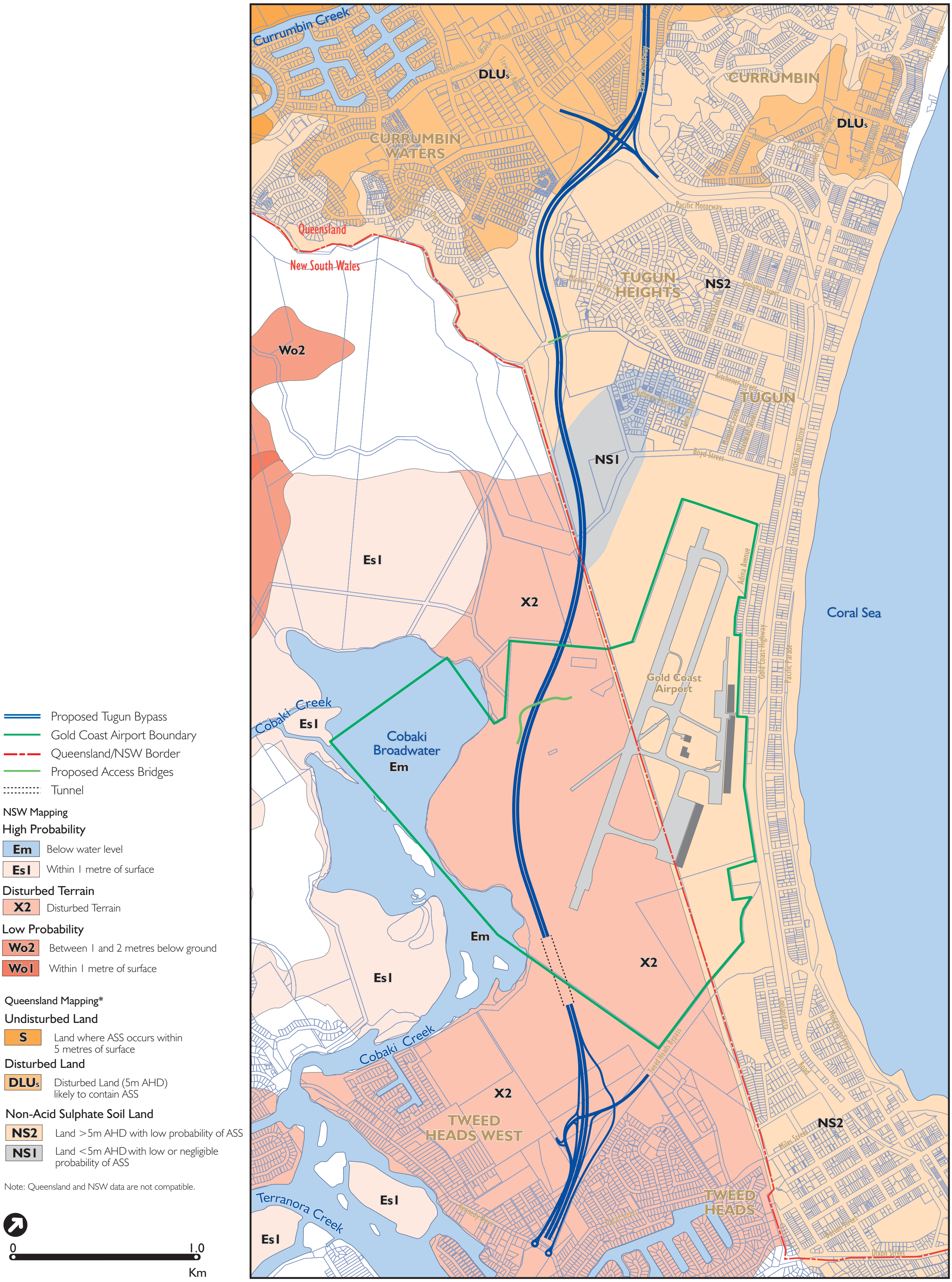
Levels of acid and oxidisable sulfur within a soil or sediment can indicate the level of risk to the environment if the soil is disturbed. The Acid Sulfate Soil Management Advisory Committee Guidelines *Acid Sulfate Soils Manual* (Stone *et al*. 1998) outline action criteria based on the percentage of oxidisable sulfur and total potential acidity. The action criteria for coarse sands are 0.03% oxidisable sulfur, and 18 mol H^+/tonne potential acidity. When either of these values is exceeded, a management plan is required.

Reference to the acid sulfate soil risk maps for Tweed Heads (9641 S4), for Bilambil (9541 S1) and the Acid Sulfate Soil Management Advisory Committee geomorphic criteria suggests a low-to-negligible probability of acid sulfate soils occurring within the soil profile along the northern section of the alignment, but a high probability within the deep alluvial soil profile along the southern section. The extent and risk of acid sulfate soils within the study area is shown on Figure 8.2.

Field and laboratory investigations were undertaken to define the extent of acid sulfate soils along the proposed corridor. Test results confirm the presence of potential acid sulfate soil between chainages 5,000 and 7,000 in the vicinity of the proposed cut-and-cover tunnel and the southern portion of the alignment near the proposed Tweed Heads Bypass interchange. Generally the depths of the potential acid sulfate soils are 0.5 to 9 m below the surface.

Potential contamination

Sites directly affected by the proposed alignment, and where there are contaminated areas, are as follows:



Source: Acid Sulphate Soil Risk Maps (9641 S4)/Acid Sulphate Soils - Tweed Heads to Redcliffe (DNR-SEA-1-A0 3234)
* Queensland Acid Sulphate Soil Risk Map has been compiled using different assessment criteria from that in NSW.

Figure 8.2 **Areas with Potential Acid Sulfate Soils**

- Tugun Landfill
- Gold Coast Airport disused dump site
- the sandblasting area.

The location of these sites is shown in Figure 8.3

In addition to these sites, there are also a number of other sites adjacent to the proposed alignment. These are listed in Table 8.1. More information is available in Technical Paper 6.

Tugun Landfill

Tugun Landfill is owned and operated by Gold Coast City Council. Activities at the site are regulated by the Queensland Environmental Protection Agency.

Operation of the site is classed as an environmentally relevant activity (ERA) under the Queensland *Environmental Protection Act 1994*. The landfill receives between 2,000 and 5,000 tonnes of waste per year and therefore is classified as type 75 (a) (ii): 'Waste Disposal — operating a facility for the disposal of general waste or limited regulated waste only'.

Tugun Landfill has accepted only inert waste since 1974. Before that, acceptance of material at the site was not regulated. Landfilling at the north-eastern end of the site commenced approximately 50 years ago (Bruce Lewins, Gold Coast City Council, pers. comm.). This area has now been covered and rehabilitated for recreational purposes, incorporating the Betty Diamond Sporting Complex. This area is at the northern end of the main airport runway.

The site is included on the Environmental Management Register as a landfill, and a petroleum product or oil storage facility. These are classified as notifiable activities under Section 374 of the *Environmental Protection Act 1994*.

The current operating face of the landfill is directly to the east of the proposed alignment. Work on this area began approximately 20 years ago. It is estimated that the facility has another 3 years of life, with the exact timeframe dependent on the volume of waste received.

The landfill was not constructed with an impervious liner, and in some areas material may have been placed below the water table. Groundwater monitoring has been undertaken at the landfill as part of licensing requirements. Details of groundwater quality are provided later in this chapter.

Airport dump sites

In 2004 Gold Coast Airport Limited completed a site assessment of the old dump sites (Parsons Brinckerhoff 2004) that defined the extent of the sites and identified the types of waste disposed in them. Three sites are on the western side of the airport and are shown on Figure 8.3.

The results showed that the sites contain a range of wastes, with the majority being old building materials and metal. Asbestos-containing material was found in each of the sites. The depth of waste burial averaged 0.5 m below the surface.

Soil samples showed elevated levels of metals such as lead, nickel and zinc, while groundwater samples showed elevated levels of ammonia.

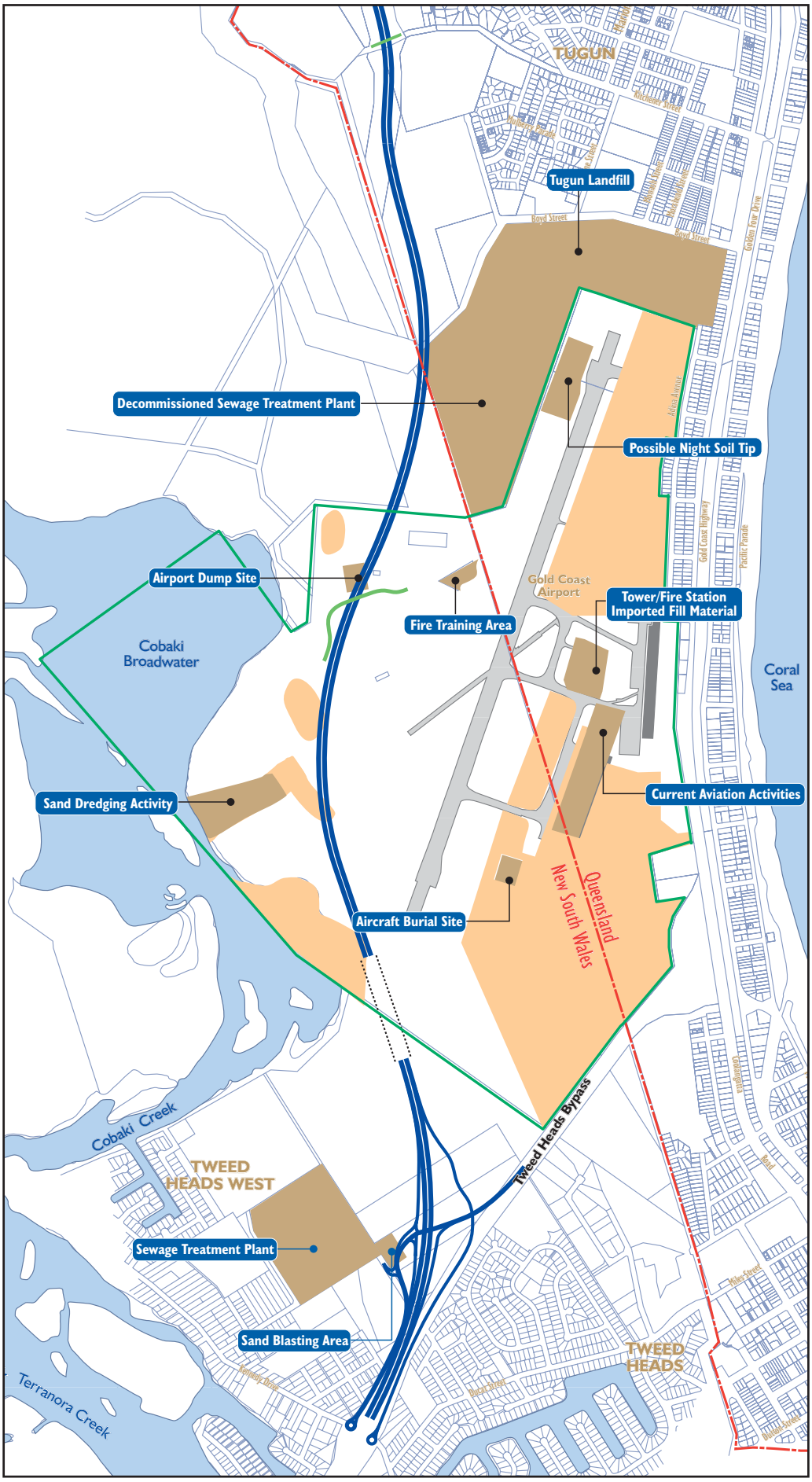


Figure 8.3 **Areas of Potential Contamination**

Sandblasting area

An area formerly used for sandblasting is located adjacent to the southern end of the proposal, to the west of the proposed Tweed Heads Bypass interchange. A small portion (100 m^2) of the site was used for this activity. Sandblasting can result in the presence of potential contaminants including tributyl-tin, heavy metals (particularly lead and chromium), petroleum hydrocarbons and polyaromatic hydrocarbons.

Table 8.1: Sites adjacent to the proposed alignment with the potential to contaminate land through existing or previous land uses

Site	Comments
Tugun Sewage Treatment Plant	The Tugun Sewage Treatment Plant has been decommissioned and is now used as a pumping station. It is situated to the east of the Tugun Landfill site and comprises two lagoons and an emergency overflow pond, two-thirds of which is currently used as a sedimentation basin.
Sandmining	Heavy mineral sandmining has taken place throughout the area of Gold Coast Airport. Testing for concentration of radioactive sands (Douglas Partners 1994) found that all readings were well below the given cleanup threshold of 0.3 mR/hour. Figure 8.3 shows the areas where sandmining has occurred within Gold Coast Airport. The extent of mining outside of the airport boundary is unknown.
Night Soil Tip	The Gold Coast Airport Environmental Strategy refers to anecdotal data suggesting that a sanitary waste tip existed in the northern part of the airport to the west of the runway. While it is unknown when dumping started and ceased, it is known that the dump site was partially removed in 1950 for an upgrade of the airport. No further dumping since that time has been recorded.
Fire training area	A fire training ground is located within the grounds of Gold Coast Airport to the west of the main runway. The site is used as an emergency training area by Air Services Australia and has been identified within the Gold Coast Airport Environment Strategy as a site with known soil and groundwater contamination. Soil and water quality sampling from the site has indicated that kerosene had been identified in the soil, but had not reached the water table, with no distinct spatial or preferential flow direction of hydrocarbon contamination across the site.
Tower/fire station	The control tower/fire station complex has been identified as an area in which a clay gravel fill material was used. The contamination status of this fill is unknown.
Gold Coast Airport	The main sources of potential contamination from the aviation facilities at the airport are leakage from the storage of fuels in underground storage tanks and accidental spillage of fuels or chemicals. These tanks are situated to the east of the main runway, 800 m from the proposed alignment.
Aircraft burial site	An area at the south of the airport and west of the main runway has been identified as a dumping ground in which an aircraft fuselage has been buried.
Tweed Heads West Sewage Treatment Plant	The Tweed Heads West Sewage Treatment Plant is to the west of the proposed Tweed Heads Bypass interchange. The facility is owned and operated by Tweed Shire Council and is currently in use.
Sand-dredging area	Sand-dredging operations were conducted at the Cobaki Broadwater by the Brodhurst-Hill Company, under licence to the Gold Coast Airport Limited. The site is at the southern end of runway 17/35, adjacent to the National Estate area. Sand was dredged from the Broadwater and piped back to a stockpile area on the banks. The sand was drained and the water returned to the Broadwater via sedimentation basins. Gold Coast Airport Limited discontinued dredging in 1999. Potential contamination created by sand-dredging activities includes acid generation and radioactive sands.

8.2.3 Potential impacts and mitigation measures

Soils

The argillite and greywacke underlying the northern section of the alignment would tend to weather rapidly on exposure and potentially cause erosion of the batters. The batters would be vegetated as soon as practicable after excavation to mitigate any erosion potential. Alternatively, slope stabilisation of the batter to minimise the erosion potential could be adopted as required.

The alluvium found beneath the southern section of the alignment consists of sand and occasional silty clay. The use of these materials in structures such as embankments can result in erosion of steep slopes. To prevent this erosion, batter slopes would be constructed at two horizontal to one vertical, and be vegetated as soon as practical following construction. Hydro seeding, hydro mulching and/or erosion-control matting would be utilised where required. Where practical, hydro seeding and hydro mulching would include native seeds.

All run-off water from above the embankments would be directed to the constructed wetlands. An open drain would be provided behind the crest of the fill slope, connecting to a concrete-lined batter drain to minimise the flow of water over the face of the embankment. The crests would be rounded to assist in the minimisation of scouring. Energy dissipation structures may also be required at the toe of the slope.

Soft soils identified in low-lying areas exhibit relatively low strength and high compressibility characteristics. Therefore, before construction of the road pavements, these soils would need to be treated with the placement of a bridging layer and geofabric to improve their suitability for carrying traffic.

In areas unaffected by acid sulfate soils, materials unsuitable for use in embankments, such as topsoil and other soft compressible materials, would be removed before placement of embankment materials. Replacement materials would be compacted to achieve the required compaction standard within the range of optimum moisture content.

Potential acid sulfate soils

Potential acid sulfate soils have been identified in the vicinity of the proposed road tunnel and the southern section of the alignment adjacent to the Tweed Heads Bypass.

Construction work in areas containing acid sulfate soils has the potential to disturb these soils and allow oxidation of the pyritic material, leading to the generation of acid run-off. The pollution potential of acidic drainage is high, particularly if it is allowed to enter nearby watercourses. This can result in the lowering of pH in the water, which in turn can mobilise metals, deplete dissolved oxygen, reduce rates of photosynthesis, and significantly affect aquatic flora and fauna.

Construction activities likely to have an impact on potential acid sulfate soils are those which involve the excavation of soil or alterations to surface or groundwater flows, such as embankment construction, construction of erosion and sedimentation control structures, and dewatering during tunnel construction.

If they are suitable, materials excavated from the tunnel construction would be used as road embankment materials, and would therefore require treatment to control acid generation. Acid neutralisation is considered the most effective treatment option. The treatment process would

ensure that acid sulfate soils and any associated acidic run off are treated in accordance with the guidelines provided in the Acid Sulfate Soil Manual. The treatment would be as follows:

- A site-specific soil sampling and testing program would be established before construction. The program would follow guidelines from the Acid Sulfate Soils Management Manual and the Queensland Acid Sulfate Soils Investigation Team.
- Liming rates would be based on the results of the testing program. The amount of lime required would be based on the formula kg $CaCO_3$/tonne soil = kg H_2SO_4/tonne soil. In estimating the lime requirement, a factor of safety would be applied to allow for inefficient mixing of lime.
- Stockpiles of lime would be kept on site at all times. The supply would be covered and stored in a bunded area. Similarly, a supply of lime would be kept to treat any acid leachate.
- Before placement of excavated materials, the base of the embankment pad would be limed with a precautionary amount of fine agricultural lime at a minimum rate of 2.5 tonnes per hectare.
- Excavated material would be placed in the embankment area within one day of excavation. Material would be spread to a maximum thickness and covered with the required amount of lime as determined from the acid sulfate soil analysis. Soils would be dried out to allow trafficking and mixing. Thorough mixing and aeration are essential, and testing trials would be conducted before the layer is compacted.
- The final profile of the embankment would be covered with topsoil and vegetated to restrict the ingress of water to minimise the possibility of leachate being generated in the embankment.
- Naturally low pH conditions in the south of the airport would be maintained.

The treatment process would neutralise the acid sulfate soils, and the covering of the embankment would minimise the generation of leachate. In general, run-off from areas of treated acid sulfate soil should not be appreciably acidic. However, if periods of heavy or sustained rainfall occur during the establishment of the embankment, leachates may be generated that have a pH less than the receiving water. This would be due to the acid sulfate soil materials not having sufficient time to contact and react with the lime.

Toe drains would be constructed along embankments where treated acid sulfate soil materials have been placed. These would collect any run-off or leachate and direct it to a holding pond. Any discharge from the holding pond would be tested for pH before release. If the pH of the pond is lower than the receiving water, the pond would be dosed with slaked lime until the pH is brought to acceptable levels.

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

The construction of the road tunnel would necessitate a local drawdown of the groundwater table. This can result in exposing previously submerged potential acid sulfate soils to oxygen, which would in turn result in acid generation.

To minimise the oxidation of potential acid sulfate soils during tunnel construction, groundwater pumped from the excavation would be reinjected into the ground immediately adjacent to the works. This would ensure that the surrounding soils remain saturated and free of oxygen. The pumping system would be sealed to minimise the possibility of oxidation of the groundwater.

All other water collected in the excavations, such as rainfall and seeping groundwater, would be pumped to a holding pond. The water would be tested before discharge to ensure that its pH is similar to that of the receiving water.

Contaminated areas

Tugun Landfill

The construction of the proposed bypass would require some excavation of the Tugun Landfill. The area to be excavated is shown in Figure 8.4. Material from the excavation would either be placed in the landfill or transported to an alternate landfill site. Preliminary test results indicate that material to be removed would have elevated levels of metals and nutrients. These parameters indicate that decay of putrescible material is occurring in the area, and therefore any material or water from the excavation should be treated as solid waste or leachate.

Potential impacts of the proposed excavation and construction works include:

- increase in the rate of decay of putrescible materials
- increase in the volume of leachate produced
- accelerated migration of leachate from Tugun Landfill to areas downstream of the landfill towards the Cobaki Broadwater. As the landfill is elevated above the natural areas to the west leading to Cobaki Broadwater, it is likely that leachate is migrating from the landfill. Most of this would be captured in drains and the wetland areas in the vicinity, as the groundwater gradients are very small beyond the landfill
- potential to increase any harmful effects on the environment from the migration of leachate
- exposure of construction workers to harmful chemicals in the landfill material or in leachate during the excavation and removal operation.

The limited water chemistry data available suggests that the leachate could contain elevated levels of nutrients (nitrogen and phosphorus), may have slightly raised levels of heavy metals (cadmium and iron) and could contain dissolved organic matter such as phenolics. However, the organic results are not conclusively different from those for the natural groundwater. More details of the groundwater investigations are included in Technical Paper 9.

As the groundwater flows toward the NSW border and the Cobaki Broadwater, there is a strong possibility that migration of contaminants from the landfill is occurring.

However, the extent and rate of migration depends on a number of factors. Nutrient concentrations would be rapidly reduced by the surrounding vegetation, and anaerobic wetland conditions would assist in the removal of heavy metals. Organic contaminants have the highest potential for more distant migration, but as groundwater gradients are very small at some distance from the landfill, it would take many years (70 or more) for these contaminants to

reach the Broadwater. Many organic contaminants would degrade before this occurred. However, a few, including some pesticides and polychlorinated biphenyls (PCBs), do not degrade and may, if present, persist for a sufficient time to reach the Broadwater.

The following mitigation measures would be used for road construction works at the Tugun Landfill:

- placement of an high-density polyethylene membrane over the exposed waste
- capping with clay to a thickness of 0.5 m
- reinforcement of clay layer
- backfilling the excavated area to the top of the works for drainage purposes
- using material for backfilling that has a low permeability, to prevent leachate seeping through to the surface
- surrounding the work area with an impermeable bund and collecting all surface water/leachate for treatment or appropriate disposal
- disposing of all excavated waste to a suitable containment cell within the Tugun Landfill or off site to a licensed facility.

A work method statement would be prepared detailing safe working practices for construction workers involved in the excavation and transport of the solid waste, and the environmental protection measures required. This would be prepared in consultation with the Queensland Environmental Protection Agency and the NSW Department of Environment and Conservation. Figure 8.4 details the proposed mitigation measures at the landfill.

Airport dump sites

The proposed alignment passes over two of the former dump sites, which would require the removal of approximately 1,600 m^3 of waste. All excavated waste would either be disposed of to a suitable containment cell within the Tugun Landfill or taken to a suitable licensed facility.

A work method statement would also be prepared for these sites in consultation with the NSW Department of Environment and Conservation and Gold Coast Airport Limited.

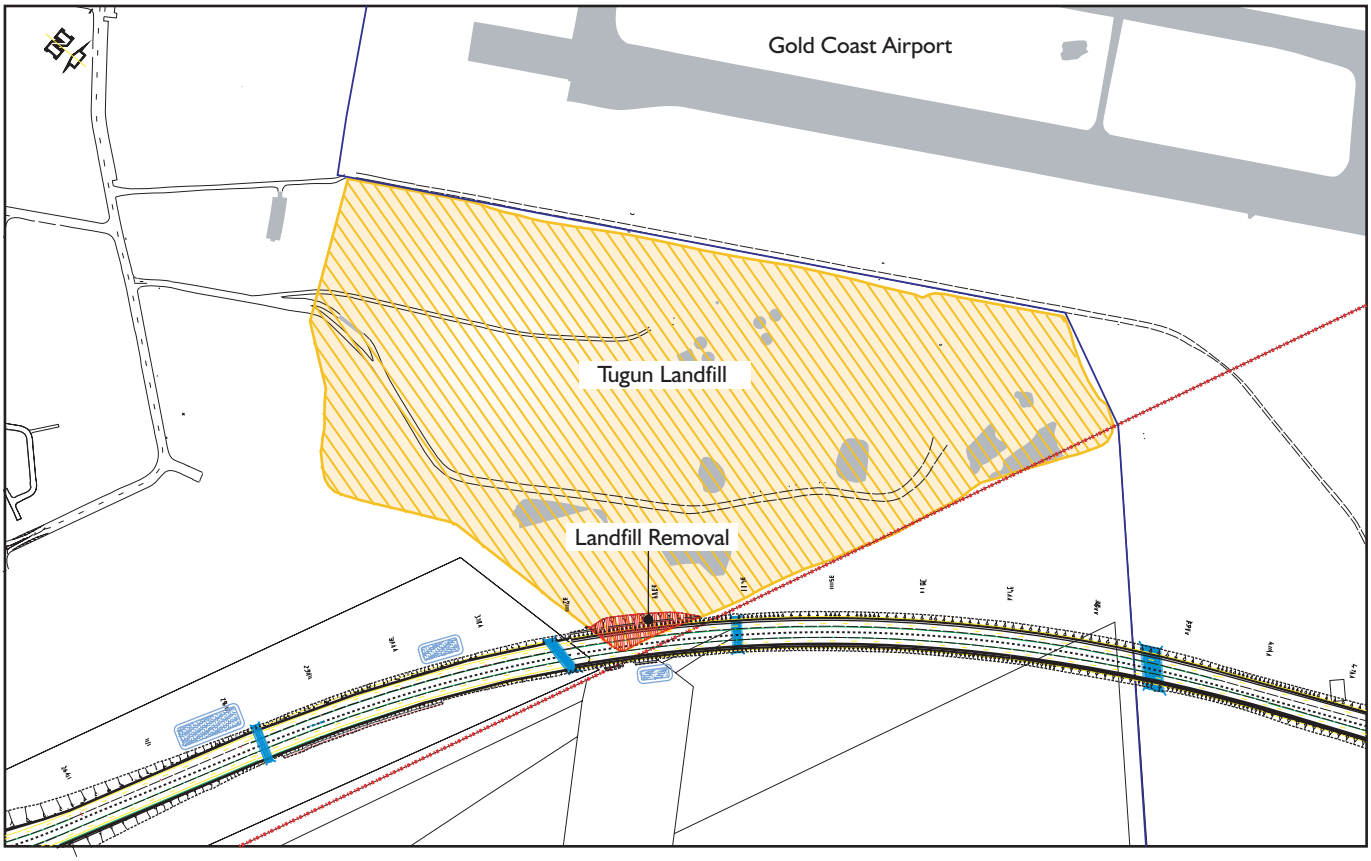
Tunnel excavation

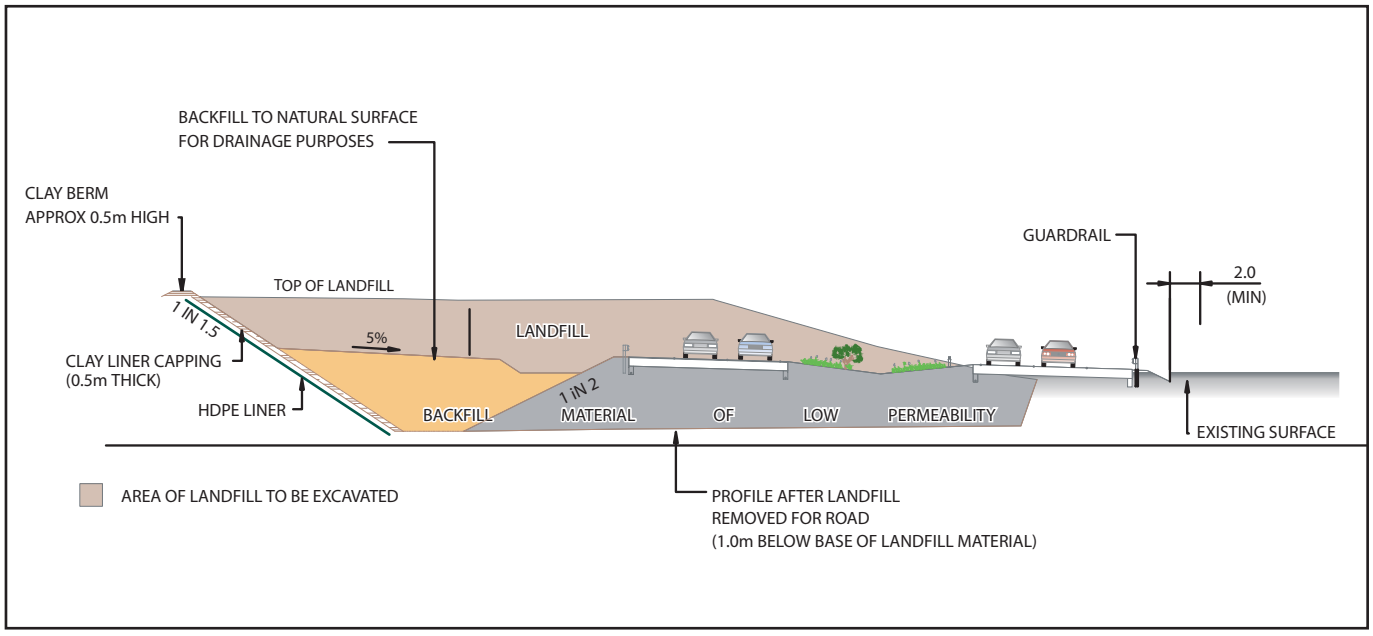
The construction of the road tunnel and ramps, and the initial stage of the rail tunnel, would require the excavation and removal of 240,000 m^3 of material. This material, if suitable, would be used as fill elsewhere along the alignment.

The soils in the tunnel area have not been tested for contaminants. On the basis of results from the site inspection, land use analysis and groundwater testing, it is expected that these soils would be characteristic of the area and not likely to be contaminated. However, they have been identified as potential acid sulfate soils.

If the excavated material is used on site and treated as recommended in Technical Paper 5, it is unlikely that contamination would result in unacceptable impacts.

If excess or unsuitable material is to be disposed of off-site, it would first be tested, and if contaminants are found it would disposed of to a licensed facility.





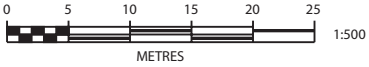


Figure 8.4 **Proposed Landfill Mitigation Measures at the Tugun Landfill**

Sandblasting area

The construction of the ramps for the Tweed Heads Bypass interchange could affect an area of land previously used for a sandblasting operation.

Impacts of construction would be related to the disturbance of potential contaminants, including tributyl-tin, heavy metals, petroleum hydrocarbons and polyaromatic hydrocarbons, and the potential exposure to humans and the ecosystem to contamination. A work method statement would also be prepared for this site in consultation with the NSW Department of Environment and Conservation.

8.2.4 Environmental management

Acid sulfate soils

The proposed development would involve excavation, alteration to surface-water and groundwater flows, and lowering of groundwater levels, particularly in the vicinity of the road tunnel. As a result, mitigation measures are part of construction procedures. They include:

- preventing excessive drawdown during dewatering by reinjection of groundwater
- using construction methods that require a minimum of dewatering
- undertaking dewatering in phases, related to small segments of construction.

Operational mitigation includes the incorporation of cross-tunnel drains to allow free groundwater movement across the tunnels to maintain existing flows and levels.

An Acid Sulfate Soils Management Plan would be prepared, based on guidelines devised by the Acid Sulfate Soil Management Advisory Committee. The plan would include:

- establishing background trends in groundwater chemistry, as site-specific criteria need to be developed, rather than relying on guideline levels
- controlling soil pH by treatment with agricultural lime in bunded areas, and regular testing of pH levels and rates of acid generation
- controlling groundwater pH based on regular monitoring to determine the level of treatment necessary
- maintaining existing low pH conditions as suitable for 'acid' frogs (see Chapter 10.)

More details relating to the management of acid sulfate soils are available in Technical Paper 5.

Site contamination

Potential impacts associated with the identified sites would be managed by the implementation of environmental management measures. Before the start of construction, soil would be tested for the following:

- polynuclear aromatic hydrocarbons
- total petroleum hydrocarbons
- tributyl-tin (sandblasting area only)
- metals.

The extent of testing would be determined in accordance with the *Draft Guidelines for the Assessment and Management of Contaminated Land in Queensland* (Queensland Environmental Protection Agency 1998), *Contaminated Sites Sampling Design Guidelines* (NSW Environment Protection Authority 1995b), *Contaminated Sites: Guidelines for Consultants Reporting on Contaminated Sites* (NSW Environment Protection Authority 1995a) and *Australian and New Zealand Guidelines for the Assessment and Management of Contaminated Sites* (Australian and New Zealand Environment and Conservation Council/National Health and Medical Research Council 1992). The extent of contamination found would determine whether treatment is required and, if so, what treatment methods would be appropriate. Available methods include removal and disposal to a licensed landfill, containment and capping.

8.2.5 Topsoil

Following appropriate testing, all topsoil suitable for reuse would be removed to temporary locations along the alignment. The volume to be accommodated is estimated to be 80,000 m^3. All stockpiles of potentially erodible material would be protected by temporary seeding, together with other erosion and sediment control measures.

Locations for all stockpiles, and procedures required for management, would be included as a component of the Construction Environmental Management Plan.

8.3 Flooding and drainage

8.3.1 Approach and method

The hydrological investigations undertaken for the EIS included an assessment of both catchment-wide and local impacts expected to result from the proposed bypass development. They also included consideration of the cumulative effects of the road, rail and proposed airport development on flooding conditions in the Tweed River catchment.

The hydrodynamic ESTRY model of flooding processes on the Tweed River used in this study is the culmination of more than 15 years of development, refinement and verification. The latest version has been calibrated to the April 1989 flood, and verified for the March 1974 and March 1978 floods. It also includes the representation of the Chinderah Bypass and the northern section of the Yelgun to Chinderah upgrade on the Pacific Highway. This model was used to define existing flooding characteristics of the catchment and to assess the effect of the Tugun Bypass proposal on future peak flood levels, taking account of the anticipated sea-level rise and other phenomena.

Flood impacts on local catchments crossed by the proposal were also considered using a RAFTS-XP hydrological model of the catchment and an EXTRAN-XP hydraulic model of the waterway elements. The outputs from the modelling process were used to determine the size of the drains crossing the road alignment that would be needed to maintain the existing hydrological regime along the route.

Technical Paper 7 provides more detail of flooding and drainage issues.

8.3.2 Existing environment

The proposed Tugun Bypass would be located within the Tweed River catchment, which incorporates Cobaki Broadwater. The Broadwater is tidally connected to the Tweed River. The

alignment would not traverse any major watercourses, although it would pass through a number of smaller natural drainage lines at various points along the route.

The alignment crosses the catchments of three local watercourses. The section of the alignment running south from the John Flynn Hospital and Medical Centre drains into the Cobaki Broadwater and Tweed River catchment. North of the hospital, Hidden Valley forms the western part of the Coolangatta Creek catchment, with the valley draining to the east. The portion of the alignment north of Hidden Valley to the Stewart Road junction is part of the Currumbin Creek catchment.

The proposed alignment would traverse the Currumbin Creek and Coolangatta Creek catchments in the north of the study area.

The location of the proposed alignment with respect to these catchments is shown on Figure 8.5.

All drainage lines are either Class 3 or 4 in accordance with *Policy and Guidelines for Bridges, Roads, Causeways, Culverts and Similar Structures* (NSW Fisheries 1999), and *Why do fish need to cross the road? Fish Passage Requirements for Waterway Crossings* (Fairfull & Witheridge 2003).

Tweed River catchment

The main arm of the Tweed River is approximately 40 km in length and has a catchment area of approximately 1,100 km^2. Its major tributaries include the Oxley River and the Rous River, which originate inland in mountainous terrain at elevations between 600 and 1,100 m. Most of the upper catchment is heavily timbered with natural vegetation, while the lower catchment and floodplains have been cleared for cropping, plantation and urban development.

The Tweed River catchment is particularly susceptible to major flooding. The relatively small size of the catchment, the steepness of the terrain, and the high rainfall all result in the rapid onset of major flooding. The average annual rainfall at Murwillumbah, for example, is 1,600 mm.

Peak flood levels in the vicinity of the route during 20- and 100-year average recurrence interval (ARI) flood events are shown in Table 8.2. These levels are relatively high, as the model was based on an assumption that a storm surge or peak spring tide could coincide with a Tweed River flood, and result in higher flood levels.

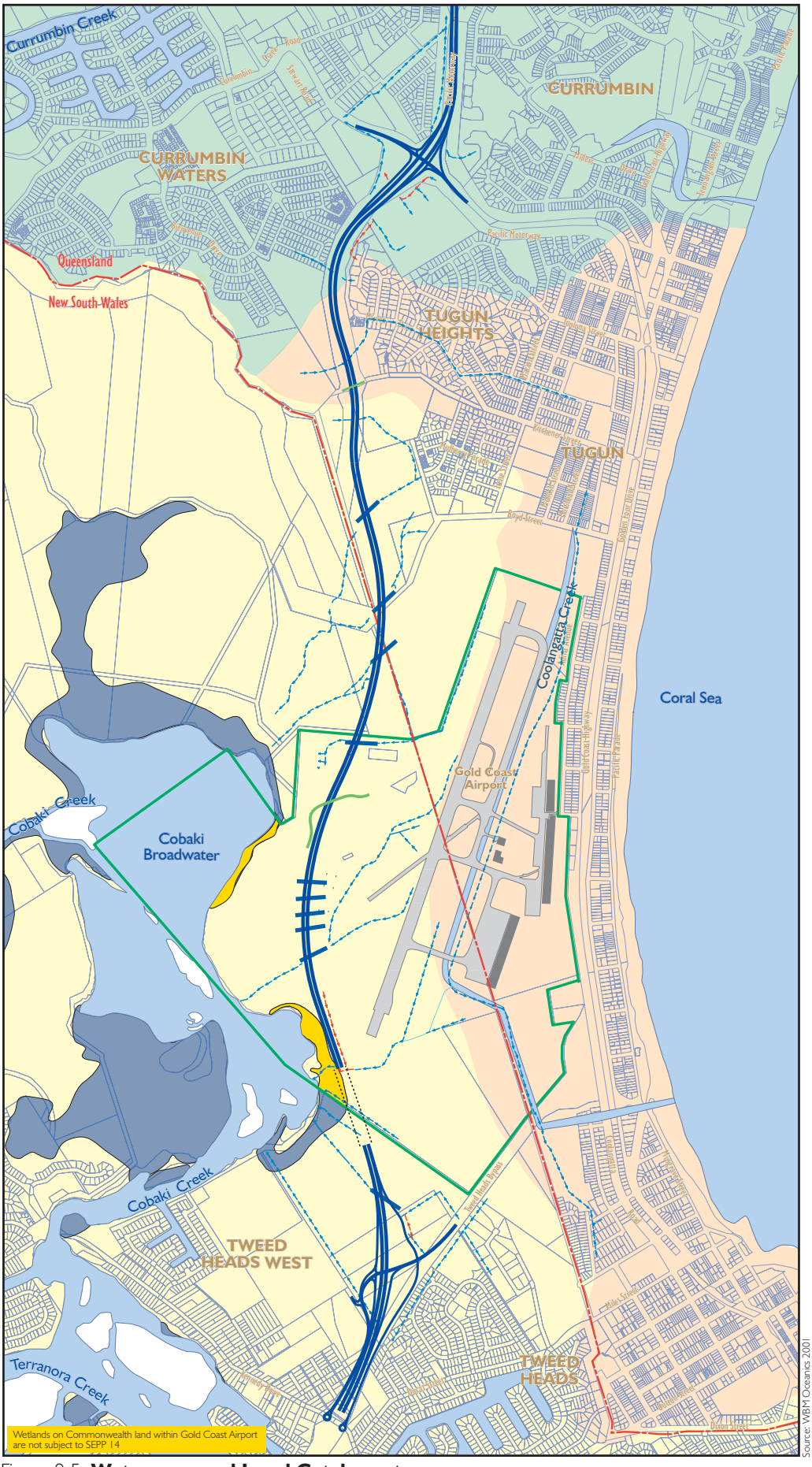
Table 8.2: Design water levels in the Tweed River

Average recurrence interval	Peak water level in the Tweed River (metres AHD)
20 years	2.25
100 years	2.70

Source: WBM Oceanics.

Currumbin Creek catchment

The northern section of the alignment drains to Currumbin Creek. The catchment in this area consists of many smaller catchments that drain from the elevated areas of Tugun Heights to low-lying floodplains to the north-east, near Currumbin Creek.



Proposed Tugun Bypass
Gold Coast Airport Boundary
Queensland/NSW Border
Proposed Access Bridges
Tunnel
Currumbin Creek Catchment
Coolangatta Creek
Cobaki Broadwater and Tweed River Catchment
NSW State Environmental Planning Policy 14 Wetlands
Continuation of Wetland Boundary
Proposed Road Culverts
Proposed Watercourse
Existing Watercourse

0 1.0 Km

Figure 8.5 **Waterways and Local Catchments**

Coolangatta Creek catchment

Coolangatta Creek is a highly disturbed stream existing within a catchment that is almost entirely urbanised. Urban development, sandmining and airport construction have substantially modified the creek and its catchment. The creek is either piped or channelled over most of its length. The only section that exhibits more natural conditions occurs where the creek traverses Gold Coast Airport to the east of the runway area. The creek crosses under the Tweed Heads Bypass downstream of the airport and through a 400-metre-long culvert, before discharging onto the beach at Kirra. An overflow drain at the southern end of the airport directs high flows in large flood events (larger than the 20-year ARI flood) into Cobaki Broadwater.

A weir where the creek runs under the Tweed Heads Bypass controls water levels. The standing water level in the creek is considered to be contiguous with the groundwater level in the sand aquifer. The creek is thus sustained by groundwater baseflow. Downstream of the weir the creek course has been modified by urban development.

Local minor catchments

The proposed alignment crosses several local minor catchments. The existing flooding and drainage characteristics of these catchments are discussed in Table 8.3. These would be incorporated in the design of the proposed Tugun Bypass.

Waterway structures for the local drainage network and minor catchments associated with the proposed bypass were designed according to individual hydrological and catchment characteristics. The dimensions of the culverts required can be found in Technical Paper 7.

Figure 8.5 indicates the waterways and drainage lines within the vicinity of the proposed Tugun Bypass, pre- and post-construction.

Table 8.3: Local minor catchments crossed by the proposed alignment

Crossing Location[1] (chainage)	Comments
2,800	The waterway drains from the Pacific Beach development and the John Flynn Hospital and Medical Centre. The area of the catchment is 50.5 ha and contains a mix of urban (residential) and vegetated areas. The critical duration for this catchment is the 60-minute storm. The 60-minute duration 100-year ARI peak flow for the catchment is 6.5 m^3/s. Ground levels are approximately 3.5 m AHD. Hence flooding of the Tweed River (which peaks at 100-year ARI at 2.7 m AHD) would not affect this catchment.
3,200	This catchment has an area of 24.8 ha. The peak 100-year ARI flow is estimated to be 6.8 m^3/s.
3,900	This catchment has an area of 50 ha. The peak 100 year ARI flow is estimated to be 11.1 m^3/s.
4,900	This catchment currently discharges through an open channel. A service road for Gold Coast Airport crosses the channel at approximately the same location as the proposed bypass alignment. The peak 100-year ARI flood levels upstream of the service road are estimated to be 2.07 m AHD.
5,450 to 6,000	There are three minor catchments that discharge across the area where the road tunnel is proposed. This section also includes the overflow channel from Coolangatta Creek.
6,000	Freshwater overland flows in the vicinity of chainage 6,000 would be diverted in a catch drain away from the tidal drain (which would also be diverted).

Note 1: Chainages are shown on Figures 6.1a to 6.1e.

Source: WBM Oceanics

8.3.3 Potential impacts and mitigation measures

Tweed River

Impacts on peak flood levels

The primary impact of the proposal on the Tweed River floodplain would be the loss of floodplain storage resulting from the filling required for the road embankments. A loss of storage has the potential to increase flood levels.

Results of flood modelling showed that filling for the proposal would result in increases in flood levels of less than 5 mm for the 20-year and 100-year ARI flood events. Impacts would be less than 2 mm for the 5-year ARI flood event. The magnitude of these impacts and increased flood damage resulting from increased flood levels would be negligible. The potential flooding impacts of the proposal are shown in Figure 8.6.

The area of floodplain affected by the increased flood levels has been subject to development over recent years. Most of the filling for residential development taking place on the lower parts of the Tweed River floodplain has been to levels above the 100-year ARI flood level, in compliance with Tweed Shire Council policy.

Impacts on duration of inundation

Impacts on the time that flood-prone land is inundated during Tweed River flood events would be negligible due to the minor impact of the proposal on general flooding behaviour. Any loss of floodplain storage would be insignificant in the context of the Tweed River catchment as a whole.

Rates of flood rises and recessions

Impacts on the rate of flood rise and recession during flood events would be negligible due to the slow rising behaviour of the downstream end of the Tweed River floodplain during flood events.

Currumbin Creek

The 100-year ARI flood level for Currumbin Creek is 2.30 m AHD, based on Gold Coast City Council flood maps. It is therefore important that the culverts be placed at a height at or above 2.30 m AHD to prevent the backflow of water through the culvert. Areas of particular susceptibility would include land below 2.30 m AHD, including the western and eastern portions of the Stewart Road interchange. The level of the existing highway is above 3.0 m AHD, so there would be no major impacts on the alignment.

Coolangatta Creek

There would be no impacts on the nature and behaviour of flooding in Coolangatta Creek due to the negligible change in the characteristics of the overflow channel from Coolangatta Creek to Cobaki Broadwater. This channel would be reinstated as an open channel as part of the proposal and would be sized to replicate its current capacity.

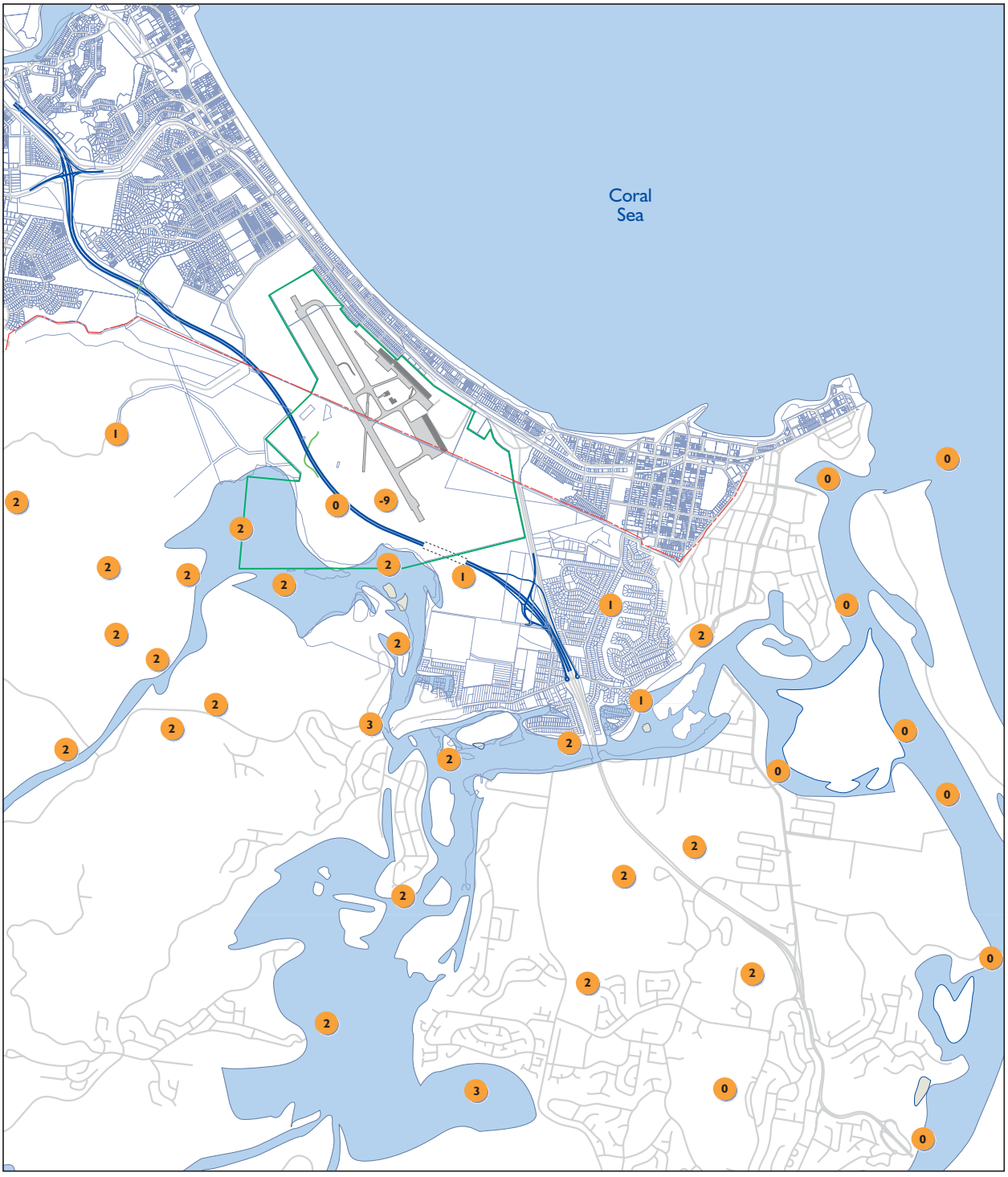


Figure 8.6 **Impacts on Tweed River Flooding during the 100-Year Average Return Interval Event**

Local and minor catchments

The construction of the proposed bypass over a series of drainage channels would require the incorporation of waterway openings into the concept design to maintain natural overland flow and drainage. In some circumstances, the construction of waterway openings and synthetic channels would increase the velocity of the flow of water and consequently increase flood levels. However, the impact of this increase would be negligible, given the existing and proposed land use of the catchments, and the expected low flood levels.

In accordance with the *Policy and Guidelines for Bridges, Roads, Causeways, Culverts and Similar Structures* (NSW Fisheries 1999), the crossings have been designed as box culverts and sized to maintain existing low and peak flows and facilitate fish passage as much as is practical.

Three minor catchments discharge where the proposed road tunnel would be located from chainage 5,450 to 6,000. It is proposed to divert these catchments to discharge over the reinstated ground over the tunnel, which would alleviate any potential flow problems.

It is proposed to construct a catch drain on the eastern side of the bypass to maintain existing overland flows across the areas at chainage 5,800 to 6,000. This would be required to divert flows around the tunnel approach embankment.

Design details of all drainage structures, including locations, associated with the proposal can be found in Technical Paper 2.

8.3.4 Environmental management

The primary means of managing the potential impacts of the proposal on flooding is to include the necessary waterway openings across the alignment of the Tugun Bypass and provide adequate drain rerouting where this is required. These structures would maintain flood levels to an acceptable level of afflux. The locations of the proposed culverts are shown on Figure 8.5.

8.4 Groundwater

8.4.1 Approach and method

The groundwater investigations focused on the identification of any impacts that might ensue from the construction and operation of the proposed Tugun Bypass. These investigations included a desktop study, field investigations and development of a groundwater model.

Field investigations involved aquifer testing, groundwater level measurement, groundwater monitoring using electronic sensors and loggers, and groundwater sampling and chemical analysis. The data obtained was used to construct a numerical groundwater model (MODFLOW) which:

- evaluates groundwater flow direction and volume in the vicinity of the proposed road tunnel
- identifies mitigation measures necessary to maintain groundwater conditions as close as possible to those existing
- assesses potential impacts during the construction and operational phases of the proposal with the mitigation measures in place.

Details of the model and an assessment of the results are included in Technical Paper 9.

8.4.2 Existing environment

The northern section of the study area has a single geological environment that influences the hydrogeology. In this area the alignment passes over impervious rock. The rock underlying the northern section is classified as part of the Neranleigh–Fernvale Group, and consists of predominantly fine-grained sediments of marine origin which weather to clayey soils. Due to their texture, these sediments have very low primary permeability, and any groundwater in the rock flows in fracture zones.

Bores installed to a depth of 30 m in the ridge behind the John Flynn Hospital and Medical Centre were dry on drilling, and were still dry three months after installation.

In the southern section of the study area, the rocks are covered by sand. The sand forms an aquifer, while the older impervious rocks under the sand form the base of the aquifer and are termed the 'bedrock'. The water table is shallow, varying from 0.1 m to 3.7 m below ground level. Results from permeability testing are lower than those typically encountered in coastal dune systems. This has been attributed to the widespread cementation in the sand sequence (known as 'coffee-rock').

Groundwater recharge

'Groundwater recharge' is the term used to describe the replenishment of the water table. In the southern section, this is from direct rainfall infiltration through the unsaturated zone. Recharge over the sand aquifer depends on the topography and vegetation, with a high proportion of rainfall infiltrating in the flat, grassed areas around the airport. Infiltration would be lower in areas with well-established native vegetation and impermeable surfaces.

Run-off from the main runway at Gold Coast Airport would discharge onto the ground surface at the runway edges. Although this is a line recharge, the groundwater level rise at the edges of the runway rapidly dissipates into the aquifer, and the overall effect is similar to groundwater conditions without the runway.

Groundwater flow

The combination of recharge and topography has formed a groundwater mound roughly in line with the runway. This results in groundwater movement away from the mound towards Cobaki Broadwater in the south-east and towards Coolangatta Creek in the north-west. Water would enter the groundwater system as direct rainfall recharge and discharge to Coolangatta Creek and Cobaki Broadwater. Existing groundwater levels are shown in Figure 8.7.

Groundwater flow velocities are a function of the aquifer permeability and the hydraulic gradient. Despite the mound, groundwater gradients are low and groundwater movement slow. The vertical flow restrictions imposed by the cemented lenses of coffee-rock imply that deep groundwater movement would be restricted and most groundwater flow would take place in the upper 4 m of the aquifer.

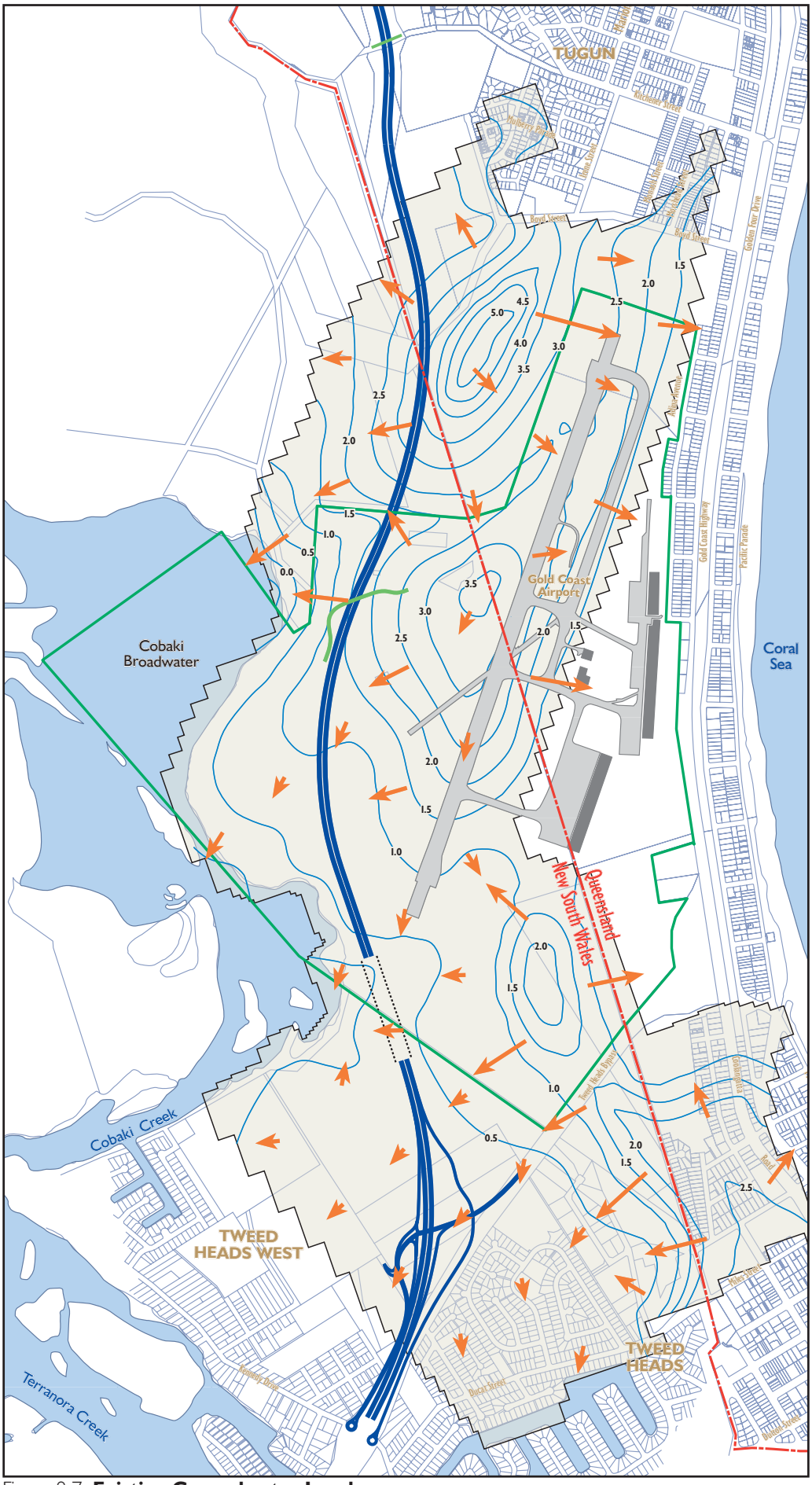


Figure 8.7 **Existing Groundwater Levels**

Groundwater use

The sand aquifer potentially offers reasonable bore yields because of its relatively high permeability. It thus comprises a valuable groundwater resource, although of relatively small size. Extensive extraction of groundwater would, however, be restricted by coupled intrusion of saline water from the estuary.

Groundwater, as part of the natural water balance, is used by vegetation (shrubs and trees), particularly in low-lying areas. Coolangatta Creek and the wetland areas close to Cobaki Broadwater would also receive groundwater as part of their base flow.

Groundwater quality

In undisturbed areas, the sand aquifer contains low-salinity groundwater. Existing and past land uses, such as the Tugun Landfill, however, appear to have affected groundwater quality in the area.

Groundwater sampling and analysis were carried out at 14 boreholes across the study area. Eight are monitoring bores around the Tugun Landfill site, one is a monitoring bore for the airport fire training area, and the remaining five were installed as part of the geotechnical investigation for the EIS and are in the area close to the proposed tunnel.

Groundwater is generally of low salinity, with total dissolved solids between 34 and 622 mg/L, with one sample from a bore adjacent to the landfill of 1,514 mg/L. This suggests that most of the groundwater is fresh, with total dissolved solids below 1,000 mg/L. Conditions are acidic to slightly acidic, with pH ranging from 4.35 to 6.85.

Major ion chemistry indicated a sodium-chloride-type groundwater. Bicarbonate content is low, with slightly raised values indicating increased dissolved carbon dioxide associated with the landfill site.

Ammonia concentrations of up to 61 mg/L occur in the area of the Tugun Landfill site. Ammonia was not analysed in bores at some distance from this site, but other nutrients (nitrogen and phosphorus) were detected. Levels were above Australian and New Zealand Environment and Conservation Council aquatic ecosystem guidelines, but the source could be natural, as estuarine muds accumulate high nutrient levels from decaying plant matter and estuarine organisms.

Samples from the boreholes around the Tugun Landfill indicated elevated salinity, sulfate, ammonia and iron concentrations compared to background water quality in the sand aquifer, suggesting the possibility of leachate contamination of the groundwater.

Observations regarding the quality of the groundwater in the study area are summarised in Table 8.4.

Table 8.4: Groundwater quality

Parameter	Comments
Salinity	Low salinity levels, with values for total dissolved solids ranging from 34 to 622 mg/L (one sample located adjacent to the landfill had the result of 1,514 mg/L).
pH	Acidic to slightly acidic conditions with pH ranging from 4.35 to 6.85.
Ion chemistry	Major ion chemistry indicates a sodium-chloride-type groundwater.
Bicarbonate content	Low bicarbonate content, with slightly raised values indicating increased dissolved carbon dioxide associated with the landfill site.
Ammonia	Concentrations of ammonia of up to 61 mg/L have been recorded in the Tugun Landfill area.
Nitrogen and phosphorus	Nitrogen and phosphorus have been detected away from the landfill. However these levels are not unnatural for estuarine sediments.
Dissolved metals	Low levels of dissolved metals, with higher levels of zinc (up to 0.49 mg/L) and iron (up to 3.12 mg/L, higher around the landfill site). The presence of dissolved metals is probably due to the low pH resulting in increased solubility and migration.

8.4.3 Potential impacts and mitigation measures

General road construction

Potential impacts on groundwater resulting from general road construction are considered to be minor. Changes in recharge to the sand aquifer would be small because of the linear nature of the road corridor, and no detectable change in groundwater levels is expected.

All other potential impacts would be minimised by ensuring that site practices follow the requirements of the Construction Environmental Management Plan, as set out in Chapter 18.

Tunnel construction

A number of aspects of the road tunnel construction have potential groundwater impacts.

These were investigated using a numerical groundwater model. Details of the model and an assessment of the results are contained in Technical Paper 9. The modelling included the effects of both the road and rail tunnels.

Dewatering

Lowering of the groundwater around the road tunnel has the potential to reduce groundwater levels and/or groundwater flow to receptors, particularly Cobaki Broadwater and its associated wetlands. Dewatering could also allow the intrusion of saline water from the estuary into the adjacent sand aquifer.

Widespread lowering of groundwater levels around the proposed tunnel would be unacceptable because of the proximity to wetlands and the potential reduction in water flows and levels that would result. Pumped groundwater would therefore need to be reinjected into the sand aquifer to maintain groundwater levels outside the tunnel at, or close to, natural conditions.

Groundwater removed from the sand aquifer during dewatering would be reinjected using a series of wells on either side of the tunnel. During the three main phases of construction and dewatering, different volumes of water would be removed from the aquifer. These would be returned via the injection wells.

Injection wells on either side of the tunnel would be installed to return water removed during diaphragm wall construction. This would allow localised drawdown at the dewatering point, but prevent drawdown beyond the injection points. The results of the groundwater modelling indicated no noticeable change to levels or flows at the nearby wetlands. Modelled groundwater contours after 6 months with and without mitigation measures in place are shown in Figure 8.8.

Obstruction of groundwater flow

Construction of diaphragm walls and tunnel walls would create obstructions to groundwater flow. Such obstructions would result in increased groundwater levels on the upgradient side, and decreased levels and flow to Cobaki Broadwater and associated wetlands on the downgradient side.

Mitigation of these obstructions during construction, via the dewatering and injection approach, would ensure that groundwater flow continues past the tunnel.

Settlement of soft soils under embankment loading could also result in changes to subsoil permeability. Such changes could affect groundwater flow patterns. Monitoring would be undertaken to determine if there are impacts on groundwater flow.

Turbidity

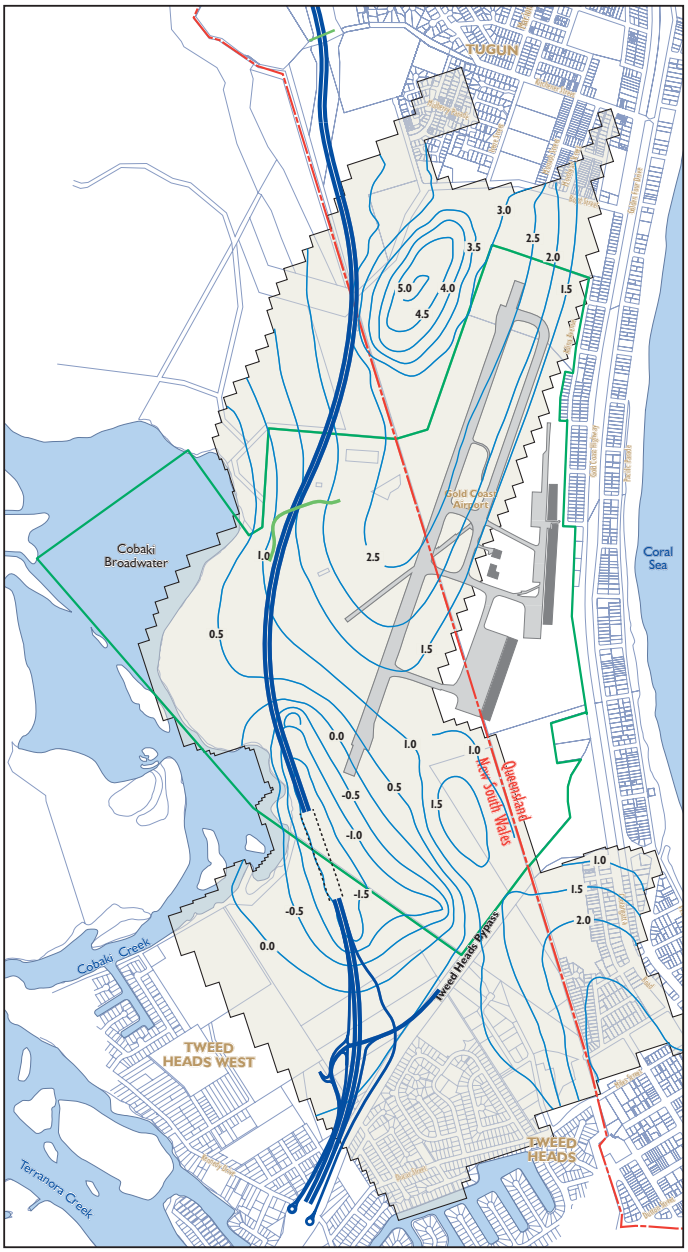
Disturbance of the aquifer, pumping, and excavation and placement of diaphragm walls could allow mobilisation of fine material in the groundwater. However, the nature of the sand aquifer would limit the extent of this effect by physical filtration of the material during groundwater flow.

Turbidity of the pumped water poses serious implications for injection (such as blinding of injection well screens). Turbidity would therefore be monitored, and settling basins used to remove suspended material if necessary.

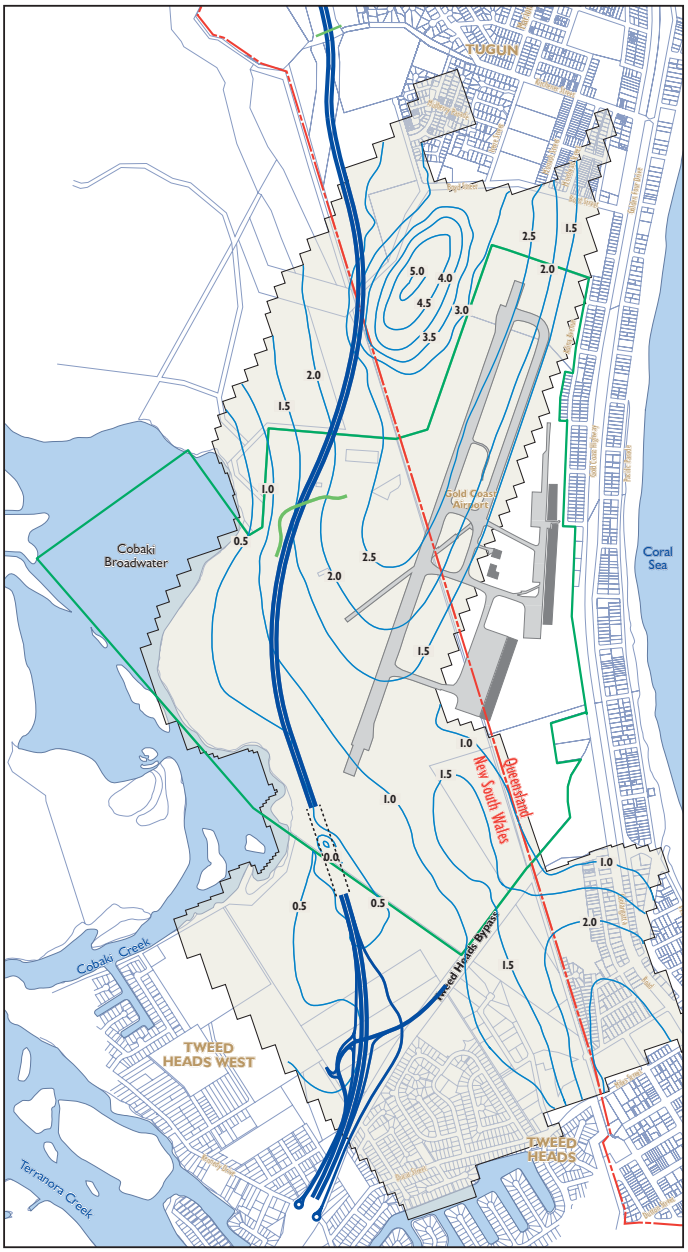
Production of acid groundwater

Lowering of the water table would allow oxygen to reach affected parts of the aquifer, which could result in the oxidation of sulfide minerals. This process generates acid which, on rewatering, could migrate as acidic groundwater, potentially affecting groundwater receptors.

The model shows that mitigation prevents extended or prolonged groundwater drawdown during all phases of construction. Therefore the temporary, small-scale dewatering required during construction is unlikely to generate acidic groundwater. All groundwater resulting from the tunnel excavation would be reinjected into the aquifer. In the event that high turbidity levels require the treatment of groundwater in settling basins, pH would also be monitored and the water treated prior to reinjection, if necessary.



Without Mitigation Measures



With Mitigation Measures

0 500 m

Figure 8.8 **Groundwater Contours after Six Months**

- Proposed Tugun Bypass
- Gold Coast Airport Boundary
- Queensland/NSW Border
- Proposed Access Bridges
- Tunnel
- Extent of Groundwater Model
- 1.5 Groundwater Elevation (mAHD)

Groundwater salinity

Measurements of groundwater salinity have shown that salinity levels at the southern end of the study area are high, almost equivalent to those of seawater. This is natural in a tidal environment, with evaporation after tidal inundation leading to efflorescence.

Operational phase

Road run-off

Road run-off can contain pollutants resulting from normal use of the road, as well as from leaks, spills, and accidents. Pollutants can include hydrocarbons (petrol, diesel, oils), metals, nutrients (nitrogen compounds from exhausts) and other compounds.

Groundwater recharge

The presence of impermeable surfaces along the road alignment would reduce groundwater recharge unless run-off is directed to soakways. Over the sand deposits, recharge would be reduced, but the relatively narrow width of the road means that this is unlikely to affect groundwater levels.

Obstruction of groundwater flow

The proposed road tunnel would form an impermeable barrier across the groundwater flow path, extending below the surface to a depth of 20 m. Groundwater would be able to flow across the roof of the tunnel through the replaced sand, but this is unlikely to be sufficient to prevent mounding of groundwater on the upgradient side (potentially causing waterlogging and localised flooding), and reducing groundwater levels and flows to the wetlands on the downgradient side.

Mitigation during the operational phase would be in the form of drains connecting both sides of the tunnels to equalise groundwater levels. The effect of the drains is to reinstate groundwater levels and allow unhindered groundwater movement, as before construction. Refer to Technical Paper 2 for further design details.

Modelled impacts

Modelling has shown that dewatering for cut-off wall construction would lower water levels by 2 m adjacent to the tunnel walls. During ramp and tunnel construction, water would be removed at the same time as the subsurface material is excavated. This would have an effect similar to, but less widespread than, dewatering for the diaphragm walls.

The groundwater model shows that, in the absence of mitigation measures, undesirable lowering of groundwater levels would occur adjacent to sensitive wetland areas during construction. Impacts would be minimised by the use of re-injection spears, resulting in little or no change to groundwater quantity and quality.

During the operation of the tunnel, cross-alignment drains would equalise groundwater levels on either side. This would allow unhindered groundwater movement, reinstating flows across the barrier provided by the tunnels and their access ramps.

Table 8.5 provides a summary of the proposed mitigation measures during construction and operation for the proposed tunnel.

Table 8.5: Summary of groundwater mitigation measures for the tunnel

	Potential impact	Mitigation measure
Construction phase		
Diaphragm wall installation	Groundwater drawdown.	Groundwater returned via injection wells on both sides of the tunnel.
Roof excavation	Groundwater drawdown between diaphragm walls.	Limited depths of dewatering and excavation. Diaphragm walls limit impacts.
Ramp excavation	Groundwater drawdown between diaphragm walls.	Groundwater returned via injection wells. Diaphragm walls limit impacts.
Tunnel excavation	Groundwater drawdown between diaphragm walls.	Groundwater returned via injection wells. Diaphragm walls limit impacts.
Operation phase		
	Groundwater flow restricted by barrier.	Cross-tunnel and ramp drainage reinstates groundwater flow.

8.4.4 Environmental management

Environmental management during both construction and operation would include monitoring of water levels and pumped water quality. During operation, additional inspections of the drainage system would be necessary. In all cases, if monitoring indicated inadequate performance of the measures included in the design, remedial actions would be initiated. These could include increasing the number of injection wells and in-line treatment of the pumped water. Management measures relating to the maintenance of groundwater flow, levels and quality for the road and tunnel are summarised in Table 8.6.

Table 8.6: Summary of groundwater management measures for the road and tunnel

	Potential impact	Mitigation measure
All phases		**Monitoring and management**
	Groundwater drawdown.	Water level monitoring. Increase number of injection wells used if drawdown impacts extend beyond injection line or if rate of injection is slow. Monitoring bores included for water level monitoring, pH measurement and sampling.
	Acid generation.	Pumped water quality monitoring. Inline treatment to commence if pH trend changes by more than 0.2 of a unit from background trend.
Operation phase		**Monitoring and management**
	Drain operation.	Water level and regular drain inspection. Water levels should equalise. Rising or falling levels on one side of the tunnel indicate drain malfunction.
	Water quality impacts from road run-off.	Water quality monitoring to include major iron chemistry and expected organic contaminants.

8.5 Water quality

8.5.1 Approach and method

Investigations of surface water quality focused on the determination of existing conditions, the identification of potentially adverse effects during construction and operation, and the definition of mitigation measures to be included in the design and management procedures aimed at maintaining water quality at acceptable levels. Technical Paper 8 provides more details of the water quality assessment.

8.5.2 Existing environment

Cobaki Creek and Broadwater

Data on water quality was obtained from both existing information and field investigations within and around Cobaki Broadwater. These data were compared to water quality guidelines in *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (Australian and New Zealand Environment and Conservation Council 2000). Water quality monitoring locations are shown in Figure 8.9 and the results summarised in Table 8.7.

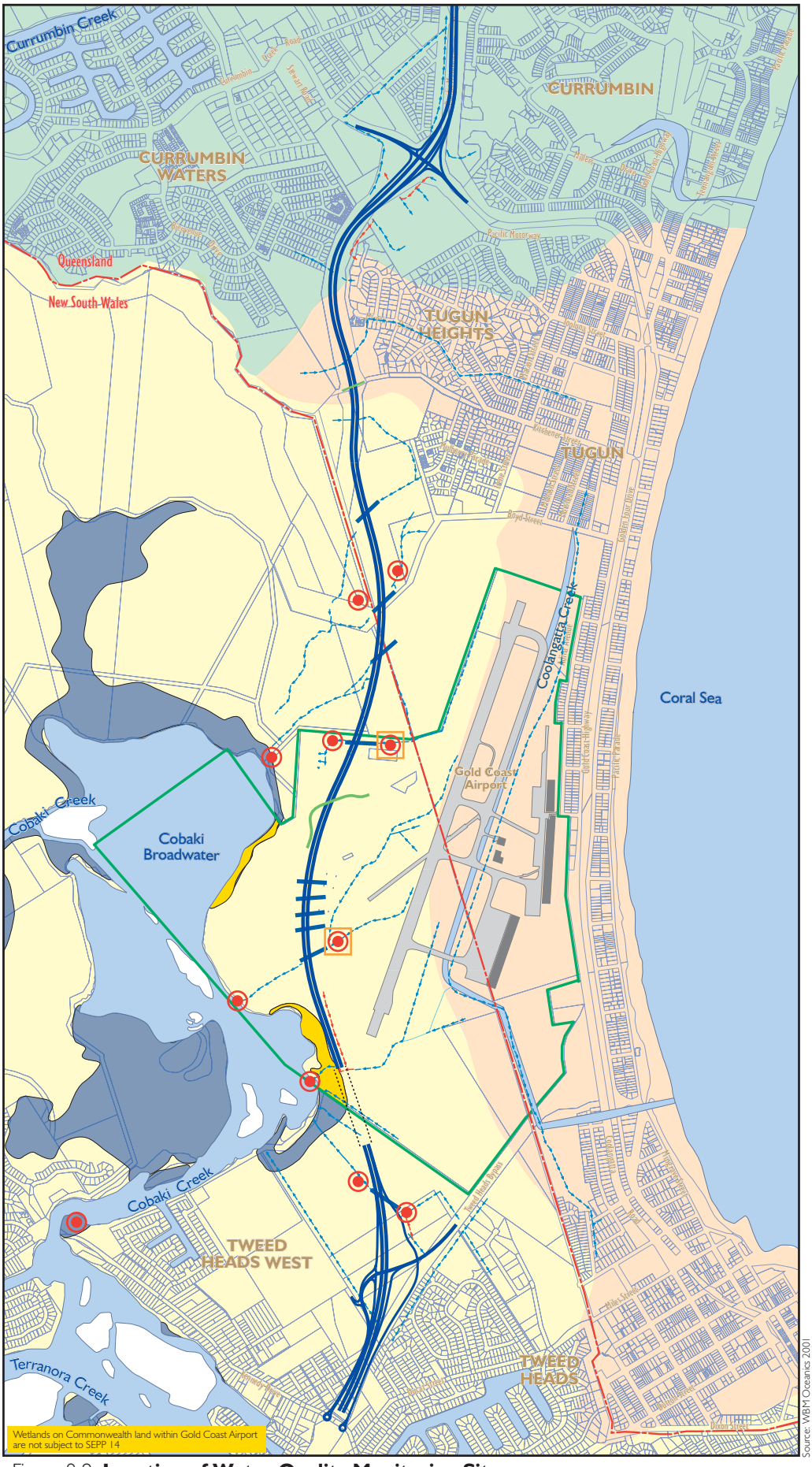
Table 8.7: Water quality in Cobaki Broadwater

Parameter	Comments[1]
Dissolved oxygen	Levels were typically within the range specified by ANZECC (2000) default trigger values of 90–110% saturation.
pH	Levels were typically above neutral (pH 7.0), although they did appear to drop slightly following significant run-off.
Salinity	Salinity levels during dry weather flows were generally high (>30 g/L), though they did appear to decrease following significant run-off.
Turbidity and total suspended solids	Turbidity and total suspended solid levels were seen to vary according to preceding rainfall conditions. During the monitoring, turbidity concentrations exceeded the upper ANZECC (2000) default trigger at three sites. Generally, however, levels were typically low to moderate throughout the monitoring period, indicating good water clarity. Wind-induced re-suspension of bed sediments and impact of turbid inflows from the upstream catchment are likely to account for much of the elevated turbidity levels.
Ortho-phosphorus and ammonia	Concentrations typically exceeded ANZECC (2000) guideline levels. However, they are not outside the range of values typically observed in similar estuaries throughout Queensland and northern NSW. The low chlorophyll-a concentrations observed during the monitoring episode conducted for this study indicate that nutrient levels do not appear to be causing undesirable levels of phytoplankton growth.

Note 1: Derived from historical data and measurements taken during field investigations for the EIS.

Source: WBM Oceanics

Results suggest that waters of Cobaki Broadwater have salinity levels near those of seawater during dry weather. Following considerable rainfall events (24 hours of rainfall), salinity levels in the Broadwater have been observed to be approximately 30% of those of seawater. Cobaki Broadwater exhibits typically healthy dissolved oxygen and pH levels and shows little stratification. Ortho-phosphorus and ammonia concentrations have, however, frequently exceeded Australian and New Zealand Environment and Conservation Council (ANZECC) guideline levels.



- Proposed Tugun Bypass
- Gold Coast Airport Boundary
- Queensland/NSW Border
- Proposed Access Bridges
- Tunnel
- Currumbin Creek Catchment
- Coolangatta Creek
- Cobaki Broadwater and Tweed River Catchment
- NSW State Environmental Planning Policy 14 Wetlands
- Continuation of Wetland Boundary
- Proposed Road Culverts
- Proposed Watercourse
- Existing Watercourse
- Suggested Water Quality Monitoring Sites
- Integrated Ground Water Sampling Sites (Monthly)

0 1.0 Km

Figure 8.9 **Location of Water Quality Monitoring Sites**

Currumbin Creek

Water quality data for Currumbin Creek shows that salinity levels appear consistently high and are approaching those of seawater. Dissolved oxygen levels and pH are within acceptable limits, and turbidity and total suspended solid levels are low, as would be expected in a saline environment.

Nutrient levels are generally low; however, the results show that the ANZECC criterion for ammonia has been exceeded on occasion. Faecal coliform levels show high variation, which is likely to occur during high-rainfall events when sewer overflows can occur.

Coolangatta Creek

Water quality in Coolangatta Creek, in the vicinity of the proposal, is monitored routinely by Gold Coast Airport Limited.

Water quality monitoring results demonstrate large fluctuations in pH and nutrient levels in the creek, on occasion exceeding the ANZECC (2000) default trigger values for zinc, aluminium, copper, lead, nickel, pH and total phosphorus.

8.5.3 Potential impacts and mitigation measures

Impacts during construction

The most serious potential risks to water quality in Cobaki Broadwater, Cobaki Creek, Currumbin Creek, Coolangatta Creek and the Tweed River would be during the construction phase, through export of sediment and associated pollutants, such as nutrients, and the discharge of untreated acid drainage from acid sulfate soils. Mitigation of water pollution is best achieved by optimising control measures as close to the source as possible.

A comprehensive Soil and Water Management Plan, which includes an Erosion and Sediment Control Plan, would be developed for the construction period. This would require:

- adopting best management practices for the control of erosion sediments and pollutants during the construction period
- ensuring that the construction of the proposal minimises impacts on existing water quality of surrounding catchments.

The Soil and Water Management Plan and Erosion and Sediment Control Plan would be prepared as part of the Construction Environmental Management Plan, which would be completed before the start of construction. This is discussed further in Chapter 18.

Impacts during operation

The proposed bypass has the potential to impact the water quality of downstream watercourses by introducing contaminants associated with the use of the road, including:

- stormwater-related contaminants:
  - suspended sediment from roadway surface or embankments
  - contaminants such as heavy metals attached to particles washed off the road surface
  - oil, grease and other hydrocarbon products

- litter.

- accidental spillage of pollutants released into the drainage system either as a result of a collision or some other incident.

These pollutants potentially affect the environment in the following ways:

- suspended sediments reduce clarity of water and cause the silting of downstream waterways
- heavy metals are toxic to aquatic biota
- oils and grease are unsightly and cause water quality problems in streams
- litter is unsightly and pollutes streams
- accidental spills of chemicals or petrol can cause severe damage to the ecology of waterways.

8.5.4 Environmental management

Management measures during construction

Due to the high environmental values of the receiving waters (particularly Cobaki Broadwater), sedimentation basins would be installed as part of the controls to settle sediment before discharge to the receiving environment.

A sedimentation basin is a barrier or dam designed to intercept sediment-laden run-off and retain the sediment. It is usually located at the lower side of a construction site or at another stormwater collection point. The purpose of the basin is to hold run-off for a sufficient period to allow suspended sediment to settle before release. Flocculants would be used if required.

Such basins minimise the release of sediments into creeks and receiving waters and the resulting damage to vegetation and wildlife. They also minimise any potential for clogging of stormwater pipes and floodways.

Erosion and sediment controls would be designed during the period of detailed design of the proposed bypass, before the commencement of construction. All erosion and sediment controls (including sedimentation basins) would be designed to be consistent with the requirements of *Managing Urban Stormwater — Soils and Construction* (NSW Landcom 2004). They would also be designed to dry out quickly after rainfall events.

Birds attracted to the area by the basins are considered to be a problem for airport operations and would be considered in the siting of basins. The presence of birds would be monitored, and appropriate action taken should this prove to be a problem. Netting of ponds has proven to be effective in other situations and would be used here if necessary.

The locations of the proposed sedimentation basins are shown in Technical Paper 8 and on Figure 6.13.

Management measures during operation

Road drainage treatment

The concept design for the treatment of stormwater has the aim of ensuring that run-off from the bypass would receive appropriate treatment before release. A number of stages of treatment would be used, known collectively as a 'treatment train'.

The measures that would make up the treatment train are as follows:

- **Filter strips and swales:** These are vegetated surface features that drain water evenly off impermeable areas. Swales are long shallow channels, while filter strips are gently sloping areas of ground. They allow run-off to flow in sheets through vegetation, slowing and filtering the flow. Swales also act to temporarily store and infiltrate the run-off into the ground. Sediments are removed from the water, and vegetation can take up any nutrients in the water. However, they are less effective in removing hydrocarbons. Maintenance consists of clearing litter, and periodic removal of excess silt.
- **Constructed wetlands:** A constructed wetland uses natural geochemical and biological processes in a wetland ecosystem to treat pollutants in road run-off. Removal of pollutants is accomplished through adsorption, wetland plant uptake, retention, gravitational settling, physical filtration and microbial decomposition, thus improving run-off quality. These processes account for the strong removal rates for suspended solids, oils and grease, organic matter (particulate BOD), and sediment-attached nutrients and metals. Typical features of a constructed wetland include a deep sedimentation zone to allow for the settlement of suspended solids, areas of reeds and other wetland plants, an overflow spillway and an outlet point. Discharge from the wetlands would be directed to the receiving waters of Cobaki Creek and Broadwater, and to Coolangatta Creek. Some of the ponds used for sedimentation control during construction would be converted to constructed wetlands on completion of the site works. Area requirements are similar to those for sediment control. Bird issues associated with the airport would need to be considered in the siting of these.

Accidental spill management

The proposed bypass would be used as a freight route in the southern Gold Coast – Tweed region, and hazardous materials would be transported along it. The high safety standard of the road means that the risk of a collision or accident is reduced, although some risk of accidental spillage of hazardous materials would always remain.

Stormwater channels would be designed to allow for the use of temporary bunding and containment of run-off to mitigate the potential impacts of accidental spills.

Stormwater and spill management within the tunnel

Heavy rainfall in the area of the tunnel would result in surface water run-off from the approach ramps running into the tunnel. The surface run-off would be collected by roadside drains and directed to collection sumps in the tunnel. Run-off collected in the sumps would be pumped up to ground level to the nearest treatment train for disposal.

In the event of a spill of hazardous material in the tunnel, this would also be collected in the sumps. The traffic control centre monitoring the traffic in the tunnel would have a cut-off switch which would disable the pumps in the sumps. The spilt material would then be pumped out of the sumps and disposed of to an appropriate liquid-waste treatment facility.

Monitoring

The assessment of potential for impacts to water quality within the project area has identified the Cobaki Broadwater as the main water body receiving drainage water from the proposed bypass.

The high environmental values of the Cobaki Broadwater and Terranora Creek further downstream mean that the measures proposed to control water quality need to be monitored to ensure that they are performing effectively, and to establish whether any impacts are the result of the proposed bypass, or the result of other development works or land uses in the area.

Impacts on water quality of the receiving waters could arise during both the construction and operation of the proposed bypass; therefore an effective monitoring program needs to cover the pre-construction, construction and operational phases of the bypass.

Groundwater levels within the study area are close to the surface during wet periods and during those times groundwater – surface water interactions may occur.

To take account of the local conditions, the water quality monitoring program has integrated monitoring for surface water and groundwater.

The proposed bypass does not cross any permanently wet or flowing watercourses, but does cross a number of drainage lines. Monitoring would be undertaken after sufficient rainfall results in surface water run-off reaching the drainage lines.

Monitoring locations

A number of monitoring locations have been included on Figure 8.10. At present these are only indicative and would be finalised during the preparation of the Construction Environmental Management Plan. It may also be necessary to introduce other temporary monitoring locations during various phases of the construction program. The rationale behind the selection of monitoring locations is to ensure that there are a number of sites to monitor the quality of the receiving waters, in this case the Cobaki Broadwater, both upstream and downstream of areas adjacent to the proposed bypass (the Cobaki Broadwater is also tidal, so the terms 'upstream' and 'downstream' are used loosely in this context). The other monitoring locations are also chosen to be near to the proposed bypass, to monitor surface water and groundwater as close as possible to the areas where run-off is generated.

Pre-construction monitoring

The pre-construction sampling regime has included a number of surface water monitoring events as part of the studies for this EIS. Full details are listed in Technical Paper 8. As these events occurred some time ago, another two events would be undertaken before construction begins. This would occur when at least 25 mm of rainfall occurs in less than 24 hours. A selection of the following parameters would be measured depending on jurisdiction:

- pH
- conductivity/salinity
- turbidity
- dissolved oxygen
- total suspended solids (TSS)

- visible oil and grease
- temperature
- metals (copper, zinc, lead, nickel, cadmium and chromium)
- ammonia
- total nitrogen
- total phosphorous.

Monitoring of groundwater quality has also been undertaken as part of the studies for the EIS, with the last monitoring taking place in 2003. Boreholes within the airport are monitored regularly by Gold Coast Airport Limited, as part of the environmental management regime for the airport. In addition, boreholes outside the airport are also monitored as part of the assessment of old landfill sites.

Parameters that would be measured as part of the groundwater program would depend on the jurisdiction and location of the site and could include:

- pH
- conductivity
- dissolved oxygen
- total suspended solids
- temperature
- metals (As, Cd, Cr, Cu, Pb, Ni, Zn, Hg)
- total kjedhal nitrogen (TKN)
- nitrate
- nitrite
- ammonia.

Where elevated analyte concentrations are reported, this may trigger more frequent monitoring or further analytical or ecological testing. Where no problems are identified, the monitoring frequency may be reduced.

Construction monitoring

Monitoring of surface water and groundwater would continue during the construction phase. Parameters to be tested would be determined during the preparation of the Construction Environmental Management Plan. It would have the objectives of identifying if water quality problems are occurring as a result of the construction activities and of demonstrating compliance with legal and other monitoring requirements. Other new sampling sites may be introduced to take account of particular construction activities; for example, temporary sedimentation basins would require checking. before any discharge. In addition the water quality sampling would be complemented by visual inspection.

Samples would be collected at a rate of two per month during periods when rainfall results in any discharge from the site, or when discharging from a point source such as a sedimentation basin. In periods when there is no rainfall, sampling would be limited to once per month.

Operational monitoring

A practical and cost effective water quality monitoring program would continue after the opening of the bypass. The objectives for this stage of the monitoring program would be to assess and manage impacts on receiving waters as the site stabilises, and to assist in determining when the site has stabilised. The monitoring locations would be reviewed at the beginning of the operational phase of the bypass to assess if they are still suitable. Changes in the hydrological conditions along the bypass may render some of the sites redundant and others may need to be introduced to monitor the effectiveness of the stormwater management system.

Sampling frequency would be monthly until results show that all or parts of the site have stabilised, at which point the monitoring frequency may be reduced or monitoring discontinued.

Parameters monitored during the operational phase of the bypass would be considered in the Operational Environmental Management Plan in consultation with the regulatory agencies. Individual parameters and sites may be withdrawn from the program as the site stabilises or the parameter is no longer of concern — for example, where erosion has been controlled through revegetation and all operational stormwater controls have been installed.

8.6 Additional studies during the detailed design phase.

The geotechnical and groundwater investigations undertaken for the EIS have provided sufficient data to allow for the development of the concept design and to test the feasibility of the design concepts. The detailed design phase will require more detailed information geotechnical and groundwater issues. Further investigations are planned to gather the additional data.

The geotechnical activities would comprise drilling 32 boreholes, 21 test pits and 18 groundwater monitoring and pumping locations. This would provide additional data for the design of the tunnel, further refine the groundwater re-injection system and allow for detailed design of structures such as bridges and cuttings.

An environmental management plan would be prepared and implemented to ensure that any environmental impacts associated with the investigations are monitored and managed. Consultation with all affected parties including agencies, the Traditional Owners and landholders would take place prior to the start of the investigations.

8.7 Implications for ecologically sustainable development

8.7.1 The precautionary principle

The potential impacts of the proposal on soils, groundwater and surface water have been assessed following site surveys and investigations using computer-based modelling methods. Appropriate design components have been included in the proposal to mitigate undesirable effects, and management measures would be used to control the potential effects of acid sulfate soils.

The consequences of building and operating the bypass have been assessed, and the means of mitigating any impacts incorporated in the proposal. The performance of these measures would be monitored during construction and following opening, and necessary responses would be made to ameliorate undesirable consequences.

8.7.2 Intergenerational equity

Measures have been included in the proposal to manage expected impacts on soils, and on surface water and groundwater flows and quality. These measures should ensure that the local terrestrial and aquatic environments remain in a healthy condition.

8.7.3 Conservation of biological diversity

The maintenance of surface water and groundwater flows and quality would ensure that existing biological diversity is maintained.

The implications of soils and water impacts for ecological sustainability are summarised in Table 8.8.

Table 8.8: Implications of soils and water impacts for ecologically sustainable development

Precautionary principle	Intergenerational equity	Conservation of biological diversity
Geology		
The geotechnical investigations have shown that there is a risk of adverse impacts from acid sulfate soils. The implementation of an Acid Sulfate Soil Management Strategy would ensure that any impacts are managed. Therefore the consequences are predictable and the means of mitigation available.	Erosion control measures operating during construction would maintain minimum loss of soils within the local environment.	The minimal impacts on local soils would not lead to indirect impacts resulting in loss of genetic or ecosystem diversity.
Groundwater		
Computer modelling of the water table has been undertaken to assess the impacts of the tunnel during construction and operation. This particularly focused on the need to ensure that there would be no significant drawdown of the high local water table, which could affect the health of local wetlands.	Design work has been undertaken to develop a system of injection wells to ensure that drawdown is minimised during construction, and a cross-tunnel drainage system would be used to achieve equilibrium in the level of groundwater on either side of the tunnel and the approach ramps.	Groundwater levels during construction would be returned via injection wells, minimising any impacts. Groundwater flows would be reinstated following completion of the tunnel works, ensuring that the proposal would not lead to any loss of ecosystem diversity in local wetlands.
Hydrology		
Results of the hydrological modelling have shown that any afflux resulting from the introduction of the bypass into the local area would be minimal. The new structure would have little effect on the level of flooding, removing any threat of serious flood drainage attributable to the proposal.	The new bypass would not lessen the holding capacity of the local area, as suitable culverts would be included in the design to allow free passage of floodwater.	There would be no hydrological or flooding impacts that would contribute to the loss of genetic, species or ecosystem diversity.

Precautionary principle	Intergenerational equity	Conservation of biological diversity
Water quality		
Surveys have been conducted to assess existing water quality in the creeks and wetlands crossed by or adjacent to the proposed bypass.	Design work has been undertaken to include a drainage system that would ensure no deterioration of quality in any of the receiving waters during construction. Quality would be maintained during operation by the use of sedimentation basins to treat surface water run-off. This would ensure that the health and productivity of the aquatic environment is maintained.	Existing water quality in the creeks and wetlands would be maintained, ensuring that the proposal would not lead to any loss of genetic, species or ecosystem diversity within the creeks and wetlands.

8.8 Conclusions

In common with all road projects, construction of the Tugun Bypass presents a potential risk to water quality. The primary risk occurs while soils are exposed during earthworks when suspended sediment and associated pollutants can be washed into downstream watercourses. This can cause siltation of waterways and damage to ecosystems. A soil and water management plan would be prepared for the Tugun Bypass indicating guidelines to be followed to address water quality impacts. During operation of the Tugun Bypass, there is the potential for water pollution originating from the road to affect Cobaki Creek and the Broadwater. A system of filter strips and swales along with constructed wetlands will treat run-off from the bypass once it is opened.

A number of aspects of the tunnel construction have the potential to affect groundwater. These relate to the consequences of lowering the groundwater during construction and the possible obstruction of groundwater movement following the positioning of the tunnel walls within the aquifer. Lowering of the groundwater around the tunnel during its construction has the potential to reduce levels and/or flows to Cobaki Broadwater and its associated wetlands. Groundwater would therefore be pumped across the tunnel obstruction for re-injection into the sand aquifer to maintain groundwater levels at or close to natural conditions during the time it takes to build it. Computer modelling has shown that the operation of injection wells would result in no noticeable change to levels or flows at the nearby wetlands during construction.

Lowering of the water table could result in the oxidation of sulfide materials in the soil. This process generates acid which, on rewatering, could migrate as acidic groundwater. Once built the tunnel would form an impermeable barrier across the groundwater flow path extending up to a depth of 20 m. Mitigation during the operation of the bypass would consist of a network of cross-alignment drains which would equalise groundwater levels on either side of the obstruction. This would allow unhindered groundwater movement, reinstating flows across the barrier provided by the tunnel and its access ramps. Management during both construction and operation would comprise monitoring of water levels and pumped water quality. Additional inspections of the drainage system would be undertaken during operation. In all cases, if monitoring indicates inadequate performance of the measures included in the design, remedial actions would be initiated. These could include increasing the number of injection wells and in-line treatment of the pumped water.

The alignment will pass through a number of areas that have been subject to potentially contaminating uses in the past and will also require the removal of a small portion of the Tugun Landfill and old dump site on the airport. Any contaminated material will be removed to a suitably licensed facility.

9. Meteorology and air quality issues

9.1 Introduction

Motor vehicles are the principal source of airborne pollutants in areas where there is little heavy industry, such as the area around Tugun. The distribution of these pollutants is determined mainly by the changing volume and speed of traffic over the day on the local road network, the topography of the area, and the local weather conditions.

New roads cause a redistribution of traffic and, therefore, a change in the pattern of air quality impacts. Changes in pollutant levels would normally be most evident in a narrow band on either side of the road, with the level of impact increasing along new roads or where more cars are diverted onto existing roads. Pollution levels decrease along existing roads from which traffic has been diverted or along which the travel conditions have improved. The impacts experienced would depend on the type of development adjacent to the road and distance from the road.

The Tugun area currently experiences large traffic volumes with poor travel conditions for much of each day and particularly during peak holiday periods. The air quality in the Tugun area would improve significantly with the construction of the bypass. However, the existing potential for significant air quality impacts is limited by the lack of major industry and the relatively narrow strip of mainly residential and commercial development along the coast. Gold Coast Airport also contributes to pollutant loads, as does, to a lesser extent, Tugun Landfill and the Tweed Heads West Sewage Treatment Works, but there is no evidence of current air quality indicators exceeding relevant guidelines.

9.2 Approach to air quality assessment

9.2.1 Approach and methodology

The assessment of air quality impacts arising from construction and operation of the proposed Tugun Bypass required measurement of existing conditions, modelling of predicted future conditions, and the comparison of both sets of results against each other and against established criteria applicable to the project area. The criteria used are those most relevant to the more important components of vehicle exhaust or to air pollutants that may be generated in significant quantities during construction, including:

- carbon monoxide
- oxides of nitrogen
- particulate matter
- ultra-fine particles
- sulfur dioxide
- odours.

The criteria applicable to these pollutants are generally set based on their potential health effects. Some of these criteria vary between the relevant jurisdictions through which the project passes (NSW, Queensland and Commonwealth Airport Land).

To predict the concentrations of pollutants under various traffic scenarios, dispersion modelling, which is based on emission rates for each pollutant and defined atmospheric conditions, is used. The latter are normally chosen to reflect a worst-case scenario. Comparisons of the results against existing conditions and the relevant air quality goals provide an assessment of the impact of the proposal on the local area.

Changes to traffic distribution and movement characteristics because of the introduction of a new road link in the network also lead to changes in the production of greenhouse gases. Emission rates of the main greenhouse gases (carbon dioxide, nitrous oxide and methane) have been calculated from estimated fuel consumption and the various factors determining changes in vehicle emissions at differing travel speeds.

9.2.2 Meteorology

Sources of data

The meteorology of the study area is important in modelling potential air quality impacts. The nearest meteorological monitoring station with data that can be considered representative of the study area's climate is at Southport, 20 km north of the study area. Although there is monitoring equipment at Gold Coast Airport, historical data is limited and climatic averages are, therefore, difficult to extract for this location.

Queensland Environmental Protection Agency data from Helensvale, and Bureau of Meteorology data from Gold Coast Airport and the Gold Coast Seaway, have been used to determine wind direction and speed for the study area. Wind roses for each of these sites are provided in Technical Paper 11.

Atmospheric stability classes

Pasquil stability classes represent the stability of atmospheric conditions and the rate at which the mixing and dispersion of pollutants occurs. The frequency of Pasquil stability classes was obtained from the representative regional Ausplume modelling file, provided by the Queensland Environmental Protection Agency for Southport. The classes are described together with frequency data in Section 9.4.2.

Worst-case pollutant concentrations occur when winds are closely aligned with the road (within 25°), resulting in pollutants being blown along, rather than away from, the road.

9.2.3 Modelling air quality effects

Vehicle emissions

Ground-level concentrations of pollutants depend on hourly vehicle emission rates for the section of the roadway under consideration. These rates are influenced by hourly traffic flows, meteorological conditions, and local road conditions (mainly traffic speed, composition and road slope).

The CALINE-4 dispersion model (California Department of Transport 1989) was used to estimate the concentrations of carbon monoxide, nitrogen dioxide, particulate matter and

hydrocarbons that would occur as a result of predicted traffic flows for the proposed bypass. The model has been used extensively in NSW and Queensland, and is currently accepted by regulatory agencies and councils as an appropriate conservative model for forecasting near-field impacts of traffic on major roads.

Traffic emission rates were based on recent factors determined for the Brisbane vehicle fleet (Environment Australia 2000) together with adaptations for terrain and speed influences based on a power-emissions method (Williams *et al*. 1994). The various parameters were chosen to achieve a close correspondence with fleet emission factors derived from recent vehicle inventories when using flat terrain and average speeds. These were adjusted for vehicle speed and terrain using factors derived from Australian, North American and European studies (Stewart *et al*. 1982, United States Environmental Protection Agency 1991, and CORINAIR 1995).

These factors were adjusted for projected vehicle speed, number of vehicles, and grade of the road, and to represent the projected vehicle fleet age and composition.

Locations along the major roads with maximum predicted traffic flows were used in the dispersion modelling to determine the worst-case air quality impacts.

Emissions from aircraft

Operations at Gold Coast Airport contribute to emissions in the study area.

Emissions were calculated for various aircraft types based on the United States Environmental Protection Agency Code of Federal Regulation, Title 40 (United States Environmental Protection Agency 2001). The emissions were apportioned over the aircraft flight path based on the calculated emission rates, and assuming an average speed of 100 knots.

Other potential sources of emissions were not considered likely to contribute significantly to the total estimated levels of pollutants.

Greenhouse gas emissions

Pollutants of importance to greenhouse warming that are associated with transport activities are water vapour (which is not normally considered in inventories because it is present naturally at high levels), carbon dioxide, nitrous oxide, ozone, chlorofluorocarbons, and methane. Indirect greenhouse gases, such as carbon monoxide, other nitrogen oxides and non-methane volatile organic compounds, have a lesser effect through their influence on the atmospheric concentrations of the direct greenhouse gases.

Emission rates for these gases were estimated using a combination of predicted fuel consumption, and emission factors used in the air quality assessment (shown in Table 9.4). These estimates take into account the changes in vehicle emissions at different travel speeds, using a procedure developed by CSIRO (Williams *et al*. 1994) and reported average fuel consumption rates for the Australian vehicle fleet detailed in the *National Greenhouse Gas Inventory Workbook for Energy* (National Greenhouse Gas Inventory Committee 1998). Carbon dioxide emission rates were determined from the product of hourly emission factors and vehicle flow rates.

The estimates of greenhouse gas emissions from transport sources in the Brisbane region detailed in the *Review of Fuel Quality Requirements for Australian Transport* (Environment Australia 2000) were used to predict the annual emissions of nitrous oxide and methane from the estimated emissions of nitrogen oxide and total emissions.

Emission rates were adjusted to allow for the different levels of congestion that would occur on the Gold Coast Highway with and without the bypass operating. Extremely low vehicle speeds and repeated acceleration and deceleration cycles owing to congestion would adversely affect fuel usage. Conversely, an improvement in the road network and reduced congestion would result in increased fuel efficiency and reduced greenhouse emissions. However, higher vehicle speeds would also result in increased fuel consumption and encourage increased use of the road network. Both these factors would tend to reduce the benefits of a decrease in congestion.

Emission factors for congested and uncongested flow were reported in the *South East Queensland Air Emissions Inventory* for hydrocarbons, oxides of nitrogen and carbon monoxide (Coffey Partners 1995). The ratio of emissions for uncongested flow to emissions for congested flow was used as a congestion factor to adjust emissions for different scenarios as roads became congested. The carbon dioxide emission factor was assumed to be the same as for carbon monoxide, and the nitrous oxide factor was assumed to be the same as for oxides of nitrogen. An average value was used for the total suspended particles factor.

9.3 Air quality criteria

9.3.1 NSW

In 1998, the National Environment Protection Council, as part of the National Environment Protection Measures, adopted a set of air quality standards at a national level for major urban air pollutants. In its publication, *Action for Air*, the NSW Environment Protection Authority has proposed new interim air quality goals for particulate matter and nitrogen dioxide, some of which are consistent with the standards in the National Environment Protection Measures.

Table 9.2 lists air quality goals for NSW relevant to the assessment of new road proposals, including historical as well as the new interim goals.

9.3.2 Queensland

Air quality goals for Queensland are defined in Schedule 1 of the Environmental Protection (Air) Policy 1997. Goals set by other agencies, such as the United States Environmental Protection Agency, are referred to in cases where a goal for a pollutant has not yet been included in the policy. Table 9.2 lists the current Queensland air quality goals.

9.3.3 National

The National Environment Protection Council goals are applicable only to residential areas that are well away from major industries and roadways. As such, suggested use for these goals is at reference monitoring locations more than 1 km away from the nearest roads or industry.

The National Environment Protection Measures goals have been adopted as interim for the NSW Government's 25-year air quality management plan. Air quality goals do not have the same status as air quality guidelines. In addition, applying the NSW interim goals to near-road locations would result in considerable conservatism. The current national health guidelines issued by the National Health and Medical Research Council are usually applied to peak locations and have been adopted in this assessment.

In broad terms, air quality criteria define levels of various components of the ambient air that should not normally be exceeded over defined periods. They are normally based on the potential health effects of the pollutants generated by vehicular traffic.

The NSW Environment Protection Authority and Queensland Environmental Protection Agency have set a 1-hour goal and an annual average goal for nitrogen dioxide. The NSW Environment Protection Authority is now adopting, as an interim goal, the draft National Environment Protection Measure standard of 0.125 parts per million (ppm). It will also adopt the World Health Organisation's 1-hour goal of 200 µg/m3 as a long-term reporting goal.

The Airports (Environment Protection) Regulations 1987 establish ambient air quality objectives for Australian airports. In some cases, these are the same as the national air quality goals and for others they are less strict. Therefore, if the proposal meets relevant NSW, Queensland and national goals, the objectives of the Airports (Environment Protection) Regulations would also be met.

Relevant national air quality goals, and those for NSW and Queensland, are listed in Table 9.1.

Table 9.1: Relevant NSW, Queensland and national air quality goals

Pollutant	Averaging period		Goal[1]					
			NEPM[2]		NSW		Queensland	
Carbon monoxide	15	minutes			87	ppm (B)		
	1	hour			25	ppm (B)		
	8	hours	9	ppm	9	ppm (A)	8	ppm
Nitrogen dioxide	1	hour	246	µg/m³	257	µg/m³ (C)	320	µg/m³
	4	hours					95	µg/m³
		Annual	62	µg/m³	62	µg/m³ (C)	30	µg/m³
Particulate matter < 10 µm (PM_{10})	24	hours	50	µg/m³	50	µg/m³ (C)	150	µg/m³
		Annual			50	µg/m³ (C)	50	µg/m³
					30	µg/m³ (A)	50	µg/m³
Total suspended particulate matter		Annual			90	µg/m³ (C)	90	µg/m³
Ozone	1	hour	214	µg/m³	0.1	ppm (A)	210	µg/m³
	4	hours	171	µg/m³	0.08	ppm (C)	170	µg/m³

1: Sources of air quality goals are:
A — National Health and Medical Research Council of Australia
B — World Health Organisation
C — NSW Environment Protection Authority (*Action for Air* 1998)

2: National Environment Protection Council
Units are:
ppm = parts per million by volume
µg/m³ = micrograms per cubic metre

9.4 Existing environment

9.4.1 Climate

The study area is within a subtropical climatic zone and experiences consistently warm weather. Weather is generally clear and fine, with 287 days of sunshine a year. The annual average maximum and minimum temperatures experienced are 25°C and 15.3°C, respectively. January is the hottest month, with an average maximum temperature of 28.5°C. July is the coldest month, with an average minimum temperature of 9.2°C. Humidity is generally at its highest

during the earlier months of the year. Annual average rainfall is 1,454 mm, with March, on average, the wettest month.

Much of the summer rainfall, which often falls as intense downpours of up to 50 mm per hour, occurs when the moist easterly air stream is forced to rise over the coastal ranges.

There is no history of frost or fog in the study area.

9.4.2 Meteorology

Wind direction and speed

Data from Helensvale, Gold Coast Airport and the Gold Coast Seaway have been used to determine wind direction and speed for the study area.

At Helensvale, most winds are from the south to east-north-east (64.9%), with most being from the south and south-south-east (33.1%). Wind speeds of greater than 3 m per second (m/s) are relatively infrequent.

The peak wind direction appears to shift slightly to the west, and the frequency of winds greater than 3 m/s increases the further southward the monitoring stations are located. Most winds are from the east to south-west (57.9%) at the Gold Coast Seaway with 65% at speeds of greater than 3 m/s. Most winds at Gold Coast Airport are from the south-south-east to west-south-west (56.1%), with 73.2% at speeds greater than 3 m/s.

Atmospheric stability classes

The representative frequency of Pasquil stability classes for the region is based on data for Southport. The stable Class F conditions, which result in poor dispersion of pollutants, occur for approximately 20% of the time at Southport. Table 9.2 shows the frequency of stability classes for Southport, Queensland.

Table 9.2: Frequency of stability classes, Southport, Queensland

Stability class	Definition	Frequency of occurrence (%)
A	Very unstable	1.0
B	Moderately unstable	12.0
C	Slightly unstable	16.0
D	Neutral	31.9
E	Slightly stable	18.4
F	Stable	20.7

Source: Queensland Environmental Protection Agency

Alignments of both the proposed Tugun Bypass and existing Gold Coast Highway are roughly north-west to south-east. Winds from the north-west and south-east occur 3.3% and 4.5% of the time respectively. The worst-case wind direction (for pollutant dispersion) is infrequent in the study area. Taking into consideration the distribution of wind speeds and directions and the low frequency of stable Class F atmospheric conditions, the frequency of conditions giving rise to worst-case pollutant concentrations is very low.

9.4.3 Air quality in the study area

Long-term ambient air quality information is unavailable for the immediate region. The most representative information is from the Queensland Environmental Protection Agency's monitoring site at Helensvale (approximately 30 km to the north). This has been supplemented with a shorter series of Bureau of Meteorology data on wind speed and direction at Gold Coast Airport and the Gold Coast Seaway, east of Southport.

A large proportion of pollutant emissions in the area are generated by traffic on the Pacific Motorway and Gold Coast Highway, mainly in the form of particulates, carbon monoxide, and nitrogen oxides (NO_x). Other significant sources of air pollutants in the study area are the Gold Coast Airport, the Tugun Landfill, Tweed Heads West Sewage Treatment Works, and the Gold Coast Water sewage pumping station.

There is no evidence that air quality in the existing environment exceeds the relevant air quality guidelines. No regional air quality concerns have been raised, principally because of the absence of large industrial sources, the narrowness of the zone of residential/commercial land near the coast, and the prevalence of onshore winds and sea breezes.

Monitoring locations

Site-specific measurements of carbon monoxide levels were taken at two locations along the existing Gold Coast Highway on 20 and 21 December 2000. These locations are shown in Figure 9.1. The monitoring sites were selected so that the onshore winds would transport vehicle emissions towards the analyser. Full details of the monitoring program and the results are included in Technical Paper 11.

On 20 December 2000, the monitoring unit was located between the Gold Coast Highway and Coolangatta Road, south of Kitchener Street. Local access roads had very little traffic, and traffic on the highway was noted to be free flowing. On 21 December 2000, the monitoring unit was located near the intersection of the Gold Coast Highway and Karana Street. Traffic was being forced to queue briefly at the adjacent intersections, but otherwise was relatively free flowing.

Carbon monoxide concentrations were relatively uniform over the monitoring period, and well below the 8-hour health-related guidelines of 8 ppm and 9 ppm for Queensland and NSW respectively. Most concentrations were below 1.5 ppm on 20 December and below 2.5 ppm on 21 December. The results indicate that at distances greater than 10 m from the road, the 5-minute average carbon monoxide concentrations should be less than 3 ppm for free-flowing traffic with traffic flows of around 5,000 vehicles per hour.

There was little evidence of peak hour increases in carbon monoxide concentrations. This is supported by the relatively constant traffic counts recorded during the monitoring period.

Background air quality measurements in the region from the Helensvale monitoring site indicate that measured pollutant levels are generally well below relevant air quality guidelines. A recent evaluation of the NSW RTA air monitoring program (Holmes *et al*. 1998) recommended background levels of carbon monoxide and nitrogen dioxide to cover most situations. These were 1 to 2 ppm for carbon monoxide and 0.02 ppm for nitrogen dioxide. Given the prevailing wind directions and the limited number of pollutant sources in the study area, background nitrogen oxide levels at Tugun are likely to be lower.

Background levels of pollutants assumed in this assessment are presented in Table 9.3.

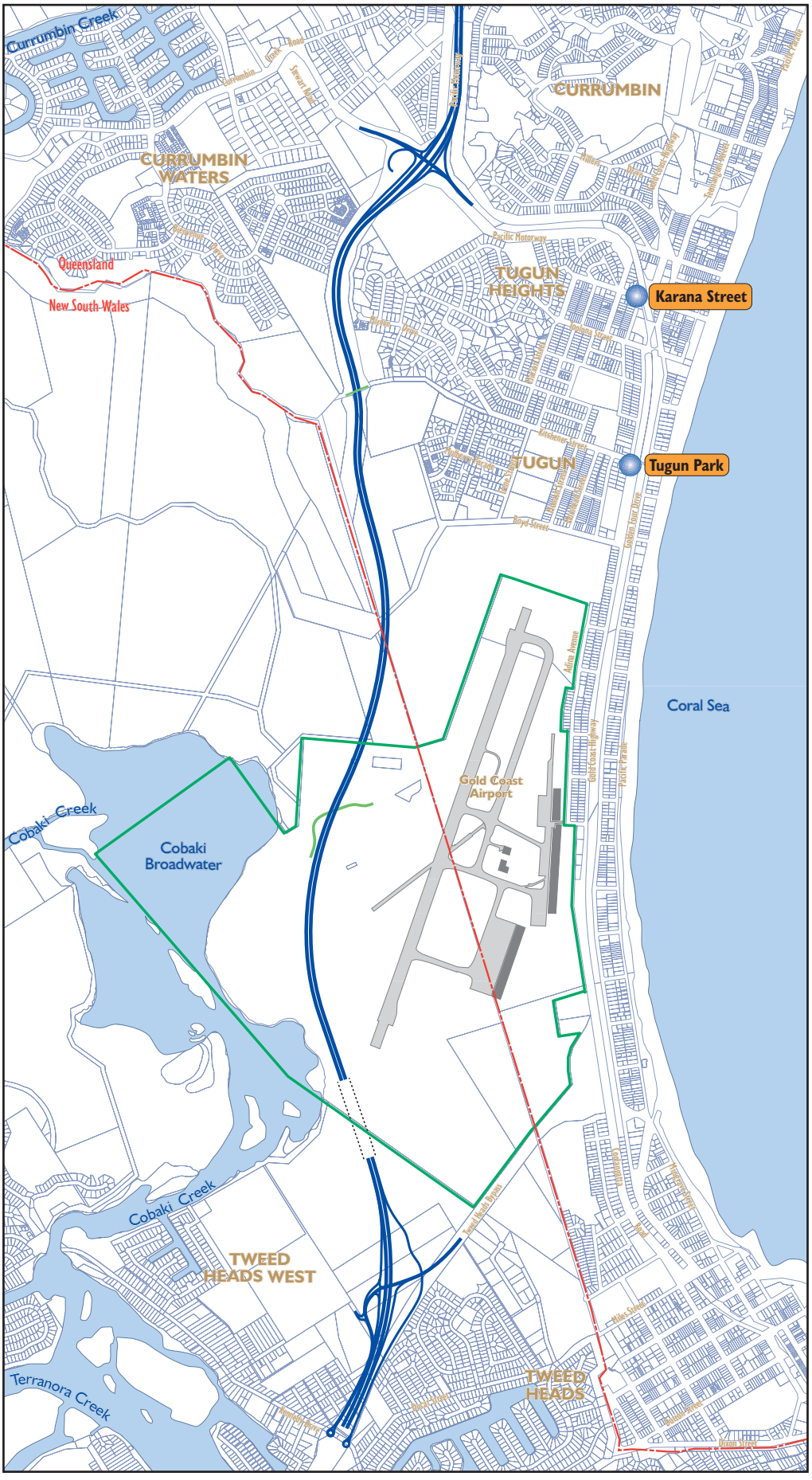


Figure 9.1 **Air Quality Monitoring Locations**

Table 9.3: Background concentrations of air pollutants used in dispersion modelling

Pollutant	Background concentration
Carbon monoxide (CO)	1 ppm
Nitrogen dioxide (NO_2)	20 µg/m^3
Particulate matter (PM_{10})	30 µg/m^3

ppm = parts per million by volume
µg/m^3 = micrograms per cubic metre
Source: Katestone Scientific

9.5 Air quality impacts

9.5.1 Sources of air emissions

The main pollutants emitted by motor vehicles are oxides of nitrogen, carbon monoxide, particulates and hydrocarbons. The greenhouse gas, carbon dioxide, is also emitted in considerable quantities from internal combustion engines. All combustion processes emit similar pollutants in varying quantities.

High emissions of ultra-fine particles can be expected from poorly maintained diesel vehicles under high load. Poorly maintained catalyst-equipped petrol engines can also be significant sources of ultra-fine particles.

Most of the oxides of nitrogen emitted from a combustion process are in the form of nitric oxide. This compound is generally oxidised relatively quickly to form nitrogen dioxide. Other compounds such as nitrous oxide and nitrogen tetroxide could be formed in smaller quantities. The total of all oxidised nitrogen species is referred to as oxides of nitrogen (NO_x). At the point of emission, oxidised nitrogen from vehicle exhausts typically comprises 95% by volume of nitric oxide and 5% of nitrogen dioxide.

Hydrocarbons and oxides of nitrogen can also react in the presence of suitable precursor compounds and sunlight to produce ozone and smog.

9.5.2 Predicting air quality effects

Locations and scenarios selected as likely to represent worst-case air quality impacts in the pollutant dispersion modelling were:

- with/without the Tugun Bypass – Pacific Motorway — Stewart Road to Gold Coast Highway
- with/without the Tugun Bypass — Gold Coast Highway, just north of Boyd Street
- without the Tugun Bypass — Tweed Heads Bypass, just north of the Tugun Bypass
- with the Tugun Bypass — along the proposed bypass, just north of Boyd Street.

The assumptions and methods used in modelling were as follows:

- Emission rates were based on factors reported in recent Australian studies (Environment Australia 2000).
- Dispersion modelling was based on two scenarios with two sets of meteorological conditions. Class F stability with 1 m/s winds was chosen to represent worst-case and

night-time dispersion conditions near the time of peak traffic flows, and Class D stability with 2 m/s winds was chosen to represent worst-case daytime dispersion conditions near the time of peak traffic flows.

- Persistence factors were used to convert 1 hour concentrations to 8 hour, 24 hour, 90 day and annual concentrations, based on recent Queensland data.
- A road gradient of 4% was used.
- Maximum current traffic flows were based on measurements carried out in December 2000.
- Maximum future traffic flows were based on projections for the years 2007 and 2017.
- A conversion rate of 15% was assumed to estimate concentrations of nitrogen dioxide from predicted levels of nitrogen oxides, as relevant for distances to 60 m from the kerb.

Emissions from aircraft

To calculate the emissions over the aircraft flight path, emissions from various aircraft types have been estimated based on the projected number of daily aircraft movements at Gold Coast Airport for 2020 and the standard emission rates assuming an average speed of 100 knots.

Airport-related emissions were calculated at 684 tonnes per year of carbon monoxide, 114 tonnes per year of hydrocarbons and 10 tonnes per year of nitrogen oxides over the 3.5 km length of the airport boundary along the Gold Coast Highway and Tweed Bypass. These are significantly lower than emissions for the existing road and are largely emitted at an altitude from which they can disperse widely. Because of their relatively small effect, aircraft emissions were not considered further.

Traffic flows

Traffic flow rates along the existing route vary with the time of day, with the day of the week, and with seasons. The road use is mixed, with substantial local traffic and long-distance transport (both commercial and tourist vehicles).

Traffic count information for the Tweed Heads Bypass for a summer day shows that there is relatively little traffic in the early morning (4:00 to 6:00 am) and evening (8:00 to 10:00 pm), periods when poor dispersion conditions are more likely. The main traffic period is 6:00 am to 8:00 pm, both for weekdays and weekends. The westerly traffic morning and evening peaks are approximately half an hour earlier than the easterly peaks, probably representing the departure and return of longer-distance commuters.

Emission factors and rates

Vehicle emission rates were adjusted for projected vehicle speed, number of vehicles, and grade of the road, and to represent the projected vehicle fleet age and composition in 2007 and 2017. Estimated vehicle emission rates for 2007 and 2017 for each section of the road under consideration are outlined in Table 9.4.

Table 9.4: Estimated vehicle emission rates

Scenario		Road section	Average speed (kph)	Vehicles[1] in peak hour	Emission rate of pollutant[2] (g/veh/km			
Year	Bypass present				CO	NO_2	PM_{10}	HC
2007	No	Pacific Motorway — Stewart Road to Gold Coast Highway	33	5,000	8.4	0.17	0.05	1.9
	Yes		60	2,700	4.6	0.15	0.05	1.2
	No	Gold Coast Highway — North of Boyd Street	3	7,400	69.2	0.30	0.05	9.5
	Yes		59	3,600	4.7	0.15	0.05	1.3
	No	Tweed Heads Bypass — North of Tugun Bypass	75	4,900	3.7	0.18	0.06	1.1
	Yes	Tugun Bypass	94	3,800	2.9	0.23	0.06	0.9
2017	No	Pacific Motorway — Stewart Road to Gold Coast Highway	13	5,000	8.6	0.10	0.04	0.7
	Yes		60	3,500	1.9	0.06	0.04	1.0
	No	Gold Coast Highway — North of Boyd Street	2	7,400	40.5	0.13	0.04	9.5
	Yes		57	5,400	2.0	0.06	0.04	1.0
	No	Tweed Heads Bypass — North of Tugun Bypass	35	4,900	5.1	0.09	0.04	2.0
	Yes	Tugun Bypass	94	4,800	1.2	0.10	0.04	0.7

1: Rounded to nearest 100
2: Pollutants are:
CO = carbon monoxide
NO_2 = nitrogen dioxide
PM_{10} = particulates
HC = hydrocarbons
Source: Katestone Scientific

Between 2007 and 2017, emission rates for carbon monoxide along the existing road network show the most variation. The large increase in the projected number of vehicles travelling on the Gold Coast Highway during peak periods and resultant congestion of the road network cause a large increase in carbon monoxide emissions. Increased congestion during peak periods is also likely to contribute to increased emission rates for hydrocarbons by 2017 if the proposed bypass is not constructed.

Emission rates for nitrogen dioxide are predicted to decrease over time, with or without the proposed Tugun Bypass, as more stringent controls are implemented to improve emissions from new vehicles. Likewise, the emission rates of particulate matter will decrease in line with improvements in control technology and engine efficiency.

9.5.3 Construction impacts

Potential air quality impacts during construction include airborne dust and exhaust fumes from construction plant.

Dust

Airborne dust would be generated from a number of sources including:

- clearing of vegetation and topsoil
- excavation and transport of materials
- loading and unloading of trucks
- disturbance of deposited dust by vehicle movements
- wind erosion from stockpiles and unsealed roads.

The guideline for dust deposition from construction activities is equivalent to a monthly average of approximately 130 mg/m^2/day of insoluble dust at residences.

High wind would increase the emission rates of airborne dust from stockpiles and exposed areas, while reducing the concentration of vehicle fumes. During high winds, particular attention should be paid to dust suppression.

Because most of the proposed bypass is distant from residences, dust is not expected to be a major issue. However, the contractors would be required to implement dust-control measures such as vegetating stockpiles and spraying water on exposed areas, under an air quality/dust management plan.

Concrete and asphalt batch plants

It is likely that one or more asphalt batch plant would need to be constructed on site. They would receive bitumen, coarse aggregate, sand and other materials such as mineral filler, to mix these and to batch-load the asphalt to trucks for the construction of the roadway. One or more concrete batch plants may also be required.

In modern, well-managed asphalt plants, offsite odour from bitumen components is generally not a significant problem. Dust from the handling of fine material in batch plants can be effectively managed using standard dust-suppression methods, including watering dusty areas and maintaining wind breaks around any open stockpiles. The plants would be located relatively remotely from residential areas, so impacts are not considered likely. Further details regarding the need for concrete and asphalt batch plants, their likely locations and control measures are given in Chapter 7.

9.5.4 Operational impacts

The operational impacts on air quality in the vicinity of the proposed bypass were assessed by comparing the predicted ground-level concentrations of vehicle emissions with relevant air quality criteria for both Queensland and NSW.

The model was used to predict pollutant levels for the worst-case meteorological and peak traffic conditions. Results indicate that relevant health guidelines for carbon monoxide, nitrogen

dioxide, particulate matter, and lead would not be exceeded even in the worst-case meteorological and traffic conditions.

Predicted vehicle emissions

In the absence of the proposed Tugun Bypass, the forecast increase in vehicle numbers between 2003 and 2017 will result in high levels of congestion, and emissions of carbon monoxide and hydrocarbons along the Pacific Motorway and Gold Coast Highway. Nitrogen dioxide and particulate concentrations are predicted to decrease over time as more stringent control measures are implemented to improve emissions from new vehicles and engine efficiencies improve.

The overall reduction in the average emission rates, coupled with the improved travel conditions resulting from the construction of the proposed bypass, would lead to an overall reduction in total vehicle emissions, particularly of carbon monoxide and hydrocarbons over the period to 2017. This would occur even in circumstances where total traffic growth continues.

Table 9.5 summarises the predicted total ground-level pollutant concentrations, taking into account background concentrations, for each year and scenario studied, at 10 m from the kerb (taken to represent worst-case conditions). These have been compared to relevant health-related air quality guidelines to determine the greatest likely potential for adverse impacts on nearby residents. Actual ground-level concentrations are likely to be lower than the predicted levels at the closest affected residences, which are all more than 10 m from the source.

The results indicate that relevant health guidelines for carbon monoxide, nitrogen dioxide and particulate matter would not be exceeded even in worst-case meteorological and traffic conditions if the bypass is built. Without the bypass, carbon monoxide guidelines might be exceeded under worst-case conditions. The worst-case concentrations reported in Table 9.5 occur when peak-hour traffic flows coincide with poor dispersion conditions (class F stability with 1 m/s wind speed). These atmospheric conditions usually occur in the early hours during cold weather (typically a winter morning before 7:00 am). Better dispersion conditions would normally be expected during the peak period. The air quality assessment is conservative in that the maximum number of vehicles using the road network would generally not occur at the same time as poor dispersion conditions.

Table 9.5: Predicted total pollutant concentrations[1]

Pollutant[2]	Averaging time	Background concentration	Concentration for class F (1 m/s)						Air quality guideline
			Without bypass (Gold Coast Highway)[3]		With bypass				
					Gold Coast Highway		Tugun Bypass		
			2007	2017	2007	2017	2007	2017	
CO (ppm)	8 hour	1	15.9	9.7	1.6	1.3	1.4	1.2	9
NO_2 (µg/m³)	1 hour	20	220.5	105.5	145.5	100.4	111.8	64.2	246
PM_{10} (µg/m³)	24 hour	30	38.6	36.5	37.5	38.5	35.8	34.7	50
HC (µg/m³)	1 hour	not applicable	6,415.8	6,388.9	534.0	579.9	361.7	318.9	not applicable

1: At 10 m from the kerb
2: ppm = parts per million by volume
µg/m3 = micrograms per cubic metre
3 North of Boyd Street
Source: Katestone Scientific

Air pollutant levels will, in general, be determined by increasingly stringent controls and decreasing emission rates for vehicles over time, increasing total vehicle numbers, and the improved traffic flow and lower concentration of traffic that would result from building the proposed bypass.

Carbon monoxide

If the bypass were not constructed, the existing road network would experience greater congestion and lower peak-hour vehicle speeds in future years. The result would be ground-level concentrations that exceed the guidelines. In contrast, the construction of the proposed bypass is predicted to help maintain carbon monoxide concentrations at less than 18% of the air quality guideline by reducing the local traffic flows and improved average traffic speeds.

Nitrogen dioxide

Ground-level concentrations of nitrogen dioxide are expected to be less for the road network with the proposed Tugun Bypass, compared to the existing situation as a result of lower local traffic flows and higher emission standards. The highest predicted 1-hour nitrogen dioxide concentration at 10 m from the road is 220 $\mu g/m^3$, in 2007, without the proposed bypass. This is just below the 1-hour air quality guideline of 246 $\mu g/m^3$.

Maximum predicted nitrogen dioxide concentrations under stable atmospheric conditions do not exceed 59% of the air quality guidelines for the estimated vehicle emissions in 2007 and 2017 with the proposed bypass.

Particulate matter

Emissions of particulate matter are not expected to change markedly with the proposed Tugun Bypass. Under worst-case atmospheric and traffic conditions, ground-level concentrations at 10 m are predicted to range between 34.7 $\mu g/m^3$ and 38.6 $\mu g/m^3$. Under worst-case conditions, the predicted emissions do not exceed 77% of the 24-hour National Environment Protection Measures and NSW Environment Protection Authority interim goal of 50 $\mu g/m^3$.

Hydrocarbons

The implementation of the proposal would result in a reduction of ground-level concentrations of hydrocarbons adjacent to the Gold Coast Highway (580 $\mu g/m^3$ compared to 6,400 $\mu g/m^3$ in 2017). Concentrations at 10 m from the bypass under worst-case conditions are predicted to be 320 $\mu g/m^3$.

Odours

Significant traffic flows, freely moving traffic and open layout are conducive to rapid dispersion of odours. Construction of the proposed bypass should, therefore, reduce the potential for odour nuisance in residential areas.

Photochemical smog

The current proposal would result in improvements in traffic flow, which would mean a reduction in the nitrogen oxide and hydrocarbon emissions presently coming from the existing road network. This should reduce the potential for photochemical smog to form in the Tugun area.

9.5.5 Health effects of air pollutants

No descriptions of potential health effects have been included in this section because the modelling of air emissions and dispersion has shown that no relevant health guidelines would be exceeded, and no impacts on human health are likely to occur as a result of the proposal. Detailed descriptions of the health effects of all relevant air pollutants are provided in Technical Paper 11.

9.5.6 Greenhouse gas impacts

Greenhouse gases affect the balance between incoming solar energy and losses owing to radiation from the earth and atmosphere. Australia is a signatory to the *International Framework Convention on Climate Change* (Pearman 1999) with commitments to monitor and report greenhouse gas emissions. At the Kyoto Convention, it was agreed that Australia should reduce its emissions to 8% above the 1990 levels by 2010 (Pearman 1999). Government agencies assessing road projects are committed to ensuring that their environmental goals and policies are consistent with those outlined in the Intergovernmental Agreement on the Environment. The Kyoto Protocol has not been ratified by the Australian Government.

Pollutants of importance to greenhouse warming and associated with transport activities are water vapour (which is not normally considered in inventories because it is present naturally at high levels), nitrous oxide, carbon dioxide, ozone, chlorofluorocarbons and methane. Of these, carbon dioxide is the most significant greenhouse gas (after water vapour) and the major contributor resulting from human activity. Indirect greenhouse gases, such as carbon monoxide, nitrogen oxides other than nitrous oxide, and non-methane volatile organic compounds, do not have a strong radiative effect in themselves, but influence atmospheric concentrations of the direct greenhouse gases. Each of these gases remains active in the environment for a different length of time, and the overall warming effect is therefore different when considered over different time horizons.

Emission rates for these gases were estimated using predicted fuel consumption and the emission factors used in the air quality assessment (shown in Table 9.4). Carbon dioxide emission rates were determined from the product of hourly emission factors and vehicle flow rates, using the anticipated flow rates for 2007 and 2017 for the appropriate roads in the bypass and non-bypass scenarios.

The estimated emission rates were adjusted to allow for changes in traffic congestion with increasing traffic flows and as a result of the construction of the proposed bypass.

These estimated emission factors were applied to four traffic scenarios, with and without the Tugun Bypass in 2007 and 2017. Calculations were based on predicted traffic levels for the entire Gold Coast City network so that all changes in emissions as a result of the bypass would be included in the estimates. Table 9.6 summarises the emissions of greenhouse gases for each scenario considered.

Table 9.6: Emissions of greenhouse gases from the road network with and without the Tugun Bypass, for 2007 and 2017

Greenhouse gas	Total emissions for all vehicles (tonnes per year)					
	2007			2017		
	Without bypass	With bypass	% change	Without bypass	With bypass	% change
Main greenhouse gases						
Carbon dioxide	4,633,132	4,654,699	+0.5	5,424,742	5,235,881	-3.5
Nitrous oxide	1,411	1,410	-0.1	1,666	1,603	-3.8
Methane	1,331	1,315	-1.2	1,597	1,539	-3.6
Indirect greenhouse gases						
Hydrocarbons	26,614	26,295	-1.2	31,945	30,781	-3.6
Oxides of nitrogen	19,232	19,593	+1.9	22,727	21,937	-3.5
Carbon monoxide	107,531	104,506	-2.8	130,108	125,608	-3.5
Total suspended particles	938	980	+4.4	1,108	1,066	-3.8

Source: Katestone Scientific

Construction of the proposed bypass is expected to result in small changes in total emissions of the various greenhouse gases when compared to the situation of increasing congestion without the proposal. Construction of the bypass would be expected to result in a small increase in total emissions of carbon dioxide in 2007, and a reduction in 2017, compared to the 'do-nothing' scenario. The increase in carbon dioxide emissions is a direct consequence of the increase in average speed made possible by the proposal and its consequent effect on fuel consumption. This increase would apply to both the Tugun Bypass and the Gold Coast Highway where traffic on both would become more free flowing. In the absence of the bypass, the congested travel conditions would result in a different pattern of emissions, including higher hydrocarbon concentrations resulting from the constant acceleration and deceleration caused by the prevailing conditions.

The total greenhouse contribution (emission rate of each gas weighted by global warning potential and lifetime) for the major components (carbon dioxide, nitrous oxide and methane) is shown in Table 9.7 for 20-year and 100-year horizons. The numerical values are dominated by the carbon dioxide contribution. The overall greenhouse contribution in 2007 is predicted to be 0.4% higher with the bypass in place decreasing to a reduction of 3.5% by 2017. These relative changes are small because of the large contribution from the rest of the Gold Coast road network.

Table 9.7: Global warming potential predictions for the road network with and without the Tugun Bypass, for 2007 and 2017

Greenhouse gas	Total emissions for all vehicles (tonnes per year)					
	2007			2017		
	Without bypass	With bypass	% change	Without bypass	With bypass	% change
20-year horizon	5,124,942	5,145,213	+0.4	6,006,871	5,796,088	-3.5
100-year horizon	5,117,383	5,138,221	+0.4	5,996,950	5,786,454	-3.5

Source: Katestone Scientific

Construction impacts

The main sources of greenhouse gases released during construction are likely to be from the removal of vegetation and the burning of fuel in construction equipment.

The maximum likely release of carbon dioxide, assuming uniformly dense vegetation across all 45 ha needing to be cleared for the proposed bypass, and all vegetation burnt without energy recovery is approximately 25,000 tonnes.

Because detailed design and construction methods will only be determined when the design and construct contract is let, no estimate of fuel has been made for construction. However, based on estimates for other major road construction projects, a total of 5 million litres of diesel might be required. This would result in the emission of approximately 16,000 tonnes of greenhouse gases.

These emissions, totalling 41,000 tonnes of carbon dioxide equivalent should be compared to the estimated annual saving of 210,000 tonnes that will be achieved by 2017 as a result of construction the bypass.

Earthmoving and other heavy construction equipment is inevitably powered by large diesel engines. It is highly unlikely that alternatives would be commercially available, and quite impractical to convert current models to other fuels. It is possible that bio-diesel would meet the manufacturer's specifications, but current production is very small and expected to represent less than 2% of total diesel use in Australia by 2007.

9.5.7 Impacts to vegetation

The main pollutants believed to cause plant damage are sulfur dioxide and ozone. Neither is found in significant concentrations near roads. Emissions of nitric oxide by vehicles reduce ambient ozone concentrations as they react to form nitrogen dioxide.

Oxides of nitrogen generally only reduce plant growth with exposure at concentrations of 1,000 $\mu g/m^3$ for periods of 3 hours or more. Queensland Environmental Protection (Air) Policy 1997 provides, as indicators for biological integrity, nitrogen dioxide goals of 95 $\mu g/m^3$ for 4 hours and 30 $\mu g/m^3$ for 1 year, based on studies of sensitive species.

The maximum 4-hour average ground-level concentration of nitrogen dioxide for the existing road network, without the proposed bypass in 2017, is predicted to be 140 $\mu g/m^3$ at 10 m from the road, including the assumed background concentration. The maximum 4-hour average ground-level concentration of nitrogen dioxide, with the proposed Tugun Bypass in operation, is predicted to be 95 $\mu g/m^3$ at 10 m from the kerb in 2007. Nitrogen dioxide emissions owing to the proposed Tugun Bypass would, therefore, meet the goal for the protection of biological integrity (95 $\mu g/m^3$).

9.5.8 Air quality in the tunnel

The proposed tunnel is approximately 400 m long and assisted by roof-mounted fans, the air within the tunnel would be vented by the piston effect of moving traffic. As the tunnel is short in length, no ventilation stacks would be required. While there would be increased levels of pollution in the vicinity of the tunnel portals, this would only extend 50 to 100 m from the tunnel openings. There are no sensitive receptors within this area, the nearest buildings being over 500 m away.

The exposure to pollutants of drivers using the tunnel was also assessed. There are no guidelines for in-tunnel air quality in Australia; however, the approval conditions for the Lane Cove Tunnel issued by the NSW Department of Infrastructure, Planning and Natural Resources included conditions for concentrations of carbon monoxide. These require that air quality in the tunnel remains below 50 ppm carbon monoxide for a 30-minute average and below 87 ppm carbon monoxide for a 15-minute period. These standards have been used to assess the likely exposure levels within the Tugun Bypass tunnel.

Table 9.8 details the expected traffic flows through the tunnel in 2007 and 2017, and the likely rates of emission of carbon monoxide. The rates in 2017 are lower than 2007 to take account of improved engine design and tighter emissions standards.

Table 9.8: Traffic flow and emission characteristics

Parameter	2007	2017
Peak-hour traffic flow	2076	2554
Carbon monoxide emission factor (g/veh/km)	2.9	1.2
Carbon monoxide emission rate (gs) for 400m length tunnel	0.67	0.34

The assessment assumed that half of the peak-hour traffic flows through the tunnel in a 15-minute averaging period and, during a 30-minute period, all peak-hour traffic passes through. A range of times for air changes in the tunnel has also been used, ranging from no air change to one change every 15 minutes. The results of the assessment are shown in Table 9.9.

Table 9.9: Carbon monoxide concentrations in ppm for the Tugun Bypass tunnel

Scenario	15-min average carbon monoxide	30-minute average carbon monoxide
2007		
No air change	34	67
1 air change per 30 minutes	22	34
1 air change per 15 minutes	17	22
2017		
No air change	17	34
1 air change per 30 minutes	11	17
1 air change per 30 minutes	9	11
NSW standard	87	50

The results show that if the air in the tunnel were to be exchanged twice within the hour during peak periods, the carbon monoxide concentrations would be well below the standard. The roof-mounted fans would be designed to ensure that, in combination with the piston effect of the traffic, this rate of air exchange can be achieved.

9.6 Environmental management

9.6.1 Environmental management during construction

Mitigation measures to manage air quality during construction would include:

- applying water by truck sprays on disturbed and trafficked areas, as required, to minimise dust emissions
- restricting dust-generating activities during high winds or during stable conditions with winds blowing towards adjacent residences
- siting the construction compounds away from existing dwellings
- avoiding spillages and achieving prompt cleanup when required
- covering haul vehicles moving outside the construction site
- restricting the speed of construction vehicles, where required
- checking particulate emissions from diesel vehicles and undertaking regular maintenance
- prohibiting burning or incineration on site
- monitoring dust near adjacent dwellings using dust gauges or other suitable ambient monitoring techniques to determine whether controls are being applied appropriately.

9.6.2 Environmental management during operation

The EIS has identified some potential impacts on the environment, and the controls required to avoid or minimise these effects. An air quality management plan would be developed as part of the overall operational environmental management plan to ensure that these actions and controls are included in the design and implemented during operation of the bypass.

In relation to air quality, these actions and controls would focus predominantly on conditions within the tunnel and at the portals, and on ensuring that the ventilation system adequately controls pollution levels. The specific requirement for tunnel airflow is that air quality must be maintained in all conditions so that the 15-minute carbon monoxide exposure of 87 ppm (World Health Organisation) is not exceeded at any location in the tunnel during normal operation.

Visibility inside the tunnel must also be maintained at levels recommended by the Permanent International Association of Road Congresses or better. These levels are extinction factors of 0.005 per metre for free-flowing traffic, and 0.007 per metre in congested conditions.

Monitoring of air quality would be included as part of the ongoing environmental monitoring program.

9.7 Implications for ecologically sustainable development

9.7.1 The precautionary principle

The impact of the proposal on air quality has been assessed against relevant Australian, NSW and Queensland standards. The proposal would meet these goals and guidelines for predictions of worst-case levels of particulates, carbon monoxide, nitrogen dioxide, lead and hydrocarbons.

Appropriate environmental management methods would be used to control airborne dust and emissions from construction vehicles. These methods have been implemented successfully in locations where construction works for major roads are located in close proximity to residences. In this instance, construction works would generally be removed from existing residences, and pollution impacts should be correspondingly lower.

Accordingly, it is considered that the proposal would not constitute a threat of serious or unreasonable damage, either now or in the future.

9.7.2 Intergenerational equity

A prime objective of the proposal is to benefit existing and future generations by improving traffic flow, increasing travel speed and safety, and improving local air quality along the Gold Coast Highway. There would be decreases in carbon dioxide emissions and decreases in all other greenhouse gases at 2017.

9.7.3 Conservation of biological diversity

National Health and Medical Research Council, World Health Organisation, United States Environmental Protection Agency, National Environment Protection Measures, and state goals and guidelines have been established in relation to the human health impacts of air quality. Queensland legislation also has goals relating to biological integrity. In meeting these goals, the proposal is considered to demonstrate acceptable performance in relation to maintenance of biological diversity and ecological integrity.

The implications of air quality impacts of the proposal for ecological sustainability are summarised in Table 9.10.

Table 9.10: Implications of air quality impacts for ecologically sustainable development

Precautionary principle	Intergenerational equity	Conservation of biological diversity
Monitoring and modelling of potential air quality changes resulting from the implementation of the proposal have been undertaken. The results indicate that there would be no threat of serious or irreversible damage to the atmospheric environment of the region as a consequence of the predicted changes.	Implementation of the proposal would lead to an improvement of local air quality, and decrease of the main greenhouse gases in 2017 would also result.	Air quality issues associated with the proposal would not result in any loss of genetic, species or ecosystem diversity in the region.

9.8 Conclusions

The impact of the proposal on air quality has been assessed against relevant Australian, NSW and Queensland standards. The proposal would meet these goals and guidelines based on predictions of worst-case levels of particulates, carbon monoxide, nitrogen dioxide, lead and hydrocarbons.

Appropriate environmental management methods would be used to control airborne dust and emissions from construction vehicles. These methods have been implemented successfully in many locations where construction works for major roads are located in close proximity to residences. In this instance, construction works are generally located at a distance from most existing residences, and pollution impacts would, therefore, be correspondingly lower.

Accordingly, it is considered that the proposal would not constitute a threat of serious or unreasonable damage or impact on air quality.

10. Biological environment

10.1 Introduction

The proposed Tugun Bypass spans an area of south-eastern Queensland and north-eastern NSW recognised for its environmental values. It is located within the region defined as the Macleay-McPherson Overlap (Burbidge 1960). This describes a biogeographical zone where temperate and subtropical regions meet, and a large number of flora and fauna species are at the northern or southern limits of their geographical range.

Tweed Shire is described as having one of the highest vertebrate fauna biodiversities of any local government area in Australia, and the highest plant species diversity within a 2,000 km section of the Australian coast (Kingston *et al*. 1999). As a result, the Gold Coast – Tweed region supports the highest concentration of threatened plants in Australia (Kingston *et al*. 1999).

This chapter describes the extensive work undertaken on the flora and fauna of the study area. It presents summaries of the information contained in the flora and fauna technical paper (Technical Paper 12) and the species impact statement (SIS) that accompany this EIS.

10.1.1 Flora and fauna investigations

Study area

A study area was defined for the flora and fauna investigations. This covered an area 1 km wide on each side of the centre line of the proposal, and along its whole length.

Flora and fauna field investigations were conducted to assess the distribution and nature of vegetation communities and fauna habitats, and to determine the flora and fauna species present and their habitats in the area.

Details of fauna habitat values (such as hollow trees) in the study area were also noted.

Database searches

In addition to standard survey techniques, records of flora and fauna species were obtained from previous studies in the immediate vicinity and in the general region. Searches were also made of the following databases:

- Atlas of NSW Wildlife
- Queensland Herbarium — HERBRECS
- Queensland Parks and Wildlife Services — WildNet
- Queensland Museum Database
- Department of Environment and Heritage, *Environment Protection and Biodiversity Conservation Act 1999* Online Database.

Flora surveys and vegetation mapping

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

Vegetation communities

The assessment of vegetation communities along the proposed bypass alignment was undertaken to conform to both Queensland and NSW requirements, and maintain consistency across jurisdictions.

Vegetation communities in the study area were identified using:

- aerial photographic interpretation (API)
- previous surveys of the area by Main Roads (1999b), Peter Parker (1999) and James Warren (1994)
- targeted surveys along the proposed route by Mike Olsen and Andrew Benwell
- ground-truthing of results by staff preparing the assessment.

Plant species

The flora assessment comprised a literature review, database searches, and vehicle and foot transects along the proposed corridor. Targeted surveys focused on the proposal footprint, with short meanders to either side. All plant species encountered were identified and recorded. Intensive searches for plants of conservation significance were undertaken in potential habitat areas. Locations of plants of conservation significance were recorded with a global positioning system. Targeted flora surveys were undertaken in spring and summer between August 2000 and January 2001.

Fauna surveys

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

- Survey for Reptiles, Amphibians and Mammals Inhabiting Coastal Lowland Areas Associated with the Proposed Tugun Bypass (Hero et al. 2000)
- Survey for Reptiles, Amphibians and Mammals Inhabiting the Northern Section of the Proposed Tugun Bypass (Hero et al. 2001a)
- Supplementary Surveys of Planigales, Eastern Long-eared Bat and Wallum Sedge Frogs within the Proposed Tugun Bypass (Hero et al. 2001b)
- Amelioration and Monitoring Measures for the Conservation of Herpetofauna along the Proposed Tugun Bypass (Hero et al. 2001c)
- Tugun Bypass Assessment of Impacts on Birds: Boyd Street Interchange to Stewart Road (Sandpiper Ecological Surveys 2001b)
- Assessment of the Impact of the Proposed Tugun Bypass: Terrestrial and Estuarine Birds (Sandpiper Ecological Surveys 2001a)
- Tugun Bypass Proposal — Aquatic Flora and Fauna (FRC Environmental 2001)
- Survey for the Land Snail *Thersites mitchellae*: Proposed Tugun Bypass Route (Stanisic 2001)

- Survey for the Giant Dragonflies, *Petalura gigantea* and *Petalura litorea*, and the Swordgrass Brown Butterfly, *Tisiphone abeona morrisi* (Reeves 2001).

The survey methodology and results from these reports are provided in full in Technical Paper 12.

Additional fauna surveys

Following the initial fauna survey work, supplementary work was also undertaken for Long-nosed Potoroos *(Potorous tridactylus)* and Common Planigales (*Planigale maculata*) by Lewis Ecological Surveys (Bali, Lewis & Brown 2003; Lewis 2004). Previous studies of the Wallum Sedge Frog (*Litoria olongburensis*) were peer reviewed in 2003 at the request of the Commonwealth Department of Environment and Heritage (Ingram 2003). More details of these and other surveys are provided in Technical Paper 12.

10.1.2 Assessment of conservation significance

Environmental legislation and policies in Australia provide a framework within which the conservation significance of flora and fauna are described. Those species or ecosystems that are most significant are those recognised to be internationally important. There is then a descending scale of significance down to locally significant.

The assessment of the conservation significance of the flora and fauna within the Tugun study area was undertaken according to the hierarchy described below:

International significance

Important species and the areas of habitat for migratory species covered under international agreements to which Australia is a signatory, such as China-Australia Migratory Birds Agreement (CAMBA) and Japan-Australia Migratory Birds Agreement (JAMBA) migratory bird agreements, the Bonn Convention, and the Ramsar Wetlands Convention. Also World Heritage properties that contain natural heritage as listed under the *Convention Concerning the Protection of the World Cultural and Natural Heritage* and considered to be of outstanding value to humanity. In Australia these matters are dealt with under the *Environment Protection and Biodiversity Conservation Act 1999.*

National significance

These are remnant ecosystems containing populations of plant or animal species considered to be nationally vulnerable or endangered and listed on the *Environment Protection and Biodiversity Conservation Act 1999*. It also includes species listed as endangered, vulnerable or rare in an action plan published by Department of Environment and Heritage.

State significance

These are remnant ecosystems containing populations of plant or animal species, or plant and animal species considered to be rare, vulnerable or endangered in NSW and Queensland, including species listed in the NSW *Threatened Species Conservation Act 1995*, the Queensland *Nature Conservation Act 1992* and *Vegetation Management Act 1999*.

Regional significance

Vegetation communities in Queensland are considered to have regional significance if they correspond to a regional ecosystem listed as endangered or of concern in the Queensland Vegetation Management Regulation 2000. There are no widely accepted criteria for regional importance in NSW. The state is divided into bioregions and much of the listing of endangered ecological communities is based around these regions in the NSW *Threatened Species Conservation Act 1995* and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. Regional importance is often determined by vegetation mapping projects and studies, such as the NSW Regional Forest Agreements.

Local significance

All remnant native vegetation and fauna habitat that does not fall into the categories already listed are considered to be of at least local significance as most areas have been reduced since European settlement. The overall assessment of importance takes into account factors such as the size of the fragments, degree of intactness and connectivity.

10.1.3 Impact assessment categories

Impact categories have been defined to assess the level of impact the proposed bypass may have on a species/community/ecosystem. The five categories listed below are based on conservation significance, abundance and distribution:

- national impact — would affect abundance and/or distribution nationally
- state impact — would affect flora and fauna abundance and/or distribution in NSW and/or Queensland
- regional impact — would affect flora and fauna abundance and/or distribution in the region (NSW north coast bioregion and/or Queensland south-eastern bioregion)
- high local impact — would affect flora and fauna abundance and/or distribution within a 10 km radius of the proposed bypass
- local impact — would affect flora and fauna occurrences and/or behaviour of species in the study area.

10.2 Terrestrial flora

10.2.1 Vegetation communities

The proposed bypass would have an impact upon vegetation within NSW and Queensland and the Commonwealth. The legislative classification and regulation of vegetation communities differs between Queensland and NSW, therefore it is not possible to apply the same criteria across both states. To overcome the differences, the following criteria were adopted for this EIS:

- as a general rule, the most stringent classification has been applied to the assessment
- vegetation communities gazetted in the NSW *Threatened Species Conservation Act 1995* are of state significance

- the NSW legislation does not include communities of regional significance; however, NSW Department of Environment an Conservation (previously National Parks And Wildlife Service) have classified regionally significant vegetation communities in the Regional Forest Agreement for North East NSW
- under Queensland legislation, vegetation communities are considered to be of conservation significance if they correspond to a regional ecosystem as gazetted under the *Vegetation Management Act 1999*
- regional ecosystems are classified as either 'endangered', 'of concern' or 'no concern at present' according to an ecosystem's current distribution relative to its pre-European distribution. Regional ecosystem classifications are based not only on current distribution, but also on condition (level of disturbance) and the presence of threatening processes.
- 'endangered' and 'of concern' regional ecosystems are managed at state level in Queensland, whereas 'not of concern' regional ecosystems are managed at a local level.

A total of 37 vegetation communities have been identified along the proposed Tugun Bypass alignment. This total comprises five communities of state significance (shown in Table 10.1) and 28 communities of regional significance. The remaining four communities are not considered as being significant. Detailed descriptions of each vegetation community are provided in Technical Paper 12.

Table 10.1: Vegetation communities of state significance along the alignment

Community name/Description	State designation	Status
Littoral Rainforest	TSC Act	Endangered Ecological Community (NSW)
Regenerating Vine Forest	TSC Act	Endangered Ecological Community (NSW)
Swamp Mahogany Forest	RE 12.3.14 NPWS (2000)	State Significant (Queensland) Regionally Rare (NSW)
Swamp Mahogany – Scribbly Gum Forest	RE 12.3.14 NPWS (2000)	State Significant (Queensland) Regionally Rare (NSW)
Paperbark Forest	RE 12.3.5 NPWS (2000)	State Significant (Queensland) Regionally Vulnerable (NSW)

TSC = NSW Threatened Species Conservation Act 1995

Impacts on vegetation communities

The proposed bypass would remove approximately 76 ha of vegetation from the study area, although some of this is already highly disturbed. If cleared land is excluded, then approximately 45 ha of vegetation would be removed. Much of the 45 ha of vegetation comprises small isolated patches or edges of previously disturbed land.

The proposed bypass would directly affect 27 of these vegetation communities. Of the 27 vegetation communities directly affected by the proposal, four communities are considered as being of state significance. Table 10.2 details the impacts on state significant vegetation communities. All of the remaining 23 communities are of regional significance in Queensland and NSW. Figure 10.1 shows the vegetation communities located in the study area.

The EIS considers the impacts of the proposal on the vegetation communities of state significance. The assessment of impacts on other communities is provided in Technical Paper 12 and the SIS. Details of the flora survey methods are also found in the SIS.

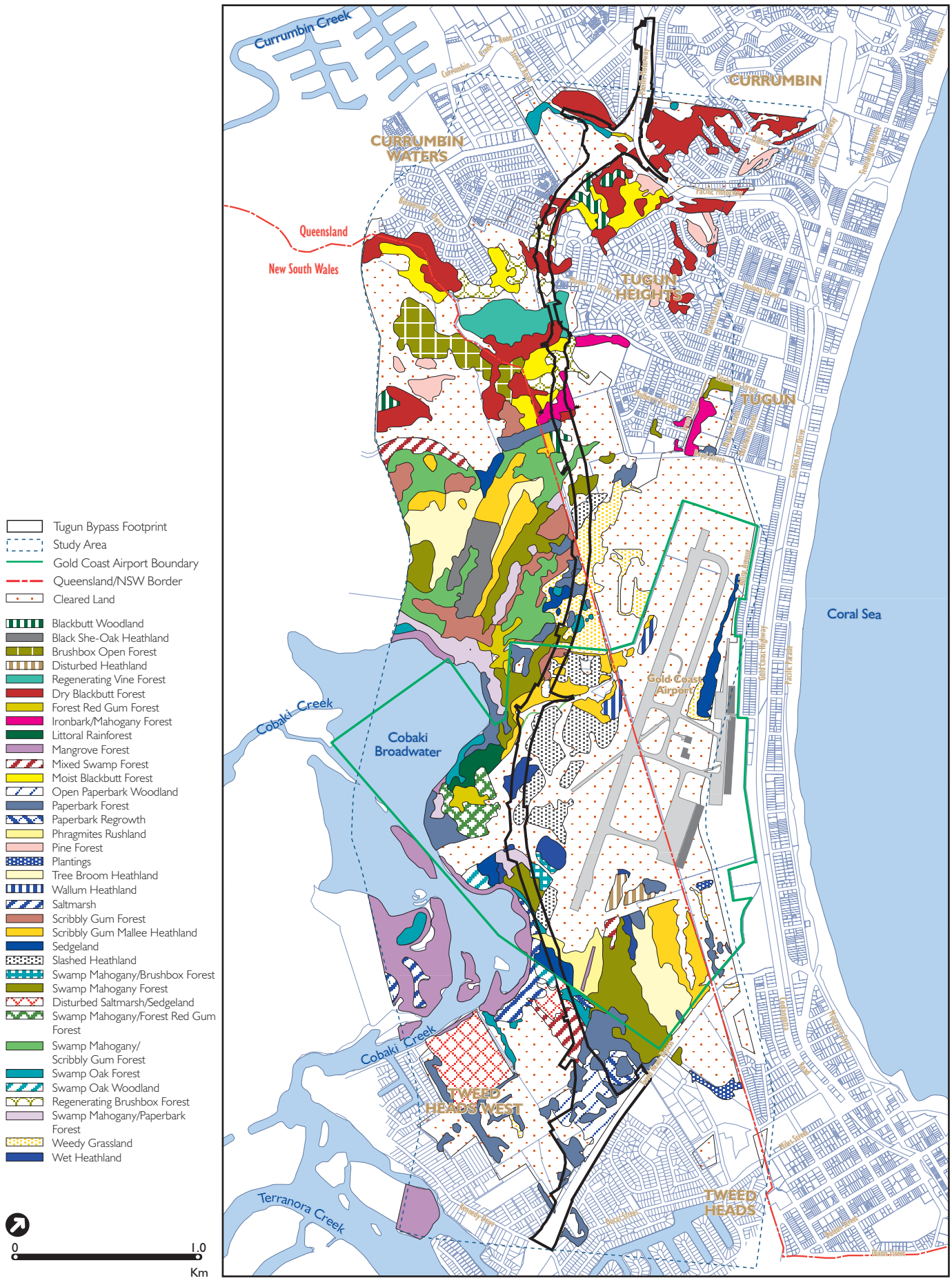


Figure 10.1 **Vegetation Communities Within the Study Area**

Table 10.2: Impacts on state significant vegetation communities

Vegetation community	Percent removed from study area (hectares or percent of total area)	Significance of impact
Littoral Rainforest	0 ha	No direct impact
Regenerating Vine Forest	0.6 ha or 5.7%	Local impact — only removing individuals from one of three communities
Swamp Mahogany Forest	3.25 ha or 8.5%	High local
Swamp Mahogany – Scribbly Gum Forest	0.5 ha or 1.8%	High local
Paperbark Forest	6.6 ha or 16.6%	High local

Mitigation and management measures

The alignment of the bypass has been refined from its original concept to the current alignment to avoid, where possible, impacts on native vegetation. As total avoidance is not possible, a compensatory habitat package to mitigate the loss of vegetation has been prepared. This is discussed in Section 10.8 of this chapter.

In addition, a number of management and monitoring measures would be adopted to ensure that the impacts of construction are managed carefully and minimised as much as possible.

Management of vegetation during construction of the proposed Tugun Bypass would include limiting adverse impacts on remnant vegetation communities, threatened plant species and fauna habitats, and enhancing vegetation in the vicinity of the proposed route. Specific management protocols for flora during pre-construction, construction and operational phases are detailed in later sections of this chapter.

Removal of vegetation would be restricted to the development footprint. Where possible, those areas that are already relatively disturbed would be used in preference to clearing native vegetation.

Where an area of native vegetation needs to be cleared and then revegetated, post-construction the following measures would be applied:

- the boundary would be fenced and the area cleared in such a way that it would not be extended during clearing works
- revegetation works would commence as early as possible within the construction phase of the project to minimise the time-lag between clearing and rehabilitation
- seeds and other propagative material would be collected from native species present within 5 km of the site
- soil erosion and sedimentation control measures would be constructed progressively to minimise the area of unstable or unprotected soil surface
- where cleared vegetation is to be placed in windrows, these would not be allowed to abut those areas of native vegetation to be retained
- topsoil would be stockpiled in long, low piles (less than 2 m high) adjacent to works to maximise the viability of seed stock in the soil.

Revegetation could be undertaken in the following areas:

- previously disturbed or cleared areas of the proposed alignment to reduce fragmentation of vegetation and assist in reducing noise impacts from the proposal
- constructed wetlands would be densely revegetated with native sedges and grasses to create potential habitat for Lewins Rail and other wetland species.

10.2.2 Flora species

A total of 586 plant species were recorded from the study area during current surveys. This comprises 479 Aboriginal and 107 introduced plant species. A complete list of flora species recorded in the study area can be found in Technical Paper 12.

A total of 23 flora species of conservation significance were recorded from the study area during current surveys. This included 15 flora species of legislative significance detailed in Table 10.3 and eight other significant plant species detailed in Table 10.4. Their locations in the study area are shown in Figure 10.2.

The remaining eight species of significance were recorded from the study area during past and present surveys. These species are notable because they are:

- at their distributional limits
- recognised as being of conservation significance for north-east NSW (National Parks and Wildlife Service Comprehensive Regional Assessment listings)
- otherwise significant in the area (e.g. disjunct distribution).

Table 10.3: Legislatively significant plant species recorded in the study area during current surveys

Species name	Legislative status	Recorded		
		NSW	Comm	Qld
Little Wattle (*Acacia baueri* subsp. *baueri*)	NCR (V); ROTAP	◎	◎	◎
White Lace Flower (Archidendron hendersonii)	TSC (V)		◎	
Veiny Lace Flower (Archidendron muellerianum)	NCR (R); ROTAP			◎
Christmas Bells (Blandfordia grandiflora)	NCR (R)		◎	
Stinking Cryptocarya (*Cryptocarya foetida*)	TSC (V); NCR (V); EPBC (V); ROTAP		◎	◎
Long-leaved Tuckeroo (*Cupaniopsis newmanii*)	NCR (R); ROTAP			◎
Black Walnut (Endiandra globosa)	NCR (R); ROTAP			◎
Endiandra muelleri subsp. bracteata	TSC (E)			◎
Geodorum densiflorum	TSC (E)		◎	
White Silky Oak (*Grevillea hilliana*)	TSC (E)			◎
Fine-leaved Tuckeroo (*Lepiderema pulchella*)	NCR (R); TSC (V), ROTAP			◎

Species name	Legislative status	Recorded		
		NSW	Comm	Qld
Rough-leaved Queensland Nut (*Macadamia tetraphylla*)	TSC (V); NCR (V); EPBC (V); ROTAP			◎
Swamp Orchid (Phaius australis)	TSC (E); NCR (E); EPBC (E); ROTAP	◎	◎	
Smooth-scrub Turpentine (*Rhodamnia maideniana*)	NCR (R); ROTAP			◎
Durobby (Syzygium moorei)	TSC (V); NCR (V); EPBC (V); ROTAP			◎

NCR = Queensland Nature Conservation (Wildlife) Regulation 1994
TSC = NSW *Threatened Species Conservation Act 1995*
EPBC = Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
ROTAP = Rare or Threatened Australian Plants (Briggs & Leigh 1996)
E = endangered
V = vulnerable
R = rare

Table 10.4: Other significant plants recorded in the study area

Species name	Reason for significance	Recorded		
		NSW	Comm	Qld
Blunt-leaved Wattle (*Acacia obtusifolia*)	Unusual lowland population on sands.	◎	◎	◎
Star Hair Plant (*Asterotricha longifolia* — Tweed Heads form)	Regionally significant — very rare in NSW.		◎	
Match Sticks (Comesperma ericinum)	Northern distributional limit of this species.	◎		◎
Coast Palm Lily (*Cordyline congesta*)	Regional significant – until recently this species was listed as 'rare' on the Queensland Native Conservation (Wildlife) Regulation 1994.		◎	◎
Mucuna gigantea	Regionally significant — rare in NSW; C2 (threatened) North-east NSW CRA.	◎	◎	
Lemon-scented Baeckea (*Ochrosperma citriodora*)	Northern limit of distribution.		◎	
Strangea linearis	Regionally significant — only found north of Byron Bay.		◎	
Chinese Burr (Triumfetta rhomboidea)	Regionally significant — at southern end of range; CI (critically threatened) North-east NSW CRA.	◎	◎	

Note: CRA = Comprehensive Regional Assessment.

Impacts on significant plant species

The distribution, habitat requirements and likelihood of impact on all of these 23 species have been examined in the SIS document. These assessments determined 14 of these species would not be significantly affected by the proposed bypass in any jurisdiction because :

- no individuals of the species would be directly or indirectly affected

Figure 10.2 **Locations of Significant Flora Species**

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

- no known or potential habitat of the species being directly or indirectly affected, and/or
- some individuals of the species or some potential habitat being affected, but the local population not being significantly affected if the mitigation measures are adhered to.

A total of 10 species of legislative and conservation significance would be affected by the proposed bypass. From that total, five species are in NSW.

These are:

- Chinese Burr (Triumfetta rhomboidea)
- Blunt-leaved Wattle (*Acacia obtusifolia*)
- Little Wattle (*Accicia baueri* subsp. *baueri*)
- Swamp Orchid (Phaius australis)
- Match Sticks (Comesperma ericinum).

The Little Wattle and Match Sticks would also be affected by the bypass in Queensland. Discussion of the Swamp Orchid is restricted to a confidential appendix owing to the sensitive nature of this species. The remaining five species are in Queensland. These are:

- Coast Palm Lily (*Cordyline congesta*)
- Stinking Cryptocarya (*Crytocarya foetida*)
- Long-leaved Tuckeroo (*Cupaniopsis newmanii*)
- Black Walnut (Endiandra globosa)
- Fine-leaved Tuckeroo (*Lepiderma pulchella*).

No legislatively significant plant species would be directly affected on Commonwealth Airport Land.

The construction of the bypass would require the removal of a number of individuals of each species. The numbers removed and the significance of the impact are presented in Table 10.5.

Table 10.5: Plant species to be removed

Species name	Number of individuals to be removed	Significance of impact
Chinese Burr (Triumfetta rhomboidea)	>100–150	High local impact — large number of individuals to be removed and remaining population fragmented; however, likely to regenerate quickly and successfully translocated.
Blunt-leaved Wattle (*Acacia obtusifolia*)	1	Local impact — removal of one individual and a small amount of habitat.
Little Wattle (*Acacia baueri* subsp. *baueri*)	2 from Queensland	Regional impact — small number of individuals to be removed, but proposal requires removal of southern-most population.
Swamp Orchid (Phaius australis)	0	Although no individuals of the nationally significant Swamp Orchid would be removed, known habitat of this species is found close to the alignment. Measures have been included into the proposal design to ensure the areas of habitat are protected and local hydrology is maintained.

Species name	Number of individuals to be removed	Significance of impact
Coast Palm Lily (*Cordyline congesta*)	1	Local impact — removal of one individuals and a small amount of habitat.
Stinking Cryptocarya (*Crytocarya foetida*)	2	Local impact — removal of two individuals and a small amount of habitat.
Long-leaved Tuckeroo (*Cupanipsis newmanii)*	1	Local impact — removal of one individual and a small amount of habitat.
Black Walnut (Endiandra globosa)	1	Local impact — removal of one individual and a small amount of habitat.
Fine-leaved Tuckeroo (*Lepiderma pulchella*)	1	Local impact — only one individual being removed.
Match Sticks (Comesperma ericinum)	1 from NSW Some individuals from Queensland	Local impact in NSW – removal of one individual and a small amount of habitat. State impact in Queensland – removal of some individuals and up to 45% of habitat.

10.2.3 Species known from the locality

In addition to the 23 significant plant species recorded from the study area during the current surveys, a further 54 significant species have been recorded within 20 km of the site. None of these species has been recorded from the study area. An assessment of the likelihood of these species occurring on the study area is provided in the SIS.

The assessment determined that none of these plant species is likely to be affected by the proposal in any jurisdiction, because:

- species unlikely to occur in the study area (too low in altitude, lacking in suitable habitat, or located outside the distributional range of the species)
- no known habitat or individuals being removed as a result of the bypass
- limited areas of potential habitat being removed in comparison to the amount of habitat available for these species in the study area and the local region
- suitable habitat areas not being directly affected, and unlikely to be indirectly affected, by the proposed bypass provided mitigation measures are adhered to.

10.2.4 Other species

An additional nine plant species are listed as subject species on the Director-General's requirements for the SIS, although they were not recorded during the current surveys and have not been recorded within 20 km of the site. These species have been assessed the in SIS.

The assessment of these nine species determined that the proposed bypass is unlikely to have a significant impact on these species, because:

- no individuals or known habitat being affected by the proposed bypass
- no suitable habitat for these species occurring in the study area or only a very low likelihood of suitable habitat being present
- potential habitat being unlikely to be directly or indirectly affected by the proposed bypass
- only a very small portion of potential habitat being likely to be affected.

Mitigation and management measures

All affected plant species of regional or state conservation significance would be translocated to areas of suitable habitat as close to their original location as possible.

A strategy for the translocation of plants would be prepared by the NSW RTA in consultation with Queensland Environmental Protection Agency, NSW Department of Environment and Conservation and/or Commonwealth Department of Environment and Heritage, depending on jurisdiction.

The two populations of swamp orchids in the study area have been subject to damage in the past, possibly by plant collectors. A recovery plan has been implemented by the NSW Department of Environment and Conservation and all known plants have been removed for propagation off-site. It is intended to re-introduce the species to secure sites after the bypass is completed.

In the case of Chinese Burr, all plants would be removed during clearing and transplanted into appropriate habitats nearby, and the topsoil containing the seed bank would be spread in adjacent areas. For the wattles and Match Sticks, the removal of the few individuals to suitable habitat nearby would be undertaken.

It is possible that more plants of conservation significance have established themselves within the footprint since the survey period. Prior to clearing the footprint, the following protocol would be followed to check for species of conservation significance:

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

In addition, a local nursery would be appointed to collect a representative sample of native species from the area of the footprint and to propagate them. These species would then be used for landscaping. Road edges and any other areas disturbed during construction would be revegetated with local native plant species, where practical, to minimise edge effects, increase habitat connectivity and provide flora and fauna habitat.

The construction of the tunnel would take place in an area where groundwater is close to the surface, and so the level would need to be lowered to allow construction to proceed (a detailed description of the construction process is provided in Chapter 6). If the construction were to proceed without any controls, the groundwater lowering would potentially impact on a number of important vegetation communities, including wetlands and habitat for the Swamp Orchid.

The groundwater draw down would be managed by a series of re-injection spikes along either side of the working area. These would pump groundwater collected from the working area back into the ground thereby ensuring that the pre-construction levels of groundwater are maintained. The number of spikes can be varied to take account of inflows of groundwater and the pace of construction can be regulated to ensure that it does not overwhelm the re-injection system. This system would ensure that groundwater lowering would not extend beyond 5 m either side of the construction area.

The tunnel, once constructed, would form a permanent barrier to groundwater movement. There would be the potential for groundwater movement to be interrupted and for levels to rise on the upstream side and lower on the downstream side. A system of cross drains and pumps would be built into the tunnel to ensure that flows of groundwater across the tunnel alignment are maintained.

The two systems would ensure that lowering of groundwater would not impact on important vegetation communities.

10.3 Terrestrial fauna habitats

10.3.1 Terrestrial fauna habitats in the study area

Twelve habitat types, based on vegetative structure and condition, were identified for terrestrial fauna within the study area. Although habitat types may correspond to vegetation communities, they are more likely to be related to type and presence of understorey and mid-stratum layer, size and presence of trees, and occurrence of weeds. These habitat types are described in Table 10.6 and their locations shown in Figure 10.3.

Table 10.6: Terrestrial fauna habitat types

Habitat type	Description
Ridge Woodland/Forest	Ridge Woodland/Forest occurs to the north of the study area. This community is dominated by Blackbutt with a wide range of co-dominant species including Tallowwood, White Mahogany and Grey Gum. The mid-stratum is generally sparse or composed of Lantana in regenerating forest. The understorey is grassy. Important habitat features include medium density of small hollows, some large hollows and ground debris.
Dune Woodland/Forest	Dune Woodland/Forest is extensive but restricted to the northern side of the survey area. It is dominated by Scribbly Gum and Red Bloodwood or Swamp Mahogany and contains a dense heathy understorey and a mid-stratum composed of banksias and wattles. A small area of old-growth Scribbly Gum Forest, located north of Cobaki Broadwater, provides large hollows. Other important habitat characteristics include some small tree hollows, shrubby understorey and a high diversity of flowering and fruiting plants.
Rainforest/ Rainforest Elements	Within the study area, Rainforest/Rainforest Elements is restricted to a narrow strip of land adjacent to Cobaki Broadwater and in Hidden Valley. The overstorey forms a dense canopy layer dominated by Bangalow Palm (*Archontopheonix cunninghamiana*) and figs (*Ficus* spp.) or occasionally by eucalypts. There are a number of layers in the mid-stratum comprising mainly rainforest fruiting trees. The ground cover consists of a dense layer of ferns. Areas of this habitat are highly disturbed by weed infestation from Umbrella Trees (*Schefflera actinophylla*) and Camphor Laurel. Important habitat characteristics include a wide diversity of fruiting trees, a low density of small and large hollows, and a dense ground cover.

Habitat type	Description
Swamp Forest	Swamp Forest occurs throughout the survey area. To the west, it is co-dominant with open woodland. Centrally, it is located between the main runway at Gold Coast Airport and Mangrove Forest along the edge of Cobaki Broadwater. It also occurs along the eastern edge of the site. It is dominated by Broad-leafed Paperbark and Swamp Mahogany. The mid-stratum comprises banksias and Cheesetree, while ferns occur in the understorey. This habitat type contains small freshwater lagoons and a small permanent creek, and is likely to become inundated after prolonged rainfall. Other important habitat features include a high density of flowering trees and shrubs, winter-flowering species, low densities of small and large tree hollows, and an abundance of decorticating (peeling) bark suitable for bat roosting and bird foraging.
Regenerating Swamp Forest	Regenerating Swamp Forest is located in the south-eastern corner in the vicinity of Tweed Heads Pony and Hack Club, on the western edge of sedgeland, and to the south of Tugun Landfill. It is dominated by Broad-leaved Paperbark with occasional Swamp Oak, Swamp Box, Cheesetree and Camphor Laurel. This habitat type is characterised by clumps of trees up to 15 m surrounded by grassy areas dominated by exotic species. Important habitat features include nectar- and fruit-producing plant species, winter-flowering species, shallow wet depressions, decorticating bark for roosting bats and foraging birds, and a dense understorey. However, the habitat does not provide hollows.
Heathland	Heathland includes both wet and dry types and is located throughout the survey area. Many of these areas adjoin cleared land and are fragmented by tracks. Some heath is characterised by the presence of occasional emergent eucalypts or mallee eucalypts. It comprises mainly Broad-leafed Paperbark, Wallum Banksia, Tree Broom Heath and Black She-oak. Heath species dominate the mid-stratum, and ferns and sedges are found in the understorey. Important habitat features include dense cover, flowering shrubs and some ephemeral ponding. No hollows are present in this habitat type.
Sedgeland/ Rushland	Sedgeland/Rushland is located as small patches in the survey area. The largest is located to the south of the airport runway and is dominated by Common Reed with emergent Swamp Oak along the drainage lines. It is subject to disturbance through airport maintenance activities. A small area of sedgeland occurs to the west. Important habitat features include dense ground cover and seeds. No hollows are found in this habitat type.
Mangroves	Mangroves are widespread within the survey area and occur as a narrow fringe along the northern edge of Cobaki Broadwater. They also occur on four islands within Cobaki Broadwater, and along the southern edge of Cobaki Creek. Dominant species include Grey Mangrove, Red Mangrove, River Mangrove, Large Leafed Orange Mangrove, Blind Your Eye Mangrove and Mangrove Fern. Important habitat features include an abundance of insects, regularly flowering plants, and fish nurseries.
Saltmarsh	Saltmarsh grows on the landward side of mangroves and comprises shrublands, sedge and rush swamps and grasslands. There are three main Saltmarsh communities: Saltcouch/Samphire; Sea Rush associations; and Bare Twig Rush (*Baumea juncea*). Important habitat features in this community include foraging resources.
Disturbed open habitats	Grassland occurs along access tracks and within the airport. It is dominated by exotic grass species and is subject to ongoing disturbance from airport maintenance activities (e.g. slashing). It provides limited habitat values for all but open-country species. A dam and a large tidal drain are located in disturbed land. Slashed heathland provides flowering plants for native birds.
Plantings	Plantings occur throughout the survey area. These are most likely to be associated with development, public parks, ovals and old plantations. These areas have few habitat values for native species although they may provide nectar of other foraging resources for birds and opportunistic fauna.
Cleared land	Cleared land represents a highly modified community that is dominated by exotic grass species (that are continually kept to a low height) or is devoid of vegetation. A number of drainage structures, which are suitable for frogs, occur in this area.

Regionally significant habitats and corridors

NSW National Parks and Wildlife Service have used aerial photographs to map regionally significant habitat areas and corridors. Corridors and significant habitats have been identified within the study area. These areas are shown in Figure 10.4.

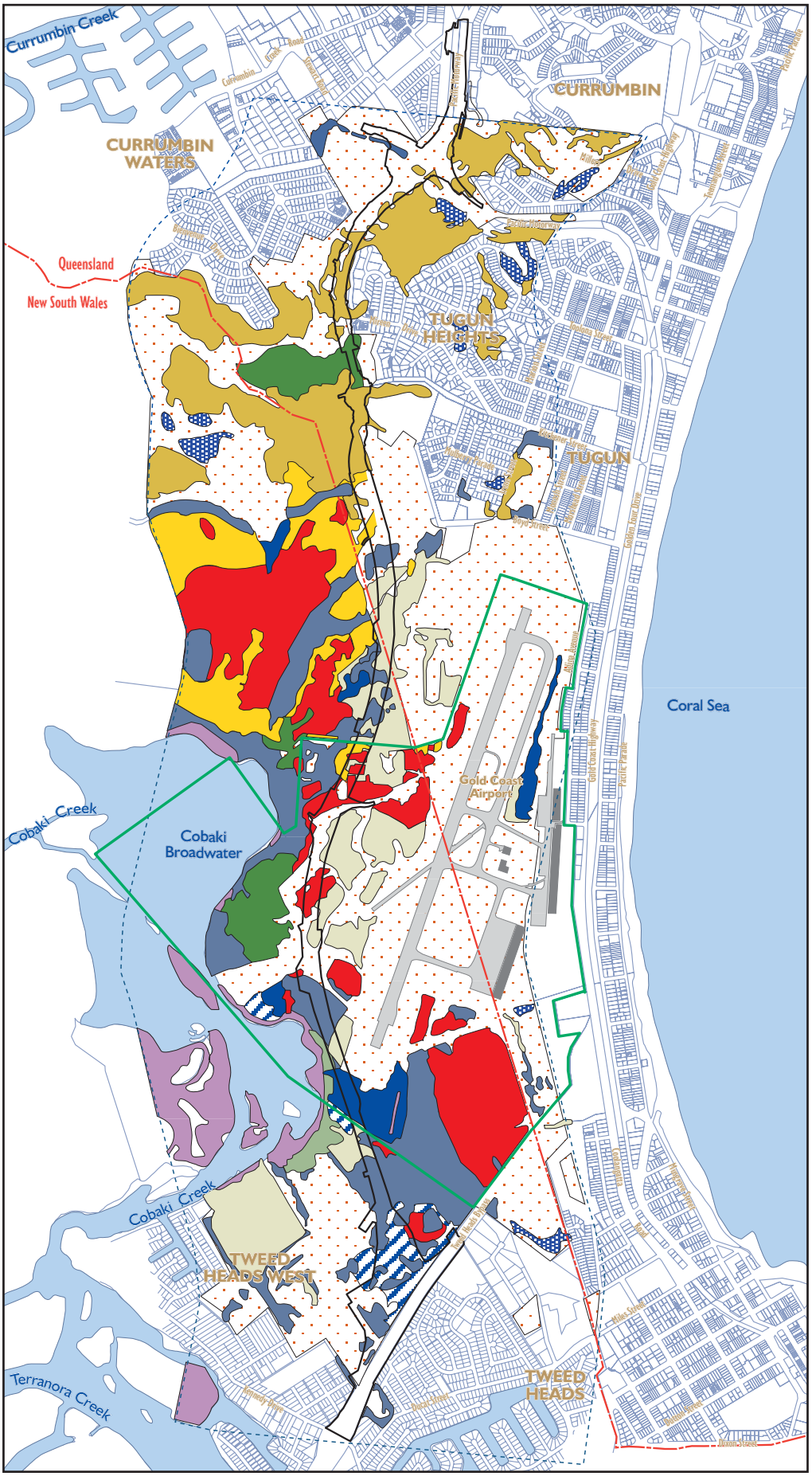
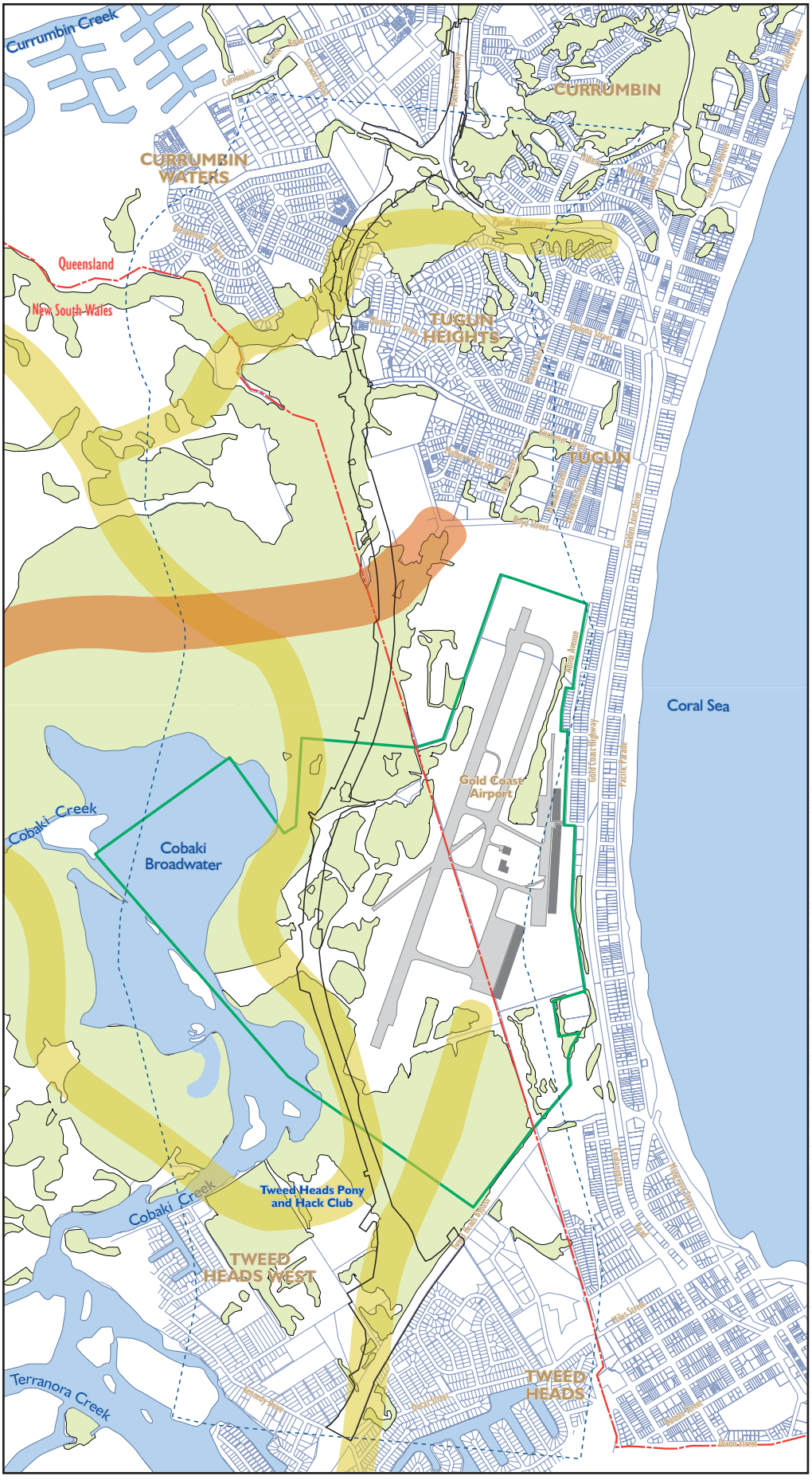


Figure 10.3 **Terrestrial Fauna Habitats**



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

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

Figure 10.4 **Potentially Significant Fauna Habitats and Corridors**

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

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

Two subregional fauna corridors and one regional corridor have been identified near the proposal in NSW. The location of these corridors is shown in Figure 10.4. The regional fauna corridor extends from Boyd Street westward through NSW Crown land. One subregional fauna corridor is located at the southern end of the proposal connecting a habitat block of habitat at the southern end of the airport with other areas to the south across the Tweed Heads Bypass. The other subregional corridor connects the vegetation lining the shore of Cobaki Broadwater, northwards to NSW Crown land. This subregional corridor also branches off towards Queensland and over the Pacific Motorway, and forms an avifauna corridor to Currumbin Sanctuary. The presence of the Pacific Motorway and the Tweed Heads Bypass across these sub-regional corridors precludes their use by grown dwelling fauna.

10.3.2 Koala habitat

Vegetation communities dominated by Swamp Mahogany and/or Forest Red Gum in the vicinity of the proposal are considered to provide primary habitat for Koalas. Phillips and Callaghan (1995) note that the primary habitat located to the south of the Queensland–NSW border, adjacent to Gold Coast Airport and bisected by the Tweed Heads Bypass, has been extensively fragmented and may no longer support Koala populations. Some secondary Koala habitat is located where the proposal intersects the northern boundary of the Gold Coast Airport.

10.3.3 Hollow trees

As part of the initial Mammal, Reptile and Amphibian Survey of the Tugun Bypass (Hero *et al*, 2000, 2001a, 2001b), the only area identified as containing tree hollows in the study area was a small patch of old growth Scribbly Gum Forest located in NSW Crown land to the west of the proposed bypass. Therefore, it was considered that the route would not impact on any hollow-bearing trees.

Subsequent work has found a total of 47 trees containing hollows within the study area. The location of the hollow-bearing trees is predominantly concentrated just north of the proposed Tweed Heads Bypass interchange and near Boyd Street, and includes the clump of old growth Scribbly Gums in the NSW Crown land identified in the original survey.

Thirty-three hollow-bearing trees would be felled along the alignment. This is a high local impact as there are still significant numbers of hollow-bearing trees to the west, and the

proposed mitigation measures would partially offset their removal. The following mitigation measures would be implemented:

- the hollow-bearing portion of the trees be removed after felling and re-instated in adjacent areas. If any hollows are damaged or destroyed during clearing, then appropriately designed nest boxes would be affixed to standing trees in the vicinity
- all hollow-bearing trees to be felled would be clearly marked, and their species and approximate dimensions catalogued so that hollows and nest boxes can be affixed to similar standing trees
- small hollows should be replaced with nest boxes designed for bats. The nest boxes would have an overhanging roof and internal baffles, and external and internal walls would be lined with flyscreen to improve grip
- medium-sized hollows should be replaced with nest boxes designed for Squirrel Gliders and Brush-tailed Phascogales
- nails used to attach nest boxes should not be galvanised or coated and should not contain zinc to avoid poisoning the trees
- metal strapping that allows for tree expansion should be used to attach nest boxes
- boxes should be placed between 4 and 8 m above the ground and oriented to minimise penetration by rainfall and sunlight
- boxes should be placed away from main access tracks to minimise the chances of them falling and injuring anyone.

In general, reinstated hollows and nest boxes would be placed in intact forest near the preferred alignment. This could occur in NSW Crown land to the north and land to the east of the route near the proposed Tweed Heads Bypass interchange. The actual placement would take into account the density and dispersion of existing hollows, would be examined in detail in the Construction Environmental Management Plan, and would be discussed with relevant landowners and NSW Department of Environment and Conservation.

10.4 Animal species

A total of 261 species of terrestrial vertebrate fauna was recorded from the study area during the fauna surveys (Table 10.7). This included 12 introduced fauna species. In addition 14 aquatic fauna species and eight invertebrates were also recorded. A list of fauna species recorded from the study area is included in Technical Paper 12.

Table 10.7: Total number of terrestrial fauna species recorded within the study area

Category	Recorded during present surveys		
	Total	Indigenous	Introduced
Birds	179	175	4
Mammals	31	25	6
Reptiles	20	20	0
Amphibians	17	16	1
Aquatic fauna	14	13	1
Total	261	249	12

10.4.1 Introduced species

The presence and density of introduced species of flora and fauna give an indication of the existing condition of native habitats and threats to their survival. A total of 11 terrestrial and one aquatic introduced fauna species were recorded. Foxes are abundant throughout the study area.

10.4.2 Invertebrates

No invertebrate species of state or national significance were recorded in the study area. Targeted searches were undertaken for three species of regional significance, Mitchell's Rainforest Snail *(Thersites mitchellae)*, Giant Dragonflies *(Petalura gigantea* and *Petalura litorea)* and Swordgrass Brown Butterfly *(Tisiphone abeona morrisi).*

No suitable habitat for the Land Snail *(Thersites mitchellae)* was found along the proposed alignment. The taxonomic diversity of the other Land Snails collected during the survey and in the general area strongly suggests that the proposal is outside the general habitat range preferred by this species.

The Director-General of NSW National Parks and Wildlife Service (now Department of Environment and Conservation) requirements for the preparation of the SIS listed the Swordgrass Brown Butterfly subspecies (*Tisiphone abeona rawnsieyi*) for inclusion. However, the distribution of this species extends from the lower valley of the Brisbane River to Fraser Island in Queensland, and is unlikely to occur in the study area. Figure 10.5 shows second instar larvae of a Swordgrass Brown Butterfly were recorded in wetlands along the western edge of Boyd Street, but these were from a separate subspecies, *Tisiphone aboena morrisi*. This sub-species has also been recorded in the airport.

The SIS also included the assessment of the Queensland Giant Dragonfly *(Petalura litorea)*. Figure 10.5 shows one individual was recorded within the study area, approximately 80 m from the proposed alignment, near Hidden Valley. Potential habitat for this species was also found at a number of locations within the study area, none of which would be directly affected by the proposal.

10.4.3 Amphibians

The study area exhibits high amphibian diversity, with 17 species known to occur there. Potentially another three amphibian species are likely to occur in the area. One species of frog, the Wallum Sedge Frog (*Litoria olongburensis*), is of national significance while the Wallum Froglet (*Crinia tinnula*) is of state significance. These species are listed in Table 10.8 and their locations shown on Figure 10.5.

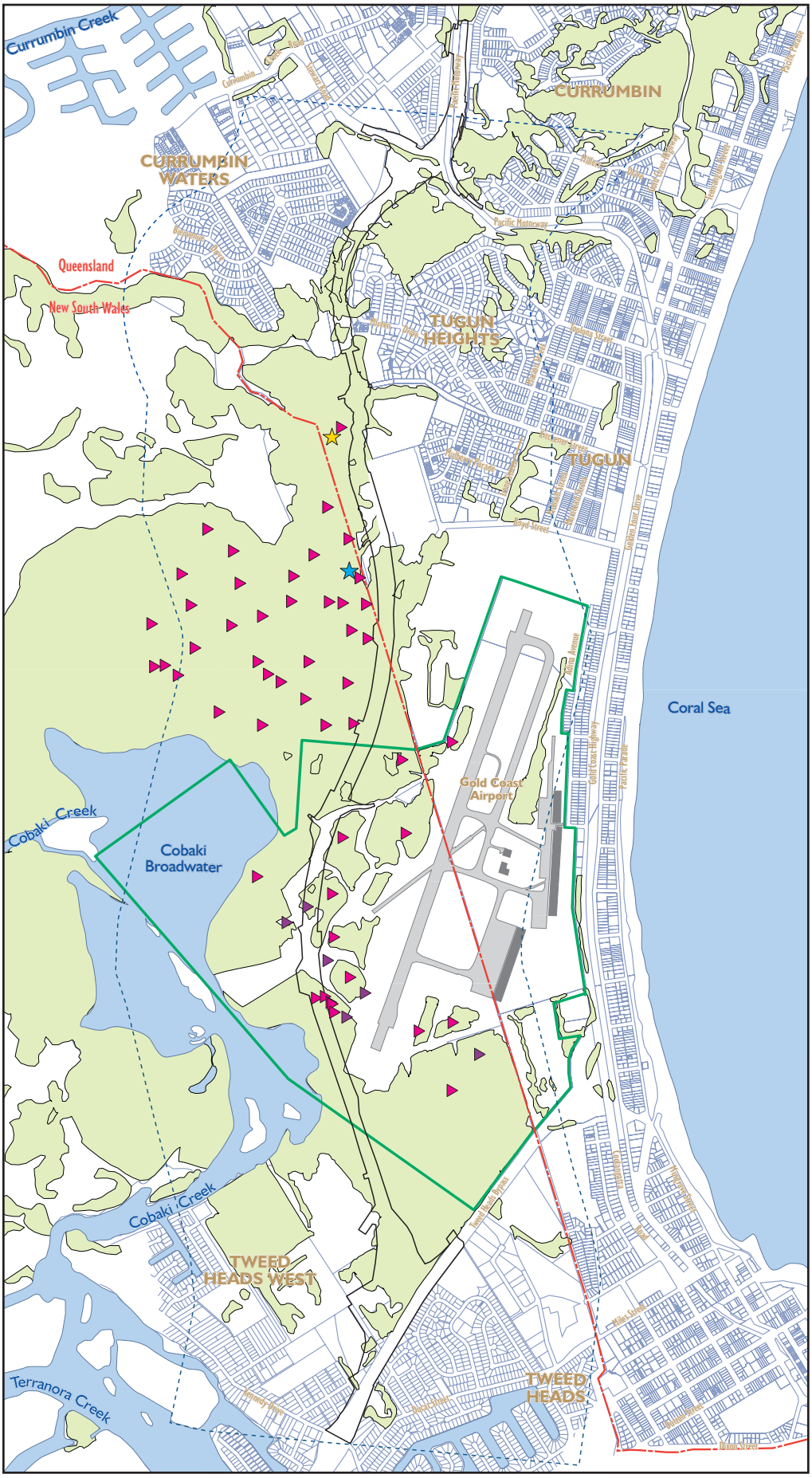


Figure 10.5 **Locations of Significant Amphibian and Invertebrate Species**

Table 10.8: Significant amphibian species recorded in the study area

Species name	Status	Recorded	Regional abundance	National distribution
Wallum Froglet *(Crinia tinnula)*	TSC (V) NCR (V)	The Wallum Froglet is widely distributed in the vicinity of the proposed Tugun Bypass in NSW, Queensland and on Commonwealth Airport Land. The population of froglets is estimated to be in excess of 10,000 individuals. Known habitat for the Wallum Froglet in the study area comprises approximately 331 ha and broadly encompasses the following vegetation communities: Slashed Heathland, Wet Heathland, Swamp Mahogany Forest, Swamp Mahogany – Brushbox Forest, Littoral Rainforest, Swamp Paperbark Forest and other moist forest types. Potential habitat comprises a further 98 ha. Breeding is confined to slow-moving water less than 1.5 m deep within the pH range of 3.0 to 5.2.	This species has been recorded in a number of sites throughout the study area and is very widespread. The population is estimated to comprise approximately 10,000 individuals (Hero *et al.* 2001a). The Wallum Froglet population estimated to comprise about 10,000 individuals is considered to be the largest recorded from the region according to Hero *et al.* 2001. However, very large populations of the Wallum Froglet occur at the Broadwater, Bundjalung, Yurragir and Myall Lakes National Parks, Tyagarah Nature Reserve and Crown land north of Lennox Head. These populations are considered to be at least equivalent in size to the Tugun population, if not larger (Lewis pers. comm.). A total of 431 records of this species are listed on the NPWS Database as occurring in NSW, with 28 of these occurring in the Tweed Local Government Area. The nearest records of the Wallum Froglet is from 1998 about 6 km to the south near Wormin Bay. A large number of records also come from Cudgen Nature Reserve and surrounds about 15 km to the south. Queensland Museum records show populations of this species about seven and then 50 km west of the Study Area in Queensland.	An acid frog adapted to acidic waters of coastal lowlands. Known from Bribie, Moreton and Stradbroke Islands and remnant wallum areas mainly along northern Moreton Bay. Usually found in dense reed beds of marshes and swamps. Distribution is restricted to coastal south eastern Qld and northern NSW. The preferred habitat is warm temperate lowland swamps and creeks. This specie inhabits the fringes of creeks and swamps and is often found amongst emergent vegetation grasping reeds or grass stems.
Wallum Sedge Frog *(Litoria olongburensis)*	TSC (V) EPBC (V) NCR (V)	Six populations of the Wallum Sedge Frog were recorded in ponds located in NSW and on Commonwealth Airport Land. However, there was not enough data to determine population size. Known and potential habitat for the Wallum Sedge Frog (*Litoria olongburensis*) comprises approximately 56 ha. Breeding habitat is characterised by low pH, and relatively deep water with some capacity to retain water for longer periods.	There is currently little ecological data available on the Wallum Sedge Frog. Lewis and Goldingay (in prep) assessed the status of the sedge frog in NSW through surveys at 145 sites across its known range and monitored transects at 10 sites to provide indices of population stability between 1996–2000. Monitoring transects in areas of sedge swamp found frog populations were rarely stable and fluctuated from year to year. Tyagarah Nature Reserve had the highest mean count of adults (41) and subadults (45) but also had large variation which peaked at 152 subadults in winter 1996 and 133 adults in winter 1999. The next largest mean count was that at Broadwater East (Broadwater National Park) with 31 adults and 18 subadults which showed a reduced level of variation. High mean counts were also recorded at Lennox East	This species is found in habitats that are typically warm, temperate grasslands and inhabits acid, paperbark swamps. Its distribution is coastal regions of southern Queensland and northern NSW.

Species name	Status	Recorded	Regional abundance	National distribution
			(Crown Land), Esk Firetrail (Bundjalung National Park), and Macaulays Lead also in Bundjalung National Park. Low mean frog counts were recorded at Tweed Heads (within the study area, identified as precinct 1 in Hero *et al*. 2001) and Bombing Range (Bundjalung NP) with one and two adults respectively. The above data appears to indicate that the Wallum Sedge Frog population in the Study Area is quite low in numbers and may be unviable in the long-term, especially given continued pressure from surrounding development. The population in the Study Area appears to be highly constrained by development and environmental conditions, with minimal interaction between this population and others within the region. A total of 78 records of the this species are listed on the NPWS Database as occurring in the NSW North Coast Bioregion, although only one of these records is listed in the Tweed Local Government Area. This record of the Wallum Sedge Frog is from 1988 about 15 km to the south of the Study Area in Cudgen Nature Reserve. There have also been sightings in Tyagarah Nature Reserve about 35 km to the south. No records for this species exist on the Queensland Museum records for South East Queensland.	

Note: The legislative status of these species is as follows:
TSC = NSW *Threatened Species Conservation Act 1995*
NCR = Queensland Nature Conservation (Wildlife) Regulation 1994
EPBC = Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
V = vulnerable

10.4.4 Reptiles

Twenty species of reptile are known to occur in the study area. Database searches indicate that potentially another 11 reptile species are likely to occur in the study area.

While no species of state and/or national significance were recorded during the most recent surveys, the White-crowned Snake *(Cacophis harriettae)* (listed as 'vulnerable' on the NSW *Threatened Species Conservation Act 1995*) has been recorded within 20 km of the site and may also occur on the site.

10.4.5 Birds

A total of 179 species of bird was recorded from within the study area, 175 of which were native and 4 introduced. A species list is included in Technical Paper 12. Bird habitat within the study area can be divided into two. Firstly, there is aquatic habitat for water birds such as waders, which is found within the Cobaki Broadwater and includes roost sites and foraging habitat. Secondly, there is terrestrial habitat to the west of the alignment, which includes swamp forest, mangroves and rainforest habitats that are of most importance to terrestrial birds.

Assessment of conservation significance of bird species

Fifteen bird species were identified as having international importance and are listed either in the Japan–Australia Migratory Birds Agreement (JAMBA) or the China–Australia Migratory Birds Agreement (CAMBA). These birds are mainly species associated with the aquatic habitats of the Cobaki Broadwater, though several are also woodland-dependent. The majority arrive in Australia from their breeding grounds in Eurasia in August and September, and spend the summer months here. These habitats are to the west of the alignment and unaffected by the proposal. A list of the species can be found in Technical Paper 12.

Fifteen bird species of state significance were also recorded during the surveys. These are listed in Table 10.9 and their recorded locations shown in Figure 10.6.

A further eight bird species considered to be of regional conservation significance were recorded from the study area. These are the Brahminy Kite *(Haliaster indus)*, Little Bronze Cuckoo *(Chrysococcyx minutillus)*, Little Shrike Thrush *(Colluricincla megarhyncha)*, Mangrove Gerygone *(Gerygone levigaster)*, Wandering Whistling Duck *(Dendrocygna arcuata)*, Forest Kingfisher *(Halcyon macleayii)*, Peregrine Falcon *(Falco peregrinus)* and Dusky Honeyeater *(Mysomela obsura)*.

Table 10.9: Legislatively significant bird species recorded within the study area[1]

Species name	Status	Recorded
Black Bittern *(Ixobrychus flavicollis)*	TSC (V)	An unconfirmed record of the Black Bittern was reported in the large vegetation patch to the north of Cobaki Broadwater.
Brolga *(Grus rubicunda)*	TSC (V)	An individual Brolga was recorded circling the study area during field surveys.
Bush Hen *(Amaurornis olivaceus)*	TSC (V)	Unconfirmed records of the Bush Hen were obtained from NSW in the vicinity of Boyd Street. North of Boyd Street, a pair of Bush Hens exhibiting nesting behaviour was recorded from a small dam in the area known locally as Hidden Valley. Unconfirmed records were also obtained from near Stewart Road. In NSW, habitat for this species is likely to be restricted to Swamp Forest along a small drainage line near Boyd Street.

Species name	Status	Recorded
Collared Kingfisher *(Todiramphus chloris)*	TSC (V)	The Collared Kingfisher has been recorded around the edge of the Cobaki Broadwater on NSW and Commonwealth Airport Land.
Eastern Curlew *(Numenius madagascariensis)*	NCR (R) J/C	The Eastern Curlew was recorded from the Tweed Heads Pony and Hack Club roost during the field survey.
Eastern Grass Owl *(Tyto capensis)*	TSC (V)	One individual of the Eastern Grass Owl was recorded in Sedgeland at the southern end of the main airport runway in NSW. The nearest historical records for this species are at Vintage Lakes and at Chinderah, south of the Tweed River in NSW. It is not clear whether the recorded individual was a resident but the area appears large enough to support a breeding pair (Sandpiper Ecological Surveys 2001a).
Glossy Black Cockatoo *(Calyptorhynchus lathami)*	TSC (V) NCR (V)	The Glossy Black Cockatoo has been recorded to the north of the Cobaki Broadwater in NSW during field surveys. This species was recorded about 105 m to the west of the proposed alignment.
Lewins Rail *(Rallus pectoralis)*	NCR (R) Regionally significant in NSW	As well as being listed as rare in the Queensland Nature Conservation (Wildlife) Regulation 1994, Lewins Rail is considered to be of regional significance in NSW. It is also considered to be near threatened in the most recent Action Plan for Australian Birds (Garnett & Crowley 2000). It was recorded calling from several sites in NSW including Saltmarsh adjacent to Mangrove Forest, small wetlands in woodland, Swamp Forest and Sedgeland. It was also recorded from disturbed grassland near Stewart Road in Queensland.
Mangrove Honeyeater *(Lichenostromus fasciogularis)*	TSC (V)	The Mangrove Honeyeater was recorded on Commonwealth Airport Land and NSW in Mangrove Forest. Habitat and populations of this species would not be directly affected by the proposal. Some indirect impacts of the proposal, such as increased noise, may affect this species.
Masked Owl *(Tyto novaehollandiae)*	TSC (V)	Unconfirmed recordings of the Masked Owl were made during recent surveys from the large vegetation area north of the Cobaki Broadwater in NSW.
Osprey *(Pandion haliaetus)*	TSC (V)	The Osprey was recorded from a number of locations in NSW, and on Commonwealth Airport Land mainly around the Cobaki Broadwater. This species would forage in the Cobaki Broadwater and shelter in vegetation nearby.
Rose-crowned Fruit-Dove *(Ptilinopus regina)*	TSC (V)	The Rose-crowned Fruit Dove was recorded from the Littoral Rainforest in NSW and on Commonwealth Airport Land. It was also recorded north of Boyd Street from the moist regrowth forest near Stewart Road and from Hidden Valley.
Superb Fruit-Dove *(Ptilinopus superbus)*	TSC (V)	Unconfirmed records of the Superb Fruit Dove came from the Littoral Rainforest on Commonwealth Airport Land and from Hidden Valley.
Wompoo Fruit Dove *(Ptilinopus magnificus)*	TSC (V)	Confirmed record from Hidden Valley in Queensland, southwest of the proposed alignment.
White-eared Monarch *(Monarcha leucotis)*	TSC (V)	The White-eared Monarch was recorded from Queensland in moist regrowth near Stewart Road. It is also likely to use habitat in Hidden Valley and moist regrowth habitat in NSW.

Note: The legislative status of these species is as follows:
TSC = NSW *Threatened Species Conservation Act 1995*
NCR = Queensland Nature Conservation (Wildlife) Regulation 1994
V = vulnerable
R = rare
J/C = JAMBA/CAMBA

10.4.6 Mammals

Thirty-one species of mammal were recorded in the study area during the field surveys. A fauna species list is included in Technical Paper 12. Results from database searches indicate that possibly another eight mammal species could occur in the area.

Assessment of conservation significance of mammal species

Two mammal species, the Long-nosed Potoroo (*Potorous tridactylus*) and the Grey-headed Flying Fox (*Pteropus poliocephalus*) are of national significance under the *Environment Protection and Biodiversity Conservation Act 1999*, and are also considered of state significance under the NSW *Threatened Species Conservation Act, 1995*. Seven other species are also of state significance. These species are listed in Table 10.10 and their locations shown on Figure 10.7.

A further two species of state and/or national significance have been recorded within 20 km of the site and may also occur on the site. These are the Yellow-bellied Sheath-tail Bat *(Saccolaimus flaviventris)* and Koala *(Phascolarctos cinereus).* No individuals of either species were captured during surveys.

One species, the Grassland Melomys *(Melomys burtoni),* was recorded on NSW and Commonwealth Airport Land in numbers that suggests the area supports a regionally significant population of the species. However this species is not listed in Commonwealth or state legislation.

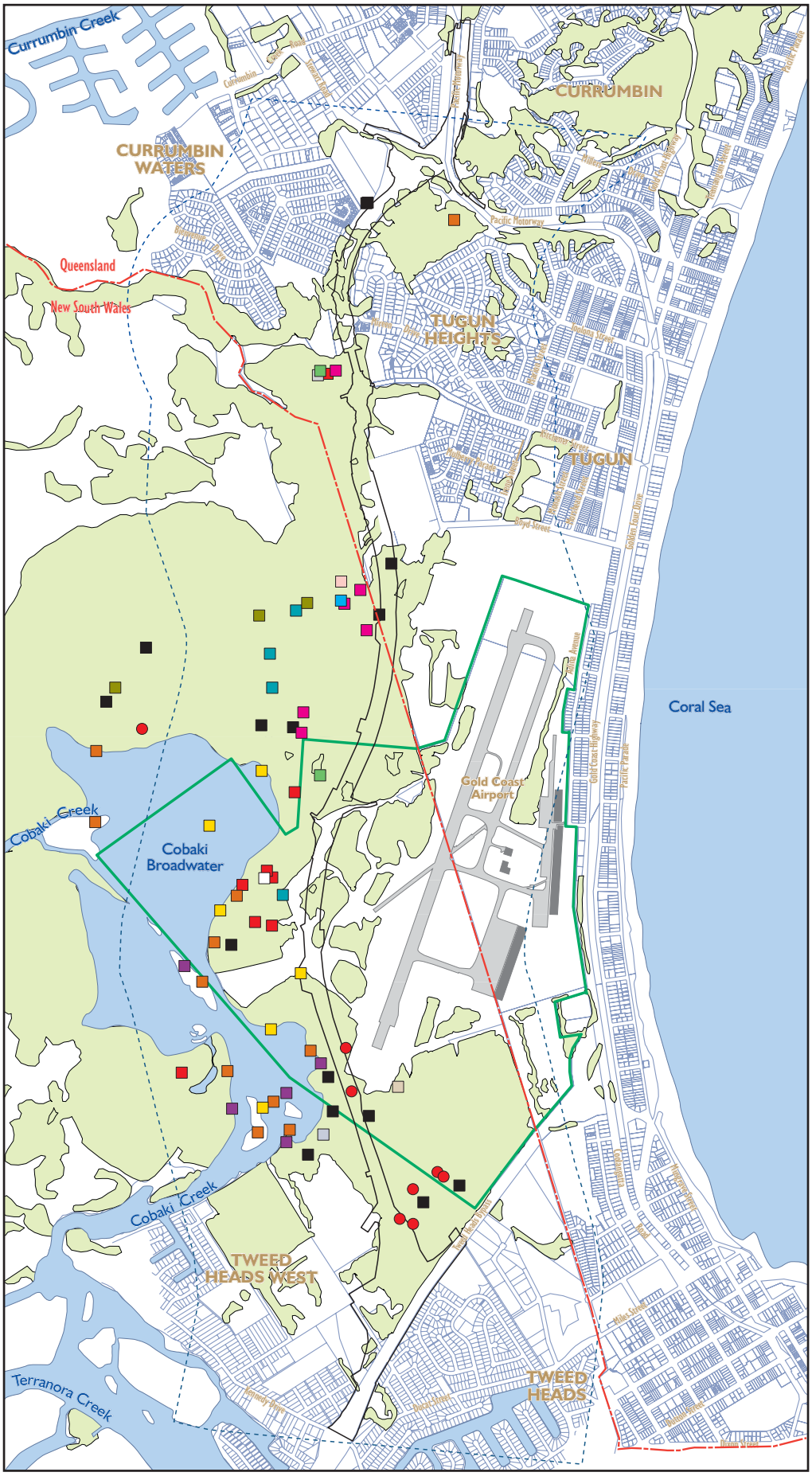


Figure 10.6 **Locations of Threatened Bird Species (Excluding JAMBA/CAMBA Species)**

Table 10.10: Legislatively significant mammal species recorded in the study area[1]

Species of national significance				
Species name	**Status**	**Recorded**	**Regional Abundance**	**National distribution**
Long-nosed Potoroo (*Potorous tridactylus*)	TSC (V) NCR (V) EPBC (V)	Although Potoroos have been detected only sporadically since 1992, recent trapping indicates the population comprises at least 55–65 individuals, but may be as high as 85 individuals. The final alignment is located as far as possible to the east of potoroo habitat, given constraints associated with the Tugun Landfill. The highest densities were recorded to the north and south of the Cobaki Lakes development access track. Of the 27 individuals captured, 15 were located in a 18 ha patch of habitat to the north of the access track. No individuals were observed crossing the track, indicating that it has effectively divided the population into two subpopulations. Habitat connectivity is likely to be permanently severed by the Cobaki Lakes development access track if no mitigation measures are implemented. Furthermore, the failure to mitigate drainage impacts along the access track has resulted in extensive seasonal flooding to the north, and the subsequent loss of potoroo habitat. The study area contains approximately 88 ha of potoroo habitat (with an additional 20 ha outside the study area) with Scribbly Gum Mallee Heathland, Tree Broom Heathland and Swamp Mahogany – Scribbly Gum Forest supporting the highest densities of Potoroos. These habitats are characterised by moist, dense to mid-dense understoreys.	The regional abundance of this species is unknown. Generally potoroo abundance is low and patchy in north-eastern NSW. Both Mason (1993) and Steve Phillips (pers. comm.) estimate that there may be only 250 Long-nosed Potoroos occurring in the region. A total of 394 records of this species are listed as occurring in NSW, with seven of these occurring in the Tweed Local Government Area. The nearest records of the Long-nosed Potoroo are from 1988 and 1989 in the vicinity of Cudgen Nature Reserve about 15 km to the south. Within 30 km of the Study Area there are populations within the Tyagarah Nature Reserve which reported three sightings. Several sightings have occurred approximately 45 km to the south-west in Nightcap National Park and the Whian Whian State Forest. Approximately 45 km to the south west of Tugun there have also been sightings in the Border Rangers National Park.	This is species, once thought to be rare in south-eastern Queensland, is known to be quite widely distributed there and common in Tasmania. It is rare in Western Australia. The specie is generally restricted to areas with an annual rainfall greater than 760 mm, it inhabits coastal heath and dry and wet sclerophyll forests. A major habitat requirement is relatively thick ground cover and it seems to be concentrated in areas where the soil is light and sandy. Populations of the species are found in Western Australia, near Albany, in Tasmania and in several isolated groups in the southern portion of Queensland and along the coastline of NSW.

Species of national significance				
Species name	**Status**	**Recorded**	**Regional Abundance**	**National distribution**
Grey-headed Flying Fox (*Pteropus poliocephalus*)	EPBC (V) TSC (V)	The Grey-headed Flying Fox was recorded in a number of locations in the study area, predominately while foraging in swamps during flowering periods. It was recorded in the same habitats as the Black Flying Fox but at different times. A roost site comprising approximately 15 to 20 individuals was also recorded from Hidden Valley.	A total of 1318 records of this species are listed on the NPWS Database as occurring in NSW, of which 36 occur in the Tweed Local Government Area. The nearest records of Grey-headed Flying Fox is from 2001 about 1 km to the south of the Study Area in Tweed Estuary Nature Reserve. It has also been recorded Ukerebagh and in Cudgen Nature Reserves. Queensland museum show the closest records for the Grey-headed Flying Fox as being about 14 km north-west of the Study Area. There were also other populations 30 km west and 45 -55 km north-west of the Study Area.	This species occurs a in a coastal belt from Rockhampton to Melbourne and occasionally individuals are found on Bass Strait Islands. It is infrequently found west of the Great Dividing Range. Camps are often found in gullies, typically not too far from water and usually in vegetation with a dense canopy.

Species of state significance				
Species name	**Status**	**Recorded**	**Regional Abundance**	**National distribution**
Black Flying Fox (*Pteropus alecto*)	TSC (V)	The Black Flying Fox was recorded from a number of locations throughout the study area in NSW and on Commonwealth Airport Land. No roosts of this species were observed in the area.	Sightings of this species are restricted to between Tweed Heads and Grafton. The sightings predominately follow the eastern coastline however there is also a sighting as far west as Kyogle. The closest sighting is located in Tweed Heads, this is close to the sighting located approximately 2 km to the west (. There are three other sighting locations in the near vicinity in the areas around the Terranora Broadwater and surrounding golf courses. Additional sightings occur to the south near Woomin Bay and Pottsville Beach.	Mangrove islands in the estuaries of most northern rivers usually contain camps of the Black Flying–fox, often consisting of hundreds of thousands of individuals. Smaller camps of several hundred to serval thousand may be found in mangroves, paperbark swamps or occasionally in patches of rainforest. It is a high roosting species and seeks rather dense leaf cover. Groups are know to travel as far as 50 km from their camp to feed. The distribution of this species borders the top half of Australia, hugging the coastline from Shark bay in Western Australia to Coffs Harbour in NSW.
Common Blossom Bat *(Syconycteris australis)*	TSC (V)	One individual of this species was recorded in mature Banksia near the Littoral Rainforest on Commonwealth Airport Land. This location is about 135 m from the proposal footprint.	Sightings closely follow the eastern coastline as far south as the Booti Booti National Park. The closest sighting of this species is at Fingal Head, approximately 1.5km to the south. Close to Fingal Head is a sighting at Kingscliff, there are also two sightings to the west in the vicinity of the Mt Warning National Park. The majority of the sightings for this species are grouped at locations at Pottsville Beach, approximately 20km south near Cudgen Nature Reserve, Lennox Head and further south near Bundjalung National Park.	This species is widely distributed in New Guinea and, in Australia, extends well into NSW. In tropical Australia, the Common Blossom-bat roosts among rainforest foliage. At the southern limits of the range, heathland and melaleuca swaps are critical feeding habitats. Subtropical rainforest and coastal eucalypt forests are visited when healthlands and paperbarks are not flowering. Coastal rainforest is a particularly important habitat in NSW, providing a moist microclimate for roosting in the sub-canopy layer. Such areas are usually adjacent to heathland feeding areas. In the wet tropics where there is no healthland, the bats often visit fruit orchards to feed. The blossom bat has been recorded as commuting up to 4km to feed from a roost, such mobility may be necessary to fully exploit spatially and temporary patchy food resources. In NSW some species such as Banksia integrifolia, flower consistently for up to six months and Blossom-bats show a great fidelity for these feeding areas. Populations of this species border the eastern coastline from the northern most point of Queensland, down to areas near Sydney in NSW.

Species of state significance				
Species name	**Status**	**Recorded**	**Regional Abundance**	**National distribution**
Common Planigale *(Planigale maculata)*	TSC (V)	A population of the Common Planigale was recorded from within a 1 ha area on Commonwealth Airport Land. The population appears to be small and localised. Habitat comprises Swamp Mahogany and Swamp Mahogany – Brushbox Forest. It is at a slightly higher elevation than the surrounding land, and appears to be critical to the survival of the populations during wet periods. Potential habitat comprising Swamp Mahogany – Brushbox Forest and Wet Heathland exists to the north of known habitat, separated by an airport access track.	Common planigale records appear to be represented by few individuals, in most cases a single individual. Such low capture rates are most likely an artefact in the specific methods required to target this species combined with their cryptic habits. Therefore it could be assumed that at least independent locations separated by obvious geographic boundaries would constitute a viable population comprising multiple individuals. Some limited abundance data are available: • one individual at Oxenford (D. White pers. comm.) • two individuals at Coombah Creek in 1996 (Rohweder & Banks 1996) • one individual recorded on two occasions at Tugun Heights (Hero et al. 2001; D. White pers. comm.) • two individuals along Coolangatta Creek in 2003 (Ecosure 2003) • one individual at lands currently being developed for SALT. Between 1 – 4 individuals at 27 locations across coastal locations in the Byron Shire (see Miller 1998) There would appear to be virtually no interaction between the Common Planigale populations in the Study Area and those elsewhere within the region due to the lack of habitat connectivity. A total of 104 records of the this species are listed on the NPWS Database as occurring in NSW, mostly in the North Coast Bioregion with 22 occurring in the Tweed Local Government Area. The nearest records of the Common Planigale is from 1998 about 5 km to the south of the Study Area near Wormin Bay. There have also been sightings near Bogangar, in the vicinity of Cudgen Creek, and further west near Yabera State Forest. Only one recorded occurrence of the Common Planigale occurs in the Queensland Museum records for south-east Queensland. This sighting is located about 30 km north-west of the Study Area.	This species occupies a range of habitats from rainforest, sclerophyll forest and grasslands to marshlands and rocky areas. It even manages to exist in low density in the outer suburbs of Brisbane. Populations exist in two isolated areas of western Australia, but are concentrated in the northern most point of Western Australia, and the Northern Territory. There are also populations that follow the eastern coastline, from the tip of Queensland as far down as Sydney in NSW.

Species of state significance				
Species name	**Status**	**Recorded**	**Regional Abundance**	**National distribution**
Eastern Long-eared Bat (*Nyctophilus bifax*)	TSC (V)	Original surveys for this species in the Study Area in February 2000 trapped the Eastern Long-eared Bat as the most common microchiropteran bat species on the site. However, follow-up surveys in January 2001 only recorded one individuals of Eastern Long-eared Bat in the area. This may be due to the 2001 survey concentrating in Paperbark Forest near the Tweed Interchange, which may not be the most widely used habitat for this species in the Study Area. The Eastern Long-eared Bat was relatively abundant in the vicinity of the proposal suggesting that it represented a significant population in the area. This species is associated with a range of habitats in Queensland but generally prefers rainforest in NSW.	Given this disparity in survey results and the lack of information available with regard to Queensland populations it is difficult to determine how important the habitat in the Study Area is for this species in a regional context. However, given the abundance of this species recorded in 2000 and the low numbers recorded elsewhere in the locality, the Study Area is considered to provide important foraging and roosting habitat for this species in the region, even if only utilised seasonally or sporadically. Surveys by Lewis Ecological Surveys in the broader locality (<20km) have generally yielded small numbers (<15 individual per survey). Along the Tweed coast small scale surveys of between 3-5 nights have captured 2-4 individuals (1999-2001). Further to the south at Byron Bay (Cumbebin Swamp) 11 individuals were captured over four harp trap nights (2 locations) in December 2000. Surveys at Suffolk Park in January 2001 recorded 7 individuals with earlier surveys at this site by Parker (2000) and Woodward Clyde (1997) also recording this species but no indication of abundance. Two individuals have been captured at Goolawah Reserve (Ingersoll & Redpath 2002) which is currently recognised as the southern range limit for this species. A total of 137 records of this species are listed on the NPWS Database as occurring in the North Coast Biogeographic Region, with 15 of these recorded in the Tweed Local Government Area. The nearest records of the Eastern Long-eared Bat are about 10-15 km to the south of the Study Area near Duranbah and Cudgen Nature Reserve. These records are mostly from 1997 to 2001. A larger group of records is from about 15 km to the south near Cudgen Nature Reserve from 1998. The abundance of the populations at these locations is not known.	This species occurs across northern Australia where it is locally common in habitats ranging from rainforest to riparian woodland. Radio-tracking in NSW indicated that individuals frequently roost communally in tree-hollows is among dense foliage and that retention of a range of roost sites is essential to its survival. Studies also show that there are seasonal changes in roost-selection from the edge of the rainforest remnant areas in summer to the centre of rainforest patches in winter. There is a population located in Western Australia near Port Headland it then reaches from Broome to and area in Queensland north of Mt Isa. The eastern distribution reaches from the Cape York Peninsula to Port Macquarie in NSW.

Species of state significance				
Species name	**Status**	**Recorded**	**Regional Abundance**	**National distribution**
Large-footed Myotis (*Myotus adversus*)	TSC (V)	The Large-footed Myotis was recorded in Littoral Rainforest on Commonwealth Airport Land during the field surveys, about 345 m from the proposed alignment.	This species has a broad distribution throughout NSW . The closest sighting location is at Boganbar located approximately 20km to the south of Tweed Heads. There are also records for Pottsville Beach, Cudgen Nature Reserve, Nightcap National Park, Tyagarah Nature Peserve and Suffolk Park	Colonies of 10-15 individuals, occasionally several hundred, are found in caves, mines or tunnels, under bridges and buildings and even in dense foliage in the tropical part of its range. Colonies of large-footed Myotis never occur far from water bodies, ranging from rainforest streams to large lakes and reservoirs. Although Myotis is more widely spread around the world than any other bat genus, usually with at least two of its 60-odd species in any large geographical region, only one species is know for certain in Australia. Distribution ranges from Derby in Western Australia to Adelaide in South Australia, after following the eastern coastline. There is also an isolated population near Broken Hill.
Little Bent-wing Bat (*Miniopteris australis*)		The Little Bent-wing Bat was recorded from a number of locations throughout the study area. The species has a high likelihood of using the site as part of its foraging habitat, but would not roost in the area because of the lack of suitable structures (e.g. caves, mines, tunnels, culverts).	Sightings of this species are predominantly along the eastern coastline north of Sydney. However, there are also a few sightings along the Great Dividing Range. There is a sighting location for this species slightly approximately 10km west of Tweed Heads. There is also a large group of sightings at Bogangar, in the vicinity of Cudgen Nature Reserve. There are additional sightings down the coastline, particularly at Broadwater, Bundjalung and Yuraygir National Parks.	The little Bentwing-bat depends upon specific nursery sites to rear its young. It occupies caves and tunnels during the day and at night forages for small insects beneath the canopy of well-timbered habitats, including rainforest, Melaleuca swamps and dry sclerophyll forests, it distribution within Australia becomes increasingly coastal to wards the southern limit of its range in NSW. The southernmost breeding population is found in the Macleay River watershed. The distribution of the species follows the eastern coastline from The Cape York Peninsula to Port Macquarie in NSW.

Species of state significance				
Species name	**Status**	**Recorded**	**Regional Abundance**	**National distribution**
Squirrel Glider *(Petaurus norfolcensis)*		The Squirrel Glider was recorded in one location in NSW in old-growth Scribbly Gum Forest, about 535 m to the west of the proposed alignment. No suitable nesting habitat (areas containing dense trees) would be removed by the proposal.	Sightings of this species are spread over the eastern portion of NSW, reaching over the full north-south extent. The closest sighting location to Tweed Heads is approximately 20km south near Mooball Nature Reserve. Other sighting locations nearby include areas in the vicinity of Mt Warning National Park. Other sightings cover a broad area down the eastern coastline, there is a group of sightings near Broadwater, Bundjalung and Yuraygir National Parks.	The squirrel glider inhabits dry sclerophyll forest and woodland in south-eastern Australia where it is absent from the dense coastal ranges. However, in northern NSW and Queensland it occurs in coastal forest and in some wet forest areas bordering on rainforest. While the squirrel glider is usually more common than the Sugar Glider in places where they co-exist, the squirrel Glider may be endangered in the southern part of its range. In northern Victoria, an important habitat for the larger species is remnant vegetation along roadsides and creek and river frontages in cleared pasture: preservation of such disjunct habitats may be vital for its continued survival. Populations exist in a band bordering the eastern coastline of Australia, through Queensland, NWS and Victoria.

Note: The legislative status of these species is as follows:
TSC = NSW *Threatened Species Conservation Act 1995*
NCR = Queensland Nature Conservation (Wildlife) Regulation 1994
EPBC = Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
V = vulnerable

10.5 Terrestrial fauna — impacts, mitigation and management

This section examines the impacts of the bypass on species of legislative significance. It identifies the level of impact and suggests mitigation measures for each species, including the development of species management plans where appropriate. It also takes a more holistic approach to the assessment by recognising that the ecosystems supporting an individual species have their own importance in supporting a range of other species. The areas identified have been termed sites of ecological significance and are discussed in Technical Paper 12.

The development of a road can form a partial obstruction by slowing or restricting movement for some species. For other species, road development can form a barrier to movement and fragment their habitats. Any species that tries to cross the road is likely to be hit by vehicles. The greatest potential for a road to act as a barrier is where it crosses a wildlife corridor. The alignment of the bypass recognises the importance of these corridors and, where possible, has been realigned to avoid them. However, the bypass would still act as a barrier to a number of species, and the impacts and mitigation measures are described below.

When the route of a new road crosses through areas of native vegetation and important habitat, in addition to the barrier effect, it also creates an effect known as an edge effect. This is degradation of habitat quality that occurs as a result of weed invasion, increased predation, disturbance, and changes in moisture regimes. The mitigation measures have taken into account impacts that are a result of edge effects.

10.5.1 Invertebrates — impacts, mitigation and management

The Queensland Giant Dragonfly *(Petalura litorea)* is the only invertebrate species of legislative significance found in the study area. The larval stage of this species lasts from 10–30 years and the larvae occupy permanent burrows built in the bottom of swamps. The adults emerge during summer and, being poor flyers, do not disperse very far. The single individual recorded during the survey was recorded from paperbark swamp some 60 m from the alignment. None of this known habitat would be directly or indirectly affected by the proposal. The level of impact on this species is therefore low local.

The removal of native vegetation would remove habitat for invertebrates along the alignment; however, the route of the bypass has been chosen to minimise the need to clear areas of native vegetation. Drainage controls included as part of the design of the bypass would ensure existing surface and subsurface water flows are maintained.

No specific mitigation measures are planned for invertebrates. The rehabilitation plans for disturbed areas would re-establish, for the invertebrates, important habitat characteristics such as dense ground cover and shrubs.

10.5.2 Amphibians — impacts, mitigation and management

Two species of frog with national and state significance were found in the study area. The Wallum Sedge Frog is a nationally listed species, while the Wallum Froglet is a state-listed species in NSW and Queensland.

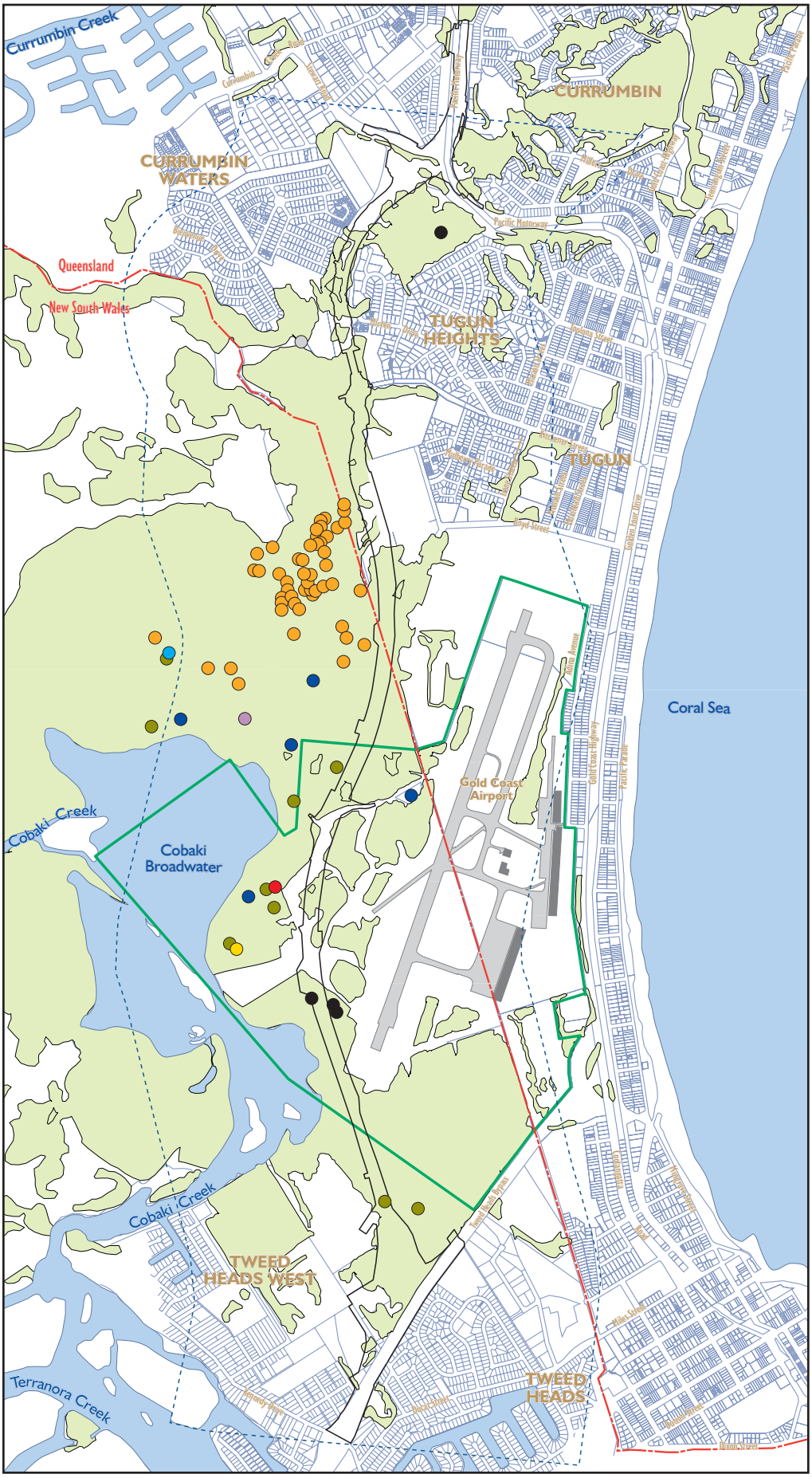


Figure 10.7 **Locations of Mammal Species of Conservation Significance**

Wallum Froglets and Wallum Sedge Frogs

Wallum Froglets were recorded throughout the study area, in particular south of Boyd Street, but also adjacent to the ridge to the north of the John Flynn Hospital and Medical Centre. Approximately 44.3 ha of known and potential habitat of this species would be removed from a total of 429 has as a result of the proposal. This represents an overall loss of 10% of the known and potential habitat.

The Wallum Sedge Frog has a more restricted distribution and approximately 4.7 ha or 8% of known and potential habitat in the study area would be lost as a result of the construction of the bypass.

Participants at the International Union for the Conservation of Nature Threatened Frog Workshop held in February 2001 recommended an objective method for assessing impacts on vulnerable frog species. By their definition, any action would have a significant impact if it would, or is likely to, modify, destroy, remove, isolate or decrease the known occupied habitat of a vulnerable frog species by 0.5% or more (Hero *et al*. 2001b).

The Wallum Froglets found in the study area are thought to represent more than 0.5% of the total mainland population. The removal of the entire local population would, therefore, be considered to be significant. However, since approximately 10% only of known and potential habitat would be removed as a result of the proposal, the impact on this species would be considered to be local but high.

Similar data relating to the size and importance of the Wallum Sedge Frog meta-population in comparison with other Australia-wide populations is lacking (Jean-Marc Hero, pers. comm.). The proposal would remove 4.7 ha or 8% of the known and potential habitat in the study area. This could be expected to represent far less than 0.5% of the known habitat for this species in Australia, and can therefore not be considered significant based on the criteria recommended at the workshop. However, as the habitat of two subpopulations of the Wallum Sedge Frog would be significantly affected by the proposed bypass, the impact of the proposal would be considered to be of regional significance.

There are no specific mitigation measures proposed for the Wallum Froglet as 90% of its habitat would remain within the study area. The proposed footprint would remove one known Wallum Sedge Frog pond and may indirectly impact on three more sites during construction/operation of the bypass.

Construction of artificial frog ponds would be undertaken to compensate for the loss of Wallum Sedge Frog breeding habitat. This would be based on the following criteria:

- The ponds would be built up with materials taken from the alignment. This would ensure that suitable substrate materials form the base of the ponds. This would also minimise the depth of the excavations below ground level, thereby avoiding saline intrusion from the Cobaki Broadwater.
- The minimum size of the ponds would be 15–20 m in length and 5–10 m in width.
- Ponds would be constructed to a minimum depth of 1.5 m with a gradient sloping to 0.3 m at the pond edges. The objective of this is to compensate for water fluctuations yet still enable the Wallum Sedge Frog to seek cover amongst sedges growing in water.

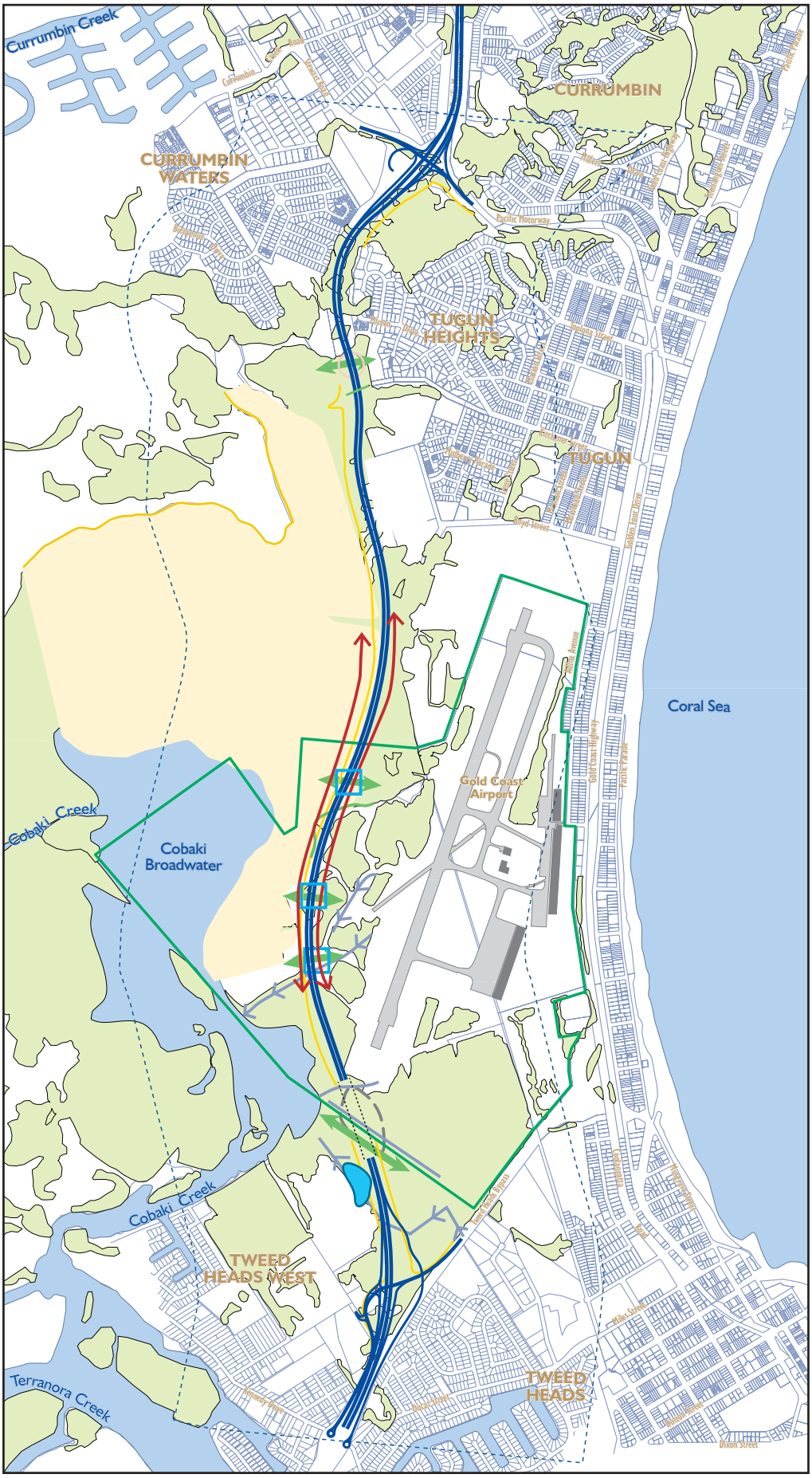


Figure 10.8 **Location of Proposed Major Mitigation Structures and Compensatory Measures**

- A slow release liner, similar to those used in dam construction and sedimentation traps, would be used in the ponds to increase the permanency of surface water (>80% time).
- The choice of vegetation would be consistent with the local habitat requirements for the Wallum Sedge Frog. Sedges such as *Restio* species would be excavated and transplanted into the pond once the liner has been fitted to the pond base. This would require the use of machinery such as a Bobcat or small backhoe to remove the vegetation by a process known as 'slabbing'. Slabbing depth would be at least 30 cm to ensure organic layers are collected. The source sites for slabbing would include any existing *Restio* vegetation at the artificial pond sites and, where applicable, augmented from areas with dense *Restio* along the proposed footprint.
- Construction works would be during a dry period (spring) leading up to a pronounced rainfall event (normally summer). The objective of this is to enable machinery to access the site with minimal damage, and enhance the likelihood that the transplanted vegetation would survive by reducing the chance of drying out.

Two culverts would be constructed under the bypass to maintain connectivity between areas of Wallum Sedge Frog habitat on either side of the alignment. These culverts would be 1 m high and 3 m wide, with their length varying between 50 and 60 m. The design of the base of the culverts would need to encourage the use of these structures by frogs. One option is to include a central channel in the culvert that would hold water.

In addition to the culverts, frog exclusion fencing would be constructed to keep frogs off the road and direct them into the culverts. This fencing would consist of a solid sheet of durable material measuring approximately 400 mm high, with a small overhang at the top to discourage individuals from climbing over it.

The effectiveness of the ponds, culverts and frog exclusion fencing would be monitored during the construction phase and also during operation of the bypass until results show that the area has stabilised.

10.5.3 Reptiles — impacts, mitigation and management

No reptile species of state, national or regional significance were found within the study area. The removal of native vegetation would remove habitat for reptiles along the alignment; however, the route of the bypass has been chosen to minimise the need to clear areas of native vegetation.

No specific mitigation measures are planned for reptiles. The rehabilitation plans for disturbed areas would re-establish, for reptiles, important habitat characteristics such as dense ground cover and shrubs.

10.5.4 Birds — impacts, mitigation and management

Removal of native vegetation along the alignment would result in the loss of habitat for birds. This would include roosting, foraging and nesting resources including fruiting and flowering vegetation. However, the rehabilitation and revegetation of cleared areas with native species would result in new foraging and roosting resources.

In order to mitigate against any loss of nesting resources any hollow bearing limbs removed from the footprint will be moved to nearby areas. A number of nesting boxes would also be placed in appropriate areas.

Within the study area, most of the prime habitat for terrestrial and wading birds is to the west of the alignment. This means that the roosts and feeding areas of the Cobaki Broadwater, and the swamp forest, mangroves and rainforest habitats that are most important to the terrestrial birds would remain largely untouched. However, 0.8 ha of swamp forest would be removed and, at the southern end of the alignment, trees used by nesting Brahminy Kites would be felled. The proposal may also cause indirect impacts associated with disturbance from traffic noise.

Bush Hen

A pair of breeding Bush Hens was recorded in Hidden Valley. Known and potential habitat for this species also occurs in NSW at the northern end of the Cobaki Broadwater. Approximately 3.5 out of the 60 ha of known and potential habitat would be affected by the proposal, and indirect impacts may occur as a result of disturbance during bridge construction.

Increased disturbance in Hidden Valley may affect the quality of habitat for the Bush Hen. Hidden Valley most likely represents an important habitat for individuals that also use habitats in the remainder of the study area. The construction of a bridge over Hidden Valley may reduce the quality of habitat for breeding Bush Hens. Birds may initially avoid foraging in the area immediately surrounding the proposed bridge. However, the proposed bypass is unlikely to place the local population at risk of extinction, so the level of impact can be considered to be local.

Bush Hens are thought to be nomadic, moving in response to rain (Marchant & Higgins 1993). They are, therefore, likely to fly over the proposed bypass when moving between sites. Notwithstanding their flight capabilities, the crepuscular and nocturnal behaviour of Bush Hens means that most movements would occur around dusk or during the night. This may place birds at greater risk of being dazzled by lights of vehicles using the highway.

Lewins Rail

An individual Lewins Rail was recorded from disturbed grassland habitat near Stewart Road during the spring field survey. This habitat, in which the species was recorded, is regarded as marginal. Although the site provides the dense vegetation preferred by this species, it lacks areas of permanent water that may be used for foraging. However, a number of other records of this species were made throughout NSW and Commonwealth Airport Land. Therefore the loss of habitat in Queensland is unlikely to place the local population at risk of extinction and, therefore, the level of impact is only considered local. No specific mitigation measures are proposed for the Lewins Rail.

Eastern Grass Owl

Up until recent airport mowing activities, the study area supported potential roosting and breeding habitat and represented the most recent record of Eastern Grass Owl in the local area and the wider (50km) locality (Wildnet 2003). Breeding records are scarce in north-eastern NSW and south-eastern Queensland: with only one locality near Harrington in NSW and another on the western outskirts of Brisbane (Higgins 1999; Barrett *et al.* 2003). Eastern Grass Owl distribution in south-eastern Queensland extends north from Coolangatta to the Noosa Heads and Toowoomba areas (Roberts and Ingram 1976; Higgins 1999). This distribution is likely to be 'patchy' in the Gold Coast area given the current level of habitat removal and disturbance. This is highlighted in the local area with almost 50% of potential Eastern Grass Owl habitat in the Tweeds Heads locality has been removed since mid 2002 (Lewis pers. comm.). Its distribution in the North Coast bioregion extends from Tweed Heads and Tenterfield Shires to Port Stephens

at the southern limit of the bioregion. The apparent stronghold for grass owl in north-eastern NSW occurs in the Richmond Valley, Ballina and Byron Shires where it is represented by 85 records.

Sandpiper Ecological Surveys (2001) identified that the Study Area may represent an essential link in the altitudinal migration paths used by the Eastern Grass Owl. Therefore, this species habitat within the study area was considered to be regionally significant. Unfortunatelyr recent airport slashing activities in the area have reduced the value of the habitat for this species and while this site is being continually slashed it would provide minimal regionally significant habitat.

Waders

Historical studies indicate that there has been a decline in the use of high tide roosts around the Cobaki Broadwater over the last 10 years. In particular, a considerable decline in the use of the Tweed Heads Pony and Hack Club roost has been noted; however, it is still the most important roost on the Cobaki Broadwater and has high local significance as a spring tide roost. The proposal would have no direct impacts on the roost but there may be indirect impacts owing to disturbance from construction works and traffic noise.

A monitoring program would begin prior to construction to monitor the use of roost sites on the Cobaki Broadwater. The program would continue during the construction and early operational phases to determine if there is any evidence of changes in usage attributable to disturbance from the proposal.

10.5.5 Mammals — impacts, mitigation and management measures

Vegetation clearance required for the construction of the proposal would mean that habitat for mammals would be removed. It is likely that species of conservation significance would also occur along the proposal, so measures would be needed to ensure that they are removed from the footprint prior to the beginning of construction. One species of national significance, the Long-nosed Potoroo, and two of state significance, the Common Planigale and the Eastern Long-eared Bat would be directly affected by the proposal.

The removal of vegetation from the footprint has the potential to result in the injury or death of any mammals using the area. Before the removal of any vegetation begins, measures would be taken to remove as many mammals as possible to safety. These include:

- surveys targeting mammals and other species by a qualified ecologist
- traps set to capture as many individuals as possible. Captured individuals would be relocated to suitable areas of habitat nearby
- a fauna rescue framework for clearing has been developed by the NSW RTA in consultation with the NSW Department of Environment and Conservation and would be used as the basis during the project
- during pre-clearing surveys bark would be removed from old growth paperbarks after bats have left roost sites (i.e. under the bark) to begin foraging at dusk to prevent individuals from being injured or killed during clearing
- once cleared, the footprint would be fenced with animal-proof fencing.

Long-nosed Potoroo

About 0.5 ha (0.4% of the total) of the eastern edge of known Long-nosed Potoroo habitat would be removed by the proposal. The proposal itself is not considered to be a major threat to the Long-nosed Potoroo population. However, in conjunction with the impacts on the population resulting from other approved developments in the area, the effect on this population is considered to be regionally significant. Already under threat from predation by feral animals, the development of two large residential areas either side of the potoroo habitat would pose a major danger to the population if no control measures were implemented. This would be owing to edge effects, disturbance and, most importantly, further predation from domestic cats and dogs. Without any mitigation measures, it is likely that the combined effect of all developments would be the local extinction of the Tugun Long-nosed Potoroo population.

To protect the Tugun Long-nosed Potoroo population, a number of protection and management measures would be implemented. The aim of these measures is to provide the population with better protection from the current pressures of habitat fragmentation and predation, and also to have measures in place to protect the population in advance of the start of other approved developments in the area. The implementation of the management measures, combined with monitoring of their effectiveness, would greatly reduce the threat of local extinction.

A species management plan would be prepared for the Tugun Long-nosed Potoroo population. This would have the goals of maintaining the Tugun Long-nosed Potoroo population at its current size, reducing current levels of predation, and maintaining the existing habitat. Key components of the plan would be:

- installation of animal-proof fencing around the areas of habitat. The function of the fencing would be to prevent potoroos from straying onto the road corridor. The fencing would also keep predators out of the habitat
- the fencing would be installed along both sides of the Boyd Street access track. If this track is further developed in the future, it is likely that underpasses would be required to reinstate the connectivity between habitat on either side of the road
- a fox control program would be initiated and maintained on NSW Crown land around the area
- a fire management plan for the NSW Crown land taking into account the habitat requirements of the potoroo by prescribing a mosaic of 'patch' burning and the prevention of catastrophic wildfires would be prepared and implemented
- a monitoring program to check on the effectiveness of the management plan and to monitor the status of the population would be prepared and implemented.

Grey-headed Flying Fox

This species is highly mobile and no known roost habitat would be directly affected by the proposed bypass. The Grey-headed Flying Fox was recorded in a number of locations in the study area, predominantly while foraging in swamps during flowering periods. It was recorded in the same habitats as the Black Flying Fox but at different times. A roost site comprising approximately 15 to 20 individuals was also recorded from Hidden Valley in Queensland, about 200 m from the proposed alignment.

No rainforest roosting habitat would be modified or removed in NSW or from Commonwealth Airport Land, although 0.6 ha of rainforest would be modified in Queensland. A total of 14.4 ha of Swamp Forest would be removed by the proposed bypass. This includes 9.6 ha in NSW,

3.0 ha in Commonwealth Airport Land and 1.8 ha in Queensland. This represents the removal of 11.2% of potential roosting habitat for the Grey-headed Flying Fox from the study area. This is not considered to be significant in relation to potential roosting habitat in the region.

The known roost may also be disturbed by construction activities. However, as this roost is only used occasionally, it should not be affected in the long term. Grey-headed Flying Foxes are also known to use roost sites adjacent to human activities. The level of impact of the proposal on this species can, therefore, be considered as local.

About 330 ha of potential foraging habitat for the Grey-headed Flying Fox occurs in the study area. The proposed bypass would result in the removal of a total of 32.2 ha or about 9.8% of potential foraging habitat for this species. This includes 16.6 ha in NSW, 3.8 ha from Commonwealth Airport Land and 11.8 ha in Queensland. Given the high mobility of this species, the loss of 32 ha of known and potential foraging habitat is not considered significant in relation to the regional distribution of potential foraging habitat for this species.

The majority of suitable habitat for the Grey-headed Flying Fox occurs to the west of the proposal area and would not be isolated from nearby habitats. The proposed bypass is also unlikely to create a barrier to movement for this mobile species.

General mitigation measures aimed at minimising habitat loss and maintaining existing hydrological regimes would minimise the impact to this species.

Common Planigale

On Commonwealth Airport Land, the Common Planigale is thought to occupy about 1 ha of known primary habitat, of which 0.05 ha or 5% would be removed as a result of the proposed bypass. This habitat appears to be important to Common Planigales, especially during wet periods because it is more elevated than surrounding secondary habitat. The bypass would also remove about 2 ha of secondary habitat out of 3 ha (67%). The proposed bypass would also fragment the existing population. The entry/exit ramps to the tunnel in this area prevent the construction of underpasses. Disturbance and edge effects, in particular vibration, may have a significant effect on the population as it is directly adjacent to the footprint. Few mitigation measures are available to minimise direct and indirect impacts on the Common Planigale, therefore, the proposed bypass could disrupt the population on Commonwealth Airport Land to such an extent that it becomes extinct. This impact can be considered as high local as its distribution is not restricted to a particular habitat.

Hero *et al.* (2001b) have recommended that individuals captured in the pre-construction phase are maintained in captivity and then released into the same area post-construction. Common Planigales are readily reared in captivity and it may be possible to keep individuals in captivity until the construction of the road is completed (David Read, pers. comm.). However, there is minimal habitat for the Common Planigales that would be retained in the area. Therefore, immediate translocation of individuals into nearby suitable habitat areas would be undertaken, rather than keeping the animals captive.

Any translocation would be undertaken in accordance with the NSW Department of Environment and Conservation translocation policy (NSW National Parks and Wildlife Service 1998).

Eastern Long-eared Bat

Surveys have shown that the Eastern Long-eared Bat is relatively abundant in the vicinity of the proposal and that it represents a significant population in the area. This species is associated with a range of habitats in Queensland but generally prefers rainforest in NSW. One of the roost sites used by the Tugun population was identified in a stand of mature paperbarks at the southern end of the bypass where the interchange with the Tweed Heads Bypass would lie. Approximately 1.5 ha of the paperback community would be removed and most of the trees would be felled; however, the abundance of the species in the study area suggests that there are also other roost sites around the study area. The level of impact on this species can, therefore, be considered as high local.

10.6 Aquatic fauna habitats and species

10.6.1 Wetland habitats

Estuarine wetlands are coastal communities that are at least occasionally inundated by saline to brackish waters. Three wetland habitat types have been described for the study area. These are listed in Table 10.11. A number of drainage lines and ephemeral ponds are scattered through the study area providing habitat for wetland species. Descriptions of these areas are provided in Technical Paper 12.

Table 10.11: Wetland habitat types

Wetland habitat type	Description
Mangrove Forest	Mangroves fringe the entire Cobaki Broadwater and densely cover several dredge spoil islands in the Broadwater. Mangroves are important habitats because they input significant amounts of vegetable matter into the food chain, trap, accumulate and release nutrients and particulate matter from surrounding land, provide habitat and shelter for a range of flora and fauna, and protect the shoreline from erosion.
Saltmarsh	Saltmarsh vegetation is located on the landward side of mangroves and comprises shrublands, sedge and rush swamps and grasslands. Saltmarsh habitats are important because they stabilise bare mud flats, remineralise terrestrial and marine debris, and provide a direct food source and habitat for terrestrial fauna, birds and marine fauna.
Seagrass	Seagrass is limited to a number of subtidal patches in the entrance to the Broadwater and is composed mainly of Eel Grass (*Zostera capricornii*). Sampling during the study demonstrated that juvenile fish catches taken in the vicinity of seagrass beds were significantly higher in both diversity and abundance than those taken above bare substrate. The seagrass underwent a significant decline in the 1960s, probably associated with extensive dredging and catchment development. Seagrasses are significant primary producers and play a critical role in coastal marine ecosystems by providing shelter and refuge for resident and transient fish of recreational and commercial importance, trapping, stabilising and holding bottom sediments, slowing and retarding water movement and promoting sedimentation of particulate matter, supplying and fixing biogenic calcium carbonate, producing and trapping detritus and secreting dissolved organic matter, providing large amounts of substrate for encrusting animals and plants, and providing a food source for some species of fish and crustacea.

10.6.2 Conservation significance of wetland habitat types

Tweed Estuary and Cobaki Broadwater

Cobaki Broadwater has been identified as an area of high scenic and ecological value in the *Lower Tweed Estuary Management Plan* (NSW Department of Public Works 1991). The Tweed Estuary supports important recreational and commercial fisheries and is recognised as one of

the highest producing rivers for both finfish and crustacea within the estuaries of northern NSW. The Cobaki Broadwater forms a substantial part of the Tweed system. The Broadwater, especially its fringing mangroves and seagrass beds, is considered to be an important breeding area for fish. Estuarine wetlands are important habitats and food sources for a variety of terrestrial and estuarine bird fauna, including migratory birds.

State Environmental Planning Policy Number 14 — Wetlands

State Environmental Planning Policy Number 14 Wetland Number 5A fringes the north-eastern shore of Cobaki Creek. This wetland is located on both Commonwealth and NSW land, and is part of a subregional wildlife corridor defined by the NSW Department of Environment and Conservation. It is regarded as an area of conservation significance in NSW, but this status is not recognised on Commonwealth Airport Land. Although the Saltmarsh and Mangrove Forest have been subject to past and continuing degradation, the mangrove community appears to be in a healthy condition.

A small area (about 0.02 ha) would be lost on the edge of this wetland. However, the margins of the wetland consist of highly degraded Swamp Oak Woodland and the more sensitive communities would not be directly affected by the proposal.

No fragmentation or barrier impacts would occur in this area, and the proposal is not expected to result in an increase in edge effects, as the tunnel would allow a connection to be maintained across the corridor.

10.6.3 Fish species

Eleven species of fish were recorded in the Cobaki Broadwater during the field study. A further 22 species have been recorded previously (Pease and Grinberg 1995). Commonly caught fish species within the Broadwater include Whiting, Flathead, Bream, Mangrove Jack, Garfish, Trevally, Herring and Mullet.

Two native fish species, the Empire Gudgeon *(Hypseleotris compressa)* and Striped Gudgeon *(Gobiomorphus australis),* were recorded from drainage lines and water bodies located throughout the study area. A crustacean, the Yabbie (*Cherax* sp.), and an introduced fish species, Mosquito Fish *(Gambusia affinis)* were also recorded at these sites. All of these species are considered to be common.

10.6.4 Significant fish species

No fish species of regional or state significance were recorded within the study area. In particular, the survey did not detect the Oxleyan Pygmy Perch *(Nannoperea oxleyana),* a species listed as endangered under the NSW *Threatened Species Conservation Act 1995*. This species is found in water bodies associated with Wallum vegetation. It is considered unlikely to occur near the proposed alignment because:

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

Three fish species of recreational or commercial significance were recorded within the Cobaki Broadwater. These were the Luderick *(Girella tricuspidata),* Yellow-finned Leatherjacket *(Meuschenia trachylepis)* and Tarwhine *(Rhabdosargus sarba).* A further 21 species may occur there. A list of commercial and recreational fish species likely to occur within the Cobaki Broadwater is included in Technical Paper 12.

10.6.5 Macroinvertebrates

One of the creeks in the vicinity of Boyd Street has diverse and abundant macroinvertebrate fauna. None of the species recorded is of conservation significance.

10.6.6 Aquatic biota — impacts, mitigation and management

Maintenance of water quality and surface and subsurface flows are integral to the preservation of sensitive wetland areas that provide foraging and roosting areas for a diversity of waterbirds and migratory shorebirds. It is also essential to protect the aquatic ecosystems of the Cobaki Broadwater that support seagrass beds and fish nurseries. The Wallum Froglet and Wallum Sedge Frogs are highly sensitive to environmental conditions, preferring a narrow range of pH, depth and water retention properties in their wetland habitats.

If the construction and operation of the proposal were to take place without any water quality controls, there would significant water quality impacts on the wetlands and the Cobaki Broadwater. Management of water quality issues has been integral to the design of the bypass and 'best practice' surface water quality management measures have been included. These are detailed in Chapter 8.

A water quality monitoring program would be implemented prior to the start of construction. The following environmental components would also be included in the program:

- the health of wetland communities that may be affected by altered groundwater levels
- the flora and fauna of the waterways adjacent to the corridor
- flora and fauna (macroinvertebrates, fish, wetland plant species) that serve as indicators of water quality would be monitored
- Saltmarsh, Sedgeland and Mangrove Forest communities would be monitored during construction and operation until all water quality management measures are established and stabilised.

10.7 Ecological significance of the study area

In addition to assessing the impacts of the proposal on significant species within the study area, the assessment must also recognise that the ecosystems supporting an individual species have their own importance in supporting a range of other species. This section summarises the ecological values of the area while the detailed assessments can be found in Technical Paper 12.

10.7.1 Values of the area

The proposed route transects an area of south-eastern Queensland and north-eastern NSW that is recognised for its high environmental values. Notable values of the study area include:

- the occurrence of significant populations of threatened species, including the Swamp Orchid *(Phaius australis)*, small disjunct populations of Common Planigales *(Planigale maculata)* and Long-nosed Potoroos *(Potorous tridactylus)*, and significant populations of the Wallum Sedge Frog *(Litoria olongburensis)*, Wallum Froglet *(Crinia tinnula)* and Eastern Long-eared Bat *(Nyctophilus bifax)*
- habitat for the Queensland Giant Dragonfly *(Petalura litorea)*, a species considered to be of at least regional significance
- the occurrence of habitat for a range of threatened and significant flora and fauna species, and important habitat for use by a number of bird species protected under migratory agreements
- a high diversity of vegetation communities
- a high diversity of bird, amphibian and bat species
- proximity to the Cobaki Broadwater, an important breeding ground for commercially and recreationally important fish in the Tweed Estuary.

When all the various ecological values of the study area are taken into account, the area can be considered to be of national significance for nature conservation. However, its importance has not been recognised to any great degree as evidenced by the lack of formal legal status for the area as a nature reserve or national park. The only formal recognition of the conservation significance of the area is found in the Tweed Shire Local Environment Plan, which zones part of the study area as 7(a) Environmental Protection (Wetlands and Littoral Rainforests) and has the aim of identifying, protecting and conserving significant wetlands and Littoral Rainforests from development. Gold Coast Airport Limited has also identified the area within the airport bordering the Cobaki Broadwater as an environmental precinct to be managed for conservation.

10.8 Compensatory habitat package

The development of the Tugun Bypass has been guided by the principle of delivering infrastructure while protecting the environment. The original C4 alignment has been altered a number of times to route it away from ecologically sensitive areas. This has included alterations to avoid orchid habitat, changes to avoid Long-nosed Potoroo habitat as much as possible, the design of a launched bridge for Hidden Valley, and changes to minimise impacts on Wallum Sedge Frog breeding ponds.

However, it has not been possible to avoid all impacts on areas of native vegetation and their associated ecosystems and residual impacts would remain. To offset the residual impacts a compensatory habitat package has been developed using the NSW RTA Draft Compensatory Habitat Policy and Guidelines. The policy specifies that compensation is one of a range of mitigation measures applied to residual impacts on key habitats associated with road development.

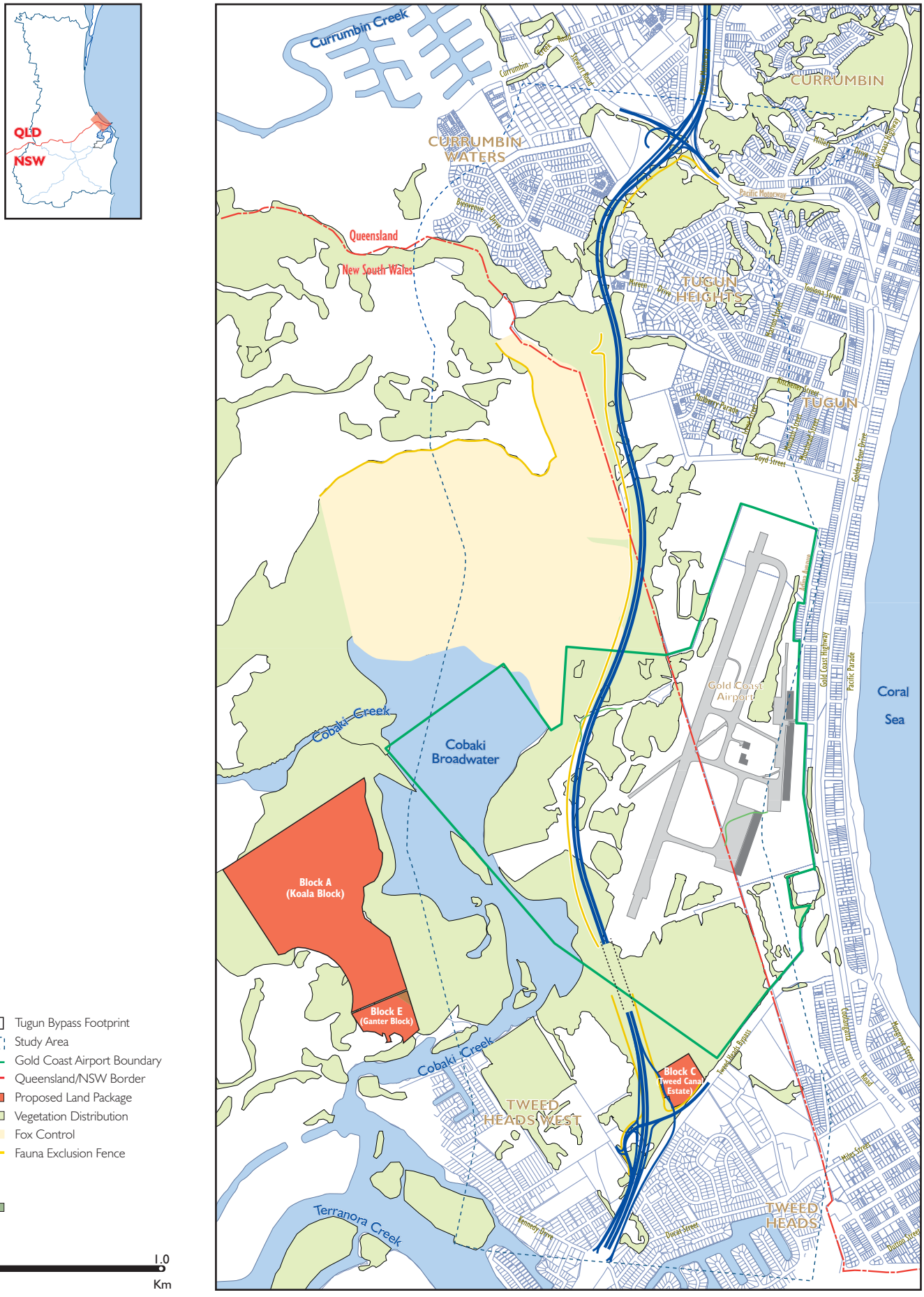


Figure 10.9 **Compensatory Habitat Land Package**

The draft NSW RTA policy states that, wherever possible, compensatory habitat should be equal or greater in area to the key habitat lost; however, this is not a legal requirement. Key habitat areas are those that support flora and fauna species of legislative and/or conservation significance. The Tugun land package has also taken into consideration the compensation of edge effects. This amounts to an additional 30 m strip being added along newly created corridors. A total of 71.1 ha of habitat would, therefore, be lost. This total consists of 45.2 ha of key habitat and 25.9 ha of edge-affected habitat.

The proposed sites forming the compensatory habitat land package are described as Block A (Koala Block), Block C (Tweed Canal Estate) and Block E (Ganter Block). These are shown on Figure 10.9. Together these blocks total 75.8 ha and are located within a kilometre from the proposal. The total land package is 4.7 ha larger than key habitat to be removed or edge-affected.

The compensatory land package is of a similar habitat quality and type to key habitat that would be removed as a result of the proposal. It shares at least eight (26%) vegetation communities in common with the Tugun study area. As a result of the compensatory habitat package, there would be a net gain in the amounts of 11 vegetation communities managed for conservation. Notably, it would result in the conservation of 12.9 ha of Swamp Oak Forest, a vegetation community considered to be of state significance in NSW and Queensland.

Similarly, the compensatory land package shares at least 25 (33%) legislatively significant flora and fauna species in common with the Tugun study area. The inclusion of Block A (Koala Block) as part of the package provides an opportunity to preserve local and regional biodiversity. It contains a remnant population of Koalas and mature hollow-bearing trees. Koalas were not recorded within the Tugun study area despite targeted surveys. Hollow-bearing trees are considered to be a limiting resource within the Tugun study area as they were only recorded in one area of Scribbly Gum Forest located to the west of the proposal.

The population of Long-nosed Potoroos recorded adjacent to the proposal is currently under threat from cumulative impacts associated with adjacent developments, including the Cobaki Lakes development and associated access track along Boyd Street. Compensatory measures are aimed at minimising predation by feral and domestic predators. The report detailing the compensatory habitat package is appended to Technical Paper 12.

An additional investigation undertaken in April 2004 (Ingram 2004) determined that portions of Block C (Tweed Canal Estate) contained approximately 1 ha of Wallum regrowth (as part of Paperbark Forest). This habitat is being considered for the building of more artificial ponds to encourage the breeding of the Wallum Sedge Frog.

The compensatory habitat package needs to be considered within the context of local and regional environmental protection. Block A (Koala Block), combined with Block E (Ganter Block), forms a strategically located link connecting habitat areas. Together with Block C — and adjacent vacant NSW Crown land, the Gold Coast Airport's environmental precinct, areas of open space within the Cobaki Lakes development, and other environmentally protected areas in Tweed Shire — they provide a continuous area of land of approximately 595 ha with varying degrees of regional biological significance and environmental protection. Towards this aim, environmental planning around the Cobaki Broadwater should focus on appropriate management of these areas to maintain their integrity and connectivity. Furthermore, the potential also exists to incorporate large parts of these lands under a single management structure with the aim of enhancing biological values.

Main Roads will establish the long term management of the compensatory habitat blocks for conservation use by transferring the title to the land to a recognised conservation organisation. Covenants would also be included on the land title, if practical. Integration of these blocks with the other areas of importance would require negotiation and agreement with the other land owners.

Overall, the land package combined with the management measures represents a favourable environmental outcome from a local, regional and national perspective for the following reasons:

- it fulfils the size and proximity criteria set out in the draft NSW RTA policy
- it compensates for key habitat that would be lost and edge-affected as a result of the proposal
- it is in close proximity to the impacted area and is directly or indirectly connected to habitat within the Tugun Bypass study area
- it compares favourably with the type and quality of habitat within the Tugun Bypass study area
- it shares 26% of vegetation communities and 33% of legislatively significant flora and fauna species in common with the Tugun Bypass study area
- it represents an opportunity to conserve 12.9 ha of Swamp Oak Forest, a vegetation community considered to be of state significance in both Queensland and NSW
- it represents an opportunity to conserve 7.55 ha of regionally significant Mangrove Forest in the Cobaki area
- it contains a regionally significant Koala population that may be one of the last populations in south and west Tweed
- it contains mature hollow-bearing trees that appear to be a limiting resource in the Tugun Bypass study area
- it represents an opportunity to further secure 22.1 ha of State Environmental Planning Policy 14 wetlands that are zoned Environmental Protection
- it forms a strategically located link connecting habitat areas around the Cobaki Broadwater for flora and fauna
- it provides an opportunity for the establishment of a continuous area of land with environmental protection around the Cobaki Broadwater.

10.9 Monitoring

10.9.1 Terrestrial flora and fauna

Monitoring programs for threatened species are described in detail in the SIS. Monitoring of the proposal impacts on aquatic and terrestrial ecosystems would be developed in consultation with the Queensland Environmental Protection Agency, NSW Department of Environment and Conservation and/or the Commonwealth Department of Environment and Heritage, depending on jurisdiction, and set out in an environmental management plan. The following should be monitored:

- size and distribution of the Tugun Long-nosed Potoroo population

- use of frog culverts
- effectiveness of frog-exclusion fencing
- Swamp Orchid colonies
- Common Planigale population
- Wallum Sedge Frog and Wallum Froglet populations
- translocated individuals of Little Wattle, Match Sticks and Chinese Burr.

10.10 Implications for ecologically sustainable development

10.10.1 The precautionary principle

The design of the proposed bypass includes a range of measures to limit or reduce potential adverse impacts on native biota and their habitats, some of which have not been rigorously evaluated in scientific terms. Notwithstanding this lack of scientific uncertainty, mitigation measures such as frog underpasses, fauna-exclusion and frog-exclusion fencing, frog pond construction and revegetation of the proposed tunnel would be implemented along the proposed bypass to limit or reduce adverse impacts on native biota and to contribute to the prevention of environmental degradation.

10.10.2 Intergenerational equity

Through the implementation of the nominated mitigation measures and proposed compensatory habitat package, an undertaking has been made to minimise long-term impacts on flora and fauna that would lead to a significant reduction in their health or quantity in the future. However, the proposed bypass is likely to adversely affect flora and fauna resources through habitat loss and fragmentation. The nominated mitigation measures are to a large degree experimental, and their success would be determined only through the implementation of a suitable monitoring program.

10.10.3 Conservation of biological diversity

The design of the proposed bypass has had careful regard to reducing the areas of vegetation to be cleared, and to the integration of features that would allow continued movement patterns for species in the locality of the proposed bypass. The range of mitigation measures (including the provision of compensatory habitat, revegetation of disturbed areas, and revegetation of the tunnel surface) before, during and after construction would minimise the risk of reducing biological diversity in the local area and region.

The implications of flora and fauna impacts for ecological sustainability are summarised in Table 10.12.

Table 10.12: Implications of flora and fauna impacts for ecologically sustainable development

Precautionary principle	Intergenerational equity	Conservation of biological diversity
The route selection process and the development of the present proposal have incorporated detailed consideration of flora and fauna issues. This has included detailed surveys of the selected route and adjacent areas. The proposed bypass would result in impacts on local habitats, including those of endangered species within the route corridor. However, future effects are predictable and mitigation measures, including compensatory habitat, are integral to the proposal.	Most known locations of significant flora and fauna species have been avoided, but the loss of some individuals from listed species or populations is expected. Habitat loss would include that of the Wallum Froglet, Wallum Sedge Frog and the Common Planigale, all listed species. The bypass would also exacerbate existing barrier effects for an isolated subpopulation of the Long-nosed Potoroo. The impacts of the proposal have been identified and compensatory measures included where feasible. However, the proposal would result in losses for current and future generations.	Mitigation measures have been included in the proposal design to minimise habitat fragmentation, barrier effects and road kills. Compensatory habitat would also be provided.

10.11 Conclusions

The flora and fauna assessments have shown that the study area can be considered to be of national significance because of the various rare and endangered plant and animal species found there. Important values of the study area include:

- the occurrence of significant populations of threatened plant species,
- small isolated populations of Common Planigales and Long-nosed Potoroos and significant populations of the Wallum Sedge Frog, Wallum Froglet and the Eastern Long-eared Bat;
- a high diversity of vegetation communities;
- a high diversity of bird, amphibian and bat species ;
- the occurrence of habitat for a range of threatened and significant flora and fauna species and important habitat for use by a number of bird species protected under migratory agreements;
- proximity to Cobaki Broadwater, an important breeding ground for commercially and recreationally important fish in the Tweed Estuary.

The alignment of the bypass has been altered to avoid areas of native vegetation and there associated ecosystems where possible. However it has not been possible to avoid all impacts on areas of native vegetation and their associated habitats and the bypass would result in the removal of around 45 ha of the native vegetation communities present.

To offset the residual impacts a compensatory habitat package has been prepared that consists of a combination of land purchases and the introduction of a number of management measures to significantly improve the conservation management of the study area.

11. Hazard and risk

11.1 Introduction

This section of the EIS identifies the hazards that may arise from the construction and operation of the Tugun Bypass, and assesses the risks to human health and safety and to the natural and built environments that may result.

A preliminary, qualitative risk assessment was undertaken to identify the significant issues that require management during the design, construction and operational phases of the project. The mitigation measures identified as part of this assessment have been considered in the relevant design and planning documents and other sections of this EIS.

The risk arising from the transport of dangerous goods was identified in the qualitative risk assessment as particularly important, and it has therefore been estimated quantitatively for the purpose of comparing the bypass with the 'do nothing' alterative, and for comparing alternatives for the management of dangerous goods transport on the bypass. The safety of residents along the existing route through Tugun and along the bypass, and the risk to users of the tunnel and to the tunnel itself were compared for a range of scenarios.

The risk assessment has been undertaken generally in accordance with the Australian Standard AS/NZS 4360:1999 – Risk Management and with its recent replacement, AS/NZS 4360:2004. Details of the hazard identification and risk assessment are contained in Technical Paper 16.

11.2 Overview

11.2.1 Risk assessment methodology

Two types of assessment were used to develop an objective view of the risks associated with the proposed bypass. Qualitative risk assessment uses categories based on broad estimates of the severity and likelihood of a hazardous event to determine a risk rating for the hazard. The rating can be used to determine which risks are more significant, to guide the decision on whether specific management practices should be adopted to reduce the risk, and to determine whether further, quantitative risk assessment should be undertaken.

Quantitative risk assessment combines information about the frequency or probability of one or more events or conditions and the consequences of the event to estimate a numerical value for a particular risk. The information used in the calculation is, in most cases, statistical data that may not always be directly applicable to the particular circumstances being examined because such data is not available. Therefore, the calculated risk is a statistical estimate only, and the results may not be an accurate prediction of the real risk to individuals. Nevertheless, such results should provide a useful comparison of risks between alternatives across a project and enable an assessment to be made against relevant criteria.

The results of a quantitative risk assessment will generally refer either to the risk to an individual or a societal risk. Planning criteria are generally specified for risks to individuals and are usually determined for a hypothetical person most at risk in a particular situation. This person is usually assumed to be present and exposed to the risk continuously. The estimated

risk is expressed as the increased risk of death to that person per year, or (because of the small numbers involved), per million years, in that location (risk of death per million person years).

Societal risk considers the risk to the general community, and therefore expresses risk as the likely number of deaths per annum for a particular population (fatalities per annum). The societal risk is equal to the risk experienced by the most at-risk individual multiplied by the number of people in the group. Planning criteria are not generally available for societal risk, but a significant risk of a large number of deaths from a single event is likely to be considered unacceptable.

The following definitions from Australian Standard AS/NZS 4360:2004 — *Risk Management* are used in the EIS:

- hazard: a source of potential harm
- risk: the chance of something happening that will have an impact on objectives.

The assessment undertaken in this section relies on accident data collected from Australian road networks, estimates of dangerous goods movements, traffic forecasting, estimates of the consequences of a necessarily limited range of scenarios relating to accidents, and assumptions about the people most affected and the affected population generally. The results will therefore be only an estimate of the risks involved, but will provide an indication of the relative risks in the various options examined.

11.2.2 Approach to the assessment

A wide range of possible hazards arising from the construction and operation of the bypass were examined in the hazard identification step. These were assessed qualitatively, and significant risks were identified and appropriate mitigation measures developed. The potential was identified for dangerous goods to impact significantly on human safety and the built and natural environments. Hazards associated with potential interaction between the road construction and operation phases and the operation of Gold Coast Airport and aircraft in flight were examined as part of this assessment.

The proposed Tugun Bypass would be used to transport a variety of materials, including dangerous goods, along its length, and it would provide an alternative to the current route through Tugun. The risks to human life and of damage to property were estimated for both routes, and included worst-case scenarios involving dangerous goods vehicles.

The *NSW State Environmental Planning Policy No. 33 — Hazardous and Offensive Development* provides definitions for hazardous and offensive industry, storage and development. Although directed at industrial developments and therefore not strictly relevant to the bypass, the requirements of the policy to follow guidelines published by the Department of Infrastructure, Planning and Natural Resources relating to hazardous and offensive development have been complied with. The process used in the assessment generally follows the relevant sections of the Hazardous Industry Planning Advisory Paper Number 3 (Risk Assessment), and refers to criteria provided in Advisory Paper Number 4 (Risk Criteria for Land Use Safety Planning) (NSW Department of Planning 1990 and 1989). It is also in accordance with the Australian Standard AS/NZS 4360:1999 — *Risk Management*.

The transport of dangerous goods in Queensland is regulated by the provisions of the Transport Operations (Road Use Management — Dangerous Goods) Regulation 1998, and the transport of explosives is regulated by the *Explosives Act 1999*.

11.3 Identification of potential hazards

11.3.1 Sources of construction hazard and risk

The assessment examined equipment and activities involved in construction, and their potential impacts on the natural and built environments, road users, residents and the operation of Gold Coast Airport. The assessment considered:

- dangerous goods used in construction of the bypass
- activities and aspects of the construction that might impact on aviation and Gold Coast Airport operations
- waste management
- contaminated soils
- traffic accidents during construction.

No dangerous goods or wastes likely to be involved in construction would have any significant potential to affect the general public or workforce if handled in accordance with good practice and regulatory requirements. No blasting is envisaged and therefore the use of explosives is unlikely.

Although the preferred route has been selected to minimise, where possible, the risks associated with discharges and spills of dangerous goods and wastes, it traverses environmentally sensitive areas and also migration pathways, such as drainage lines leading to more remote sensitive areas. Areas potentially at risk include wetlands and waterways associated with Cobaki Broadwater, covered by NSW *State Environmental Planning Policy No. 14* — Coastal Wetlands, and the National Estate area. However, no run-off from the proposed bypass would discharge directly to any sensitive area. All run-off would be subjected to preliminary treatment through pollution-control devices such as swales and artificial wetlands, and discharges would be to drainage lines with adequate path length to the nearest sensitive area to facilitate additional containment and cleanup if required. For areas of run-off/drainage into the Cobaki Broadwater or in the vicinity of known frog habitats, run-off treatment will include world best practice controls, due to the permeability of the soil, closeness of the water table and sensitivity of frog habitats.

The preferred alignment of the bypass includes approximately 2 km within the existing boundaries of Gold Coast Airport, operated by Gold Coast Airport Limited. At the southern end of the airport, the alignment would be carried in a tunnel to avoid any intrusion into the airport's existing obstacle limitation surface, which sets height limits around the airport for aircraft safety. Construction would occur outside the southern runway-end safety area, which provides an undershoot/overshoot zone clear of obstructions. Activity in this area would be strictly controlled to avoid compromising aircraft safety. In other areas where impacts on airport operations or aircraft safety might otherwise occur, construction hours would be restricted to curfew periods and other times when the main runway is not in use, and construction methods (involving, for example, temporary intrusion into the obstacle limitation surface, use of lighting, generation of smoke or dust, or any works that might increase bird numbers around the airport) would be restricted.

Some construction work outside airport land would still be within the area covered by the obstacle limitation surface. Any intrusion (by structures, equipment or temporary features such as stockpiles) must be assessed for its affect on airport operations, and approved subject to

appropriate safety measures. Other aspects of the work, for example lighting, might also need to be controlled to maintain aircraft safety. Controls on activities potentially impacting on airspace and aircraft safety in the vicinity of Gold Coast Airport are detailed in the *Airports Act 1996* and Airports (Protection of Airspace) Regulations 1996, and the *Civil Aviation Act 1988* and Civil Aviation Regulations 1998.

11.3.2 Environmental hazards during operation

The assessment examined equipment and activities involved in the operation phase of the bypass, and their potential impacts on the natural and built environments, road users, residents and the operation of Gold Coast Airport. The assessment considered:

- run-off of contaminants generated from diffuse discharges arising from normal operation of the roadway, principally during rain events
- spills of dangerous goods and other potential pollutants as a result of accidents or other unplanned events.

Diffuse discharges to the environment from highways may include:

- products of combustion from vehicle engines
- wear products from tyres, brakes and other mechanical parts
- minor leaks of lubricants, hydraulic fluid and similar material from operating vehicles
- minor discharges from leaking or damaged loads
- litter and other waste intentionally or inadvertently disposed of.

Although the potential impacts from diffuse discharges are likely to be small at any point, potentially significant cumulative impacts may occur. Run-off into coastal wetland ecosystems covered by NSW *State Environmental Planning Policy No. 14 — Coastal Wetlands*, areas included in the National Estate, and other waterways have been specifically considered in the design of the bypass stormwater run-off systems.

It is possible to estimate the frequency of accidents involving release of dangerous goods and other potential pollutants from general accident statistics and traffic data. However, the precise nature of the contaminants involved and the level and extent of any impact cannot be predicted with any certainty. Goods that might be transported in significant quantities on the bypass include petroleum products, liquefied petroleum gas, liquefied toxic gases (including ammonia and chlorine), corrosive materials (acids and alkalis), toxic materials (such as pesticides), and fertilisers. The potential impacts on biota and habitats would include physiological effects (such as burning by fire or corrosives, damage by explosions, smothering by the exclusion of oxygen, or coating with adherent substances), toxicological effects (poisoning), and chemical effects (such as increased nutrient levels in waterways leading to algal blooms).

The proposed bypass route crosses or adjoins the various wetland and waterway ecosystems associated with Cobaki Broadwater, just south of the Queensland–NSW border. Any uncontrolled discharge from accidents on the road at these points would potentially affect this sensitive area. The environmental impact of any uncontrolled discharges of dangerous goods along this section of the route would, therefore, probably be more localised, but also more serious, than for a similar discharge to the sea from the existing route.

11.4 Risk assessment

In order to assess the risks that result from the identified hazards, a range of scenarios was developed to describe the possible locations and outcomes involved.

11.4.1 Dangerous goods accident scenarios

As one of a limited number of major transport routes linking NSW and Queensland, the bypass would carry large volumes of commercial traffic, including vehicles carrying dangerous goods. Some dangerous goods give rise to a risk to the public only within a limited area, but some have the potential to create a major impact across a wide area. Hazards from dangerous goods accidents potentially affecting a wide area include toxic gases, fire and explosion. The existing route and proposed bypass route pass through areas with differing land uses adjoining or close to the road corridor, and therefore differing potential for impact.

Much of the proposed route is on undeveloped land relatively remote from residential or commercial areas and is therefore less likely to affect residents. However, along the section of the route north of the airport there are residential areas and the John Flynn Hospital and Medical Centre. These are land uses for which a risk criterion is specified in the NSW planning guidelines. An estimate of the total residential population within 250 m of the Tugun Bypass as a whole is 400, with most of these residents located along the northern part of the route.

The proposed tunnel through airport land needs to be considered separately from the rest of the route. There is no resident population, but any accident in the tunnel involving dangerous goods would be likely to put a number of road users at risk. There is also potential for damage to the tunnel as a result of fire or explosion, and this could make either or both of the tunnels unusable, requiring considerable time and money to repair. Airport operations would possibly be disrupted during the repair work.

11.4.2 Interference with or by airport operations

There is the potential for some risk to aviation and consequently to the public from vehicle headlights and road lighting interfering with aircraft operations. Road lighting or vehicle headlights may interfere with a pilot's night vision, or might dazzle or confuse a pilot during a critical phase of either landing or taking off. All road lighting for the proposal with the potential to interfere with prescribed airspace would comply with the requirements of the Airports (Protection of Airspace) Regulations 1996, to the approval of Civil Aviation Safety Authority.

The potential to disrupt airport operations in the event of tunnel damage and the need to effect repairs is discussed in the preceding section.

The construction of a road through the airport presents new security issues to the airport as a result of the possible need for airside access during construction and the changes and increased accessibility to airside perimeter fencing. The security measures needed would be subject to discussion and agreement with Gold Coast Airport Limited and the Commonwealth Department of Transport and Regional Services.

11.4.3 Qualitative risk assessment

A preliminary risk assessment was undertaken for the proposal. This assessment was based on the hazards associated with the proposal, and used information from similar assessments undertaken for other road and tunnel projects. Qualitative estimates of the likely consequences of various hazards and scenarios, and of their frequency or probability were combined using a

risk-assessment table to determine a risk score for each hazard. Hazards assessed as having a medium-level or greater risk rating were examined to identify specific design and operation features that might be required to reduce the risk to a lower level.

None of the construction phase hazards was considered likely to give rise to a high risk to human safety or the natural or built environments. There was considered to be a medium level of risk of construction activities interfering with air navigation and Gold Coast Airport operations, and of impact on the environment if waste was not properly managed. These risks are all readily managed by standard designs and procedures, and by ensuring compliance with relevant air navigation and airport regulations.

It was concluded that during operation there would be a medium to high risk of impacts on the natural and built environments and on human safety in some areas as a result of traffic accidents involving dangerous goods. There would also be a medium to high risk of impacts on the natural environment as a result of contaminated road run-off. Despite its generally diffuse nature and low concentration of pollutants, run-off from the roadway was considered to pose a high risk to the natural environment because of its high frequency (during every rain event) and significant potential for cumulative impacts.

Table 11.1 presents a summary of the results of the qualitative risk assessment for hazards with medium or high risk scores against human health and safety or the natural or built environments. The full set of results of the qualitative risk assessment, including the measures to be adopted to mitigate all identified hazards, are presented in Table 2.2 of Technical Paper 16.

11.5 Risk analysis and evaluation

11.5.1 Scenarios considered and estimation of frequency

A comparison of the risks arising from the use of the proposed bypass and the use of the existing route to transport hazardous goods has been undertaken. Several scenarios were considered, covering a range of possible accidents involving dangerous goods. The scenarios considered were accidents involving:

- flammable liquids (typically petrol)
- liquefied flammable gas (typically liquefied petroleum gas)
- liquefied toxic gas (chlorine or ammonia)
- ammonium nitrate (which in some limited circumstances can be an explosive).

The options of prohibiting all dangerous goods, or only dangerous goods of Classes 1 (explosives) and 2.1 (liquefied flammable gases, which can be explosive) were considered in order to reduce the risk to the tunnels and tunnel users.

To assess the risks involved for various scenarios, the frequency of accidents involving particular dangerous goods and the range of likely consequences were estimated.

Traffic accident data for the NSW road network indicates that dangerous goods vehicles typically make up 1% of all traffic, and the fraction of accidents involving dangerous goods is approximately 0.19%. Current and predicted traffic volumes and accident rates for the existing highway, together with estimates of the likely composition of dangerous goods types, allowed an estimate to be made of the number of accidents involving each type of dangerous goods along the existing route and proposed bypass under the various scenarios.

Table 11.1: Identified hazards with significant risk scores

Identified hazard	Potential consequences	Existing risk-management measures	Risk-assessment scores			Proposed risk-management strategies
			People	Assets	Environ-ment	
Construction						
Penetration of GCAL Obstacle Limitation Surface.	Interference with air navigation safety. Aircraft crash.	Planning and building controls, legislation protecting airspace.	Medium	Medium	Nil	Keep all equipment, works, below obstacle limitation surface and PANS-OPS limits. Comply with all planning and building controls. Erect navigation warning lights where required.
Night-work lighting interfering with pilots' vision during critical phases of landing/take-off.	Increased risk of aircraft crashes.	Planning and building controls, legislation protecting airspace.	Medium	Medium	Nil	Use only lighting that complies with GCAL and local government planning requirements and relevant legislation.
Generation of dust, plumes from construction activities.	Reduced visibility for pilots, risk of engine damage, crashes.	Legislation protecting airspace.	Medium	Medium	Low	Control dust generation, no burning off, compliance with legislation.
Waste management.	Poor occupational hygiene, soil or water pollution.	Normal waste management practices.	Low	Low	Medium	Assess hazards associated with specific wastes. Store, handle and dispose of waste in accordance with good waste-management practices to minimise risk.
Operation						
Diffuse discharges from vehicle operation, minor leaks etc contaminating road run-off.	Cumulative damage to sensitive ecosystems and susceptible species.		Low	Low	High	Control of run-off to sensitive areas. Retention ponds and interception systems to protect sensitive waterways by trapping or treating pollutants.

Identified hazard	Potential consequences	Existing risk-management measures	Risk-assessment scores			Proposed risk-management strategies
			People	Assets	Environ-ment	
Traffic accidents involving hazardous materials on bypass.	Injury or death, damage to or destruction of assets, environmental harm.	Normal handling practices, container and vehicle design according to standards and regulations. High standards of design and construction. Limited population at risk.	Low	Low	High	Police compliance with regulations and standards. Provide interception devices to protect most sensitive waterways where practical.
Traffic accidents involving hazardous materials in tunnels.	Injury or death, damage to or destruction of assets (structural damage to tunnels), disruption to airport operations.	Normal handling practices, container and vehicle design according to standards and regulations. High standards of alignment and construction, lighting, warning, ventilation, emergency response systems.	Medium	Medium	Low	Adequate rating for tunnel structure to withstand largest credible fire. Drainage to collect spills, prevent ignition/propagation of fire. Alternatively, ban dangerous goods (or certain classes of dangerous goods) from bypass/tunnels.
Traffic accidents involving hazardous materials on existing route.	Injury or death, damage to or destruction of assets, environmental harm.	Normal handling practices, container and vehicle design according to standards and regulations.	High	High	Medium	Route dangerous goods via the bypass. Redesign highest risk elements of existing route.
Oversize vehicles.	Jammed in tunnel, tunnel damage, potential accident initiator.	Warning signage and gauges ahead of tunnel.	Low	Medium	Nil	Monitoring and warning systems.

The mathematical models used to estimate dangerous goods accident rates assume that the fraction of all vehicles carrying dangerous goods would be the same along all routes unless dangerous goods are specifically excluded. In practice, it is likely that most long distance dangerous goods vehicles would use the bypass rather than the existing route through Tugun if no restrictions were in place, so predicted dangerous goods accident rates along the existing route are likely to be overestimated. For scenarios where some or all dangerous goods are diverted along the existing route, the model uses a higher proportion of dangerous goods to total vehicles for this section of road, calculated using estimated traffic flows, when calculating the accident rates.

Estimates of accident frequencies were made for current (2002) and future (2017) traffic conditions for the 'do-nothing' alternative, and for construction of the bypass with various alternatives for the management of dangerous goods to address the risk of their transport through the tunnel. Without construction of the bypass (the 'do-nothing' alternative), dangerous goods accident rates are expected to increase by 50% between 2002 and 2017. Construction of the bypass is predicted to reduce the total number of accidents as a result of improved road design and conditions, reducing the number of dangerous goods accidents overall by 37%, and on the existing route by 56%, compared with the 'do-nothing' alternative in 2017. None of these improvements in dangerous goods accident rates would be achieved if all dangerous goods were to be prohibited from the bypass, but 83% of the improvement achieved with unrestricted access is maintained if only Class 1 (explosive) and Class 2.1 (liquefied flammable gases) were to be prohibited from the bypass.

11.5.2 Consequences for persons most at risk

Many variables are involved in estimating the potential effects of a dangerous goods accident on any individual in the vicinity of a road. In practice, it is not practicable to calculate the risk for all individuals accurately because of the wide range of locations and circumstances that apply to accidents involving the movement of dangerous goods. The calculations have therefore been simplified by estimating the probability of fatality for representative 'persons most at risk', located at three nominal distances from the road. Further, by estimating the resident population within these zones, a cumulative risk to the population generally can be estimated. This is consistent with the risk quantification requirements and the risk criteria detailed in the Hazardous Industry Planning Advisory Papers 3 and 4 (NSW Department of Planning 1990 and 1989). Although the estimates are unlikely to be very accurate because of the number of assumptions and simplifications that have been made, they should provide a good indication of the level of risk and a useful comparison of risk for the various scenarios considered.

The proposed route significantly reduces the number of people exposed to involuntary hazards from dangerous goods transport by moving through-traffic away from the more densely populated residential areas along the existing route to the less densely populated bypass route. Assuming future development is limited within close proximity to the bypass, it is expected that the population within 50 m of the road would not increase significantly up to 2017. The proposed Cobaki Lakes development would be separated from the road by a significant buffer (at least 250 m). The proposed Pacific Exchange development is likely to have a reasonable buffer (approximately 100 m at most points), provided in part by the corridor for the proposed Robina to Coolangatta rail line.

The individual most at risk along the current route is estimated to be exposed to a risk of death of 73 fatalities per million person years in 2002 as a result of dangerous goods accidents. This risk is predicted to increase to 113 fatalities per million person years in 2017 for the 'do-nothing' alternative. (These estimates are for a hypothetical person located continuously within 50 m of

the road. The actual risk would be reduced in proportion to the actual time spent at this location.) Construction of the bypass would reduce the risk in 2017 to 49 fatalities per million person years on the existing route, and 25 fatalities per million years on the bypass, if all dangerous goods are allowed to use the tunnel. The risk to a person present continuously in the tunnels in this case would be 65 fatalities per million person years. However, unlike people in residential areas or in an institution such as a hospital, who may be immobile, the person most exposed to risk would be unlikely to be in the tunnels for more than two minutes per day (based on two return trips per day). The real additional risk from using the tunnels is therefore estimated to be closer to 0.1 fatalities per million person years.

If all dangerous goods were to be prohibited from the bypass and tunnel, the risk to persons living within 50 m of the existing route in 2017 would be 124 fatalities per million person years (This is slightly but not significantly higher than the estimate for the 'do-nothing' alternative because of the way in which the model uses the traffic forecasts to calculate dangerous goods accident rate. This is compared to 49 fatalities per million person years with no prohibition, while the risk to persons living along the bypass would be zero. Prohibiting dangerous goods in Classes 1 and 2.1, which are those likely to cause explosions and damage to the tunnels, reduces the risk along the existing route to 61 fatalities per million person years, but exposes people along the bypass to a risk of 21 fatalities per million person years.

These risks are summarised in Table 11.2. The significance of these levels of risk is best understood by comparison with risks that are accepted voluntarily by individuals or to which individuals are involuntarily exposed on a daily basis. These are also shown in Table 11.2.

Table 11.2: Comparison of estimated risks for dangerous goods accidents and typical risks to individuals

Risk scenario (2017)	Persons most at risk (Fatalities per million person years)	
	Existing route	Bypass
Existing route — no bypass	113	–
Bypass:		
No restrictions on dangerous goods	49	25
No dangerous goods permitted	124 [1]	–
No Class 1 or 2.1 dangerous goods permitted	61	21
Typical risk (for comparison) (whole population or participant)	**Risk of fatality (Fatalities per million person years)**	
Voluntary (average)		
Smoking	5,000	
Swimming	50	
Transportation (average)		
Motor vehicle passenger	145	
Train traveller	30	
Involuntary (whole population)		
Lung cancer	380	

Risk scenario (2017)	Persons most at risk (Fatalities per million person years)	
	Existing route	Bypass
Home accident	110	
Homicide	20	
Accidental poisoning	18	
Therapeutic drug	2	
Lightning strike	0.1	

Source: NSW Department of Planning 1990.

1: The estimated risk for residents along the existing route is higher for the case where the bypass is built but dangerous goods are prohibited, than for the 'do-nothing' alternative. This is a result of (a) simplifying assumptions commonly used in estimating accident rates (i.e. that the number of accidents is directly proportional to the distance travelled by a vehicle and is not affected by factors such as congestion, which would be related to total traffic volumes; and (b) the prediction that the bypass would attract additional traffic over the 'do-nothing' alternative. The model used to calculate accident rates assumes that the increased traffic results in increased dangerous goods traffic (in direct proportion), and that accidents would also increase in proportion, but that all of these would occur on the existing route.

It is clear that the construction of the bypass would result in a significant decrease in the risk to which residents in Tugun would be exposed by 2017 as total traffic increases. Further reductions in accident frequency on the existing route are expected through improvements to the road in high-risk areas. The risks for the bypass are considered likely to be overestimated relative to the existing route, because conservative estimates have been used for the improvement in accident frequency on the new road.

11.5.3 Cumulative community risk

Societal risk is the risk to the population as a whole from some hazard. It can be broadly estimated and compared for various scenarios. For this analysis, the simplifying assumption has been made that the person most exposed to risk is representative of the whole at-risk population within the affected area. Using this approximation, the cumulative societal risks from dangerous goods transport have been estimated and are shown in Table 11.3. While the assessment has been limited to people living within 150 m of the roads, the area of potential impact for a major accident could extend for several hundred metres, but the risks at greater distances are smaller and not likely to significantly affect the results. To estimate the population exposed to the risks, it has been assumed that the population within 50 to 250 m of the road is evenly distributed.

The risk to users of the road tunnel on the proposed bypass has been estimated from the rate of accidents involving dangerous goods expected in the tunnel and the average number of people likely to be present in the tunnel at the time of the potentially fatal event. It is assumed that all vehicles entering the tunnel behind a vehicle that is involved in a hazardous materials accident (that is, those vehicles entering before the accident is detected and the tunnel is closed) would be trapped in a closely packed grouping in a high-risk area adjoining the accident scene. Vehicles ahead of the accident are assumed to continue out of the tunnel, and vehicles travelling in the opposite direction are assumed to be unaffected.

Using typical vehicle occupancies, vehicle lengths, and traffic flows averaged across a normal day, about 70 persons on average are estimated to be at risk. Of these, approximately 35 would be expected to be within 50 m of the accident, and the other 35 within the next 100 m. The relevant distribution of dangerous goods of the various types assumed in the model, and the

corresponding estimates of probabilities of fatality arising from the involvement of these materials in accidents, have been used to estimate the societal risk for tunnel operation.

The estimated risk to the population as a result of prohibiting all dangerous goods from using the tunnel should be considered a worst case. No correction to allow for changes in accident rates with traffic congestion is available, and no basis has been identified for estimating its value at traffic flows other than the measured conditions. An attempt to introduce any such correction is not considered to be justified when the inherent uncertainties in the other assumptions and estimates in use are taken into account.

Table 11.3: Estimated risk from dangerous goods — 2017 (fatalities per year)[1,2]

Scenario	Existing Route	Bypass	Tunnel	Total
Existing route — no bypass	0.140	–	–	0.140
Bypass constructed — no restriction on dangerous goods	0.061	0.0037	0.0096	0.074
Bypass constructed — no dangerous goods in the tunnel [4]	0.153 [3]	–	–	0.153
Bypass constructed — no Class 1 or 2 dangerous goods in the tunnel [4]	0.075	0.0032	0.0063	0.084

1: Risk to the general residential population living within 150 m of the road, or all people using tunnels, from dangerous goods accidents.

2: Results are reported to a number of significant figures appropriate to the accuracy of the model used.

3: The reason for a higher risk with the bypass built but dangerous goods prohibited from the tunnel than for the 'do-nothing' alternative is described in 4 the note to Table 11.2.

4. Estimated risks assume full compliance with prohibitions on dangerous goods.

The absolute value of individual risk, while estimated using the best available statistical information and realistic values for the calculations wherever possible, should not be relied on as an accurate indication of the true risk to the individual. They can however, be used to estimate and compare the community risk for various scenarios. The estimated cumulative community risks appear credible. They indicate that along the length of the roads involved, for the various cases considered, between seven and 15 fatalities would be expected in every 100 years of operation as a result of major dangerous goods accidents. The latter figure represents the worst-case estimate for diverting all dangerous goods from the proposed bypass and through Tugun.

It is clear that construction of the bypass would result in a significant reduction in the overall societal risk from transport of dangerous goods through Tugun. The reduction in the risk to the residents living adjacent to the existing route is particularly significant.

Prohibiting only Class 1 and 2.1 dangerous goods from the bypass would reduce the risk of an accident capable of causing structural damage to the tunnel, although the estimated risk of such an event is not high. This option would maintain most of the risk reduction achieved by the construction of the bypass for the population overall and for Tugun residents in particular, compared to the unrestricted option. A decrease in the risk to Tugun residents of 47% would be achieved.

The slightly greater public safety and amenity achieved by allowing all dangerous goods to use the bypass tunnel must be weighed against the risk of damage and the need for repairs which might have to be carried out under the end of an operating runway or flight path. The existing route would still be available in the event of the closure of the bypass owing to damage to the tunnel. It is unlikely that airport operations would need to be suspended in the event of even severe damage, although the threshold on the main runway might need to be displaced while

repairs were being affected. This may reduce the runway's capacity to handle large aircraft. It is therefore unlikely that there would be any hazard directly affecting aircraft.

The estimated frequency of events capable of causing significant damage to the tunnel (principally as the result of an explosion) is 19 per million years of operation (or once in 50,000 years). In addition, the tunnel design would include a full range of advanced safety features to minimise any risk to users and protect the structure. Although NSW RTA has prohibited dangerous goods in major tunnels in Sydney (for which alternative routes are readily available), and dangerous goods are banned from using the tunnels under the main runway of Sydney Airport, it has not introduced similar bans in other tunnels constructed as part of the Pacific Highway upgrade for which suitable alternatives are not available (for example at the Coffs Harbour and Yelgun-Chinderah bypasses).

11.6 Conclusions

An assessment of the proposed Tugun Bypass was undertaken to identify hazards that might result in significant or unacceptable levels of risk to human health and safety and the natural and built environments. The transport of dangerous goods, run-off of pollutants from the new road, and activities during construction that might affect aircraft safety or operations at Gold Coast Airport were identified as potentially significant issues that might require specific management actions.

Run-off from highways during rain events contains a range of pollutants, generally at low levels. These may have a cumulative impact on sensitive waterways such as the Cobaki Broadwater. Spills of dangerous goods as a result of accidents can cause larger quantities of pollutants to be discharged, and may cause significant environmental harm if not contained. The design of the bypass incorporates specific measures to minimise the discharge of pollutants to sensitive waterways.

The bypass would run for part of its length through land under the control of Gold Coast Airport. Road lighting and vehicle headlights, structures and equipment intruding into the airport's obstacle limitation surface, and the potential to generate dust and smoke, could impact on airport operations during construction and operation. The bypass would be carried in tunnels under part of the airport to avoid any intrusion into the obstacle limitation surface and to keep the runway safety zone clear of inappropriate structures. Bypass design and construction activities would be strictly in accordance with the requirements of legislation and airport requirements for the protection of air space and aircraft safety, and would be timed to minimise any impact on airport operations.

There is a risk to residents in the vicinity of the existing route through Tugun and the proposed bypass from accidents involving dangerous goods, particularly those with the potential to result in fires, explosions or toxic gas escapes. Road users would also be exposed to some risk, particularly in the tunnels. A quantitative estimate of the risks for residents and road users was prepared, and the risk from various scenarios examined. As part of this assessment, various policies were examined for the management of dangerous goods in the tunnels. The assessment has concluded that, without the construction of the bypass, residents in Tugun would be exposed to a 50% greater risk by 2017 as a result of increasing dangerous goods traffic. Construction of the bypass would result in a decrease of 57% of the 2017 risk for residents along the existing route, assuming no restrictions on dangerous goods vehicles using the tunnels. If all dangerous goods were prohibited from using the tunnels, this improvement would not be achieved. However, a prohibition of only dangerous goods of Classes 1 and 2.1 (explosives and

liquefied flammable gases), which could cause significant damage to the tunnels, would result in most of the potential improvements in risk still being achieved for Tugun residents.

The risk to users of the tunnel is assessed as being very small because of the short times that would typically be spent in the tunnels by most people, and the safety features that would be built into the design. The risk to residents along the bypass is generally low because of the typically greater separations from the highway and higher design standards and safety of the new alignment. The frequency of a dangerous goods accident with the potential to cause significant damage to the tunnel is estimated as once in 50,000 years of operation without any restrictions being placed on dangerous goods vehicles.