Roads and Traffic Authority

Princes Highway upgrade

Gerringong upgrade

Concept Design Report

June 2010

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| Title: | Garringong upgrade  
| Concept Design Report |

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<th>Approval and authorisation</th>
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<td>Prepared by:</td>
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<td>Accepted on behalf of the RTA by:</td>
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Executive summary

The Roads and Traffic Authority of NSW (RTA) is proposing to upgrade the Princes Highway between Mount Pleasant and Toolijooa Road - the Gerringong upgrade (the proposal). The proposal is part of the RTA's program to upgrade the Princes Highway, providing increased road safety and traffic efficiency in the south coast region.

Report purpose

This concept design report has been prepared to summarise the finalised concept design parameters, assumptions and departures from standards. The report is intended to be a resource for the further development of the concept design, detailed design and construction of the proposal. The report provides an overview of:

- Issues becoming apparent since the announcement of the preferred option.
- Key decisions made in the development of the concept design.
- Issues / decisions yet to be resolved in the development of the design.
- Criteria adopted in the technical development of the concept design.

Development of the preliminary concept design

The preliminary concept design for the proposal was announced in October 2008 as part of the preferred route for the Gerringong to Bomaderry upgrade program, following consideration of:

- Community submissions.
- Recommendations from a route options value management workshop.
- Technical studies.

A second value management workshop was held in November 2008 to assist with the selection of the preferred access arrangements for Gerringong. The preferred access arrangements incorporated into the preferred route option were subsequently announced in June 2009.

At the time of display the preferred option had been developed to a preliminary concept design level only. Following display of the preferred option the design was further developed to a concept level. Community and stakeholder input to the refinements of the concept design occurred through:

- Feedback from the preferred option display.
- Feedback from the access options display.
- Discussions with affected land owners and other stakeholders.

Further geotechnical, hydraulic, environmental and engineering investigations combined with value engineering studies also contributed to the design refinements of the preferred option.

Existing highway

The Princes highway provides the principal road linking Sydney and Wollongong to the south coast and north eastern Victoria.
The horizontal and vertical alignments of the existing largely two lane highway between Mount Pleasant and Toolijooa Road require upgrading to meet current design safety and traffic efficiency requirements. The highway has limited overtaking opportunities, many junctions with rural roads and private uncontrolled accesses. The existing road also incorporates two access opportunities for the town of Gerringong, one at Fern Street (the northern end of the town) and one at Belinda Street at the southern end of the town.

Proposal description

The proposal would provide a minimum four lane carriageway arterial style highway with a posted speed of 100 km/h and two lanes in each direction. A median incorporating a barrier would provide separation of opposing traffic. Generally local road and private property connections will continue to be at-grade with left-in-left-out movements. Access to Gerringong from the proposal would be via grade-separated movements. The existing level crossing at Fern Street must be replaced with a grade-separated crossing.

The proposal would achieve 1 in 100 year flood immunity for through movements on the highway. 1 in 100 year flood immunity would also be targeted for an access point for Gerringong. Consideration would be given to how the proposal would 'tie-in' to the existing highway at Mount Pleasant and Toolijooa Road.

The proposal would consider the provision for future widening to three lanes in each direction.
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Appendix A Road Safety Audit
1 Introduction

1.1 Background

The Roads and Traffic Authority of NSW (RTA) is proposing to upgrade the Princes Highway between Mount Pleasant and Toolijooa Road - the Gerringong upgrade (the proposal). The proposal is part of the RTA’s program to upgrade the Princes Highway, providing increased road safety and traffic efficiency in the south coast region.

This document presents the concept design of the proposal.

Proposal definition:

<table>
<thead>
<tr>
<th>Proposal</th>
<th>Upgrading the Princes Highway – Gerringong upgrade</th>
</tr>
</thead>
<tbody>
<tr>
<td>RTA region</td>
<td>Southern Region</td>
</tr>
<tr>
<td>Road name</td>
<td>Princes Highway</td>
</tr>
<tr>
<td>Road number</td>
<td>Highway No.1</td>
</tr>
<tr>
<td>Proposal location</td>
<td>42.6 km to 50.1 km south of Wollongong</td>
</tr>
<tr>
<td>Proposal length</td>
<td>7.5 km</td>
</tr>
<tr>
<td>Local government area</td>
<td>Kiama Municipal Council</td>
</tr>
</tbody>
</table>

Figure 1.1 shows the proposal within the context of other proposed upgrades of the Princes Highway.

**Figure 1.1:** The proposal within the context of other proposed upgrades of the Princes Highway

![Image of the proposed upgrades of the Princes Highway](image-url)
1.2 Program development process

A summary of the route option selection process is shown in Figure 1.2. Detailed documents describing previous phases of the project are available as indicated in the figure.

**Figure 1.2: Route option and concept design development process**

- **Project familiarisation**
  - Review previous studies
  - Identify project objectives

- **Route options studies**
  - Carry out preliminary field studies
  - Identify constraints and opportunities
  - Determine potentially feasible routes

- **Route options development**
  - Stage 1 – assessment of potentially feasible routes
  - Determine feasible routes

- **Route options development report**
  - Preliminary concept design and preliminary environmental assessment
  - Document process

- **Route options display**
  - Display of feasible options

- **Value management studies**
  - Stage 2 – multi-criteria analysis
  - Recommendation on further studies
  - Identification of preferred option

- **Value Management Report**

- **Value management studies**
  - Access to Gerringong
  - Access to Berry

- **Access Value Management Report**

- **Preferred option selection**
  - Additional multi-criteria analysis incorporating any additional studies
  - Recommendation of preferred option

- **Preferred option report**
  - Document process
  - Concept design

- **Preferred option display**
  - Display of preferred option and concept design

- Concept design, environmental assessment, community consultation and planning approval under the *Environmental Planning and Assessment Act 1979*
1.3 The existing highway

The Princes Highway provides the principal road linking Sydney and Wollongong to the south coast and north eastern Victoria.

The horizontal and vertical alignments of the existing largely two-lane highway between Mount Pleasant and Toolijooa Road require upgrading to meet current design safety and traffic efficiency requirements. The highway has limited overtaking opportunities, many junctions with rural roads and private uncontrolled accesses. The existing highway also incorporates two access opportunities for the town of Gerringong, one at Fern Street (the northern end of the town) and one at Belinda Street at the southern end of the town.

The existing northern access point at Fern Street incorporates the less than desirable existing level crossing over the South Coast Rail Line, which has been identified as number 20 in the NSW Government’s top 300 priority list for safety treatment of level crossings under its Level Crossing Safety Improvement Program, coordinated by The Level Crossing Strategy Council (LCSC).

This section of highway has a particularly poor road safety record. Crash statistics collected by the RTA confirm that this section performs relatively poorly with regards to road safety.

The section from Mount Pleasant to Belinda Street also currently carries the combined traffic of the ‘Sandtrack’ and highway. At-grade junctions at Fern Street and Belinda Street connect Gerringong and communities to the south to the highway. The Belinda Street and Rose Valley Road junctions feature channelized right turn T-configurations. Rose Valley Road, Sims Road, Baileys Road, and Willowvale Road all connect to the highway with at-grade ‘all movements’ junctions.

The existing highway is susceptible to flooding where it crosses Omega Flat at the northern extremity of Gerringong. Inadequate cross-drainage also contributes to localised flooding at other locations.

To the immediate north of the proposal the existing highway has relatively poor horizontal alignment with a posted speed of 80 km/h. This section, known as the Kiama Bends, currently has a four lane configuration with a solid median barrier. To the immediate south of the proposal the existing highway also has relatively poor horizontal and vertical alignment with no median separation or barrier and a posted speed of 80 km/h.

1.4 Proposal objectives

The proposal objectives are:

- Improve road safety.
- Improve efficiency of the Princes Highway between Mount Pleasant and Toolijooa Road.
- Support regional and local economic development.
- Provide value for money.
- Enhance potential beneficial environmental effects and manage potential adverse environmental impacts.
- Optimise the benefits and minimise adverse impacts on the local social environment.
Supporting the proposal objectives are the following six objectives and design principles that make up the urban and regional design framework:

- Provide a flowing highway alignment that is responsive and integrated with the natural landscape.
- Protect the natural systems and ecology of the corridor.
- Protect and enhance the heritage and cultural values of the corridor.
- Respect the communities and towns along the highway.
- Provide an enjoyable, interesting highway with strong visual connections to the Pacific Ocean, immediate hinterland and the mountains to the west.
- Develop a simple and unified palette of elements and details that are easily maintained.

The preferred option for the proposal has been selected as that which best meets the project objectives applied across the program of projects for the Princes Highway upgrade between Gerringong and Bomaderry and which performs well across a combination of the technical input gathered through investigations carried out to date (including a review of studies from previous investigations into the upgrade), community feedback and the findings of the value management process.

1.5 Fundamental proposal features

The upgrade would provide a minimum four lane carriageway arterial style highway with a posted speed of 100 km/h and two lanes in each direction. A median incorporating a barrier would provide separation of opposing traffic. Generally local road and private property connections would continue to be at-grade with left-in-left-out movements. Access to Gerringong from the proposal would be via grade-separated movements. The existing level crossing at Fern Street must be replaced with a grade-separated crossing.

The proposal would achieve 1 in 100 year flood immunity for through movements on the highway. 1 in 100 year flood immunity would also be targeted for an access point for Gerringong. Consideration would be given to how the proposal would ‘tie-in’ to the existing highway at Mount Pleasant and Toolijooa Road.

The proposal would consider the provision for future widening to three lanes in each direction.

1.6 Specialist studies

The development of the concept design requires input from specialist investigations and studies. This document includes summaries of various investigations undertaken and the resultant influence on the concept design. Specialist investigations and studies included:

- Hydrology / hydraulics
- Targeted geotechnical investigations
- Utilities and service adjustment
- Cultural heritage (Aboriginal and non-Aboriginal)
- Water quality assessment
- Flora and fauna (terrestrial and aquatic)
- Road safety audits
- Temporary infrastructure
• Construction resources
• Detailed traffic / transportation assessment
• Property impacts and adjustments
• Urban design, landscape and visual amenity
• Concept cost estimate
• Social-economic
• Land use and planning
• Noise and vibration
• Climate and air quality
• Occupational health and safety.

1.7 Purpose of report and concept design

This concept design report has been prepared by AECOM to summarise the finalised concept design parameters, assumptions and departures from standards. The report is intended to be a resource for the further development of the concept design, detailed design and construction of the proposal. The report provides an overview of:

• Issues becoming apparent since the announcement of the preferred option.
• Key decisions made in the development of the concept design.
• Issues / decisions yet to be resolved in the development of the design.
• Criteria adopted in the technical development of the concept design.

This report should be read in conjunction with the concept design drawing set, RTA Registration Number 0001.236.CD.0004.

The purpose of the concept design is to prepare a design of sufficient detail so that it can be assessed for environmental and social impacts, and an estimate of the construction costs can be prepared. Specifically, the concept design provides details of:

• The highway vertical and horizontal alignment.
• The location and configuration of intersections and interchanges.
• Earthworks and material resource needs.
• Major structure locations and their general arrangement.
• Access provisions for land holders.
• Drainage provisions.
• Mitigation measures for flora / fauna and noise.
• Visual impact and landscape design.
• Constructability.
• Provision for future upgrading.

The concept design is intended to enable property boundaries to be set and the land acquisition process to commence.
2 The proposal

2.1 Description of the proposal

The proposal provides an upgrade of the existing highway alignment to two lanes in each direction between Mount Pleasant and Toolijooa Road. Located wholly in the Kiama Local Government Area, the proposal significantly improves the alignment, capacity and connectivity of this section of highway. Figure 2.1 presents the concept design and highlights some of the key features.

2.1.1 Typical cross-section

Figure 2.1 shows the cross-section adopted for the majority of the proposal comprising:

- Minimum 2.5 m wide outside shoulder (3.0 m when adjacent to a barrier).
- Two 3.5 m traffic lanes.
- 1.0 m wide inside shoulder.
- 5.0 m wide central median with wire rope barrier.

As described in the following section, the cross-section between Mount Pleasant and Rose Valley Road has a concrete barrier separating traffic in place of the 5.0 m median elsewhere. Figure 2.1 shows this arrangement.

2.1.2 Mount Pleasant to Rose Valley Road

From Mount Pleasant to Rose Valley Road the proposal is essentially a widening of the existing alignment to accommodate an additional lane in each direction. In this section, the alignment maintains the existing eight per cent grade and the opposing flows would be separated by a concrete barrier. The 80 km/h design standard of this section progressively introduces northbound traffic to the 70 km/h design standard of the Kiama Bends. A third climbing lane would be provided for northbound traffic.

2.1.3 Rose Valley Road to Fern Street

At Rose Valley Road the four lanes of the proposal deviate to the western side of the existing highway and remain wholly to the western side across Omega Flat before rejoining the existing highway south of the Fern Street junction.

A single grade-separated all-movements interchange at Rose Valley Road would service Rose Valley Road and Fern Street and forms a northern gateway to Gerringong and coastal communities to the south. The interchange would incorporate a bus stop and u-turn facility. The bus facility would be integrated with the landscape to lessen its potential urban design impact by placing the through lanes in cutting and spanning the cutting with an overbridge.

Between Fern Street and Rose Valley Road the existing highway is reconfigured to a two-way service road, which is an extension of Fern Street with a bridge spanning the railway and replacing the existing level crossing. The two-way service road would also provide a connection to a southbound on ramp allowing traffic from Rose Valley Road to access the highway heading south.
Across Omega Flat the proposal would be flood immune for a calculated 1 in 100 year flood return. A series of low profile bridges are proposed to span the defined waterways of Omega Flat. The service road and existing Fern Street would continue to flood in less significant flood events as currently experienced. All-movements access to Gerringong and coastal communities would be provided via the proposed southern interchange at Belinda Street in times of flood.

2.1.4 Fern Street to Belinda Street

Between Fern Street and Belinda Street the proposal would require the widening of the existing highway to the west. The proposal would improve the currently undulating vertical alignment of this section and introduce a series of cuttings and embankments.

Sims Road would connect to the highway in a cutting with a left-in-left-out junction and right turns out would be prohibited with the inclusion of the central median barrier. Southbound access to the highway from Sims Road would be provided via the Rose Valley Road interchange and the southbound on ramp at Fern Street.

A single grade-separated all-movements interchange at Belinda Street would service Belinda Street and Willowvale Road and form a southern gateway to Gerringong. The highway would be elevated on embankment in the vicinity of Belinda Street and Willowvale Road, which would provide opportunity for Crooked River, Baileys Road and Belinda Street to pass under. A proposed two-way service road would connect Belinda Street to Willowvale Road on the northern side of the main four lane alignment.

Flooding issues at the existing Belinda Street rail underpass and the junction of Belinda Street and Rowlins Road would be addressed as part of the proposal through a combination of amplification of the local road drainage infrastructure and the downstream railway drainage infrastructure in consultation with RailCorp and Kiama Municipal Council. The interchange would provide 1 in 100 flood free access for Gerringong at times when the Fern Street access is closed due to flooding.

2.1.5 Belinda Street to Toolijooa Road

West of Willowvale Road the proposal traverses a ridge spur in a section known as the Gerringong Bends. The southbound on ramp from Belinda Street would continue as a climbing lane over this spur. The existing cutting through the spur would need to be deepened to improve the vertical geometry at this location.

Following the Gerringong Bends the proposal would require the widening of the existing highway to the north. A temporary ‘tie-in’ would connect the upgraded alignment to the existing alignment immediately east of Toolijooa Road. The temporary tie-in would be configured such that traffic would be appropriately transitioned between the upgraded and existing alignment for the period following the completion of the proposal and future upgrade of the highway south of the proposal.

2.2 Proposal refinement following display

The preliminary concept design for the proposal was announced in October 2008 as part of the preferred route for the Gerringong to Bomaderry upgrade program, following consideration of:

- Community submissions.
- Recommendations from a route options value management workshop.
- Technical studies.
Figure 1.1 shows the proposal in the context of the Gerringong to Bomaderry upgrade program.

A second value management workshop was held in November 2008 to assist with the selection of the preferred access arrangements for Gerringong. The preferred access arrangements incorporating in the preferred route option were subsequently announced in June 2009.

At the time of display the preferred option had been developed to a preliminary concept design level only. Following display of the preferred option the design was further developed to a concept level. Community and stakeholder input to the refinements of the concept design occurred through:

- Feedback from the preferred option display.
- Feedback from the access options display.
- Discussions with affected land owners and other stakeholders.

Further geotechnical, hydraulic, environmental, and engineering investigations combined with value engineering studies also contributed to the design refinements of the preferred option.

### 2.3 Design refinements considered

Table 2.1 lists the more significant design refinements considered following display of the preferred option in June 2009. Some design refinements were considered but not pursued.
### Table 2.1: Significant design refinements considered following display in June 2009

<table>
<thead>
<tr>
<th>Design refinement</th>
<th>Reasons for investigation</th>
<th>Adopted / rejected</th>
<th>Reasons for adoption / rejection</th>
</tr>
</thead>
</table>
| Gerringong to Bomaderry upgrade program divided into three discrete projects.     | A strategy to deliver the Gerringong to Bomaderry upgrade program was considered. The strategy was influenced by the achievable rate of funding, road safety needs and the environmental impacts of sections of the upgrade program. The strategy proposed the Gerringong to Bomaderry program would be delivered as three distinct projects in the following order:  
  - The Gerringong upgrade (Mount Pleasant to Toolijooa Road).  
  - Foxground and Berry bypass (Toolijooa Road to Schofields Road).  
  - Berry to Bomaderry upgrade (Schofields Road to Cambewarra Road).                                                                                       | Adopted            | The Gerringong upgrade was promoted as the first project to be delivered primarily because of the road safety benefits and the lack of significant environmental impacts. Refer to Section 5 of this report for commentary on the current and anticipated future crash rates. |
| 80 km/h alignment design standard adopted between Mount Pleasant and Rose Valley Road | The Gerringong to Bomaderry upgrade program will provide a high standard 110 km/h alignment from Mount Pleasant to Bomaderry. The proposal is of sufficient length that driver reaction time will be reduced – particularly for northbound motorists approaching the Kiama Bends. Methods are required to gradually reduce driver expectation and introduce the much lower standard of the Kiama Bends. Consideration was also given to a potential future upgrade of the Kiama Bends and where this might connect to the proposal. | Adopted            | The need to lower northbound motorist's expectations and the location of a potential future upgrade of the Kiama Bends led the design team to adopt an 80 km/h design standard for the section between Mount Pleasant and Rose Valley Road. |
### Design refinement

<table>
<thead>
<tr>
<th>Reason for investigation</th>
<th>Adopted / rejected</th>
<th>Reasons for adoption / rejection</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rose Valley Road southbound on ramp</strong></td>
<td>Adopted</td>
<td>A study of the heavy vehicle movements originating from Rose Valley Road, and confirmation of the load restriction requirements in Gerringong, led the design team to consider the incorporation of this movement.</td>
</tr>
<tr>
<td>At the time of display a southbound on ramp from the Rose Valley Road interchange was not incorporated in the design. A change in vertical alignment for the Fern Street rail overpass bridge to provide a design speed of 80 km/h provided the opportunity to pass a southbound on ramp under this bridge.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Alignment shift at Rose Valley Road interchange</strong></td>
<td>Adopted</td>
<td>The design team considered a number of alternative arrangements for the interchange. All the alternative arrangements required shifting the highway alignment to the east and impacting the previously avoided Renfrew Park property. Various alignments were considered for the northbound off ramp. A loop alignment was considered which avoided impacting both trees. This was dismissed on road safety grounds. A northbound off ramp alignment was adopted which required removal of the smaller of the two fig trees.</td>
</tr>
<tr>
<td>The design presented in June '09 required the removal of two mature fig trees in the vicinity of the Rose Valley Road interchange. Further discussions with the local Aboriginal community highlighted the significance of these trees to that community. An arborist was commissioned to provide an assessment of the condition and life expectancy of the trees. The design team considered a revision to the Rose Valley Road interchange to avoid impacting one or both of the significant trees.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Design speed of the rail overpass bridge increased from 60 km/h to 80 km/h</strong></td>
<td>Adopted</td>
<td>The adoption of the higher design speed enabled a ‘flatter’ vertical alignment of the proposed bridge over the rail line and facilitates posting the speed of the service road at greater than 60 km/h.</td>
</tr>
<tr>
<td>The design team considered raising the design speed of the rail overpass bridge to better suit a posted speed of greater than 60 km/h for the service road.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Design refinement</td>
<td>Reasons for investigation</td>
<td>Adopted / rejected</td>
</tr>
<tr>
<td>----------------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>Provide for future widening to three lanes in each direction to the outside of the proposal</td>
<td>It was decided to consider and allow for the provision of future widening to the outside of each carriageway.</td>
<td>Adopted</td>
</tr>
<tr>
<td>Consideration of a northbound heavy vehicle rest area.</td>
<td>It is intended that a northbound and southbound heavy vehicle rest area be provided in the Gerringong to Bomaderry upgrade program. A suitable site for a southbound heavy vehicle rest area was not identified in the proposal. A potential site for a northbound heavy vehicle rest area was identified at a residual section of highway on the Gerringong Bends.</td>
<td>Rejected</td>
</tr>
<tr>
<td>Consideration of cattle underpasses.</td>
<td>At the time of display in June ’09, the configuration of cattle underpasses had not been considered. Existing cattle underpasses are located 500 m north of Rose Valley Road and at Crooked River.</td>
<td>Adopted</td>
</tr>
<tr>
<td>Design refinement</td>
<td>Reasons for investigation</td>
<td>Adopted / rejected</td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>--------------------</td>
</tr>
<tr>
<td>Sims Road access / connection options</td>
<td>The residents of Sims Road and Aline Bank Lane requested the design team consider options for improving connectivity of Sims Road with Gerringong. The project team considered two options; • A bridge connecting Sims Road to Bridges Road over a cutting in the upgraded highway and the railway line. • A two lane service road from Belinda Street interchange with on ramp developing from Sims Road – similar to the service road connecting to Willowvale Road.</td>
<td>Rejected</td>
</tr>
<tr>
<td>Bus provisions</td>
<td>The project team considered the current provisions for school, local and intrastate buses. A strategy of reconciling and consolidating the existing arrangements was proposed. The project team met with local bus operators and undertook observational surveys.</td>
<td>Adopted</td>
</tr>
<tr>
<td>Incorporation of emergency u-turn and cross over facilities</td>
<td>At the time of display the project team had not documented the incident management features of the proposal. The need for incident management facilities was investigated and emergency u-turn and cross over facilities were incorporated in the design.</td>
<td>Adopted</td>
</tr>
</tbody>
</table>
3 Road design

3.1 Design standards

The road design standard adopted for the proposal is the RTA’s Road Design Guide 1998. Other design reference documents have been used as referenced in the RTA scope of works and technical criteria (SWTC).

Specific design parameters for the proposal are also listed in the SWTC. Further design parameters are listed in the draft document Upgrading the Princes Highway, Gerringong to Bomaderry, Geometric Parameters – Issue 1.0. Relevant geometric parameters have been listed in the following sections.

New Austroads standards were being reviewed by the RTA at the time the design was being completed. The future adoption of Austroads standards would require a review of the design at detailed design stage.

3.2 Highway design

3.2.1 Class A and Class M design

The RTA’s brief for the proposal specified:

- Class A features where the preferred option was essentially an ‘on-line’ upgrade.
- Class M features (without declaring a motorway) where the preferred option was an ‘off-line’ upgrade – that is where the upgrade was remote from the existing highway.

The entire proposal is an ‘on-line’ upgrade and therefore has Class A features. Other sections of the Gerringong to Bomaderry upgrade program are ‘off-line’ and have M Class features. The Preferred Option Report, October 2008 provides more details.

Class A refers to an ‘Arterial’ style highway where direct access for local roads and private properties is permitted. Under a Class A arrangement local traffic and through traffic share the highway. Class M refers to ‘Motorway’ style highway where access is restricted to grade-separated interchanges and direct access to local roads or properties is not permitted. Extensive service roads, which could be a residual section of redundant highway, are a feature of Class M highways.

Whilst the minimum requirement for the proposal was a Class A standard, the proposal incorporates some of the principles of Class M standard – such as grade-separated interchanges and separation of local and through traffic movements for Willowvale Road and Rose Valley Road.

3.2.2 Design and performance requirements

Table 3.1 lists the significant geometric parameters adopted for the proposal.
<table>
<thead>
<tr>
<th>Criteria</th>
<th>Requirement</th>
<th>Reference</th>
<th>Comment</th>
</tr>
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<tbody>
<tr>
<td>Highway alignment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Design speed horizontal alignment</td>
<td>110 km/h</td>
<td>SWTC 1.6</td>
<td></td>
</tr>
<tr>
<td>Design speed vertical alignment</td>
<td>100 km/h</td>
<td>SWTC 1.6</td>
<td></td>
</tr>
<tr>
<td>Crest K min value</td>
<td>66</td>
<td>RDG Table 2.3.6 (2.5s)</td>
<td></td>
</tr>
<tr>
<td>Sag K main value</td>
<td>33.4</td>
<td>RDG Table 2.3.8 (Headlight considerations)</td>
<td></td>
</tr>
<tr>
<td>Stopping sight distance (Rt)</td>
<td>2.5 seconds</td>
<td>RDG Table 2.1.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Horizontal</td>
<td>210</td>
<td>RDG Table 2.1.1</td>
</tr>
<tr>
<td></td>
<td>Vertical</td>
<td>175</td>
<td>RDG Table 2.3.6 (2.5s)</td>
</tr>
<tr>
<td>Plan transition</td>
<td>&lt;1000 m Radius</td>
<td>RDG Table 2.2.2 &amp; 2.2.3 (C)</td>
<td></td>
</tr>
<tr>
<td>Superelevation transition</td>
<td>&lt;1000 m Radius</td>
<td>RDG Table 2.2.2 &amp; 2.2.3 (C)</td>
<td>Must not overlap causing “butterfly” shaped pavements.</td>
</tr>
<tr>
<td>Sightline Eye Height Car Truck</td>
<td>1.15 m</td>
<td>RDG Table 2.3.6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.4 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Horizontal stopping sight distance</td>
<td>210 m</td>
<td>RDG Table 2.1.1</td>
<td></td>
</tr>
<tr>
<td>Vertical stopping sight distance</td>
<td>175 m</td>
<td>RDG Table 2.3.6 (2.5s)</td>
<td></td>
</tr>
<tr>
<td>Approach sight distance and safe</td>
<td>1.15 to 0 m</td>
<td>RDG Figure 2.3.3</td>
<td>At all intersections, emergency cross overs, truck rest areas, farm</td>
</tr>
<tr>
<td>intersection sight distance</td>
<td>1.15 m to 1.15 m</td>
<td></td>
<td>accesses and paddock accesses</td>
</tr>
<tr>
<td>Horizontal radius</td>
<td>Min 600 m for on-line upgrade</td>
<td>RDG Table 2.2.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Min 750 m for off-line construction</td>
<td>As directed by RTA</td>
<td>Gerrigong upgrade alignment considered to be online</td>
</tr>
<tr>
<td>Arc length</td>
<td>20% reduction acceptable</td>
<td>RDG Table 2.2.2</td>
<td>Anything less than the RDG must be reported</td>
</tr>
<tr>
<td>Compound curves</td>
<td>If unavoidable must be in same design speed range</td>
<td>Upgrading the Pacific</td>
<td>Must be reported</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Highway – Design Guidelines 4.2</td>
<td></td>
</tr>
<tr>
<td>Reverse curve spacing for curves</td>
<td>&gt; Design speed in metres</td>
<td>RDG Section 2.2.23</td>
<td></td>
</tr>
<tr>
<td>Criteria</td>
<td>Requirement</td>
<td>Reference</td>
<td>Comment</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>-------------</td>
<td>---------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Highway alignment</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grade</td>
<td>%Des Max 6%</td>
<td>RDG Table 2.3.1 (Rolling terrain)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>%Abs Max 8%</td>
<td>As directed by RTA</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Min in cutting 0.5%</td>
<td></td>
<td>As directed by RTA</td>
</tr>
<tr>
<td>General arrangement (on-load and off-load)</td>
<td>Upgrading the Princes Highway - Figure 6</td>
<td>RTA Entry and Exit Ramps Rev 1.1 Figure 6 and Grade Separated Interchanges (A Design Guide) NAA SRA 1984</td>
<td>Must have full deceleration occur in the auxiliary lane. ie no deceleration in the through lane</td>
</tr>
<tr>
<td>Level of Service – For design year 20 years after completion</td>
<td>LoS C or better</td>
<td>Austroads Traffic Engineering Practice – Part 2</td>
<td>Design flow based on 100th highest hour</td>
</tr>
<tr>
<td>Design Speed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Off load Ramp</td>
<td>110 km/h at start of diverge and gore area</td>
<td>Upgrading the Princes Highway - Figure 6</td>
<td>60 km/h at local road intersection</td>
</tr>
<tr>
<td>On load Ramp</td>
<td>60 km/h at local road intersection</td>
<td></td>
<td>Trucks minimum acceleration to 85 km/h at point “T”</td>
</tr>
<tr>
<td>Provision for cyclists</td>
<td>Comply with RTA guidelines</td>
<td>RTA NSW Bicycle Guidelines and Austroads Traffic Engineering Practice – Part 14</td>
<td>Include provision at all interchanges RTA Guidelines, see Figure 7.22</td>
</tr>
<tr>
<td>Sightline</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>To start of auxiliary lane</td>
<td>350 m desirable</td>
<td>Upgrading the Princes Highway - Figure 6</td>
<td></td>
</tr>
<tr>
<td>To gore nose</td>
<td>350 m absolute min</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reaction time</td>
<td>2.5 seconds</td>
<td>As directed by RTA</td>
<td></td>
</tr>
<tr>
<td>Horizontal alignment (ramp proper)</td>
<td>To suit speed regime</td>
<td>RDG Section 2</td>
<td></td>
</tr>
<tr>
<td>Vertical alignment (ramp proper)</td>
<td>To suit speed regime</td>
<td>Upgrading the Princes Highway - Figure 6</td>
<td>Table</td>
</tr>
<tr>
<td>Terminal</td>
<td>To suit 19 m semi trailer unless designated a B-Double access</td>
<td>RDG Section 4 and RTA Roundabouts Geometric Design Method</td>
<td>Provide furniture to suit B-double turning movements. Linemarking to suit 19 m semi trailer turning movements</td>
</tr>
<tr>
<td>Criteria</td>
<td>Requirement</td>
<td>Reference</td>
<td>Comment</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>-------------</td>
<td>-----------</td>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Highway and ramp cross section</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upgrade lanes (in each direction) Ramps</td>
<td>22</td>
<td>SWTC 1.3</td>
<td>With provision for future widening on the outside</td>
</tr>
<tr>
<td>Climbing lanes</td>
<td>Loss of truck speed to 40 km/h and LoS D 20 years after construction</td>
<td>As directed by RTA.</td>
<td>Climbing lane to occupy ultimate 3rd lane (narrow median, Ref Upgrading the Princes Highway - Figure 3)</td>
</tr>
<tr>
<td>Lane width (including interchange ramps and aux lanes)</td>
<td>3.5 m</td>
<td>As directed by RTA</td>
<td></td>
</tr>
<tr>
<td>Nearside (outside) shoulder</td>
<td>2.5 m</td>
<td>As directed by RTA</td>
<td>3.0 m sealed clearance adjacent to safety barrier to cater for cyclists, maintenance and emergency services vehicles (also applies to auxiliary lanes)</td>
</tr>
<tr>
<td>Offside (median) shoulder</td>
<td>Min 1.0 m</td>
<td>RDG Section 3.3.3</td>
<td></td>
</tr>
<tr>
<td>Median width – No right turn bay (Case 1)</td>
<td>35.0 m</td>
<td>As directed by RTA</td>
<td>Provision for future widening on the outside</td>
</tr>
<tr>
<td>Median width – Right turn bay treatment required (Case 2)</td>
<td>32.6 m</td>
<td>RDG 4.8.18</td>
<td>To facilitate proposed local road access / u-turn facility where required</td>
</tr>
<tr>
<td>Outside verge (adjacent 4 to 1 or flatter batters)</td>
<td>Adopt 2 m rounding commencing at shoulder</td>
<td>RDG Table 6.10</td>
<td>For driver to maintain control</td>
</tr>
<tr>
<td>Outside verge (adjacent barrier)</td>
<td>Adopt 2 m rounding commencing 0.5 m outside wire rope safety barrier</td>
<td>As directed by the RTA</td>
<td>To maintain max 10:1 slope at extremity of wire rope deflection</td>
</tr>
<tr>
<td>Median verge (adjacent 4 to 1 or flatter batters)</td>
<td>Min 0.5 m</td>
<td>As directed by RTA</td>
<td>Only applies on independent alignments</td>
</tr>
<tr>
<td>Cutting berm (adjacent SO gutter)</td>
<td>Min 0.5 m</td>
<td>To suit recommendations of the geotechnical report</td>
<td>Note that it may exceed these dimensions to accommodate sight lines, rock fall zones and catch fence treatments</td>
</tr>
</tbody>
</table>

Princes Highway – Gerringong upgrade
Concept Design Report
<table>
<thead>
<tr>
<th>Criteria</th>
<th>Requirement</th>
<th>Reference</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highway and ramp cross section</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outside clear zone</td>
<td>&lt; 10% slope – 11.0 m 10% to 4:1 batters Max 14 m</td>
<td>RDG Section 3.7</td>
<td></td>
</tr>
<tr>
<td>Clearance to boundary</td>
<td>Min 6.0 m</td>
<td>As directed by RTA</td>
<td>Need to allow for sedimentation structures and access for maintenance between catch or diversion drains and boundary. Consider widening on a case by case basis where a geotechnical risk exists</td>
</tr>
<tr>
<td>Gutters</td>
<td>Located outside of shoulders in cuttings and on embankments greater than 2.5 m high and steeper than 2:1</td>
<td>Upgrading the Princes Highway - Figure 2 and 5</td>
<td>WRSB located 0.2 m from edge of gutter G4 SB 0 m offset from SO gutter</td>
</tr>
<tr>
<td>Flood immunity</td>
<td>1:100 years for new structures. A minimum of 1:20 years if an existing structure can be utilised subject to structural capacity adequate for new design life</td>
<td>SWTC 1.2 (assumed both lanes in both directions)</td>
<td>Provide a clearance of 0.5 m above the 1:100 year flood level to the lowest edge of shoulder. Prove that the adoption of a structure with a 1:20 year flood capacity does not exacerbate flooding</td>
</tr>
<tr>
<td>Batters</td>
<td></td>
<td>Refer to the project Geotechnical Reports</td>
<td></td>
</tr>
<tr>
<td>Fill &lt; 1.5 m high</td>
<td>4:1 2:1 7 m maximum between benches 10 m maximum between benches</td>
<td></td>
<td>Not to exceed clear zone 4 m wide bench at max 10 m. Provide 50 m long end rounding</td>
</tr>
<tr>
<td>Fill &gt; 1.5 m high</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cut 2:1 or flatter</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cut steeper than 2:1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Criteria

<table>
<thead>
<tr>
<th>Bridges</th>
<th>Requirement</th>
<th>Reference</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outside shoulder</td>
<td>2.0 m – 3.0 m</td>
<td>As directed by RTA</td>
<td>Shoulder width on bridges to match approach shoulder width</td>
</tr>
<tr>
<td>Median shoulder</td>
<td>Min 1.0m</td>
<td>As directed by RTA</td>
<td></td>
</tr>
<tr>
<td>Vertical clearance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Over highway</td>
<td>5.3 m</td>
<td>RDG Section 3</td>
<td>Allow for duplication on western side of existing track</td>
</tr>
<tr>
<td>Over regional and local</td>
<td>4.6 m</td>
<td>Railcorp Engineering</td>
<td></td>
</tr>
<tr>
<td>road</td>
<td></td>
<td>Standard ESC 215</td>
<td></td>
</tr>
<tr>
<td>Over railway (future</td>
<td>5.9 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DC electric)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. No criteria regarding maximum length of grade applies.
2. Provision for future widening on the outside. Climbing lanes to occupy ultimate 3rd lane.
3. Measured edgeline to edgeline. Case 1: 5.0 m with wire rope. Case 2: 2.6 m with Type F concrete barrier.
4. From toe of formation or top of cutting to boundary.
### 3.2.3 Other design parameters

#### Table 3.2: Other design parameters

| Design vehicles | • Highway alignment  
|                 | - 25.0 m B-Double  
|                 | - 12.5 m single unit truck (Emergency u-turn bays)  
|                 | - 19.0 m semi-trailer (Access u-turn bay)  
| • Local road | - Up to 19.0 m semi-trailer (unless designated a B-Double access)  
| • Property access | - 19.0 m semi-trailer (farm residence and paddock access by negotiation with the land owner and depending on land use)  
| Alignment – temporary tie-ins | • Design speed (horizontal and vertical alignment)  
|                 | - Longer term situations such as tie-ins between construction stages  
|                 | ▪ 80 km/h minimum  
|                 | ▪ 100 km/h – when speed environment may be perceived as high speed  
|                 | - Short-term – 40 km/h  
| • Reaction time | - 2.5 seconds, longer-term  
|                 | - 1.5 seconds, short-term  
| • Clear zone | - RDG clear zones apply  
| • Cross section | - 1.0 m minimum shoulders (subject to sightlines)  
|                 | - 2 x 3.5 m minimum traffic lanes  
| Alignment – local roads | • Design standard  
|                 | - Road Design Guide  
| • Design Speed (horizontal and vertical alignment) | - 60 km/h  
| • Vertical alignment | - Grade – desirable maximum 6%  
|                 | - Maximum 8% or as required to match existing  
| • Reaction time | - 1.5 seconds  
| • Clear zones | - RDG clear zones apply  
| • Cross section | - 2.0 minimum sealed shoulders (subject to RDG requirement for 3.0 m when adjacent to barrier lines)  
| • Council requirements | - To be negotiated  
|
3.2.4 Sight distance

Sight distance requirements for the proposal have been provided in accordance with design guidelines, in particular:

- Stopping sight distance (SSD) along the highway; excluding adjacent to bridge barriers / parapets and through wire rope safety barrier (WRSB) (refer Table 3.3).
- Safe intersection sight distance (SISD) at at-grade intersections and property accesses (left-in-left-out arrangements).
- Approach sight distance (ASD) at the at-grade intersections.
- Headlight sight distance in sags.
- Benching for sight distance was not required.

Details of where sight distance requirements have not been achieved are provided in Table 3.3.

### Table 3.3: Sight distance

<table>
<thead>
<tr>
<th>Location / chainage</th>
<th>Sight distance adopted</th>
<th>Reason for departure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highway / general</td>
<td>Stopping Sight Distance (SSD) of 210 m not achieved on curved alignments with WRSB along the median. WRSB offset 1.7 m from inside lane line to maximise stopping sight distance provides 175 m on a 600 m radius curve (100 km/h – 2.5 second reaction time with longitudinal friction factor d=0.39)</td>
<td>Considered acceptable practice to assume WRSB does not provide a visible obstruction to the line of sight</td>
</tr>
<tr>
<td>Belinda Street / Ch 4475</td>
<td>210 m SSD required, approx 120 m southbound and 150 m northbound achieved due to bridge parapet obstruction. Sighting over barrier possible, however line of sight for southbound vehicles may be interrupted by vehicles in the on-coming northbound carriageway.</td>
<td>Excessive widening required under SSD requirements</td>
</tr>
<tr>
<td>Belinda Street / southbound off ramp intersection</td>
<td>105 m (60 km/hr) Safe Intersection Sight Distance (SISD) achieved, however may be restricted.</td>
<td>Possible obstructions within the service station may limit SISD for approaching northbound vehicles along Belinda Street</td>
</tr>
</tbody>
</table>
## Departures from sight distance requirements

<table>
<thead>
<tr>
<th>Location / chainage</th>
<th>Sight distance adopted</th>
<th>Reason for departure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northbound exit ramp to Willowvale Road / Belinda Street service road</td>
<td>350 m sight distance required to the diverge taper, approx 190 m achieved</td>
<td>The auxiliary lane has been extended over the crest to improve sight distance, however sight lines are still obstructed by the cutting on the inside of the curve. It is not considered practical to achieve 350 m sight distance due to the tight geometry and the significant cuttings associated with this alignment.</td>
</tr>
<tr>
<td>Southbound exit ramp at Rose Valley Rd interchange.</td>
<td>350m sight distance required to the diverge gore nose, approximately 200m achieved.</td>
<td>The alignment is constrained by the vertical geometry associated with the Rose Valley Rd interchange. The start of the diverge has been extended to compensate for this non-conformance.</td>
</tr>
</tbody>
</table>

1. Ref: Austroads GRD Part 3.5.5 - Sight distance requirements on horizontal curves with roadside barriers. Application of the normal SSD requirements in this situation produces excessive lateral offsets, which can have the following adverse operational effects:
- Cars and trucks parking in the widened area, reducing sight distance.
- Errant vehicles potentially impacting the barrier at a greater angle, increasing the severity of these type of accidents
- Cost of providing the widened area becomes expensive

### 3.2.5 Cross section

The road cross section consists of a single carriageway with:

- Four 3.5 m wide lanes.
- A 5.0 m wide median (between edgelines) with WRSB separation.
- A 2.5 m nearside (outside) shoulder (3.0 m wide adjacent to barriers) and a 1.0 m offside (median) shoulder.
- A 1.0 m wide verge with 2.0 m wide rounding.
- Superelevation provided in accordance with RTA RDG Table 2.2.2.
- Provision for future widening on the outside of the proposed carriageways.

Further details are shown in the design parameter Table 3.2. Typical road cross sections are also shown in the concept design drawings.

### 3.2.6 Provision for cyclists

Provision for cyclists is provided in the 2.5 m wide highway shoulder. A shared cycleway / footpath is also proposed to link Sims Road residents to Gerringong via the Belinda Street interchange.

### 3.2.7 Horizontal geometry

The proposed horizontal alignment is shown on the concept design drawings. The minimum radii as specified in the geometric design parameters have been achieved, excluding the alignment at Mount Pleasant (discussed further below). Typical horizontal alignment details and
considerations used to develop the alignment are as follows:

- Curve radius 600 m for upgrading online (to the existing highway).
- Curve radius 750 m for upgrading offline (to the existing highway). Gerringong upgrade alignment considered to be totally online.
- Plan transitions adopted for curve radii below 1000 m.
- Lane widening not required.
- Provide good coordination with the vertical alignment;
- Minimise property acquisition;
- Consideration of construction staging (ie online construction in deep cuts / high fills);

Details of horizontal alignment requirements that have not been achieved are provided in Table 3.4.

### Table 3.4: Horizontal alignment geometry requirements

<table>
<thead>
<tr>
<th>Location / chainage</th>
<th>Geometry adopted</th>
<th>Reason for departure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mount Pleasant / Ch350</td>
<td>R320m</td>
<td>Proposed upgrade to match existing alignment (80 km/hr)</td>
</tr>
<tr>
<td>Mount Pleasant / Ch650</td>
<td>R320m</td>
<td>Proposed upgrade to match existing alignment (80 km/hr)</td>
</tr>
<tr>
<td>Mount Pleasant / Ch1050</td>
<td>R900m curve length of 245 m (320 m required at 20% reduction – Refer RDG Table 2.2.2)</td>
<td>The curve alignment at this location is constrained by the preceding geometry required at Mount Pleasant (refer above) and the Rose Valley Road interchange. Therefore the standard curve length cannot be achieved without greater impacts elsewhere.</td>
</tr>
<tr>
<td>Gerringong Bends / Ch5650</td>
<td>R600 / curve length 280 m (340 m required – Refer RDG Table 2.2.2). 20% reduction in curve length permitted however must be reported.</td>
<td>Due to the series of curve radii adopted along this alignment the standard curve lengths were not achievable without compromising the minimum curve radii. Alternate alignments were investigated by the team, however due to the adjoining constraints along this alignment these were not considered practical with regard to meeting the project objectives (ie excessive earthworks, property acquisition etc).</td>
</tr>
<tr>
<td>Gerringong Bends / Ch5925</td>
<td>R600 / curve length 267 m (340 m required – Refer RDG Table 2.2.2). 20% reduction in curve length permitted however must be reported.</td>
<td>As above</td>
</tr>
</tbody>
</table>
3.2.8 Vertical geometry

The proposed vertical alignment is shown on the concept design drawings. In general the terrain traversed is considered rolling with a desirable maximum longitudinal grade of six per cent and an absolute maximum of eight per cent (as directed by the RTA). The minimum acceptable grade in a cutting is 0.5 per cent. The longitudinal grades adopted comply with these requirements. The vertical alignment has also been developed to meet the following requirements and considerations:

- Achieve vertical clearances for structures over and under the proposed alignment.
- Provide vertical curve lengths / values to meet stopping sight distance requirements.
- Achieve clearances over drainage crossings, creeks, tributaries and to provide flood immunity.
- Provide clearance over proposed cattle underpasses.
- Consideration of construction staging (i.e. online construction in deep cuts / high fills).
- Provide good coordination with the horizontal alignment.
- Consideration of sheet flow and aqua-planning at locations of flat grade and superelevation transitions.
- Consideration of steep grades with regard to merge / auxiliary lane locations and lengths.

Details of vertical alignment geometry requirements that have not been achieved are provided in Table 3.5 below:

**Table 3.5: Vertical alignment geometry requirements**

<table>
<thead>
<tr>
<th>Location / chainage</th>
<th>Geometry adopted</th>
<th>Reason for departure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Omega Flat / Ch1600 - 2600</td>
<td>Poor coordination of vertical and horizontal alignment – crest vertical curves on a straight horizontal alignment.</td>
<td>Due to the flat terrain across Omega Flat, a vertical alignment with two crest curves has been developed to provide longitudinal fall to resolve drainage issues. An alternative single grade / crest alignment was investigated, however this option was dismissed due to the extensive earthworks required, increased footprint and adjoining constraints such as the Fern Street bridge alignment.</td>
</tr>
</tbody>
</table>

3.2.9 Interchanges

- Provide for Level of Service “C” or better, in accordance with Austroads Traffic Engineering Practice Series part 2, for design year 20 years after opening, for the 100th highest hourly volume.
- Exit and entry ramp geometry / standards generally in accordance with Upgrading the Princes Highway - Figure 6.
3.2.10 Access arrangements

A fundamental feature of the proposal is the incorporation of a continuous median barrier to separate opposing traffic. This feature would result in significantly reduced potential for head-on crashes. The incorporation of a median barrier restricts the ability for right turn median movements. The undesirability of right turn at-grade movements lead the design team to move away from the consideration of at-grade junctions.

Examples of current local access movements and the impact on that movement as a result of the proposal are shown in Figure 3.1.

Local roads

The design team devised and evaluated several arrangements to connect the upgraded highway with Gerringong. All arrangements incorporated grade-separated connections with the highway. Three alternative arrangements were publicly displayed and extensive comments were received from the community. A value management study involving community members and a range of stakeholders was held to assist with the identification of the preferred arrangement. The community strongly believed that connections with the highway should include all-movements at both ends of the town – essentially replicating the existing arrangement but with grade-separated movements.

Combining the Gerringong ‘northern interchange’ with the Rose Valley Road junction provided an opportunity to consolidate the Fern Street and Rose Valley Road junctions with a single grade-separated interchange. Similarly, Willowvale Road and Baileys Road were combined with the Belinda Street interchange via a relatively short service road. Hence, local roads are well serviced by all-movements grade-separated interchanges. Sims Road and Omega Lane remains as the only local road junction with direct ‘left-in-left-out’ only access.

Properties

Right turn (across median) access to property is not permitted. Access to private properties would be ‘left-in-left-out’ only. Motorists wishing to turn right onto the highway from minor roads and property accesses are required to first turn left and travel to the nearest interchange to make a u-turn. U-turn provision is via the grade-separated interchanges at Rose Valley Road, Belinda Street, and ultimately Toolijooa Road when this is completed in the next stage. A small number of properties north of Rose Valley Road would be required to travel to Weir Street at the northern end of the Kiama Bends to u-turn.

All property accesses have sight lines meeting the road design standards. A sealed shoulder of at least 2.5 m width would provide provision for slowing or accelerating traffic at property entrances. All property accesses have geometry suitable for a rigid truck to turn from the left-most lane of the highway. Turning for articulated trucks from the left-most lane has been provided if discussions with property owners have indicated that this is currently required.
Figure 3.1: Example local access movements

<table>
<thead>
<tr>
<th>Property accesses between Belinda Street and Toolijooa Road</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>From</strong></td>
</tr>
<tr>
<td><strong>To</strong></td>
</tr>
<tr>
<td><strong>Traffic circulation</strong></td>
</tr>
<tr>
<td><strong>Maximum additional travel (typical conditions)</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sims Road and access</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>From</strong></td>
</tr>
<tr>
<td><strong>To</strong></td>
</tr>
<tr>
<td><strong>Traffic circulation</strong></td>
</tr>
<tr>
<td><strong>Additional travel</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Property accesses north of Rose Valley Road</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>From</strong></td>
</tr>
<tr>
<td><strong>To</strong></td>
</tr>
<tr>
<td><strong>Traffic circulation</strong></td>
</tr>
<tr>
<td><strong>Maximum additional travel (typical conditions)</strong></td>
</tr>
</tbody>
</table>

| Local access constraint | Requires northbound travel on the Princes Highway and U-turn at Belinda Street interchange |
| Maximum additional travel (typical conditions) | 7.1 km (4.7 minutes) |

| From | Properties south of Mount Pleasant lookout, accessed via southbound carriageway |
| **To** | Princes Highway northbound |
| **Traffic circulation** | Requires southbound travel on the Princes Highway and U-turn at Rose Valley Road interchange |
| **Maximum additional travel (typical conditions)** | 2.6 km (2.1 minutes) |
| **Traffic circulation** | Requires continuing southbound travel on Princes Highway and U-turn at Belinda Street interchange |
| **Additional travel** | 2.1 km (2.1 minutes) |
3.2.11 Provision for future six lanes

Consideration has been given to potential need for widening to three lanes in each direction over the length of the proposal. The intention is to recognise that widening is required in the future to improve capacity and provide for this allowance if it is economical and practical to do so. Property acquisition and the setting of corridor boundaries allows for this potential. Where it is considered economical and practical to do so, significant structures have been designed to accommodate future widening needs. Specifically this applies to the cutting and bridge structure at the Rose Valley Road interchange, the embankment across Omega Flat, and the cutting at Gerringong Bends south of Willowvale Road. On ramps and off ramps at interchanges have been configured to allow for the introduction of a third lane on the outside of the carriageway.

3.2.12 Truck stops and inspection facilities

The RTA’s brief for the Gerringong to Bomaderry upgrade program required the consideration of suitable sites for a northbound and southbound heavy vehicle rest area with possible incorporation of a heavy vehicle inspection facility. No suitable sites were identified in the Gerringong upgrade section of the proposal. Potential sites have been identified in the remaining sections of the upgrade program.

Provision for light vehicle rest areas was not considered. The proximity of Gerringong, Berry, and Bomaderry town centres provides opportunity for rest stops.

3.2.13 Emergency u-turn, public u-turn, lay-bys and cross over facilities

Emergency u-turn facilities provide opportunity for emergency services vehicles to execute a quick u-turn manoeuvre rather than travelling to the next grade-separated interchange. The wire rope median barrier is discontinued and a permanent gap is available. Signposting would denote that the facility is for use by emergency vehicles only. A lay-by with emergency telephone is incorporated with this facility. The regular spacing of grade-separated interchanges does not warrant the incorporation of dedicated at-grade public u-turn facilities.

Unlike emergency u-turn facilities, emergency cross over facilities are intended to enable contra-flow arrangements to be put in place by emergency services in the case of a significant traffic incident blocking one direction of flow. These facilities operate in tandem – with one facility directing traffic into the contra-flow arrangement, and another directing traffic back to the normal arrangement. For these facilities to service the majority of the proposal they should be placed as close as possible to the ramps of interchanges. Emergency cross over facilities are not intended to be used to facilitate routine maintenance activities. It is likely that the wire rope would be continued through the emergency cross over facility with provision for the rope to be ‘dropped’ when the facility was needed.

There are no suitable locations for emergency cross over facilities in the proposal.

3.2.14 Pavement design

Pavement analysis has not been completed for the concept design. For the purposes of costing it has been assumed that a similar pavement type to other recently completed Princes Highway upgrade sections will be adopted. A semi-rigid pavement incorporating asphalt surfacing over a heavily bound base has been adopted on the Oak Flats to Dunmore and North Kiama bypass upgrade sections. Pavement material is in plentiful supply as a co-product of the steel manufacturing industry at Port Kembla and the quarries in and around Bombo. It is unlikely that a concrete pavement would provide value for money because of the relatively short length of the proposal and the need to build the new pavement under traffic.
4 Existing road infrastructure and transport

4.1 Review of existing alignment

The existing highway alignment was constructed in the early 1930s. Over the years improvements have been made to keep pace with traffic growth and road safety advances.

The single carriageway has no median or barrier to separate opposing flows. Lane widths are 3.5 m with variable width shoulders. Additional lanes have been incorporated to provide overtaking opportunities. Local road junctions are at-grade with protected right turn facilities at Rose Valley Road, Fern Street, and Belinda Street. An at-grade rail crossing intersects with Fern Street in close proximity to the junction with the highway.

Generally the alignment tracks the natural undulating landform with relatively shallow cuttings and embankments. From Mount Pleasant the alignment descends on an eight per cent grade before traversing Omega Flat. Flooding in the Omega Flat area can overtop the existing highway making it impassable. Similarly sections of Fern Street and Belinda Street are subject to inundation. Access to and from the town in times of flood is via the ‘Sandtrack’ to Gerringong and Shoalhaven Heads except that during a major flood Shoalhaven Heads to Bomaderry section suffers long-term inundation from the Shoalhaven River of at least two to three days, and Berry about 12 hours.

From Omega Flat to Belinda Street the alignment follows a series of undulations before crossing another low-lying area in the vicinity of the Crooked River crossing. From the Crooked River the highway steeply climbs over a ridge spur and again descends to another low-lying area subject to inundation. At the southern extent of the proposal the highway commences an ascent of a fourth ridgeline in the vicinity of Toolijooa Road.

4.2 Existing highway access

All local road junctions are currently at-grade. The local road junctions are:

- Omega Lane
- Rose Valley Road
- Fern Street
- Sims Road
- Belinda Street
- Baileys Road
- Willowvale Road.

Fern Street and Belinda Street provide access to Gerringong and communities beyond. The Fern Street junction has a high standard ‘seagull’ arrangement while Belinda Street has a protected right turn arrangement. With no median separation or barrier, all movements are available at all existing local road junctions with the exception of the right turn movement into Fern Street.

Numerous rural properties have direct access to the highway. Many of these accesses have poor sight lines due to the current horizontal and vertical geometry. Right turn movements are currently permitted at property accesses, however many property owners choose not to make these movements due to safety concerns.
Many rural properties require access for articulated vehicles such as milk tankers and cattle trucks. Currently, many of these movements are made with difficulty and with compromised safety. In some instances trucks are required to move into the opposing traffic lane to make turns into and out of properties.

4.3 Existing modes of transport

4.3.1 Public transport

Table 4.1 provides details of the percentage of daily trips travelled by mode of transport in the Kiama and Shoalhaven local government areas. Table 4.1 shows a high car dependency in the project area with over 83 per cent of daily travel made by private vehicles. Public transport accounts for five per cent or less of the mode share in both local government areas, indicating extremely low levels of patronage compared to urban areas.

Table 4.1: Kiama and Shoalhaven mode share (by number of trips made, 2007)

<table>
<thead>
<tr>
<th>Local government area</th>
<th>Private vehicle</th>
<th>Train</th>
<th>Bus</th>
<th>Walk</th>
<th>Other modes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kiama</td>
<td>83%</td>
<td>1%</td>
<td>4%</td>
<td>9%</td>
<td>3%</td>
</tr>
<tr>
<td>Shoalhaven</td>
<td>86%</td>
<td>1%</td>
<td>2%</td>
<td>10%</td>
<td>1%</td>
</tr>
</tbody>
</table>

Source: Transport Data Centre - 2007 Household Travel Survey

4.3.2 Bus and coach services

Local and regional bus and coach services utilise the Princes Highway route, although the frequency and location of services available to the general public is limited. School services transporting students from Gerringong, Berry and Bomaderry frequent the route during term time.

In the local area, private operator Shoal Bus offers services in Gerringong and to the south, with Service 705 extending from Werri Beach in the north-east of Gerringong, travelling south through the town and then onto Berry, Bomaderry and Nowra. Shoal Bus users can change services to access other areas further south (for instance changing at Berry to travel to Shoalhaven Heads, or at Bomaderry / Nowra to travel further south towards St. Georges Basin).

Shoal Bus Service 705 operates a minimum of two services per day on weekdays, although two additional ‘Shoal Shopper’ services operate on Tuesday and Friday, bringing the total services on these days to four. The time these services run depends primarily on school holiday schedules, although at all times there is a minimum one morning and one afternoon service. There are no local services in Gerringong on weekends.

The primary stops for service 705 are located in Gerringong, Berry and Nowra, with limited services serving Werri Beach, Gerroa and Shoalhaven Hospital. The express service travelling between Gerringong and Nowra typically takes between 30 and 45 minutes, while all stop services can take in excess of one hour.

Kiama Coachlines offers local services 701 and 702 that travel north from Gerringong, providing a connection to Kiama and further north as far as Jamberoo and Minnamurra Falls. There are a minimum of two services a day between Gerringong and Kiama, with times again dependent on school holidays.
The primary stops for services 701 and 702 are Gerringong, Kiama Heights and Kiama. The express service between Gerringong and Kiama takes 15 to 20 minutes. All stop services also include Minnamurra Falls, Jamberoo, Gerroa and Seven Mile Beach. The all stop services can take in excess of one hour to travel from Minnamurra Falls to Seven Mile Beach.

A number of local bus operators also run school-specific buses and coaches which use the highway in the project area. Shoal Bus operates two services which travel to Nowra and Bomaderry. One service runs from Gerringong, down the ‘Sandtrack’ (Gerroa Road), before heading across from the ‘Sandtrack’ to Berry via Beach Road, and then onto Bomaderry along the Princes Highway. The other starts in the Foxground area and travels south along the Princes Highway through to Nowra. This service is typically flexible, generally stopping at property gates where children reside as well as at Croziers Road and Strongs Road.

Gerringong Buses offers services which pick up and drop off students between Toolijooa Road and Rose Valley Road. Kiama Coachlines run a service northbound from Gerringong, collecting and depositing students at Sims Road, Rose Valley Road, and in the Kiama Bends; this service currently only collects and drops off students when travelling northbound, due to a lack of facilities to pull over on the southbound side. At the southernmost point of its route this service uses Belinda Street to turn around. Premier Motor Service also provides a school service running from Bomaderry to Toolijooa Road.

Premier Motor Service provides two daily bus services in each direction between Sydney and Melbourne via Kiama, Gerringong and Nowra on the Princes Highway, although this is a service typically used by passengers travelling long distances / interstate, rather than by local residents.

4.3.3 Rail

The use of rail services in the project area is limited, with the south coast line terminating at Bomaderry, north of the Shoalhaven River. The South Coast Rail Line links Sydney, Wollongong and North Nowra / Bomaderry. There is a station serving the project area located in Gerringong. Berry and Bomaderry to the south both have stations, while Kiama is the nearest station to the north. As there are no direct services from Gerringong to Sydney, passengers are required to change trains at Wollongong, Dapto or Kiama.

There are 18 services in each direction stopping at Gerringong during weekdays, with 14 services in each direction during the weekends. Services operate approximately once every hour during the morning and afternoon peak hours through the week. There are train services every two hours during the inter-peak period between 9.30am and 3pm. Buses replace some late night and early morning train services.

Travelling between Gerringong and Berry takes approximately 10 minutes, and a further 10 minutes from Berry to Bomaderry. Heading north, Gerringong to Kiama takes 10 minutes, while travelling between Gerringong and Wollongong takes around 60 minutes. For those travelling further still, the journey between Wollongong and Sydney takes between 90 and 105 minutes.

RailCorp publishes annual New South Wales station entry and exit statistics. The latest data was released in 2008 and is contained in the “A Compendium of CityRail Travel Statistics, Sixth Edition, June 2008”. Table 4.2 shows Gerringong and other stations near to the project area at various time periods during an average weekday in 2007. Patronage at Gerringong Station is similar to Berry; however both have much lower passenger numbers than other stations in the region, again underlining the reliance in the area on private vehicles.
Table 4.2: 2007 average week day station entries and exits

<table>
<thead>
<tr>
<th>Station</th>
<th>AM Peak 6am to 9:30am</th>
<th>Inter Peak 9:30am to 3pm</th>
<th>PM Peak 3pm to 6:30pm</th>
<th>24 hours</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>In</td>
<td>Out</td>
<td>In</td>
<td>Out</td>
</tr>
<tr>
<td>Bomaderry (Nowra)</td>
<td>140</td>
<td>20</td>
<td>150</td>
<td>130</td>
</tr>
<tr>
<td>Berry</td>
<td>40</td>
<td>10</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Gerringong</td>
<td>30</td>
<td>10</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>Kiama</td>
<td>140</td>
<td>40</td>
<td>210</td>
<td>200</td>
</tr>
<tr>
<td>Dapto</td>
<td>500</td>
<td>100</td>
<td>140</td>
<td>140</td>
</tr>
<tr>
<td>Wollongong</td>
<td>800</td>
<td>410</td>
<td>460</td>
<td>410</td>
</tr>
</tbody>
</table>

Source: A compendium of CityRail Travel Statistics, Sixth Edition, June 2008

4.3.4 Walking and cycling

There are no footpaths along the Princes Highway within the project area and very few pedestrians travel along this route. Shoulders and verges provide a means for pedestrians to travel along the Princes Highway; however the speed of traffic on this route combined with significant travel distances to nearby towns (ie Kiama and Berry) result in very little pedestrian activity.

In 1996, Kiama Municipal Council adopted a cycleway plan developed by the Walking Tracks and Cycleways Committee. The plan provided details of cycleways in major towns within the local government area. There are currently no cycle facilities along the Princes Highway in the project area.

An off-road cycle route linking Gerringong and Gerroa along Fern Street (and extending to the northern end of Fern Street) was completed in 2000, and a six kilometre walking track between Kiama and Gerringong along the coast was opened in October 2009.
5 Current and proposed traffic

A traffic and transportation assessment for the proposal was completed in two stages: a preliminary traffic and transportation assessment; and detailed traffic and transportation assessment.

The preliminary study included a review of existing conditions and a traffic impact assessment of the proposed route options. The *Preliminary Traffic Assessment Report* was one of several supporting studies that assisted the RTA in developing the preferred route for the Gerringong upgrade.

Traffic modelling was subsequently undertaken for the proposal to assess the operational performance of various interchange arrangements linking the upgrade to Gerringong. The results provided input to the selection of the preferred access options, which were displayed to the local community in June 2009.

The detailed study includes the development of future year traffic volumes for the proposal and an assessment of the Gerringong upgrade carriageway and access performance measures. In addition, the impact of increased travel demand in the locality of Gerringong during and after construction is assessed.

This chapter includes a summary of the analysis and findings from the detailed traffic assessment.

5.1 Existing traffic patterns

5.1.1 Existing traffic volumes

In addition to the permanent RTA traffic count site 07.800 on the Princes Highway north of Rose Valley Road, the RTA commissioned traffic surveys during May and June 2009 to measure current traffic volumes at other key locations on the Princes Highway and adjacent ‘Sandtrack’ route in the study area.

Automatic traffic count (ATC) tubes were located on the Princes Highway south-west of Belinda Street and on the ‘Sandtrack’ to the south of the Belinda Street intersection. A summary of the average peak and daily traffic volumes (seasonally adjusted) are shown in Table 5.1.

<table>
<thead>
<tr>
<th>RTA site ID</th>
<th>Location</th>
<th>Source</th>
<th>AM peak (veh/hr)</th>
<th>PM peak (veh/hr)</th>
<th>100th hour (veh/hr)</th>
<th>AADT (veh/day)</th>
<th>% heavy vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.800</td>
<td>Princes Highway, north of Rose Valley Road</td>
<td>RTA permanent</td>
<td>1,495</td>
<td>1,798</td>
<td>2,429</td>
<td>20,902</td>
<td>8%</td>
</tr>
<tr>
<td>7.045</td>
<td>Princes Highway, west of Belinda Street</td>
<td>ATC</td>
<td>749</td>
<td>900</td>
<td>1,214</td>
<td>10,447</td>
<td>12%</td>
</tr>
<tr>
<td>7.101</td>
<td>‘Sandtrack’, south of Belinda Street</td>
<td>ATC</td>
<td>620</td>
<td>758</td>
<td>1,010</td>
<td>8,692</td>
<td>3%</td>
</tr>
</tbody>
</table>
Table 5.1 shows that the highest daily volume of traffic in the area is on the Princes Highway north of Rose Valley Road with an annual average daily traffic (AADT) of 20,902 vehicles. South of Gerringong, the combined AADT flows on the Princes Highway (west of Belinda Street) and on the ‘Sandtrack’ (south of Belinda Street) are 19,139 vehicles suggesting a net loss of traffic of around 1,800 vehicles to the town of Gerringong. The ‘Sandtrack’ route south of Belinda Street currently accommodates 8,692 vehicles per day, which equates to 45 per cent of the total traffic south of Gerringong. The other 55 per cent of trips currently travel on the Princes Highway.

In addition to AADT, Table 5.1 shows the average AM peak, PM peak and 100th busiest single hour traffic volumes, and the daily proportion of heavy vehicles for each location. As the Princes Highway is in a rural area and a major route for tourism with significant peak period travel demand during school holidays, it is not necessarily appropriate to focus analysis at typical weekday morning and evening peak periods. Therefore, further analysis was carried out to identify the true periods of peak demand and found that these usually occurred on Friday or Sunday evening of a public holiday weekend or during other holiday periods.

Since it is not economical to design to a level of capacity that is required only for a few hours per year, a design hour must be chosen upon which to base design analysis. The design hour is normally chosen between the 30th and 100th busiest hour of the year; with the 100th hour selected to assess carriageway and access operational performance measures for the Gerringong upgrade. As expected, analysis of the RTA permanent traffic data for site 7.800 (north of Rose Valley Road) showed that the 100th hour was considerably higher than traffic flows during the ‘typical’ AM and PM peak periods with the 100th hour representing 11.6 per cent of the AADT compared to 7.2 per cent and 8.6 per cent for the AM and PM peaks respectively.

The 100th hour factor of 11.6 per cent was applied to the 2009 AADT for the other two count locations to synthesise a 100th hour traffic flow for the ‘Sandtrack’ and the Princes Highway south of Gerringong. The resultant traffic volumes are shown in Table 5.1.

5.1.2 Midblock level of service

Level of service (LOS) is a measure to determine the operational conditions and efficiency of a roadway or intersection. The definition of LOS generally describes the operating conditions in terms of speed and travel time, freedom to manoeuvre, traffic interruptions, comfort and convenience, and road safety.

There are six levels of service, A to F, with LOS A representing optimum operating conditions (free flow) and LOS F the poorest (forced or breakdown in flow). Common RTA practice suggests that when a roadway falls to LoS D, investigations should be initiated to provide suitable remediation prior to the link falling to LOS E or F.

The current midblock LOS on the Princes Highway (north of Rose Valley Road and west of Belinda Street), based on 2009 AM Peak, PM Peak and 100th hour two-way traffic volumes, is summarised in Table 5.2. The table shows that both highway locations operate at an unacceptable LOS E during 100th hour conditions, which reflects high volume recreational traffic, particularly noticeable in the southbound direction on Friday afternoons, and northbound direction on Sunday afternoons.
Table 5.2: Midblock level of service (LOS) summary (2009)

<table>
<thead>
<tr>
<th>Location</th>
<th>AM peak hour (veh/hr)</th>
<th>PM peak hour (veh/hr)</th>
<th>100th hour (veh/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Flow</td>
<td>LOS</td>
<td>Flow</td>
</tr>
<tr>
<td>Princes Highway, north of Rose Valley Road</td>
<td>1,495</td>
<td>E</td>
<td>1,798</td>
</tr>
<tr>
<td>Princes Highway, west of Belinda Street</td>
<td>749</td>
<td>D</td>
<td>900</td>
</tr>
</tbody>
</table>

5.1.3 Intersection performance

The current LOS and delay at three key intersections has been assessed using SIDRA intersection modelling software. Table 5.3 provides a summary of intersection performance for existing 100th hour traffic volumes.

Table 5.3: 100th peak hour intersection analysis (2009)

<table>
<thead>
<tr>
<th>Intersection / approach</th>
<th>Veh/hr</th>
<th>LOS</th>
<th>DOS</th>
<th>95% back of queue (m)</th>
<th>Av delay (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Princes Highway / Fern Street</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fern Street</td>
<td>607</td>
<td>B</td>
<td>0.842</td>
<td>86</td>
<td>36.3</td>
</tr>
<tr>
<td>Princes Highway north</td>
<td>1,215</td>
<td>A</td>
<td>0.364</td>
<td>0</td>
<td>4.8</td>
</tr>
<tr>
<td>Princes Highway south</td>
<td>683</td>
<td>A</td>
<td>0.379</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Total</td>
<td>2,505</td>
<td></td>
<td>0.843</td>
<td>86</td>
<td>9.7</td>
</tr>
<tr>
<td>Princes Highway / Belinda Street</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Belinda Street</td>
<td>216</td>
<td>F</td>
<td>1.351</td>
<td>427</td>
<td>510.8</td>
</tr>
<tr>
<td>Princes Highway north</td>
<td>722</td>
<td>A</td>
<td>0.311</td>
<td>0</td>
<td>2.3</td>
</tr>
<tr>
<td>Princes Highway south</td>
<td>590</td>
<td>A</td>
<td>0.293</td>
<td>3</td>
<td>1.5</td>
</tr>
<tr>
<td>Total</td>
<td>1,528</td>
<td></td>
<td>1.348</td>
<td>427</td>
<td>73.9</td>
</tr>
<tr>
<td>Belinda Street / Fern Street</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fern Street south</td>
<td>515</td>
<td>A</td>
<td>0.442</td>
<td>29</td>
<td>8.2</td>
</tr>
<tr>
<td>Belinda Street east</td>
<td>106</td>
<td>A</td>
<td>0.146</td>
<td>8</td>
<td>1.25</td>
</tr>
<tr>
<td>Fern Street north</td>
<td>546</td>
<td>A</td>
<td>0.463</td>
<td>32</td>
<td>8.6</td>
</tr>
<tr>
<td>Belinda Street west</td>
<td>202</td>
<td>A</td>
<td>0.262</td>
<td>15</td>
<td>12.6</td>
</tr>
<tr>
<td>Total</td>
<td>1,369</td>
<td></td>
<td>0.463</td>
<td>32</td>
<td>9.3</td>
</tr>
</tbody>
</table>

The Princes Highway and Fern Street intersection has an overall average delay of 9.7 seconds per vehicle. Both the approaches from and departure to the Princes Highway experience minimal intersection delay, however the average delay on the Fern Street approach increases to 36.3 seconds, resulting in LOS C.

Table 5.3 also shows the degree of saturation (DOS), which is a ratio of the number of vehicles entering an intersection in the specified 100th busiest hour to the number which could enter if all approaches were fully saturated during this period. Acceptable DOS ratios for priority intersections and roundabouts are <0.85 and ratios greater this value would indicate that the approach is operating over capacity with excessive average delays.
The Princes Highway and Belinda Street intersection is currently over capacity with an overall DOS of 1.348. The Princes Highway itself operates well within capacity through the intersection having a DOS for the major northbound and southbound approaches at 0.311 and 0.293 respectively. The Belinda Street approach pushes the intersection over capacity with a DOS of 1.351. Belinda Street is currently operating at LOS F, meaning a breakdown in traffic flow, with the 95th percentile back of queue extending an estimated 427 m in 100th hour conditions.

The Belinda Street and Fern Street roundabout performs well within capacity at LOS A. This is consistent across all approaches with an overall average delay of 9.3 seconds. The highest average delay per vehicle is recorded on the Belinda Street west approach at only 12.6 seconds. All approaches operate within capacity with the highest DOS being 0.442 on the Fern Street south approach.

5.1.4 Traffic crashes

The 7.5 km section of the Princes Highway between Mount Pleasant and Toolijooa Road has a poor crash record. Between 1 July 2003 and 30 June 2008 a total of 87 crashes were recorded, including five fatalities and 38 injuries. Table 5.4 shows the crash statistics for this period for the specific highway section where they occurred.

Table 5.4: Crash statistics for the Princes Highway in proposal project area (1 July 2003 to 30 June 2008)

<table>
<thead>
<tr>
<th>Section from</th>
<th>Section to</th>
<th>Section length (km)</th>
<th>Total crashes</th>
<th>Fatal crashes</th>
<th>Injury crashes</th>
<th>Tow-away crashes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mount Pleasant</td>
<td>Rose Valley Road</td>
<td>1.6</td>
<td>21</td>
<td>2</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>Rose Valley Road</td>
<td>Fern Street</td>
<td>0.8</td>
<td>31</td>
<td>1</td>
<td>13</td>
<td>17</td>
</tr>
<tr>
<td>Fern Street</td>
<td>Belinda Street</td>
<td>2.2</td>
<td>23</td>
<td>1</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>Belinda Street</td>
<td>Toolijooa Road</td>
<td>2.9</td>
<td>12</td>
<td>1</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>7.5</td>
<td>87</td>
<td>5</td>
<td>38</td>
<td>44</td>
</tr>
</tbody>
</table>

Crash severity indices provide an assessment of road safety based on the type and number of crashes occurring on a route. Fatal, injury and tow-away crashes carry different weightings, with traffic volumes excluded from the calculation. The following formula was used to calculate these indices:

\[
\text{Severity Index} = \frac{[(\text{Number of fatal crashes} \times 3.0) + (\text{Number of injury crashes} \times 1.5) + (\text{Number of non-injury crashes})]}{\text{Total number of crashes}}
\]

The average crash severity index along the length of the project area is 1.33, with two sections approaching or higher than 1.40. By comparison the severity index across NSW between 2001 and 2005 is 1.23, indicating the Princes Highway currently has a higher than average proportion of fatal and injury crashes in the proposal project area.
5.2 Potential impacts

5.2.1 Forecast traffic volumes

The detailed modelling methodology used to forecast traffic volumes for the proposal incorporated the following three key stages, which are described in more detail in the Gerringong upgrade Detailed Traffic Assessment Report:

- Analysis of 2009 traffic patterns.
- Base and future year TRACKS traffic model development.
- Application of a traffic forecasting spreadsheet model.

Table 5.5 provides a summary of the forecast AADT at key locations for the 2009 base year and the following two design year scenarios:

- 2014 Gerringong upgrade opening year.
- 2034 Gerringong upgrade opening +20 design year.

Table 5.5: Final Gerringong upgrade forecast traffic volumes (key locations)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Princes Highway, north of Rose Valley Road</td>
<td>20,902</td>
<td>24,193</td>
<td>3.1%</td>
<td>37,356</td>
<td>2.7%</td>
</tr>
<tr>
<td>Princes Highway, west of Belinda Street</td>
<td>10,447</td>
<td>12,114</td>
<td>3.2%</td>
<td>24,011</td>
<td>4.9%</td>
</tr>
<tr>
<td>'Sandtrack', south of Belinda Street</td>
<td>8,692</td>
<td>9,912</td>
<td>2.8%</td>
<td>11,827</td>
<td>1.0%</td>
</tr>
</tbody>
</table>

Note: Forecast traffic volumes on the 'Sandtrack' only include heavy vehicles up to five tonnes due to load limit.

The Gerringong upgrade is programmed to be completed by 2014. During the period 2009 to 2014 it is expected that:

- AADT volumes on the Princes Highway north of Rose Valley Road are expected to have increased by more than 3,000 vehicles; an increase of over 3.0 per cent per annum.
- South of Gerringong, traffic is expected to have increased by 3.2 per cent and 2.8 per cent per annum on the Princes Highway and the ‘Sandtrack’ respectively.
- Traffic is expected to follow current patterns and distributions, with a 55 per cent / 45 per cent split in traffic between the Princes Highway and the ‘Sandtrack’ in 2014.

The potential cumulative impact of the predicted traffic growth of the proposal combined with the planned road network improvements on the Princes Highway south of Gerringong is likely to result in a transfer of traffic from the ‘Sandtrack’ to the Princes Highway. This is due to improved traffic efficiency, road safety and travel time savings on the upgraded Princes Highway. During the period 2014 to 2034 it is expected that:

- AADT volumes on the Princes Highway north of Rose Valley Road are estimated to increase by 2.7 per cent per annum over the 20 year post construction design period (from 24,193 to 37,356 vehicles per day).
Further south on the Princes Highway west of Belinda Street, AADT volumes are expected to grow by 4.9 per cent per annum.

The split between the Princes Highway and the ‘Sandtrack’ traffic is estimated to change from 55 per cent / 45 per cent in 2009 to 67 per cent / 33 per cent in 2034.

### 5.2.2 Consequence of no action

Table 5.6 shows the LOS that has been estimated for the existing route should the highway not be upgraded. Projected 100th hour traffic volumes for 2034 would result in congested peak period conditions with the Princes Highway west of Belinda Street and north of Rose Valley Road operating at an unacceptable LOS E and LOS F respectively.

#### Table 5.6: Midblock level of service (LOS) summary – without upgrade (2034)

<table>
<thead>
<tr>
<th>Location</th>
<th>AM peak hour (veh/hr)</th>
<th>PM peak hour (veh/hr)</th>
<th>100th hour (veh/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Flow</td>
<td>LOS</td>
<td>Flow</td>
</tr>
<tr>
<td>Princes Highway, north of Rose Valley Road</td>
<td>2,672</td>
<td>E</td>
<td>3,213</td>
</tr>
<tr>
<td>Princes Highway, west of Belinda Street</td>
<td>1,350</td>
<td>E</td>
<td>1,622</td>
</tr>
</tbody>
</table>

Table 5.7 shows the intersection performance for the 100th hour volumes in 2034 without the proposal. As anticipated the intersection of Princes Highway and Fern Street would operate over capacity with excessive queuing and delays. This is entirely accountable to the Fern Street approach with the Princes Highway north and south approaches recording acceptable DOS ratios of 0.657 and 0.683 respectively. The Fern Street approach is estimated to operate with a queue length of 7,896 m and at LOS F.

#### Table 5.7: 100th peak hour intersection analysis without upgrade (2034)

<table>
<thead>
<tr>
<th>Intersection / approach</th>
<th>Veh/h</th>
<th>LOS</th>
<th>DOS</th>
<th>95% Back of queue (m)</th>
<th>Average delay (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Princes Highway / Fern Street</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fern Street</td>
<td>1,070</td>
<td>F</td>
<td>6.176</td>
<td>7,896</td>
<td>8,984</td>
</tr>
<tr>
<td>Princes Highway north</td>
<td>2,171</td>
<td>A</td>
<td>0.657</td>
<td>0</td>
<td>4.7</td>
</tr>
<tr>
<td>Princes Highway south</td>
<td>1,232</td>
<td>A</td>
<td>0.683</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Total</td>
<td>4,473</td>
<td>-</td>
<td>6.185</td>
<td>7,896</td>
<td>2,151</td>
</tr>
<tr>
<td>Princes Highway / Belinda Street</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Belinda Street</td>
<td>390</td>
<td>F</td>
<td>4.667</td>
<td>2,154</td>
<td>5,072</td>
</tr>
<tr>
<td>Princes Highway north</td>
<td>1,302</td>
<td>A</td>
<td>0.529</td>
<td>0</td>
<td>2.3</td>
</tr>
<tr>
<td>Princes Highway south</td>
<td>1,064</td>
<td>A</td>
<td>0.529</td>
<td>14</td>
<td>2.6</td>
</tr>
<tr>
<td>Total</td>
<td>2,756</td>
<td>-</td>
<td>4.667</td>
<td>2,154</td>
<td>720</td>
</tr>
<tr>
<td>Belinda Street / Fern Street</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fern Street south</td>
<td>895</td>
<td>B</td>
<td>0.866</td>
<td>143</td>
<td>17</td>
</tr>
<tr>
<td>Belinda Street east</td>
<td>193</td>
<td>C</td>
<td>0.584</td>
<td>46</td>
<td>29</td>
</tr>
<tr>
<td>Fern Street north</td>
<td>962</td>
<td>B</td>
<td>0.930</td>
<td>214</td>
<td>23</td>
</tr>
<tr>
<td>Belinda Street west</td>
<td>364</td>
<td>D</td>
<td>0.853</td>
<td>109</td>
<td>43</td>
</tr>
<tr>
<td>Total</td>
<td>2,414</td>
<td>B</td>
<td>0.930</td>
<td>214</td>
<td>24</td>
</tr>
</tbody>
</table>
The Belinda Street approach at the Princes Highway intersection would operate at LOS F in 2034. The forecast increase for the right turn movement from Belinda Street to the Princes Highway between 2009 and 2034 is not as great as that for the right turn movement from Fern Street to the Princes Highway. Despite this the DOS for the Belinda Street approach exceeds capacity at 4.667. The SIDRA modelling indicates that both Princes Highway approaches would operate at LOS A.

The overall performance of the Belinda Street and Fern Street intersection is estimated to be LOS B. The forecast overall average delay is 24.2 seconds per vehicle with a DOS of 0.930. This is over capacity and improvement measures would need to be considered at the roundabout with queue lengths for the Fern Street north and Fern Street south approaches forecast to extend 214 m and 143 m, respectively. The Belinda Street approach from the west is predicted to operate at LOS D, with an average delay of 43 seconds.

Travel times on the Princes Highway along the proposed upgrade would increase as the level of congestion increases. Delays would be caused by local traffic conflicting with major through traffic movements at the main Belinda Street and Fern Street intersections. Long delays would also result in economic impacts, especially to freight and tourist traffic travelling either to local areas or long distance regional destinations.

The potential for crashes is likely to increase with increased traffic volumes especially at major intersections along the route, such as Fern Street and Belinda Street in Gerringong.

5.2.3 Construction impacts

Construction impacts of the Gerringong upgrade would include an increase in heavy vehicle activity on the Princes Highway and local routes due to on/off road earthworks haulage. Traffic control details are limited at this stage in the project due to the uncertainty associated with the ultimate contractor’s work methods. The construction sequencing and any temporary works identified would be based on minimising user delay whilst providing sufficient flexibility for the contractor to efficiently plan the construction of the Gerringong upgrade.

Although it is the RTA’s goal to maintain an 80 km/h construction speed zone where possible, delays for traffic using the Princes Highway would be expected during the construction phase in those periods when the Gerringong upgrade ties in with the existing highway. There would also be delays to local traffic during periods when other minor or private roads are being bridged or tied in with the proposal.

In order to construct the new railway overbridge at Fern Street there would be a need to temporarily close Fern Street for a period of up to 12 months. The traffic impacts would be associated with the temporary loss of the northern access to Gerringong and the resultant redistribution of traffic to the town via the southern access at the Belinda Street interchange, which is proposed to be fully upgraded and operational prior to the closure of Fern Street.

An assessment of the resultant traffic impacts has been undertaken to determine the operational performance of the detour route during the closure of Fern Street. Table 5.8 shows the estimated midblock LOS for the existing Princes Highway carriageway during the construction of the Fern Street overbridge. Projected 100th hour traffic volumes would operate in poor traffic flow conditions, with the highway performing at an unacceptable LOS F north of Belinda Street.
Table 5.8: Midblock level of service (LOS) summary – temporary Fern Street closure (2014)

<table>
<thead>
<tr>
<th>Location</th>
<th>AM peak hour (veh/hr)</th>
<th>PM peak hour (veh/hr)</th>
<th>100th hour (veh/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Flow</td>
<td>LOS</td>
<td>Flow</td>
</tr>
<tr>
<td>Existing Princes Highway, north of Belinda Street</td>
<td>1,715</td>
<td>E</td>
<td>2,061</td>
</tr>
</tbody>
</table>

Table 5.9 provides details of the operating conditions, during the closure of Fern Street in 2014, for the grade-separated interchange at Belinda Street and also the main Fern Street and Belinda Street intersection in Gerringong.

Table 5.9: 100th peak hour intersection analyses – temporary Fern Street closure (2014)

<table>
<thead>
<tr>
<th>Intersection / approach</th>
<th>Veh/h</th>
<th>LOS</th>
<th>DOS</th>
<th>95% back of queue (m)</th>
<th>Av delay (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Princes Highway / Belinda Street interchange west ramps</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Willowvale Road south</td>
<td>212</td>
<td>D</td>
<td>0.831</td>
<td>53</td>
<td>44.4</td>
</tr>
<tr>
<td>Belinda Street east</td>
<td>863</td>
<td>A</td>
<td>0.490</td>
<td>0</td>
<td>9.1</td>
</tr>
<tr>
<td>Total</td>
<td>1,075</td>
<td>-</td>
<td>0.833</td>
<td>53</td>
<td>16.1</td>
</tr>
<tr>
<td>Princes Highway / Belinda Street interchange east ramps</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Belinda Street east</td>
<td>989</td>
<td>A</td>
<td>0.540</td>
<td>0</td>
<td>1.3</td>
</tr>
<tr>
<td>Princes Highway off-ramp north</td>
<td>856</td>
<td>F</td>
<td>1.008</td>
<td>570</td>
<td>72.3</td>
</tr>
<tr>
<td>Belinda Street west</td>
<td>192</td>
<td>A</td>
<td>0.122</td>
<td>13</td>
<td>6.8</td>
</tr>
<tr>
<td>Total</td>
<td>2,037</td>
<td>-</td>
<td>1.009</td>
<td>570</td>
<td>31.7</td>
</tr>
<tr>
<td>Belinda Street / Fern Street</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fern Street south</td>
<td>571</td>
<td>C</td>
<td>0.902</td>
<td>153</td>
<td>37.8</td>
</tr>
<tr>
<td>Belinda Street east</td>
<td>267</td>
<td>B</td>
<td>0.606</td>
<td>50</td>
<td>25.1</td>
</tr>
<tr>
<td>Fern Street north</td>
<td>541</td>
<td>B</td>
<td>0.798</td>
<td>99</td>
<td>25.2</td>
</tr>
<tr>
<td>Belinda Street west</td>
<td>949</td>
<td>A</td>
<td>0.777</td>
<td>93</td>
<td>10.9</td>
</tr>
<tr>
<td>Total</td>
<td>2,328</td>
<td>B</td>
<td>0.906</td>
<td>153</td>
<td>22.5</td>
</tr>
</tbody>
</table>

At the Princes Highway and Belinda Street interchange, the Belinda Street east approach (from Gerringong) operates well with LOS A and a delay of only 9.1 seconds despite a significant increase in traffic. However, the give-way approach from Willowvale Road south (which includes the northbound off ramp traffic) operates at a LOS D, with average queuing and delays of 53 m and 44.4 seconds respectively. The overall DOS for the intersection is 0.833.

Both Belinda Street approaches at the Princes Highway and Belinda Street interchange east ramps operate at LOS A, with very little queuing or delays. Conversely, the Princes Highway off ramp approach operates at LOS F, with a DOS of 1.008, signifying the junction is over capacity due to the volume of traffic on this approach. The result is lengthy queues in excess of 500 m, and an average delay of 72.3 seconds.

The Belinda Street and Fern Street roundabout operates adequately in this scenario. The lowest LOS is C, for the Fern Street approach from the south, with a DOS of 0.902, queue length of 153 m and average delay 37.8 seconds. All of the other approaches operate at LOS A or B. The intersection operates at an overall LOS B, with an average delay of 22.5 seconds.
5.2.4 Operational impacts

*Midblock level of service*

Table 5.10 shows the midblock LOS that has been estimated for the two main carriageway sections of the proposal for the AM peak, PM peak and worst case 100th hour peak period scenarios. Projected 100th hour traffic volumes for the 2034 design year would operate in acceptable traffic flow conditions, with the highway performing at an acceptable LOS C north of Rose Valley Road and west of Belinda Street. The predicted midblock level of service at both highway locations falls within the concept design criteria set out for the project, which states that the proposal must perform at LOS C or better for the 100th highest hour.

<table>
<thead>
<tr>
<th>Location</th>
<th>AM peak hour (veh/hr)</th>
<th>PM peak hour (veh/hr)</th>
<th>100th hour (veh/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Princes Highway, north of Rose Valley Road</td>
<td>2,663</td>
<td>3,222</td>
<td>4,341</td>
</tr>
<tr>
<td>Princes Highway, west of Belinda Street</td>
<td>1,723</td>
<td>2,065</td>
<td>2,790</td>
</tr>
</tbody>
</table>

*Interchange performance*

Table 5.11 provides details of the 2034 operating conditions for the two grade-separated interchanges and the Fern Street and Belinda Street intersection in Gerringong.

The table shows that the majority of approach arms on the Princes Highway, Rose Valley and Fern Street interchange west and east ramps would operate at LOS B or better, with only the minor Rose Valley Road east approach performing at LOS C. The average delay for ramps on the western side of the interchange would be 10.4 seconds and 5.1 seconds for ramps on the eastern side. The overall DOS for the interchange is 0.309 for the western side and 0.268 for the eastern side.

Similarly, the majority of approach arms on the southern Princes Highway and Belinda Street interchange would operate at LOS B or better, with only the Willowvale Road south approach performing at LOS C. The average delay for ramps on the western side of the interchange would be 11.4 seconds and 5.9 seconds for ramps on the eastern side. The overall DOS for the interchange is 0.481 for the western side and 0.544 for the eastern side.

The Belinda Street and Fern Street roundabout would operate within capacity at LOS C with an overall average delay at the roundabout of only 21.5 seconds. The highest average delay per vehicle and DOS is recorded on the Fern Street south approach at 30.5 seconds and 0.906 respectively.
### Table 5.11: 100th peak hour intersection analyses (2034)

<table>
<thead>
<tr>
<th>Intersection / approach</th>
<th>Veh/h</th>
<th>LOS</th>
<th>DOS</th>
<th>95% back of queue (m)</th>
<th>Av delay (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Princes Highway / Rose Valley / Fern Street interchange west ramps</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rose Valley Road east</td>
<td>509</td>
<td>B</td>
<td>0.309</td>
<td>20</td>
<td>10.6</td>
</tr>
<tr>
<td>Princes Highway on / off ramp</td>
<td>68</td>
<td>A</td>
<td>0.055</td>
<td>3</td>
<td>8.4</td>
</tr>
<tr>
<td>Rose Valley Road west</td>
<td>44</td>
<td>B</td>
<td>0.055</td>
<td>3</td>
<td>10.7</td>
</tr>
<tr>
<td>Total</td>
<td>621</td>
<td>B</td>
<td>0.309</td>
<td>20</td>
<td>10.4</td>
</tr>
<tr>
<td><strong>Princes Highway / Rose Valley / Fern Street interchange east ramps</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fern Street</td>
<td>492</td>
<td>A</td>
<td>0.268</td>
<td>0</td>
<td>8.2</td>
</tr>
<tr>
<td>Princes Highway off ramp</td>
<td>519</td>
<td>A</td>
<td>0.260</td>
<td>1</td>
<td>0.4</td>
</tr>
<tr>
<td>Rose Valley Road east</td>
<td>80</td>
<td>C</td>
<td>0.159</td>
<td>5</td>
<td>16.4</td>
</tr>
<tr>
<td>Total</td>
<td>1,091</td>
<td>-</td>
<td>0.268</td>
<td>5</td>
<td>5.1</td>
</tr>
<tr>
<td><strong>Princes Highway / Belinda Street interchange west ramps</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Willowvale Road south</td>
<td>258</td>
<td>C</td>
<td>0.481</td>
<td>26</td>
<td>16.4</td>
</tr>
<tr>
<td>Belinda Street east</td>
<td>542</td>
<td>A</td>
<td>0.303</td>
<td>0</td>
<td>9.0</td>
</tr>
<tr>
<td>Total</td>
<td>800</td>
<td>-</td>
<td>0.481</td>
<td>26</td>
<td>11.4</td>
</tr>
<tr>
<td><strong>Princes Highway / Belinda Street interchange east ramps</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Belinda Street east</td>
<td>715</td>
<td>A</td>
<td>0.392</td>
<td>0</td>
<td>2.5</td>
</tr>
<tr>
<td>Princes Highway off ramp north</td>
<td>458</td>
<td>B</td>
<td>0.541</td>
<td>40</td>
<td>12.4</td>
</tr>
<tr>
<td>Belinda Street west</td>
<td>233</td>
<td>A</td>
<td>0.138</td>
<td>10</td>
<td>3.3</td>
</tr>
<tr>
<td>Total</td>
<td>1,406</td>
<td>-</td>
<td>0.544</td>
<td>40</td>
<td>5.9</td>
</tr>
<tr>
<td><strong>Belinda Street / Fern Street</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fern Street south</td>
<td>702</td>
<td>C</td>
<td>0.906</td>
<td>171</td>
<td>30.5</td>
</tr>
<tr>
<td>Belinda Street east</td>
<td>353</td>
<td>C</td>
<td>0.643</td>
<td>56</td>
<td>22.3</td>
</tr>
<tr>
<td>Fern Street north</td>
<td>542</td>
<td>B</td>
<td>0.652</td>
<td>61</td>
<td>14.9</td>
</tr>
<tr>
<td>Belinda Street west</td>
<td>576</td>
<td>B</td>
<td>0.690</td>
<td>69</td>
<td>16.2</td>
</tr>
<tr>
<td>Total</td>
<td>2,173</td>
<td>C</td>
<td>0.917</td>
<td>171</td>
<td>21.5</td>
</tr>
</tbody>
</table>

**Travel time analysis**

The 2006 base year TRACKS traffic model has been developed with inputs including traffic volume, travel time and land use and demographic data. Using these inputs the model has been calibrated to ensure an accurate representation of current highway conditions in the proposal project area.

Following the development of a model to represent current traffic conditions, a 2026 future year model has been developed to estimate the effects the proposal would have on future travel times and speeds. The results of this modelling are included in Table 5.12 with the extent of the routes shown in Figure 5.1.
Future year modelling of the proposal shows that upgrading the alignment of the highway (minor shortening the effective length of the route) combined with an increase in posted speeds; create a travel time saving of 1.4 minutes in the northbound direction, and 1.1 minutes in the southbound direction in comparison to current conditions on the Princes Highway. It is estimated that travel times along the ‘Sandtrack’ would remain roughly constant at between 10.0 and 10.5 minutes. This means that travel times on the Princes Highway are estimated to 50 per cent faster than the corresponding ‘Sandtrack’ route.

Table 5.12: TRACKS modelled travel times pre-upgrade (2006) and post upgrade (2026)

<table>
<thead>
<tr>
<th>Route</th>
<th>Direction</th>
<th>Pre-upgrade (2006)</th>
<th>Post-upgrade (2026)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Dist (km)</td>
<td>Average speed (km/h)</td>
</tr>
<tr>
<td>Princes Highway</td>
<td>Northbound</td>
<td>7.0</td>
<td>75.0</td>
</tr>
<tr>
<td></td>
<td>Southbound</td>
<td>7.0</td>
<td>79.9</td>
</tr>
<tr>
<td>‘Sandtrack’</td>
<td>Northbound</td>
<td>8.8</td>
<td>52.0</td>
</tr>
<tr>
<td></td>
<td>Southbound</td>
<td>8.8</td>
<td>50.9</td>
</tr>
</tbody>
</table>

Figure 5.1: Travel time analysis routes in the study area

Climbing lane assessment

A climbing lane assessment has been undertaken for the following three locations on Gerringong upgrade:

- Location A: North of Rose Valley Road to Mount Pleasant, northbound.
- Location B: Approximately 500 m south of Belinda Street, southbound.
- Location C: Approximately 400 m north of Toolijooa Road, northbound.
The locations include significant inclines, which may result in heavy vehicle speeds dropping below the 40 km/h threshold. The current Gerringong upgrade concept design includes a climbing lane in the northbound direction on the Princes Highway north of Rose Valley Road to Mount Pleasant and in the southbound direction south of Belinda Street.

Of the three locations analysed, only Location A: north of Rose Valley Road meets the criteria warranting a climbing lane, with a truck speed less than 40 km/h and LOS D in the 2034 design year.

The concept design includes a second climbing lane on the Gerringong upgrade at Location B, approximately 500 m west of Belinda Street. This location does not meet the criteria included in the assessment as the average grade is less than 6.0 per cent, with LOS C in the 2034 design year. However, the climbing lane analysis does not take into account the impacts of connecting road sections or interchanges, which have been assessed separately in the highway design process.

Although there is no warrant for a climbing lane for through traffic at this location, there is a need for trucks entering the traffic stream from the Belinda Street southbound on ramp to accelerate to a suitable speed before merging. The length required for trucks to attain this speed along an uphill grade takes the on ramp over the crest at chainage 5km545, effectively creating a third lane of approximately 1,000 m for slow moving through traffic.

Traffic crashes

The proposed highway upgrade would be expected to significantly improve road safety conditions along and adjacent to, the Princes Highway corridor. Traffic crash analysis has been undertaken by comparing existing and proposed conditions to determine corresponding crash reduction statistics based on historical data for the five year period between 1 July 2003 and 30 June 2008. The results from the analysis are shown in Table 5.13.

The most effective road safety improvements of the proposal would be the upgrade of major at-grade intersections to interchanges and the inclusion of median barriers, preventing opposing direction crashes (100 per cent reduction). Highway improvements would reduce crashes between vehicles travelling in the same direction (-75 per cent), as well as ‘off-path’ crashes (-13 per cent on straights, -42 per cent on curves). It is estimated that total crashes would have been reduced by 69 per cent under the proposed conditions.

Table 5.14 shows that the improved alignment along with the installation of a median barrier for the length of the proposal and median closure at all interchanges is expected to result in a annual reduction of around 11 crashes between Mount Pleasant Lookout to Belinda Street, with the potential to eliminate all of the fatal crashes that occurred during this period. The crash rate per vehicle kilometre also experiences a large reduction, falling by 39.3 to 14.3.

Between Belinda Street and Toolijooa Road, road safety improvements are not as dramatic as between Mount Pleasant Lookout and Belinda Street, due to the lower base level of crashes. Total crashes reduce by around 50 per cent, as do tow-away crashes. Casualty crashes are estimated to drop by 20 per cent, while fatal crashes would potentially reduce to zero.
## Table 5.13: Existing and proposed crash statistics based on Highway Safety Improvements (1 July 2003 – 30 June 2008)

<table>
<thead>
<tr>
<th>Section</th>
<th>Scenario</th>
<th>Intersection (adjacent approaches)</th>
<th>Vehicles from opposing directions</th>
<th>Vehicles from same direction</th>
<th>Off-path (on straight)</th>
<th>Off-path (on curve)</th>
<th>Other</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mount Pleasant Lookout to Rose Valley Road</td>
<td>Existing</td>
<td>0</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>9</td>
<td>0</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>Proposed</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>4</td>
<td>5</td>
<td>0</td>
<td>11</td>
</tr>
<tr>
<td>Rose Valley Road to Fern Street, Gerringong</td>
<td>Existing</td>
<td>24</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td>Proposed</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Fern Street to Belinda Street, Gerringong</td>
<td>Existing</td>
<td>10</td>
<td>2</td>
<td>5</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>Proposed</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Belinda Street, Gerringong to Toolijooa Road</td>
<td>Existing</td>
<td>0</td>
<td>3</td>
<td>2</td>
<td>6</td>
<td>1</td>
<td>0</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Proposed</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>5</td>
<td>1</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>34</td>
<td>10</td>
<td>12</td>
<td>15</td>
<td>12</td>
<td>4</td>
<td>87</td>
</tr>
<tr>
<td></td>
<td>Proposed</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>13</td>
<td>7</td>
<td>4</td>
<td>27</td>
</tr>
<tr>
<td>Crash reduction (%)</td>
<td></td>
<td>100%</td>
<td>100%</td>
<td>75%</td>
<td>13%</td>
<td>42%</td>
<td>0%</td>
<td>69%</td>
</tr>
</tbody>
</table>
Table 5.14: Crash statistics: annual average 1 July 2003 - 30 June 2008 (existing and proposed conditions)

<table>
<thead>
<tr>
<th>Crash statistic</th>
<th>Total</th>
<th>Fatal</th>
<th>Casualty</th>
<th>Tow-away</th>
<th>Crash rate (Total / 100MVKM)</th>
<th>Crash severity index</th>
<th>Crash costs</th>
<th>Change in conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mount Pleasant Lookout to Belinda Street</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Existing conditions</td>
<td>15.0</td>
<td>0.8</td>
<td>6.6</td>
<td>7.6</td>
<td>53.5</td>
<td>1.33</td>
<td>$581,422</td>
<td>-11.0</td>
</tr>
<tr>
<td>Proposed conditions</td>
<td>4.0</td>
<td>0.0</td>
<td>2.0</td>
<td>2.0</td>
<td>14.3</td>
<td>1.25</td>
<td>$107,148</td>
<td>-$474,274</td>
</tr>
<tr>
<td>Change in conditions</td>
<td>-11.0</td>
<td>-0.8</td>
<td>-4.6</td>
<td>-5.6</td>
<td>-39.3</td>
<td>-0.08</td>
<td>-$2,181,660</td>
<td></td>
</tr>
<tr>
<td>Belinda Street to Toolijooa Road</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Existing conditions</td>
<td>2.4</td>
<td>0.2</td>
<td>1.0</td>
<td>1.2</td>
<td>21.7</td>
<td>1.38</td>
<td>$151,414</td>
<td>-1.0</td>
</tr>
<tr>
<td>Proposed conditions</td>
<td>1.4</td>
<td>0.0</td>
<td>0.8</td>
<td>0.6</td>
<td>12.7</td>
<td>1.29</td>
<td>$62,883</td>
<td>-$88,531</td>
</tr>
<tr>
<td>Change in conditions</td>
<td>-1.0</td>
<td>-0.2</td>
<td>-0.2</td>
<td>-0.6</td>
<td>-9.0</td>
<td>-0.09</td>
<td>-$256,740</td>
<td></td>
</tr>
</tbody>
</table>

Source: AECOM, based on RTA Southern Region Crash Data & RTA Crash Reduction Guide
5.3 Safeguards and management measures

5.3.1 Construction

- A detailed traffic management plan (TMP) would be prepared as part of the construction environmental management plan (CEMP). The TMP would include the guidelines, general requirements and procedures to be used when activities or areas of work have a potential impact on existing traffic arrangements. The TMP would be submitted in stages to reflect the progress of work and would:
  - Identify the traffic management requirements during construction.
  - Describe the general approach and procedures to be adopted when producing specific traffic control plans.
  - Ensure the continuous, safe and efficient movement of traffic for both the public and construction workers.
  - Maintain the capacity of local roads.
  - Provide an 80 km/h construction zone speed.
  - Minimise delays and disruptions are kept to a minimum.
  - Minimise impacts on existing Princes Highway and local traffic.
  - Provide access to local roads and properties, including the use of temporary turn-around bays.
  - Provide temporary works and traffic signals.
  - Determine the number and width of traffic lanes in operation.
  - Identify traffic barrier requirements and placement.
  - Public transport, pedestrian and bicycle facilities.
  - Include methods for implementing the traffic management plan.
  - Include methods for minimising road user delays.
  - Provide signposting.
  - Road closures, including Fern Street, during construction of the new railway overbridge.

- Construction methods and staging would be designed to minimise road closures, subject to other proposal constraints and ensure that disruption to the existing traffic is maintained within acceptable levels.

- Traffic diversions or stages would include lane and shoulder closures on either the existing, temporary or new pavements. Road occupancy licences would be obtained for each type of construction work involving closures.

- Provide traffic management measures during the closure of Fern Street, such as temporary traffic lights, to improve the performance of the off ramp approaches.

- Ensure the Belinda Street interchange is fully upgraded and operational prior to the closure of Fern Street.

5.3.2 Operation

- Traffic monitoring would be undertaken for the Princes Highway and key local roads in Gerringong including Belinda Street and Fern Street. Traffic volumes would be assessed against those predicted.
6 Structures

6.1 Existing structures

Existing structures include existing culverts and bridges. Existing structures servicing the current highway have been reviewed, and it was found that generally they would be unable to accommodate the geometric constraints of the highway upgrade. Several existing culverts can be retained and would remain in operation under service roads alongside the upgraded carriageway, however none of the bridges or any culverts could be retained under the new carriageway alignment.

The reasoning behind the replacement of the majority of the existing structures is that they do not meet the geometric requirements of the upgraded highway alignment. The new alignment must accommodate a higher design speed, extra lanes, an additional carriageway, loading requirements to AS5100 and sight distance requirements. In order to accommodate these, the upgraded alignment differs greatly from the current highway alignment, in both vertical and horizontal location. As such, none of the existing structures were suitable for reused.

Five culverts would be retained for use under service roads or the railway line. These are all situated in locations adjacent to the Omega Flat bridges.

6.2 Bridges

6.2.1 Concept bridge design summary

Each bridge has been designed as a new structure, due to the inability of the existing structures to facilitate the highway upgrade (as outlined in Section 6.1 above).

The proposed bridges to be constructed for the highway upgrade are summarised below in Table 6.1. A concept design for each bridge is shown in the concept design drawing set.

<table>
<thead>
<tr>
<th>Chainage</th>
<th>Description</th>
<th>Type</th>
<th>No. of spans</th>
<th>Total length (m)</th>
<th>Width (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ch 1460</td>
<td>Rose Valley Road overbridge</td>
<td>In-situ prestressed concrete girders</td>
<td>1</td>
<td>34</td>
<td>12.0</td>
</tr>
<tr>
<td>Ch 4480</td>
<td>Belinda Street twin underbridges</td>
<td>PSC super T girders</td>
<td>1</td>
<td>28</td>
<td>11.0</td>
</tr>
<tr>
<td>Ch 4825</td>
<td>Willowvale Road / Crooked River underbridge</td>
<td>PSC planks</td>
<td>5</td>
<td>60</td>
<td>Varies from 28.5 to 33.5</td>
</tr>
<tr>
<td>Ch 4825</td>
<td>Crooked River underbridge (minor)</td>
<td>PSC planks</td>
<td>2</td>
<td>26</td>
<td>13.0</td>
</tr>
<tr>
<td>Chainage</td>
<td>Description</td>
<td>Type</td>
<td>No. of spans</td>
<td>Total length (m)</td>
<td>Width (m)</td>
</tr>
<tr>
<td>----------</td>
<td>-------------</td>
<td>---------------</td>
<td>--------------</td>
<td>------------------</td>
<td>-----------</td>
</tr>
<tr>
<td>Ch 1700</td>
<td>Omega Flat</td>
<td>PSC planks</td>
<td>3</td>
<td>45</td>
<td>11.5</td>
</tr>
<tr>
<td>Ch1700</td>
<td>Omega Flat – Off ramp</td>
<td>PSC planks</td>
<td>3</td>
<td>45</td>
<td>7.5</td>
</tr>
<tr>
<td>Ch1900</td>
<td>Omega Flat</td>
<td>PSC planks</td>
<td>3</td>
<td>45</td>
<td>11 southbound 14.5 northbound</td>
</tr>
<tr>
<td>Ch2300</td>
<td>Omega Flat</td>
<td>PSC planks</td>
<td>3</td>
<td>45</td>
<td>7.5 on ramp 11.0 southbound 11.0 northbound</td>
</tr>
<tr>
<td>Ch2450</td>
<td>Omega Flat</td>
<td>PSC planks</td>
<td>3</td>
<td>45</td>
<td>14.5 southbound 11.0 northbound</td>
</tr>
<tr>
<td>Ch 2075</td>
<td>Omega Flat Structure 3 (Culvert)</td>
<td>RC culvert</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Ch 1980</td>
<td>Fern St Bridge</td>
<td>Precast concrete I-girders</td>
<td>9</td>
<td>260</td>
<td>11</td>
</tr>
<tr>
<td>Ch 7050</td>
<td>Crooked River tributary underbridge</td>
<td>PSC planks</td>
<td>4</td>
<td>60</td>
<td>11</td>
</tr>
</tbody>
</table>

### 6.2.2 Design parameters

**Cross section**

Bridge cross sections have been designed to accommodate the requirements of the RTA scope of work and technical criteria (SWTC), including sight distance and design speed of the carriageway. The bridge cross sections are matched with the roadway cross sections.

**Design life**

Bridge structures would be designed for a 100 year life. Where certain bridge components require maintenance or replacement (such as bearings) for the structure to achieve the 100 year design life, provision for maintenance has been allowed for in the design. All items unable to be maintained (for access or other reasons) would be designed to last for the full 100 year life of the structure.

**Design loads**

Design loads for all new structures have been adopted in accordance with the AS5100 – Bridge Design Code, along with the RTA requirements set out in the SWTC.

The design vehicle adopted is SM1600 in accordance with AS5100.2. This accommodates a B-Double vehicle as specified in the SWTC.

HLP400 (Heavy Load Platform) has been allowed for in the design of main highway underbridges only.
Clearance
Required vertical clearances to the soffit of all overbridges crossing the highway have been adopted to be 5.3 m. The minimum clearance provided to the soffit of the bridges on service roads is 4.6 m. This lesser clearance has been adopted where oversize or heavy vehicle access is not required or there is an alternative route.

A vertical clearance of 5.9 m has been adopted over the South Coast Rail Line for the Fern Street bridge. This is in accordance with RailCorp’s Transit Space guideline for electrified rail with wiring attached to the bridge structure.

Barrier loads
All bridge barriers have been adopted as medium level barriers as per AS5100.

Foundations
Generally cast in-situ bored piles have been adopted as foundations where there is adequate strength rock at an appropriate depth. Where this is not the case, PSC driven piles with pilecaps would be adopted.

Flood immunity
A 1:100 year ARI flood level has been allowed for all new bridges over Crooked River, Omega Flat, and other creeks and streams.

Pavement drainage
A minimum crossfall of three per cent has been adopted to match the road design and provide adequate pavement drainage.

Where practical, the vertical alignment of the bridges has adopted a minimum longitudinal grade of 0.5 per cent to allow for pavement drainage along the bridge.

For the majority of bridges, drainage conduits have not been required on the bridges. Stormwater will be channelled to the drainage system at each end of the bridges. The 300 m long Fern Street bridge and the wide, 60 m long Crooked River bridge however require drainage conduits in the bridge barriers to transport the quantity of water gathered over such an area. No pavement drainage from the bridges has been allowed to fall directly into surrounding watercourses without prior capture.

Public utilities
Conduits within the concrete bridge barriers have been allowed for on all bridges to allow for services and public utilities to cross the bridge if required in the future.

Fauna and cattle crossings
A specific cattle crossing has been provided at the Crooked River bridge.
7 Flooding and drainage

7.1 Design criteria

The design criteria for this concept design are drawn from the guidelines “Princes Highway Gerringong to Bomaderry, Concept Design Criteria” and the Scope of Works and Technical Criteria (SWTC). The criteria are summarised in the following table.

<table>
<thead>
<tr>
<th>Table 7.1: Flooding and drainage design criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General</strong></td>
</tr>
<tr>
<td>• Cross (transverse) drainage should be separated from pavement drainage.</td>
</tr>
<tr>
<td>• All existing structures and cattle underpasses where function is required for the upgraded highway must be replaced.</td>
</tr>
<tr>
<td>• A climate change allowance should be made by increasing storm intensity by six per cent.</td>
</tr>
<tr>
<td>• The following minimum average recurrence intervals apply for drainage:</td>
</tr>
<tr>
<td>- Channels and open drains  5 years</td>
</tr>
<tr>
<td>- Major storm event check for no property damage  100 years</td>
</tr>
<tr>
<td>- Major storm event check for no structural damage  2000 years</td>
</tr>
<tr>
<td><strong>Cross (transverse) drainage</strong></td>
</tr>
<tr>
<td>Flood immunity for a design event requires the lowest edge of shoulder to be 0.5 m above the respective flood level</td>
</tr>
<tr>
<td>The following minimum average recurrence intervals apply for cross drainage:</td>
</tr>
<tr>
<td>- Culverts where surcharge is allowable  50 years</td>
</tr>
<tr>
<td>- Structures where surcharge is undesirable  100 years</td>
</tr>
<tr>
<td><strong>Pavement drainage</strong></td>
</tr>
<tr>
<td>• A minimum pipe size of 450 mm diameter</td>
</tr>
<tr>
<td>• The following minimum average recurrence intervals apply for pavement drainage:</td>
</tr>
<tr>
<td>- Piped system (including pits)  10 year</td>
</tr>
<tr>
<td>- Gutter flow spread limited to width of shoulder  10 year</td>
</tr>
<tr>
<td><strong>Local roads</strong></td>
</tr>
<tr>
<td>• A flood immunity target of 20 year ARI</td>
</tr>
<tr>
<td>• Retain existing structures where possible</td>
</tr>
<tr>
<td><strong>Bridge drainage</strong></td>
</tr>
<tr>
<td>• The bridge drainage system would be designed such that all collected water is conveyed longitudinally to the abutments, rather than allowing scuppers to discharge directly into the receiving waters untreated.</td>
</tr>
<tr>
<td>• Pipe work would be hidden from view, except when viewed from underneath the bridge</td>
</tr>
<tr>
<td>• Pipe work would be corrosion and fire resistant.</td>
</tr>
<tr>
<td>• Flow across deck joints would be minimised.</td>
</tr>
<tr>
<td>• All drainage structures would be readily accessible for cleaning and maintenance.</td>
</tr>
<tr>
<td><strong>Minimum pipe sizes</strong></td>
</tr>
<tr>
<td>• Cross (transverse) drainage 1500 mm high (box culverts)</td>
</tr>
</tbody>
</table>
Water quality

- Pavement drainage should incorporate methods for retention of polluted runoff from a spill incident. A specific volume is not specified in the SWTC or concept design criteria documents, but a volume of 20,000 litres has been provided.
- An oil baffling system has not been detailed in the concept design but should be incorporated in the detail design and construction of sediment basins.
- The drainage system must preserve existing elements such as natural channels, wetland and riparian vegetation
- Treatment must be as close as possible to the source of drainage outlets.

Safety criteria

Concentration of water and long surface drainage paths on pavement super-elevation transitions areas has not been considered in the concept design. Maximum water depths, and rate of change in water depth, should be considered during detailed design. Similarly, the need for safety barrier to protect culvert headwalls, water quality basins and excavated channels will be assessed during detailed design.

Environmental criteria

A high standard of environmental design must be developed for the permanent and temporary works, including:
- Acid sulphate soil impact on drainage structures.
- Erosion, sedimentation and water quality infrastructure.
- Fauna underpasses.
- Fish friendly structures.

Acid sulphate soils (ASS) may impact on structures where culverts, pipes, piles and piers come into contact with acidic soils, or groundwater. Where possible, drainage and water quality structures should be formed from fill placed over existing ground rather than excavated into the ground.

7.2 Transverse drainage design details

7.2.1 Overview

The proposal crosses a total of 24 watercourse crossings spanning the Werri Lagoon and Crooked River catchments (refer Figure 7.1). The northern end of the proposal traverses Mount Pleasant Ridge, consisting of steep undulating terrain and well incised watercourses that form the upper reaches of the Werri Lagoon catchment. The central section of the proposal traverses Omega Flats, a flat low lying area that also drains to Werri Lagoon. The southern section of the proposal crosses gently undulating country that includes Crooked River and a number of its tributaries.
7.2.2 Hydrology and flooding

Catchment areas for each watercourse crossing have been defined using 1:25,000 topographic maps and available survey in the vicinity of the highway. The contours used to determine catchment areas for the creek crossings were at two metre or 10 m intervals, supplemented with aerial photogrammetric survey and detailed field survey along the proposal corridor.

For larger catchments (ie in excess of 40 ha) hydrologic analysis was undertaken using the watershed bounded network model (WBNM) software. Hydrologic analysis of the smaller catchments (less than 40 ha) were estimated using the probabilistic rational method, which was also used to provided a comparison to the WBNM results for the larger catchments.

Flood levels along the proposal were determined using a range of hydraulic analyses commensurate to the nature and magnitude of flooding and the level of detail required for concept design. The low lying and hydraulically complex area around Omega Flat was modelled with the two-dimensional TUFLOW software. The larger one-dimensional crossings of Crooked River at chainage 4850 and the tributary of Crooked River at chainage 7050 were modelled using HEC-RAS. The remaining culvert crossings were generally assessed using the culvert hydraulic software CulvertH and CulvertQ.
7.2.3 Transverse culvert design

Table 7.2 summarises the waterway crossing requirements for the proposal. Where appropriate, existing culverts have been extended upstream and/or downstream. These culverts are identified by an asterisk in the culvert length column. In some locations, existing culverts have been augmented. Five bridge crossings are proposed along Omega Flat. Bridges are also proposed for the Crooked River crossing at chainage 4850 and the tributary of Crooked River at chainage 7050.

At a number of the existing culvert locations overtopping of the existing highway occurs in a 100 year ARI flood event. The road level and bridge / culvert arrangements for the proposal have been designed to provide the required flood immunity as set out in Section 7.1. Consideration has also been given to potential flood impacts on upstream and downstream properties due to the proposal.

A summary of each waterway crossing is provided below.

**Chainage 530**

The existing culvert crossing comprises two 900 mm diameter concrete pipes. Hydrologic / hydraulic assessment shows that the existing culvert arrangement has a capacity of three m³/s, which approximately equates to the two year ARI flow. Flows in excess of the culvert capacity would overflow along the road to the south as the road is on grade.

Three 1500 mm wide by 1200 mm high box culverts are proposed to provide 100 year capacity and meet minimum cover requirements. This is less than RTA’s desirable minimum culvert height of 1500 mm. However, to provide 1500 mm high box culverts would require regrading of the downstream channel for approximately 30 m.

Compared to existing conditions the proposed culvert arrangement would result in an increase in the localised discharge of flows at the culvert outlet. Consequently, outlet scour protection works would be required to control the potential for increased scour downstream.

**Chainage 740**

The existing culvert, comprising an 1800 mm diameter concrete pipe, is predominantly used for cattle access across the existing highway. Only a relatively small section of the road embankment currently drains to the existing culvert. An upgraded cattle crossing is proposed at chainage 1010 and consequently the need for this culvert is largely obsolete.

For the purpose of concept design it is proposed to remove the culvert and provide a diversion swale to discharge into the existing watercourse at chainage 970.
<table>
<thead>
<tr>
<th>Culvert tag</th>
<th>Design chainage (m)</th>
<th>Existing culvert</th>
<th>Catchment area (Ha)</th>
<th>100 year ARI flow (m³/s)</th>
<th>Type</th>
<th>Number of cells</th>
<th>Width or diameter (mm)</th>
<th>Height (mm)</th>
<th>Length (m)</th>
<th>Depth of fill (m)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>C0.53</td>
<td>530</td>
<td>Pipe 2x900</td>
<td>21.6</td>
<td>14.2</td>
<td>Box</td>
<td>3</td>
<td>1500</td>
<td>1200</td>
<td>41.5</td>
<td>1.6</td>
<td>Replace existing culvert.</td>
</tr>
<tr>
<td>C0.74</td>
<td>740</td>
<td>Pipe 1800</td>
<td>2.3</td>
<td>2.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Remove culvert and provide diversion swale to discharge into watercourse at 970.</td>
</tr>
<tr>
<td>C1.43</td>
<td>1430</td>
<td>Pipe 2x1050</td>
<td>188</td>
<td>63</td>
<td>Pipe</td>
<td>4</td>
<td>1050</td>
<td>7.3</td>
<td>2.8</td>
<td></td>
<td>Extend existing culvert upstream and downstream and augment with additional 2 cells.</td>
</tr>
<tr>
<td>Rose Valley Road</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Omega Flat bridge 1A</td>
<td>1640</td>
<td>Box 2.7hx4.6w</td>
<td>533</td>
<td></td>
<td>Bridge</td>
<td>Refer to bridge structures section</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Existing culvert to be replaced by bridge.</td>
</tr>
<tr>
<td>Omega Flat bridge 1B (northbound off ramp)</td>
<td>1640</td>
<td></td>
<td>136</td>
<td></td>
<td>Bridge</td>
<td>Refer to bridge structures section</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Omega Flat Bridge 2</td>
<td>1900</td>
<td>Box 2x1.2hx1.5w</td>
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<td></td>
<td>Bridge</td>
<td>Refer to bridge structures section</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Retain existing culvert in conversion of existing highway to local road.</td>
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<tr>
<td>C2.07</td>
<td>2070</td>
<td>Box 0.9hx3.0w and 0.9hx2.0w</td>
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<td></td>
<td>Box</td>
<td>8</td>
<td>3600</td>
<td>1800</td>
<td>75.6</td>
<td>5.5</td>
<td>Replace existing culvert.</td>
</tr>
</tbody>
</table>

Table 7.2: Cross drainage summary
<table>
<thead>
<tr>
<th>Culvert tag</th>
<th>Design chainage (m)</th>
<th>Existing culvert</th>
<th>Catchment area (Ha)</th>
<th>100 year ARI flow (m³/s)</th>
<th>Type</th>
<th>Number of cells</th>
<th>Width or diameter (mm)</th>
<th>Height (mm)</th>
<th>Length (m)</th>
<th>Depth of fill (m)</th>
<th>Comments</th>
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</thead>
<tbody>
<tr>
<td>Omega Flat bridge 4</td>
<td>2290</td>
<td>Box 1.8hx3.0w</td>
<td>107</td>
<td>Box</td>
<td>Bridge</td>
<td>Refer to bridge structures section</td>
<td>Replace existing culvert with bridge.</td>
<td></td>
<td></td>
<td></td>
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<td>Omega Flat bridge 5</td>
<td>2480</td>
<td>Box 1.8hx3.0w</td>
<td>107</td>
<td>Box</td>
<td>Bridge</td>
<td>Refer to bridge structures section</td>
<td>Replace existing culvert with bridge.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C2.75</td>
<td>2750</td>
<td>Box 2.4hx2.7w</td>
<td>51</td>
<td>Box</td>
<td>1</td>
<td>2400</td>
<td>2700</td>
<td>43.9</td>
<td>2.4</td>
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</tr>
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<td>Box 1.2hx2.1w</td>
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<td>2100</td>
<td>1200</td>
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<td>1500</td>
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<td>Modify or replace existing culvert.</td>
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<td>Pipe 1050</td>
<td>6.5</td>
<td>Pipe</td>
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<td>1050</td>
<td>0</td>
<td>46.4</td>
<td>4.6</td>
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<td>Extend existing culvert upstream and downstream.</td>
</tr>
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<td>3400</td>
<td>Box 1x2.4hx1.2w</td>
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<td>Box</td>
<td>1</td>
<td>1200</td>
<td>2400</td>
<td>12.2</td>
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<td>C4.05</td>
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<td>1800</td>
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<td>2</td>
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<tr>
<td>C4.44 Belinda Street, east</td>
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<td>Pipe 375</td>
<td>2.4</td>
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<td>0.5</td>
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<td></td>
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<tr>
<td>Culvert tag</td>
<td>Design chainage (m)</td>
<td>Existing culvert</td>
<td>Catchment area (Ha)</td>
<td>100 year ARI flow (m³/s)</td>
<td>Type</td>
<td>Number of cells</td>
<td>Width or diameter (mm)</td>
<td>Height (mm)</td>
<td>Length (m)</td>
<td>Depth of fill (m)</td>
<td>Comments</td>
</tr>
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<td>Box 4x1.5h x1.5w</td>
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<td>Box</td>
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<td>2100</td>
<td>1500</td>
<td>200.1</td>
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<td>267</td>
<td>79.5</td>
<td>Bridge</td>
<td>Refer to bridge structures section</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>C5.55</td>
<td>5550</td>
<td>Pipe 375</td>
<td>0.9</td>
<td>1.0</td>
<td>Pipe</td>
<td>1</td>
<td>750</td>
<td>68.3</td>
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</tr>
<tr>
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<td>Pipe 750</td>
<td>1.8</td>
<td>1.7</td>
<td>Pipe</td>
<td>1</td>
<td>750 450</td>
<td>56.1* 50.0</td>
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</tr>
<tr>
<td>C5.90</td>
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<td>Pipe 900</td>
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<td>1.8</td>
<td>Pipe</td>
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<td>900</td>
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</tr>
<tr>
<td>C5.95</td>
<td>5950</td>
<td>Pipe 900</td>
<td>6.4</td>
<td>5.0</td>
<td>Pipe</td>
<td>2</td>
<td>900</td>
<td>83.0* 15.2</td>
<td>Augment existing culvert with additional cell.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C6.40</td>
<td>6400</td>
<td>Pipe 1050</td>
<td>14.6</td>
<td>10</td>
<td>Pipe</td>
<td>1</td>
<td>1050</td>
<td>39.0</td>
<td>3.4</td>
<td>Extend existing culvert.</td>
<td></td>
</tr>
<tr>
<td>C6.45</td>
<td>6450</td>
<td>Pipe 2x450</td>
<td>3.5</td>
<td>11 (including overflows from 6400)</td>
<td>Box</td>
<td>3</td>
<td>2100 1500</td>
<td>34.2 1.7</td>
<td>Replace existing culvert.</td>
<td></td>
<td></td>
</tr>
<tr>
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<td>6750</td>
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<td>35.6</td>
<td>21</td>
<td>Pipe</td>
<td>4</td>
<td>600</td>
<td>46.4</td>
<td>2.4</td>
<td>Extend existing culvert.</td>
<td></td>
</tr>
<tr>
<td>C7.05</td>
<td>7050</td>
<td>Pipe 4x1200</td>
<td>350.8</td>
<td>117</td>
<td>Bridge</td>
<td>Refer to bridge structures section</td>
<td>Replace existing culvert with bridge.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Chainage 1430 (Rose Valley Road)

The existing culvert comprises two 1050 mm diameter concrete pipes and has a capacity in the order of five m³/s. This equates to less than the one year ARI flow. Significant overflow across Rose Valley Road occurs at this location in a 100 year ARI event (the 100 year ARI flow is estimated to be 60m³/s). Other culvert crossings on Rose Valley Road immediately to the west have a similar level of capacity. Consequently there is limited benefit in providing a 20 or 100 year ARI capacity at this location as it would not improve the overall flood immunity of Rose Valley Road.

The vertical alignment of Rose Valley Road would be adjusted to tie in with the proposed highway upgrade and associated Rose Valley Road interchange. This would involve raising the level of Rose Valley Road at the existing culvert crossing and shifting the sag point further west.

In light of the above, it is proposed to upgrade this crossing to offset potential impacts upstream and downstream of the road as a result of proposed adjustments to the vertical alignment. Based on preliminary hydrologic / hydraulic modelling the proposed culvert arrangement consists of four 1050 mm diameter pipes (involving the construction of two additional pipes to augment the existing two pipes). The proposed arrangement would need to be refined with more detailed flood modelling during the detailed design. The more detailed flood modelling will be needed to confirm the final culvert arrangement required to offset any adverse impacts of the proposed adjustment to the vertical alignment of Rose Valley Road on properties upstream and downstream.

Chainage 1640 to 2760 (Omega Flat)

The catchment area draining to Omega Flat is relatively large, comprising approximately 1,337 ha. The existing highway embankment located within the lower reaches of Omega Flat results in significant floodplain storage upstream of the existing highway alignment. Omega Flat has a number of man-made channels and culvert crossings under the Princes Highway and South Coast Rail Line, thus impacting on the natural drainage system. The channel capacities are generally small in terms of the design flows and are overtopped in moderate rainfall events. Floodwaters spill across the flats once the channel capacity is exceeded. Since the area is very flat and wide, velocities are low and the area can take some time to drain. The existing highway and railway culverts also limit and control flows. Other issues that need to be taken into account during detailed design include tidal influences and entrance conditions at the mouth of Werri Lagoon, particularly when the sand dune of the mouth of the lagoon is high.

Given the complex nature of flooding in the Omega Flat area, and the need to determine road level and waterway opening arrangements to meet flood immunity requirements, a two dimensional hydraulic model was established using TUFLOW software.

Flood assessment using the established TUFLOW model has provided the following results:

- The 100 year flow across Omega Flat at the highway is approximately 220 m³/s (including flow through the culverts and over the highway).
- The flood regime at the existing highway is controlled hydraulically by the existing railway culverts located downstream of the highway.
- The 100 year flood level upstream of the railway line varies from approximately RL2.7m in the north, to RL3.45m in the south. At this flood level, all five existing railway culverts are hydraulically connected but flood waters do not overtop the railway embankment.
- The 100 year flood level upstream of the highway is estimated to range between RL3.5m in the north, to RL 3.6m in the south. The existing highway is overtopped by
up to 0.6 m (minimum existing roadway level is approx RL3.0m) across Omega Flat. The 100 year ARI flow over the highway is estimated to be approximately 170 m$^3$/s under existing conditions.

- To provide 100 year ARI flood immunity the proposed highway is to be set at a minimum level of between RL4.1m to RL4.2m at the edge of road (allowing for a 0.5 m freeboard in accordance with the SWTC requirements). The level of the road at bridge crossings is set higher to provide 0.3 m freeboard between the underside of the bridge deck and the 100 year ARI flood level.

As the proposed highway embankment is higher than the predicted existing 100 year ARI flood level it is likely to significantly impact on flooding in the area if not adequately mitigated by upgraded waterway structures. The concept design allows for five waterway crossings across the Omega Flat floodplain, comprising four bridge crossings of varying total span, and one culvert crossing of eight 3.6 m wide by 1.8 m high box culvert cells.

**Chainage 3240 to 3400**

The existing culvert at chainage 3240 (a 2400 mm by 2400 mm box culvert) is significantly oversized for the size of the upstream catchment. It is possible that the culvert was previously used as an accessway. Subject to structural conditions, this culvert will need to be modified or replaced with a 1500 mm high culvert to provide adequate clearance to the proposed highway, which is lower in this location than the existing highway.

The other two culverts along this section of the upgrade, at Chainage 3260 and 3400 are largely conventional and have 100 year ARI capacity under existing conditions. Consequently, subject to structural condition, it is proposed to extend these culverts to accommodate the widened highway alignment.

**Chainage 4050**

The existing highway crossing at this location comprises four 1500 mm wide by 900 mm high box culverts and a 750 mm diameter pipe. The railway culvert immediately downstream of the highway consists of a 2700 mm wide by 2400 mm high box culvert.

Preliminary flood assessment using the CulvertH program has identified that the flood regime at the existing highway is controlled hydraulically by the existing railway culvert. As a result, the existing highway culverts are estimated to have a flow capacity in the order of 14 m$^3$/s before overtopping of the existing highway occurs. This equates to between a two and five year ARI capacity.

Flood assessment has also identified the following results for the 100 year ARI event:

- The peak flow at the highway is estimated to be 40 m$^3$/s, which would result in inundation of the existing highway to a depth of approximately 0.5 m (the level of the highway is at RL19.4m).
- The flow over the highway is estimated to be 23 m$^3$/s, with 17 m$^3$/s travelling through the highway culverts.
- The flow through the railway culvert is estimated to be approximately 22 m$^3$/s, while overflow across the railway line could be in the order of 8 m$^3$/s. Overflows estimated to be in the order of 10 m$^3$/s would occur along the western side of the railway line and travel south toward Belinda Street. These overflows are likely to contribute to known flooding issues in Belinda Street at the railway underpass. More detailed flood modelling is required to better quantify the distribution of flows between the culvert and the overflow paths.
• Overflows along the railway line that head towards the Belinda Street underpass occur once the flows in the railway culvert exceed approximately 20 m$^3$/s.

• To provide 100 year ARI flood immunity the proposed highway is to be set at a minimum level of RL20.4m the edge of road (allowing for a 0.5 m freeboard in accordance with the SWTC requirements).

To provide 100 year ARI flood immunity to Belinda Street (to provide access to Gerringong in times of flood as discussed further in the next section) it will be necessary to address the overflows that travel south along the railway corridor and contribute to known flooding issues at the Belinda Street underpass. Options of achieving this include:

• Restricting the flow at the railway culvert to 20 m$^3$/s by detention of flows upstream of the highway, or by diverting flows upstream of the highway toward the culverts at the Belinda Street interchange (4450).

• Providing culverts to convey overflows across the Belinda Street underpass.

Of the options available, diversion of flows to the culverts at 4450 is considered the most feasible. The volume of detention storage required to reduce flows at the railway culvert to 20 m$^3$/s would require significant acquisition and excavation of land upstream of the highway. There is limited room and cover available at the Belinda Street underpass to provide the size of culverts necessary to convey the estimated 10 m$^3$/s overflows.

In light of the above, for the purposes of concept design a 15m wide channel is proposed to divert flows upstream of the highway toward the culverts at Belinda Street interchange (4450). The channel has been sized to convey 20 m$^3$/s, thus restricting flows at the railway culverts to 20 m$^3$/s and alleviating overflows along the railway corridor toward the Belinda Street underpass. To convey the remaining 20m$^3$/s across the highway the existing culverts are proposed to be upgraded to two 2.4 m wide by 1.8 m high box culverts.

The proposed diversion would reduce peak flows downstream of the railway line, through the industrial area that also has known flooding issues. However, the diversion of flows will results in an increase in flows and potential flood impacts downstream of the Belinda Street interchange culverts (4450). More detailed flood assessment will be required to confirm that these impacts are within acceptable limits.

To reduce flood impacts it may be feasible to provide some detention storage upstream of the highway. This would offset the amount of flow to be diverted toward the culverts at 4450.

Possible arrangements to provide additional flood storage and attenuate peak flows downstream of the highway may involve bunding upstream of the highway to achieve additional storage volume by increasing the ponding level and/or excavation upstream of the highway.

Further design effort in consultation with RailCorp, Kiama Municipal Council, and affected property owners is required in order to achieve a solution acceptable to all parties.
Chainage 4060 (on Belinda Street at Union Creek crossing)

During the access value management workshop it was decided that access to Gerringong during times of flood would be via the Belinda Street interchange. Providing flood immunity access via the northern end of town would require Fern Street and the existing highway (now a service road) to be raised above the 100 year ARI flood level.

To provide 100 year ARI flood immunity to Belinda Street it would be necessary to carry out upgrade works at the Union Creek crossing, immediately west of the Rowlins Road / Belinda Street intersection. The existing crossing comprises a 4.6 m wide by 1.8 m high box culvert. The existing crossing is estimated to overtop in a 100 year ARI event, with floodwaters flowing across Belinda Street to a depth of approximately 0.5 m (RL16.5m).

The proposed arrangement involves augmenting the existing culvert with four additional box culvert cells, comprising two 2.7 m wide by 1.8 m high and two 2.4 m wide by 1.8 m high. The 100 year ARI flood level would be lowered to RL15.9m, which is approximately level with the edge of road level at the crossing.

Such a reduction in flood level would reduce the flood storage upstream of Belinda Street and this could have adverse impacts on flood behaviour downstream of the crossing. Consequently, the HECRAS model was run in unsteady state mode to assess the impacts on flood behaviour downstream of the crossing. Flood model results show that changes in peak flows and flood levels downstream of the crossing would be negligible.

The proposed works would provide flood free access past Union Creek. It should be noted that the assessment of flood accessibility throughout the entire Gerringong township is beyond the scope of this project and would normally fall under a floodplain risk management study.

Chainage 4430 (on Belinda Street east of railway underpass)

A culvert would be required at Belinda Street east of the railway underpass to collect overland flows from the local catchment and prevent excessive ponding at the railway underpass in a 100 year ARI event. The peak 100 year ARI flow from the local catchment is estimated to be two m$^3$/s. There is currently a 375 diameter pipe crossing Belinda Street at this location. To provide 100 year ARI flood immunity would require an additional 1800 mm wide by 600 mm high box culvert. Cover to Belinda Street would preclude the use of culverts of a greater height.

Chainage 4440 (on Belinda Street west of railway underpass)

A culvert would be required at Belinda Street west of the railway underpass to collect overland flows from the local catchment and prevent excessive ponding at the railway underpass in a 100 year ARI event.

The peak 100 year ARI flow from the local catchment is estimated to be 2m$^3$/s. There is currently a 375 diameter pipe crossing Belinda Street at this location. To provide 100 year ARI flood immunity would require an additional 1800 mm wide by 600 mm high box culvert. Cover to Belinda Street would preclude the use of culverts of a greater height. The existing clearance between Belinda Street and the railway underpass would preclude raising the road level to allow for taller culverts.

A series of culverts would be required at Belinda Street west of the railway underpass to collect overland flows that travel along the western side of the railway line from Chainage 4050, before they flow across Belinda Street at the railway underpass. The peak 100 year ARI flow could be up to 10 m$^3$/s. Depending on the extent of flood mitigation works at Chainage 4050 (refer to preceding discussion on Chainage 4050) additional culverts may also be required to collect...
overland flows that travel along the western side of the railway line from Chainage 4050, before they flow across Belinda Street at the railway underpass.

**Chainage 4450 (Belinda Street interchange)**

The peak 100 year ARI flow at the Belinda Street interchange is estimated to be 20 m³/s from the local contributing catchment. It is also proposed to divert up to 20 m³/s of flow in the 100 year ARI event to this location. As noted in the discussion on Chainage 4050, more detailed flood modelling is required to assess the impacts of this diversion on flooding downstream of the culvert outlet at 4450.

The culverts at 4450 are also potentially subject to flows that breach the bank of Crooked River upstream of the highway at Chainage 4850 and also travel toward the Belinda Street intersection. Overflows from Crooked River could be in the order of 15 m³/s in the 100 year ARI event.

More detailed flood modelling is required to better quantify the magnitude of overflows from Chainage 4050 and Crooked River and their impact on flows at Belinda Street interchange. The final design solution at Belinda Street would be subject to potential flood mitigation works at Chainage 4050 (where it is proposed to divert flows toward 4450) and chainage 4850 (where it is proposed to restrict overflows diverting toward 4450).

The existing 900 diameter pipe under rail embankment immediately south of the Belinda Street underpass is estimated to have a capacity in the order of one year ARI before overflows travel through the road underpass and restrict access via Belinda Street from the highway. Raising the road level through the underpass is constrained by the existing clearance to the underside of the railway bridge. Consequently, in order to provide 100 year ARI flood immunity to Belinda Street it would be necessary to significantly upgrade the railway culvert.

It is proposed to install a long culvert (approximately 200 m long) from the northbound on ramp to the eastern side of rail embankment. The concept design shows three 2700 mm wide by 1500 mm high box culvert cells, which allows for 20 m³/s diverted flow from 4050 but no overflows from Crooked River.

The final culvert arrangement is dependent on the final solution at Crooked River (Chainage 4850). If it is not feasible to prevent any overflows from Crooked River in the 100 year ARI event then additional culvert capacity would be required and the final arrangement could be up to five 2400 mm wide by 1500 mm high box culvert cells.

The proposed amplification of the existing 900 mm culvert under the railway line would result in an increase in the concentration of flows discharging directly into the downstream property. This will need to be addressed through appropriate outlet energy dissipation and downstream channel works. Discussions should be undertaken with council and the affected property owner to ensure that proposed works are consistent with any future development planned for the site.

**Chainage 4850 (Crooked River)**

The existing Crooked River embankment is breached in significant events with flow towards Belinda Street (up to 15 m³/s peak in the 100 year ARI event).

It is proposed to upgrade the bridge at Crooked River and realign the existing watercourse. These proposed works would improve the hydraulic efficiency of the bridge crossing. However, overflows would still occur in the 100 year ARI event and travel toward the Belinda Street interchange.
To alleviate flooding at the Belinda Street interchange, in conjunction with the Crooked River bridge and channel works, it is also proposed to construct a 190 m long levy along the eastern bank of Crooked River from the service road bridge abutment. The levee would be between 0.5 m and 1.2 m high and would prevent overflows being directed to Belinda Street for flows up to the 100 year ARI event. Further flood assessment is required to quantify potential impacts resulting from increased flows being directed down Crooked River.

Levees, particularly grassed levees, have the potential to deteriorate over time, reducing their level of protection. This problem is exacerbated in areas where the levee would be exposed to traffic from pedestrians and/or cattle. Consequently, to guarantee a continued level of flood protection it would be necessary to implement a program to monitor and maintain the level and condition of the levee. Long-term maintenance requirements of the levee would need to be factored in to the final solution developed for Crooked River.

**Chainage 5550**

The existing culvert, a 375 mm diameter pipe, collects flows from the catch drains running along the top of the existing cutting. The pipe is estimated to have a capacity of 0.2 m$^3$/s, which approximately equates to the two year ARI flow. The proposed highway is approximately eight metres lower than the existing highway at this location. While the existing highway is in cut on the northern side but in fill on the southern side, the proposed highway would be in cut on both sides.

It is proposed to replace the existing pipeline with a 750 mm diameter pipe to provide 100 year ARI capacity. The new pipeline will require an eight metres drop structure or batter drain at the inlet and would need to outlet approximately 20 m downstream of the road cutting.

**Chainage 5840**

The existing culvert, a 750 mm diameter pipe, has a capacity of 1.7 m$^3$/s which is approximately equivalent to the 100 year ARI flow. Under proposed conditions the culvert would need to be extended upstream beyond the widened footprint of the upgraded highway. The higher invert level of the extended section of pipe would result in a flow capacity of approximately 1.4 m$^3$/s.

The concept design provides for an additional 450 mm pipe at this location to augment the existing pipe and provide a 100 year ARI capacity under proposed conditions. The new pipeline should be constructed higher than the existing culvert to reduce the depth of excavation required. An alternative option would be to size the roadside swale to convey overflows toward the culvert at Chainage 5900 in lieu of the augmented pipe.

**Chainage 5900**

This culvert, comprising a 900 mm diameter pipe, is largely conventional and has 100 year ARI capacity under existing conditions. Consequently, subject to structural condition, it is proposed to extend the culvert to accommodate the widened highway alignment.

**Chainage 5950**

The existing culvert, a 900 mm diameter pipe, has a capacity of 3.2 m$^3$/s which is equivalent to between a 20 year to 50 year ARI flow. Overflows in excess of the culvert capacity would travel along the roadside swale toward the culvert at Chainage 6400. The peak 100 year ARI flow is estimated to be five m$^3$/s.

It is proposed to augment the existing culvert with an additional 900 mm pipe to provide a 100 year ARI capacity under proposed conditions.
The area downstream of this culvert is owned by Sydney Water and is used for dairy purposes. Given the existing land use the proposed culvert amplification is not expected to have any significant impacts on the downstream property. However, more detailed flood modelling should be undertaken in future design stages to better quantify impacts.

**Chainage 6400 and 6450**

The existing culvert at Chainage 6400, a 1050 mm diameter pipe, has a capacity of 2.5 m$^3$/s which is approximately equivalent to the two year ARI flow. Overflows in excess of the culvert capacity currently travel along the roadside swale to the culvert and lowpoint in the highway at Chainage 6450.

Amplification of the existing culvert at Chainage 6400 could have potentially adverse flood impacts on the property downstream of the culvert outlet. Consequently, for the purposes of the concept design it is proposed to extend the existing culvert at Chainage 6400 and provide a drainage swale along the edge of the road to convey overflows to Chainage 6400. The swale would be grass lined and in the order of seven metres wide and 0.7 m deep. Riprap would be required along the base of the swale to provide scour protection.

The culvert at Chainage 6450, which is currently a 450 mm diameter pipe, would need to be upgraded to provide adequate capacity in the 100 year ARI event. For the purpose of concept design, three 2100 mm wide by 900 mm high box culverts are proposed. Allowable cover would preclude the use of taller culverts without raising the road alignment. Compared to existing conditions the proposed culvert upgrade would result in an increase in the localised discharge of flows at the culvert outlet. Consequently, outlet scour protection works would be required to control the potential for increased scour downstream.

More detailed flood modelling should be undertaken in future design stages to confirm the size of the proposed swale between chainages 6400 and 6450, investigate any opportunity to amplify the existing culvert at Chainage 6400 without having adverse impacts on the downstream property and better quantify the magnitude of flow arriving at Chainage 6450.

**Chainage 6750**

The existing crossing, consisting of four 600 mm diameter pipes, has a capacity of three m$^3$/s which is between a one year and two year ARI flow. Overflows in excess of the culvert capacity currently travel along the road toward the culvert at Chainage 7050. The peak 100 year ARI flow is estimated to be 21 m$^3$/s.

Amplification of the existing culvert capacity could have potentially adverse flood impacts on the property downstream of the culvert outlet. Consequently, for the purposes of the concept design it is proposed to maintain the existing culvert and provide a drainage channel along the edge of the road to convey overflows to Chainage 7050. The proposed channel would run between Chainage 6750 and 7040 grassed lined with dimensions in the order of 15 m wide and 1.2 m deep running along the edge of the road embankment. Riprap would be required along the base of the swale to provide scour protection. The size of the channel could be reduced between Chainage 6900 and 7040 as this area is currently flood affected in the 100 year ARI event under existing conditions.

More detailed flood modelling should be undertaken in future design stages to confirm the size of the proposed swale and any opportunity to amplify the existing culvert without having adverse impacts on the downstream property.
The existing culverts, comprising four 1200 mm diameter pipes, are estimated to have a capacity less than the one year ARI flow. This is supported by local reports that indicate that floodwaters pond along the highway in this area frequently.

Due to the nature of the crossing and the size of the upstream catchment a one dimensional HECRAS model hydraulic model was established to define existing flood behaviour and guide the design of the road to provide the necessary flood immunity whilst minimising adverse flood impacts on surrounding development.

The flood assessment undertaken for concept design has provided the following results:

- The 100 year flow at the highway is estimated to be in the order of 120 m$^3$/s allowing for overflows from Culvert 6750. More detailed flood modelling should be undertaken during future design stages to define the impact of flows from Culvert 6750.
- The 100 year flood level upstream of the highway is estimated to be RL 11.80m under existing conditions, which is approximately 0.5 m above the existing road level.
- To minimise flood level impacts and provide the required flood immunity the proposed arrangement consists of a bridge with a total span of 60 m. Realignment of the existing watercourse is also proposed due to the highway upgrade encroaching on sections of the watercourse.
- The 100 year ARI flood level upstream of the highway is estimated to be RL 11.62m, which is 180 mm lower than the corresponding flood level under existing conditions. Proposed flood levels converge with existing flood levels approximately 20 m upstream of the highway and so any impacts of lowered flood levels on reduced flood storage are likely to be negligible.

### 7.3 Pavement drainage design details

The pavement drainage design has been developed to meet the requirements of the scope of works and technical criteria (SWTC) and the Princes Highway Gerringong to Bomaderry, Concept Design Criteria. The longitudinal drainage system has been designed to collect pavement runoff and direct it towards water treatment facilities, comprising a combination of grassed swales and retention ponds.

#### 7.3.1 Drainage in cuttings

The drainage systems for cuttings have been designed to collect runoff from the road pavement and the lowest cut face using the RTA system of SO gutter, pits and pipes. The runoff is directed to water treatment facilities which capture any spillage and provide water quality improvement prior to discharge into natural water courses. Longitudinal pipes in cuttings would be provided within the median between carriageways.

Where cuttings are benched, bench drains collect clean water from the cut faces and direct it to transverse drainage if possible, or to the pavement drainage system if necessary.

Catch drains would be provided along the high side of cuttings to prevent inflow of surface water from outside of the cuttings. These catch drains would convey clean water only and would outlet to transverse drainage via level spreaders to prevent erosion.
7.3.2 Drainage on embankments

Pavement runoff is collected via pits and pipes and discharged to water quality facilities at various locations along the alignment. Swale drains have been provided at the toe of the batter to convey pavement runoff to water quality facilities. Where possible (ie at low embankments) pavement runoff would be allowed to sheet flow over the embankment and collected in vegetated swale drains.

Channels would also be used to divert clean runoff to the transverse drainage.

7.3.3 Bridge drainage

A preliminary assessment suggests that the proposed bridges are relatively short and/or narrow such that the total catchment area and flows generated are small. However, bridge drainage would be required on approximately nine bridge crossings (twin bridges counted as one bridge) for one of the following reasons:

- On mainline bridges (five off), the flow capacity of shoulders is limited without encroaching within trafficked lanes.
- On transverse bridges where expansion joints are required (seven off), runoff must be captured upstream of an expansion joint

For these bridges scuppers and associated collection pipes and connection pits would be required.

7.4 Scour and erosion control

Where exit velocities from drainage culverts exceed natural velocities, scour of the downstream watercourses can be expected unless protective measures are provided.

Scour is also possible at the culvert inlets where water contracts and accelerates to enter the structure or where the channels approaching the culvert are steepened to match the culvert invert if the culvert entrance has been placed below the existing ground level. A standard RTA apron would be sufficient to prevent this scour problem at most locations. However, where it is considered that these aprons would not be sufficient, additional protection may be required in the form of dumped rock rip rap.

Energy dissipators would be provided on the outlets to drainage structures that have the potential to cause scour. In general, RTA Type A dissipators would be used which comprise a rock rip rap dissipator pool with a rip rap apron downstream of the pool. Fauna access would not be inhibited by the presence of the Type A dissipator.

For the purposes of the concept design, scour protection requirements were quantified using the following assumptions:

Protection length = 3*diameter
Protection width = 3.5*diameter

These are based on requirements on RTA standard drawings. More detailed assessment of scour protection requirements would be required during future design stages.
7.5 Water quality

7.5.1 Design details

The permanent sedimentation and spillage containment basins have been provided to capture and treat first flush from pavement surface and prevent liquid tanker spills from discharging onto adjacent land and watercourses. As per RTA’s Water Policy, a series of water quality basins and elongated vegetated swales have been proposed to minimise the potential for adverse impacts on waterways.

Elongated vegetated swales are provided in areas where project boundary limits provision of water quality basins. For the purposes of concept design no allowance has been made for sediment basin requirements during construction. As a general rule, construction sediment basins could be expected to be in the order of three times the size of operational basins.

Basins have been generally been provided at the outlets to the drainage lines consisting of three or more pits. However, consideration would need to be made to provide measures to control any spillages that could potentially discharge from any drainage lines.

Table 7.3 summarises the proposed water quality basins.

<table>
<thead>
<tr>
<th>Chainage</th>
<th>Catchment area m²</th>
<th>Volume required m³</th>
<th>Volume achieved m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>500</td>
<td>8860</td>
<td>177</td>
<td>177</td>
</tr>
<tr>
<td>700</td>
<td>5780</td>
<td>116</td>
<td>116</td>
</tr>
<tr>
<td>1050</td>
<td>9270</td>
<td>185</td>
<td>185</td>
</tr>
<tr>
<td>1600</td>
<td>22590</td>
<td>452</td>
<td>452</td>
</tr>
<tr>
<td>1650</td>
<td>5310</td>
<td>106</td>
<td>106</td>
</tr>
<tr>
<td>2600</td>
<td>4510</td>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td>2750</td>
<td>13230</td>
<td>265</td>
<td>265</td>
</tr>
<tr>
<td>3300</td>
<td>1600</td>
<td>32</td>
<td>32</td>
</tr>
<tr>
<td>3400</td>
<td>8930</td>
<td>179</td>
<td>179</td>
</tr>
<tr>
<td>4000</td>
<td>6600</td>
<td>132</td>
<td>132</td>
</tr>
<tr>
<td>4400</td>
<td>6940</td>
<td>139</td>
<td>0</td>
</tr>
<tr>
<td>4500s</td>
<td>37400</td>
<td>748</td>
<td>748</td>
</tr>
<tr>
<td>4500n</td>
<td>6010</td>
<td>120</td>
<td>0</td>
</tr>
<tr>
<td>4850</td>
<td>16390</td>
<td>328</td>
<td>328</td>
</tr>
<tr>
<td>5250</td>
<td>13910</td>
<td>278</td>
<td>278</td>
</tr>
<tr>
<td>5800</td>
<td>11090</td>
<td>222</td>
<td>222</td>
</tr>
<tr>
<td>6350</td>
<td>13200</td>
<td>264</td>
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</tr>
<tr>
<td>6750</td>
<td>11180</td>
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<tr>
<td>6950</td>
<td>4280</td>
<td>86</td>
<td>86</td>
</tr>
<tr>
<td>7200</td>
<td>3800</td>
<td>76</td>
<td>76</td>
</tr>
</tbody>
</table>

During detailed design, basin sizes would need to be confirmed to ensure a first flush amounting to 20 mm of rainfall is provided. This can also be expressed as 13 mm and an additional 50 per cent storage volume.
Note that the required basin volume has been achieved at all but two locations (the exceptions being chainages 4400 and 4500 north). However, significant land acquisition would be required to provide for the necessary footprint for the proposed basins. It is recommended that further consideration be made to the required land acquisitions prior to finalising the basin design. It should also be noted that there may be opportunities in future design stages to rationalise the proposed basin arrangements and supplement with grassed swales or other water quality features.

7.6 Design issues / risks

7.6.1 Provision for blockage for transverse drainage

The design of transverse drainage does not provide for blockage for structures greater than 600 mm wide. This might not be a significant issue, as the catchments are not large and the largest catchments use bridge crossings which do not have the same blockage potential. It may however lead to an increase in waterway area requirements in some locations.

7.6.2 Downstream channel conditions

The hydraulic properties of culverts and energy dissipators are affected by downstream channel conditions which determine backwater levels. At some crossing locations, depending upon factors such as channel slope and geometry, it may be necessary to obtain cross sectional information for a considerable distance downstream of the highway upgrade in order to define backwater conditions accurately. During detailed design appropriate survey information may be required downstream of the hydraulic structures in order to allow the backwater conditions to be accurately assessed. This may lead to some modifications to the design of waterway structures.

7.6.3 Flood levels

Flood levels along the upgrade were determined from a range of hydraulic analyses. The low lying and hydraulically complex area of Omega Flats was modelled with two-dimensional software TUFLOW. More significant one-dimensional crossings of Crooked River, and its tributary at Chainage 7050 were assessed using HECRAs. Finally, culvert crossing along the bypass in the north were generally assessed using CulvertH and CulvertQ. Hydrological analysis was undertaken using WBNM and Probabilistic Rational Method.

The models have been developed for the purposes of providing a level of detail suitable for Concept Design. During detailed design, all models would be reviewed and refined. A key input may be improved survey outside the project corridor.

7.6.4 Erosion protection

The dimensions of the energy dissipators or scour protection can vary depending upon site specific factors, which can include velocity, tailwater conditions, soil type and erodibility. These might result in adjustments to scour protection requirements.

7.6.5 Water quality treatment

The default form of water quality treatment is usually basins. Whilst water quality treatment is required, it is understood basins per se are not. This provides scope for alternative measures to be adopted. Where basins are not practicable or require significant land acquisition, bunded elongated swales may be preferable. These are essentially an elongated basin, although it cannot be argued that they are completely equivalent. Their use is a practical response to a constrained site.
At detailed design, further consideration should be given to adjusting alignment or even boundaries to accommodate basins wherever possible.

7.6.6 Water quality basins

All basins would be provided with a stabilised spillway at least 3000 mm width which would permit outflows from the basin in a controlled manner for storms up to the 100 year ARI event and prevent overtopping of the embankment which could result in embankment failure.

The presence of acid sulfate soils might limit the depth of excavation / extent of water quality basin works.
8 Earthworks

8.1 Introduction

A preliminary geotechnical investigation was undertaken for the entire study area in 2007 to inform the route selection process. A concept design geotechnical investigation targeting the proposal was completed in 2009. The results of these combined investigations allowed the design team to make more accurate assessments of the ground conditions and their influence on cuttings, embankments, bridge foundations and earthworks quantities.

The following chapter briefly describes the ground conditions and the significant geotechnical aspects along the proposed alignment.

8.1.1 Objectives

The main objective of the reporting on the geotechnical concept design report is to provide the data required to inform the concept design, and also assist in the detailed design, by highlighting the geotechnical aspects and constraints requiring consideration during the detailed design stage. The information and recommendations provided would be typically used in the geometrical design, structural and civil design and for selecting of the locations of major structures such as; interchanges, bridges and earthworks.

8.1.2 Scope of work

The geotechnical concept design comprised the following:

- Review of geotechnical data from previous and recent geotechnical investigations.
- Carry out concept design assessments with regards to the design of earthworks, foundations and other structures.
- Provide input for the concept design drawings.
- Reporting on the geotechnical concept design.

8.2 Background information

In preparing the concept design reference was made to the following project geotechnical reports prepared for the project by Coffey Geotechnics and Golder Associates:


Princes Highway – Gerringong upgrade  Concept Design Report
The information provided in this report is largely based on the data provided in the above reports. Please refer to the latest geotechnical factual report (GFR) and the geotechnical interpretive report (GIR) for the preferred alignment for detailed information on the geotechnical conditions along the alignment.

8.3 Geotechnical investigations

Geotechnical site investigations have been carried out as provided below.

- RTA site investigation in 1989.
- Preliminary site investigation by Coffey Geotechnics in 2007.
- Preferred option geotechnical site investigation by Coffey Geotechnics between 2009 and 2010.

There possibly have been other geotechnical investigations carried out prior to 1989 in the area for the purpose of the Princes Highway road upgrade that AECOM is unaware of.

8.4 Topography

The area within the Gerringong upgrade alignment extends from the Mount Pleasant Lookout north of Gerringong to the Toolijooa Road junction along the existing Princes Highway. The topography of the alignment is characterised by the following main features.

8.4.1 Mount Pleasant

The alignment connects with the existing highway at the southern end of the Kiama Bends on the side slopes of Mount Pleasant. The alignment begins from the top of a ridgeline in the Mount Pleasant area and drops in elevation as a curved alignment towards the west, south-west and south. The existing road has been constructed by cutting along the northern side and by filling along the southern side of the alignment.

8.4.2 Rose Valley Road

This part of the alignment appears to be within the remanent of a hill on the edge of the Omega Flat flood plain. The site is on a terraced ground near the southern extents of a minor foothill south of Mount Pleasant.

8.4.3 Omega Flat

Omega Flat is situated between Rose Valley Road and Gerringong township and is described as a lowland marsh / floodplain that is regularly inundated during periods of high rainfall periods. Omega Flat was earth filled in the 1870s to create usable pasture.

8.4.4 Sims Road junction vicinity - end of Omega Flat to Belinda Street interchange

This part of the alignment extends from the Omega Flat to the north and the Crooked River floodplain on the south-west. The ground along the alignment within this section is elevated and it is higher than the Omega Flat and the Crooked River flood plain. The ground profile is slightly undulating. There are two minor water courses running in the west-east direction in the low land between Sims Road and the minor hill before Belinda Street.
8.4.5 Crooked River floodplain

The Crooked River floodplain where it occurs within the study area includes the low lying areas to the south-west of Gerringong, generally between Toolijooa Road or the Princes Highway and the Illawarra Rail Line. Crooked River originates in the Broughton Vale highlands and flows south-east across the Crooked River floodplain and then south-west after crossing over the Princes Highway before flowing into the Crooked River coastal lagoon.

8.4.6 Gerringong Bends

The Gerringong Bends are within an elevated land to the west of the Crooked River floodplain. The existing alignment slightly meanders along the southern side of two main ridge features and two gully head features.

8.4.7 Toolijooa Road flood plain

The alignment along this section is within a low land and constitutes a flood plain between Gerringong Bends and the Toolijooa Road interchange.

8.5 Geology and main geological units

The geology along the proposed alignment within the Gerringong upgrade is classified under the Budgong Sandstone and the Gerringong Volcanic Facies. The alignment is predominantly underlain by weathered rock and residual soils of these formations. Significant sections along the alignment are underlain by alluvial and estuarine deposits. These are typically highly compressible and include occasionally acid sulfate soils.

The site is underlain by weathered rock and residual soils in the elevated areas where cutting is required and alluvial and estuarine soils in the low lying area where filling will be required. Table 8.1 provides a summary of the main geotechnical units that would be encountered along the alignment as reproduced from the Coffey GIR.

Table 8.1: Summary of the main geological units along the alignment

<table>
<thead>
<tr>
<th>Unit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Topsoil</td>
<td>Topsoil layers (up to 0.5 m thick) – dark brown to brown, clayey silt, with many roots and organic materials.</td>
</tr>
<tr>
<td>Fill</td>
<td>Encountered in existing highway embankments and hardstand areas. Imported asphalt, road base or local soil fill for highway embankments and pavement fill materials.</td>
</tr>
<tr>
<td>Estuarine deposits</td>
<td>Sandy Clay, Clay and Clayey Sand: high plasticity, brown to grey and dark grey. Firm in upper one metre to 1.5 m, very soft to soft below this zone. Some intact shells five millimetres to 20 mm in size. This unit generally encountered in Omega Flat area. Can be encountered interlayered with alluvial deposits.</td>
</tr>
<tr>
<td>Alluvial deposits</td>
<td>Firm to very stiff clays, silty clays and sands, with some hard zones, brown-grey, often mottled.</td>
</tr>
<tr>
<td>Alluvial gravels and boulders</td>
<td>Predominantly gravel and cobble sized alluvial deposits.</td>
</tr>
<tr>
<td>Residual soils</td>
<td>Very stiff to hard clays and extremely weathered rock developed on units associated with the underlying rock materials. Some residual soils also present between transported soils and highly weathered (or less weathered) rock materials.</td>
</tr>
<tr>
<td>Kiama Sandstone</td>
<td>Fine to medium grained, indistinctly bedded, red or grey.</td>
</tr>
</tbody>
</table>
### Unit Description

<table>
<thead>
<tr>
<th>Unit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Westley Park Sandstone</td>
<td>Fine to medium grained, indistinctly bedded to massive, grey.</td>
</tr>
<tr>
<td>Blow Hole Latite</td>
<td>Normally mid grey often with a brownish tinge and has a very fine grained groundmass. Pillow structures and columnar jointing are found in the Blow Hole Latite as well as breccia zones.</td>
</tr>
<tr>
<td>Bumbo Latite</td>
<td>Generally porphyritic (but can be aphanitic also) with a fine grained groundmass varying from mid grey to black. Can be vesicular with vesicles partially infilled with a brownish-yellow mineral. Columnar jointing and breccia zones common and also inclusions of metamorphosed sandstones.</td>
</tr>
</tbody>
</table>

### 8.6 General geotechnical conditions

#### 8.6.1 Mount Pleasant

In the vicinity of Mount Pleasant the alignment is underlain by shallow residual soils overlying extremely weathered latite extending to about Ch 320. There is evidence of thin colluvial material overlying the weathered latite. The natural groundwater level could reach 0.5 m below the existing road level (bgl) in this area.

Within the first 200 m of the alignment extensive subsoil drainage work has been undertaken by RTA in early 1987 to stabilise a slip zone on the northern side of the existing highway. A series of six metre deep, with a minimum of one metre wide at the base, soil drains (counterfort drains) were constructed perpendicular to the existing alignment.

The potential for instability as a result of the proposed widening is expected to be very low as the widening would be mainly on the southern side of the highway. However, to maintain the function of the existing drains extending of the drains is required. The cut face appears to be stable at present. However, as the cut face is exposed there is a moderate potential for minor erosion or fretting.

Excavation in underlying soils and rock is likely to be feasible using conventional earthmoving machinery. The excavated soils and weathered rock would be suitable for general earthfill.

#### 8.6.2 Mount Pleasant to Rose Valley Road

The ground profile on both sides of the alignment towards Rose Valley Road is moderately undulating and is underlain by strong blowhole latite under 1.5 m to two metres of residual soils. Groundwater is likely to be deep in this area. This profile continues on approach to the Rose Valley Road interchange.

The latite has vertical and horizontal fracture joints due to the columnar jointing of the material. Some small rock fragments observed at the base of the existing cut indicates moderate potential for material fracturing. The geotechnical information and site topography indicate that the existing ground conditions are suitable for the proposed widening by cut and fill in this section.

Excavation in the underlying soils and weathered rock would likely be feasible using conventional earthmoving machinery. However, excavation in the fresh latite would be difficult and may require blasting. The excavated soils and weathered rock would be suitable for general earthfill whilst the slightly weathered and fresh latite may be suitable as select, rip rap, stone pitching or as drainage blanket material.
8.6.3 Rose Valley Road interchange

At the proposed Rose Valley Road interchange, ground conditions consist of deeper soils varying from three metres to up to seven metres bgl. The soils are residual consisting of very stiff to hard gravelly clay and include latite boulders or thin latite layers. These are underlain by extremely weathered and highly fractured latite overlying moderately weathered latite and sandstone. The natural groundwater level is at approximately two metres to three metres bgl in this area.

The potential geotechnical constraints consist of the following:

- Stability of the steep cuts proposed for the interchange. This will require a permanent retention system. Soil nailed vertical wall with reinforced concrete facing, which has been assessed to be the optimum in terms of constructability, risks and costs.
- Constructability of earth retention systems in soils containing latite boulders or layers which could cause delays.
- Groundwater drawdown has been assessed to likely have minor effects on the existing structures and trees in the vicinity of the cut.
- Constructability of the foundations of the proposed overpass bridge due to the variability of the underlying soils in terms of composition, strength and drillability / drivability of piles. These could cause delays and additional costs.

Excavation of underlying soils and rock is likely to be feasible using conventional earthmoving machinery. Some of latite layers may require blasting or rock breakers. Excavation in the fresh latite and sandstone would be difficult. The excavated soils, weathered latite and sandstone would be suitable for general earthfill whilst any slightly weathered to fresh latite may be suitable as select, rip rap, stone pitching or as drainage blanket material.

8.6.4 Omega Flat

Along Omega Flat the proposed alignment is within an area underlain by estuarine deposits overlying alluvial and residual soils. The bedrock is the Westley Park Sandstone and it was inferred to be present at about 13 m bgl.

The estuarine deposits are very soft to soft, normally consolidated, highly compressible and are assessed to have acid sulfate potential. The alluvial soils are typically interbeded normally consolidated clays and sandy clays overlying gravelly sands at depth. They have soft consistency increasing with depth to firm consistency.

Horizons of very loose to loose sands and gravelly sands are present at isolated locations (likely to be between Ch 1700 to Ch 2040) at varying depths below about five metres of cohesive soils in the estuarine deposits. These horizons include minor contents of silts and clays. Gravelly sands and sandy gravels are present at depth in the alluvial soils to approximately 10 m to 13 m bgl. The granular soils encountered in the estuarine and alluvial deposits have been assessed to be slightly to moderately susceptible to liquefaction.

The geotechnical data indicate a deep paleo-channel up to 13 m deep, which is infilled with the estuarine deposits, alluvium and thin cover of residual soils. It is likely to extend from about Ch 1740 to Ch 1860. It is possible that there are a number of shallow paleo-channels present across the alignment within the Omega Flat area. The natural groundwater level is shallow and it was measured to be at approximately 0.7 m to one metre bgl in this area.
The potential geotechnical constraints consist of the following:

- Excessive on-going settlement in the insitu soils under the embankment of the road widening.
- Stability of the embankment of the road widening.
- Stability of the abutments of the proposed four bridges and one culvert.
- The down drag loads on the foundation piles of the bridges due to the negative skin friction of very soft normally consolidated and highly compressible soils.
- The requirement for deep foundations and associated constructability and cost issues.
- The effects of handling acid sulfate soils during earthworks and effects of these soils on foundations and structural elements of the proposed bridges and culvert.

### 8.6.5 Fern Street extension

An overbridge is proposed for the Fern Street diversion which crosses the South Coast Rail Line. The ground conditions in the Fern Street area are typical of the conditions within the Omega Flat area. The data of the nearest borehole to the bridge site drilled during the latest investigation (BH3) and other boreholes and CPTu soundings positioned in the vicinity of the footprint of the proposed bridge indicate the following:

- The ground profile consists of:
  - One metre of fill which appears to be non-engineered
  - Very soft becoming stiff at depth estuarine sandy clay and clay to approximately six metres bgl
  - Medium dense / stiff alluvial sandy gravelly clay to approximately 9.1 m bgl
  - Soft to firm alluvial clay to 12 m bgl
  - Hard residual soils to approximately 13.2 m bgl
  - Highly weathered Westley Park Sandstone
- Groundwater was encountered at approximately 0.7 m to one metre bgl

The potential geotechnical constraints consist of the following:

- Stability of the embankments of the approach roads and the bridge abutments.
- Settlement of the insitu soils under the embankments of the approach roads and the bridge abutments.
- The down drag loads on the bridge foundation piles due to the presence of very soft normally consolidated highly compressible soils.
- The requirement for deep foundations and associated constructability and cost issues.
- The effects of handling acid sulfate soils during earthworks and effects of these soils on foundations and structural elements of the proposed bridge.

### 8.6.6 Sims Road junction vicinity – end of Omega Flat to Belinda Street interchange

Between the end of Omega Flat and the Sims Road Junction the alignment is underlain by up to 1.5 m of residual soils overlying highly weathered latite becoming slightly weathered with depth. The area between Ch3220 and Ch3580 (near Sims Road) is low lying and includes pockets of alluvial soils.
In the vicinity of the Sims Road junction the alignment crosses an elevated area underlain by up to 1.2 m of residual soils underlain by moderately weathered latite. This profile is visible at the existing exposed cut at the Sims Road junction.

The alignment between the Sims Road junction and the Belinda Street interchange is characterised by a low lying area between Ch3860 to Ch4220 and a hill between Ch4220 to the edge of the Crooked River flood plain where the Belinda Street interchange is proposed.

The low lying area is underlain by up to four metres of alluvial deposit over residual soils. The bedrock is at approximately 6.5 m bgl. The hill is underlain by up to 1.8 m of residual and extremely weathered sandstone. The bedrock under the low lying area and the hill is the Kiama Sandstone which overlies the Blow Hole Latite. The groundwater level is at about two metres to four metres bgl in this area.

The potential geotechnical constraints consist of the following:

- Settlement in the low lying areas under the proposed embankments for road widening.
- Erosion and fretting of the proposed 1V:1H cut batters in the service road in the highly weathered latite.

Excavation in the underlying soils, highly weathered latite and the moderately weathered sandstone at this location will be feasible using conventional earthmoving machinery and the materials will be suitable for general fill only. There is also the possibility of excavation of slightly weathered to fresh latite between chainage 2940 – 3220 that may require blasting or rock breakers. This material may be suitable for select, rip rap, stone pitching or as drainage blanket material.

### 8.6.7 Belinda Street interchange

At the Belinda Street interchange and service road the alignment is underlain by shallow alluvial deposits over deeper residual soils. The latite is at approximately seven metres bgl. The groundwater level is at about two metres bgl in this area.

The potential geotechnical constraints consist of the following:

- Settlement in the alluvial soils under the approximately 8.5 m high proposed embankment.
- The presence of a pond and a small dam.
- Bridging over the Eastern Gas Pipeline (EGP).
- The effects of flooding on the embankment such as erosion and instability.
- The effects of the embankment on the flood path and potential damming effects.
- The requirement for pile foundations for the proposed bridge.
- Stability of the embankment during construction.
- Stability of cuts for the proposed approach road on the northern side.
8.6.8 Crooked River crossing

At the Crooked River crossing the underlying materials consist of 2.5 m of residual soils underlain by extremely weathered latite. In the vicinity of the Crooked River crossing, the proposed alignment also passes through a section of Kiama Sandstone overlying the latite. Alluvial soils are present in the river basin as well as in the area towards Belinda Street intersection.

The potential geotechnical constraints consist of the following:

- The effects of flooding of the Crooked River such as scour and instability on the bridge foundations, embankments and Bailey Road carriageway.
- Settlement under the approximately 4.5 m high proposed embankment.
- The requirement for pile foundations for the proposed bridge.

Excavation that may be required for the river realignment will be feasible using conventional earthmoving machinery.

8.6.9 Willowvale Road intersection

At Willowvale Road the underlying rock is the Kiama Sandstone overlying latite. The red / brown coloured sandstone is visible in the existing exposed cut face immediately west of the Willowvale Road junction. The groundwater level is at about three metres to four metres bgl in this area. The ground conditions are generally favourable for the proposed earthworks in this area.

8.6.10 Gerringong Bends - cut

In the vicinity of the existing shotcreted cutting at Gerringong Bends the alignment is underlain by the Bumbo Latite and the Kiama Sandstone. The Bumbo Latite at this location is vesicular, extremely weathered to highly weathered in nature, down to the interface with the underlying Kiama Sandstone. The groundwater level is at about seven metres to nine metres bgl in this area.

Excavation in the underlying soils and weathered rock would generally be feasible using conventional earthmoving machinery however excavation in the Kiama Sandstone in the vicinity of Ch 5000 to Ch 5200 may require hard ripping. The excavated material would be suitable for reuse as general fill.

Northern side

According to the RTA the shotcreted cutting, as completed in 1999, was steeper than it would be normally due to flatter batters chasing the hillside and to provide room for future duplication of the highway in front of the batter. The batter was shotcreted for erosion protection. The material was volcanic-tuffaceous, vesicular and did not have major discontinuities.

The geotechnical interpretation report indicates that the material underlying the site is extremely weathered latite with some highly weathered latite layers. Other geotechnical information, such as BH7 borelog, indicates that the rock may be highly fractured and some soils would be encountered within the shallow depth of the cut for the proposed road.
The potential geotechnical constraints consist of the following:

- The risk of instability may increase as a result of excavation and increase in the overall height of the benched cut.
- Groundwater flow during excavation as the groundwater level could be above the cut level.
- Erosion of the cut face materials.

Southern side

The geotechnical information indicates the site is underlain by about 14.0 m of residual soil to extremely weathered rock with Standard Penetration Test (SPT) ‘N’ values varying from seven to 16 blows / 300 mm penetration. A weak layer with N value of two blows / 300 mm was encountered at approximately 12.5 m bgl. The groundwater level is about 7.5 m bgl.

The potential geotechnical constraints consist of the following:

- Instability of the proposed 1V:0.75H batter and 9.3 m deep cut.
- Groundwater flow during excavation.

8.6.11 Gerringong Bends - fill

The alignment after the section of shotcreted cutting is underlain by fill of the existing embankment that was constructed in 1998. The natural ground beneath the existing embankment consists of shallow residual soils (in the order of 0.7 m thick) underlain by the Kiama Sandstone. The groundwater level is shallow in the natural soils underlying the existing embankment.

Drainage measures were installed in the foundations and along the toe of the embankment during construction in 1998. The drainage measures incorporated trench drains. Construction was required to bench the surface of the bedrock and the overburden was removed. Cut-off and trench drains were installed near the toe.

The potential geotechnical constraints consist of the following:

- The effects of elevated groundwater level and flooding on the northern side of the alignment.
- Differential settlement under the approximately 7.3 m high proposed embankment widening over the existing embankment.
- Stability of the embankment during construction.

8.6.12 End of Gerringong Bends to Toolijooa Road flood plain

The alignment between Gerringong Bends and Toolijooa Road intersect some existing minor cuttings in residual soils and weathered sandstone. The geotechnical information indicates that in general, alignment is underlain by residual and extremely weathered Kiama Sandstone to approximately one metre bgl overlying highly weathered sandstone. Slightly weathered sandstone extends to approximately 5.7 m bgl overlying the fresh sandstone. The groundwater level is at approximately six metre bgl in this area.
Ch 6050 to Ch 6320

Up to 7.5 m deep cuts are proposed on the northern side the alignment within the section between Ch 6050 and Ch 6320. The results of the geological mapping indicate that the existing cut consists of two parts. The first part is extremely to highly weathered latite, highly fractured to friable. The second consists of extremely weathered to highly weathered sandstone possibly becoming slightly weathered to fresh at depth. The proposed cut slope of 1V:0.75H is assessed to be feasible but requires a permanent retention structure.

The potential geotechnical constraints consist of the following:

- Stability and retention of the 1V:0.75H cut and encroachment on nearby property on the northern side.
- Groundwater flow during excavation and long-term drainage control.

Excavation in the underlying soils and weathered rock will likely to be feasible using conventional earthmoving machinery. However excavation in the slightly weathered to fresh sandstone may require hard ripping machinery or rock breakers. The excavated material will be suitable for use as general earthfill.

Ch 6320 to Ch 6480

The ground conditions are generally favourable for the approximately 2.1 m high proposed embankment in this section.

Ch 6480 to Ch 6700

Construction of the alignment within this section requires up to 6.7 m deep cuts on the northern side of the alignment. The results of the geotechnical investigation indicate the alignment within this section is underlain by approximately 2.5 m of hard residual soils and extremely to highly weathered sandstone overlying moderately fractured sandstone. The groundwater was encountered at approximately 6.2 m bgl.

The potential geotechnical aspects related to the proposed cuts consist of the following:

- Cut batters are currently proposed at 1V:2H.
- Groundwater flow during excavation and long-term drainage control.

Excavation in underlying soils and weathered rock will likely to be feasible using conventional earthmoving machinery. The excavated material will be suitable for use as general earthfill.

8.6.13 Toolijooa Road flood plain

The alignment within the Toolijooa Road flood plain (from Ch 6700 to Ch 7500) is underlain by alluvial to approximately seven metre bgl overlying residual soils. The upper three metres of the alluvial soils consist of soft compressible clays. These are underlain by slightly over-consolidated firm clays becoming stiff with depth. The groundwater level is at six metres to seven metres bgl in this area.

The potential geotechnical constraints consist of the following:

- The effects of flooding such erosion and instability on the proposed embankment.
- Settlement under the approximately 4.5 m high proposed embankment.
• The requirement for pile foundations for the proposed bridge between Ch7050 to Ch7080.

8.7 Geotechnical concept design

8.7.1 Concept design philosophy

The alignment generally requires earth fill to be placed in low lying areas where estuarine, alluvial and residual soils are present and cuttings in areas of residual soils and weathered rock.

Apart from areas such as Omega Flat and the Belinda Street interchange, the ground conditions along the alignment are generally favourable for the proposed geometrical design. Alternative cut batters, stability and drainage measures were assessed necessary for some areas and were incorporated in the geotechnical concept design. Nevertheless, the actual ground conditions may vary with reference to the assumed model and further measures may be required during the detailed design stage and during construction.

The philosophy of the geotechnical concept design is based on the following:

• Achieve the value engineering objectives of the project.
• Attempting to incorporate soft engineering measures, low risk, economical and sustainable solutions.
• Attempting to maintain the aesthetic aspects and avoidance of impact on the local communities and the environment.

This section details the general geotechnical design recommendations for the proposed earthworks, stabilisation measures, ground improvement and structures, followed by details of concept geotechnical design specific for main areas along the alignment of the Gerringong upgrade.

8.7.2 Earthworks – cuts

Existing exposed cut faces indicate the ground profile to be encountered. Proposed cuttings generally correspond to the location of existing cuttings. The cut batters selected by the geometrical design vary from 1V:0.1H to 1V:3H depending on factors such as the ground conditions and land constraints. The geotechnical concept design is based on the following:

• 1V:0.1H to 1V:0.75H batters: These batters are appropriate for fresh or slightly weathered rock with minor fracturing, and where it is expected that minor stabilisation works such as spot bolts would be required. For cuts in weathered or fractured rock stabilisation would be required. These include soil nailing with either thick (precast or cast in situ) reinforced concrete facing or shotcrete. Drainage measures are also required.
• 1V:1H batters: These batters are appropriate for deep cuts in moderately to slightly weathered rock where instability may not be a significant issue and only erosion protection is required. For highly weathered rock, additional stabilisation such as soil nails, shotcrete or teccomesh may be required.
• 1V:2H batters: This ratio is generally suitable for stiff to hard residual soils and extremely to highly weathered rock. Erosion protection measures are typically required.
• 1V:3H batters: This ratio was selected to satisfy the urban design requirements for the Rose Valley Road interchange.
For cuts in soils the upper up to one metre requires chamfering at a lesser slope to reduce the potential effects of erosion.

For all the above options measures such as bored drains can be used to reduce the potential of instability due to elevated groundwater levels. Counterfort drains are typically used for cuts not steeper than 1V:1H.

For significant cuts, suitable erosion protection measures may be required and include hydroseeding, resin based rock facing, geosynthetics and geocells. The selection of the drainage and erosion protection measures would be typically decided during the detailed design stage and during construction.

8.7.3 Earthworks – embankments

The materials resulting from excavation would be predominantly residual soils and extremely to highly weathered sandstone and latite. Most of the material would be clean and have low organic content. Material resulting from alluvial soils would typically require testing for organic matter during construction prior to use in earthworks.

The geotechnical concept design is based on the following:

- Undercutting of about 300 mm of the surface within the footprint of the embankment would be carried out to remove the topsoil and any organic soils that may be present. Weak soils within the surface of existing embankment should also be removed prior to construction. The excavated material can be stockpiled and reused in landscaping. Unsuitable soils, such as those containing high organic and acid sulfate contents, should be cut to waste.
- Benching of the fill into the natural ground or in existing embankments would be required where the slope ratio of the subgrade is steeper than 1V:4H.
- Any existing sub-soil drains or stormwater pipes should be extended for embankment widening.
- Installation of underfill drains during the embankment construction is required where there is a potential for groundwater to be elevated to above the base of the embankments.
- Construction is carried out in stages to avoid increase in the pore water pressure in the foundation soils, existing embankment or the new embankment and the potential for subsequent instability.
- The earthworks would be undertaken in accordance with the RTA specification R44 for ‘earthworks’.
- All works related to ‘vegetation’ should be carried out in accordance with the RTA specification R178.
- The embankment batters are to be hydroseeded
- Provisions for construction of shear keys along the toe of embankments if:
  - There is a potential for creep such as the case of embankments on reasonably steep to steep sloping ground; and
  - There is a potential for deep seated instability through the foundation soils

The typical design fill batter for this project is 1V:2H. This batter is assessed to satisfy the short-term and long-term stability requirements if the fill is engineered, the above requirements are adopted and erosion protection measures are provided.
Similar to the general aspects of the cuts, the adoption and selection of some the measures discussed above (such as the shear key and underfill drains) would be made during the detailed design stage and during construction.

8.7.4 Ground improvement

The Geotechnical Interpretive Report (GIR) by Coffey referenced in Section 8.2 provides detailed assessment of the appropriate ground improvement design for the alignment within the Omega Flat area. Coffey divided the alignment across Omega Flat into three geotechnical models. These are:

- GM1 from Ch1640 to Ch2000
- GM2 from Ch2000 to Ch2480
- GM3 from Ch2480 to Ch2780

The concept design of the ground improvement for the alignment for all the three models is based on the following:

- Placement of a preload surcharge for 12 months duration.
- Installation of wick drains to the following configuration:
  - Width of wick drain of 0.1 m.
  - Triangular grid pattern with one metre to 1.3 m centre to centre spacing.
  - Depth extending to below the estuarine deposits in the alluvial or residual soils.
- Post construction settlement limits of 50 mm to 100 mm over a 40 year design life.
- Total thickness of the fill to be placed for a 50 mm post construction settlement (preload surcharge) is:
  - GM1 – additional fill of two metres to 2.5 m for 2.25 m to 3.25 m embankment heights respectively.
  - GM2 – additional fill of 0.5 m to 1.1 m for two metres to 3.5 m embankment heights respectively.
  - GM3 – additional 500 mm.

8.7.5 Soil nailing

The geotechnical concept design of the soil nailing is based on the following:

- Construction of soil nails would be by staged excavation and include installation of the nails and the facing shotcrete.
- At-rest (Ko) lateral earth pressure will be adopted in the design for near vertical cuts and for critical cases such as for cuts supporting existing or future structures.
- The nails would be positioned at two metres x two metres diamond shape (staggered) distribution with effective spacing of one metre x one metre.
- The number of nails is increased (spacing is decreased) for cuts under shallow footing of bridges.
- The length of the nail is approximately 70 per cent of the cut height and should be adjusted to avoid any existing or proposed buried structure in the retained earth.
- The nails are typically inclined at 15 degrees to the horizontal or at steeper angle to suit the cut inclination.
- The nail diameter to be at least N24 and the nail hole at least 100 mm diameter.
- The nail is of high yield capacity complying to AS4671-2001 and AS1650.
• The steel works of the nails and fittings are hot dipped galvanised for corrosion protection.
• A RC facing 150 mm thick min would be required for cuts steeper than 1V:1H in materials other than slightly weathered to fresh rock.
• Each nail would have a 300 x 300 x 20 mm galvanised steel plate.
• Drainage would be provided by installation of strip drains at about two metre horizontal spacing and have a collection pipe at the toe of the cut discharging into a dish drain at the toe of the cut.

8.7.6  Bridge foundations

The geotechnical concept design of the bridge foundations is based on following:

• Due to the expected loading and the ground conditions all bridges (listed in Table 8.2 below) are to be supported by a pile foundation system. The piles would be either bored or precast RC driven depending on the ground conditions.
• The minimum pile embedment should be to such depth that the “embedment / height ratio” (as defined below) is at least 1:1 in order to satisfy the lateral capacity requirements. This is providing that the bridge deck would prop the piles and substantial lateral forces would not be applied on the piles prior to construction of the bridge deck. For calculation of the “embedment / height ratio”, the embedment depth is the length of the pile below the final ground level. The height is the length of the pile from the top of the pile headstock to the ground level.
• The length of the bored pile would be sufficient to provide a socket length of at least three times the pile diameter into the appropriated rock socket material.

Table 8.2 below provides a summary of the geotechnical concept design for the bridge foundations.

<table>
<thead>
<tr>
<th>Bridge name</th>
<th>Pile type</th>
<th>Approximate minimum pile length below natural ground level / road level</th>
<th>Minimum pile rock socket length</th>
<th>Pile rock socket type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rose Valley Road bridge</td>
<td>Bored</td>
<td>8.0 m</td>
<td>2.7 m</td>
<td>Blow hole Latite and Budgong Sandstones</td>
</tr>
<tr>
<td>Fern Street overbridge</td>
<td>Driven Precast RC</td>
<td>17.0 m</td>
<td>2.25 m</td>
<td>Budgong Sandstones</td>
</tr>
<tr>
<td>Omega Flat bridge STN1700</td>
<td>Driven Precast RC</td>
<td>17.25 m</td>
<td>2.25 m</td>
<td>Budgong Sandstones</td>
</tr>
<tr>
<td>Omega Flat bridge STN1700 SR (service road bridge)</td>
<td>Driven Precast RC</td>
<td>17.25 m</td>
<td>2.25 m</td>
<td>Budgong Sandstones</td>
</tr>
<tr>
<td>Omega Flat bridge STN1900</td>
<td>Driven Precast RC</td>
<td>17.25 m</td>
<td>2.25 m</td>
<td>Budgong Sandstones</td>
</tr>
<tr>
<td>Omega Flat bridge STN2300</td>
<td>Driven Precast RC</td>
<td>15.25 m</td>
<td>2.25 m</td>
<td>Budgong Sandstones</td>
</tr>
<tr>
<td>Bridge name</td>
<td>Pile type</td>
<td>Approximate minimum pile length below natural ground level / road level</td>
<td>Minimum pile rock socket length</td>
<td>Pile rock socket type</td>
</tr>
<tr>
<td>--------------------------</td>
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<td>------------------------------------------------------------------------</td>
<td>--------------------------------</td>
<td>-----------------------</td>
</tr>
<tr>
<td>Omega Flat bridge STN2450</td>
<td>Driven Precast RC</td>
<td>11.75 m</td>
<td>2.25 m</td>
<td>Budgong Sandstones</td>
</tr>
<tr>
<td>Belinda Street bridge</td>
<td>Bored</td>
<td>9.0 m</td>
<td>2.7 m</td>
<td>Bumbo Latite</td>
</tr>
<tr>
<td>Crooked River bridge</td>
<td>Bored</td>
<td>Varies from 5.0 m at the abutments to 6.0 m for the central piles. Additional 2.0 m for scour for the piers adjacent to the river.</td>
<td>2.7 m</td>
<td>Bumbo Latite</td>
</tr>
<tr>
<td>Crooked River service road bridge</td>
<td>Bored</td>
<td>5.0 m</td>
<td>2.7 m</td>
<td>Blow Hole Latite and Bumbo Latite</td>
</tr>
<tr>
<td>Bridge STN7050</td>
<td>Bored</td>
<td>15.0 m</td>
<td>2.7 m</td>
<td>Budgong Sandstones</td>
</tr>
</tbody>
</table>

For the geotechnical ultimate end bearing and shaft adhesion capacities for the main types of pile rock socket reference should be made to the following:

- Table 6.3 of the Coffey GIR for the Budgong Sandstones (Jamberoo Sandstone, Kiama Sandstone, Westley Park Sandstone)
- Table 6.4 of the Coffey GIR for the Blow Hole Latite and Bumbo Latite
- Table 6.5 of the Coffey GIR for the Sandstone beds within Berry Siltstone
- Table 6.6 of the Coffey GIR for the Siltstone beds within Berry Siltstone

### 8.7.7 Bridge abutments

The abutments of the bridges within the Omega Flat area would involve construction of up to six metres (for Fern Street overbridge) embankment over the underlying estuarine and alluvial soils. Differential settlement between the bridge and the embankment is expected to be an ongoing issue and would require regular maintenance even with the use of preload ground improvement within the abutments of the bridges. To reduce the on-going effects of differential settlement the geotechnical concept design for the abutments of the bridges within the Omega Flat area incorporates the following:

- Light weight fill for the construction of the abutments using materials such as polystyrene (commercially known as Polyrock) or any other light weight granular soil such as pumiceous sands and gravels.

Additionally with the following aspects for all other bridges:

- Provide adequate surface drainage and internal drainage (such as pipe drains and weep holes) to reduce the potential for saturation of the abutment backfill soils and subsequent effects related to increase in the pore water pressure in the soils.
• Install a filter material between the abutment backfill soils and the stone pitched facing.
• The use of densely compacted material with the use of geogrid reinforcement for the platform under the approach slab to 1.5 m below the road level.
• The use of steel sleeves for the piles supporting the bridge structure through the abutment soils. A gap of about 75 mm around the bridge pile filled with compacted clean sand would reduce the lateral earth pressure of the abutments on the pile.

8.7.8 Earth retention

Earth retention structures would be required for two areas along the alignment where steep cutting is required due to the restriction imposed by the corridor boundaries. If the cut batters are able to be relaxed earth retention would not be required. However, this would impact on the close proximity dwellings.

Due to the ground conditions consisting of soils or extremely weathered rock steep cuts would be unstable and would require permanent earth retention. The areas where earth retention is required are:

- The southern side of the Gerringong Bends cuts between Ch 5250 and Ch 5800
- The northern side of the alignment after Gerringong Bends between Ch 6050 and Ch 6325

Retaining wall options include solider pile or post and panel walls and gravity wall. These should be designed based on the following:

- A coefficient of active lateral earth pressure $k_a=0.333$ (Active) and coefficient of passive earth pressure $k_p=3$ for general design. A coefficient of lateral earth pressure of $K_o$ (At-rest) where deflection induced by mobilisation of the active earth pressures could impose risk on any existing building or structure above the retained earth.
- An undrained shear strength of $C_u=100$ kPa for embedment in soils and $C_u=500$ kPa for embedment in rock.
- Installation of drainage material behind the retention system is required.
- Additional pressure resulting from elevated groundwater level to mid height of the wall should be allowed for in the design.

For embedded retaining wall systems, the following is recommended:

- The upper 1.5 x pile diameter from the ground level should be ignored in the calculation of the passive resistance.
- A typical embedment length would be equal to the retaining height. However for an inclined wall the embedment length may be less subject to confirmation by calculation.
- The pile / pole spacing should be at maximum 2.5 x the pile diameter.
- Suitable options include:
  - Driven steel piles consisting of 310UC x 96.8 kg galvanised steel sections for the posts and two 150 mm thick x 300 mm wide treated timber planks for the panels. An architectural facing may be required.
  - RC bored piles of 600 mm in diameter with reinforced shotcrete facing for the spacing between the piles, a precast architectural facing would be required for aesthetic reason.
Gravity walls are generally suitable for heights up to four metres. For any gravity wall system the footing of the wall should be keyed into the underlying soils to provide vertical as and horizontal resistance for the wall.

### 8.7.9 Drainage structures

The alignment requires new drainage structures including culverts, stormwater pipes and transverse drains to be constructed mainly within the fill areas. Detention basins are included in the concept design. Pavement drains have been designed to collect surface water within the carriageway and divert water to the stormwater collection system.

The geotechnical concept design of drainage structures is based on the following:

- The culverts and transverse drains are mainly located in the areas underlain by alluvial soils. The founding materials if consisting of weak alluvial soils would require removal and replacement with engineered fill.
- For the stormwater and possibly the transverse drains trenchless technology such as pipe thrusting would be required for new pipes through the existing highway embankment. The ground conditions in the areas where the drains are proposed consist of mainly estuarine, alluvial or residual soils. Pipe thrusting in general is feasible in these soils. Adequate measure as a protection against erosion and scour near the inlets and outlets consisting of riprap underlain by geotextile would be provided.
- The detention basins would have a typical design consisting of 1V:2H inside batter and 1V:3H outside batter. The width at the top of the bank is three metres wide. The basins have been designed for water depth of 1.5 m. Two ponds were designed for two metres water depth. The embankment material would consist of engineered cohesive soils. Appropriate scour protection consisting of riprap underlain by geotextile would be provided for the inlet and spillway structure.

### 8.8 Site specific geotechnical concept design

#### 8.8.1 Mount Pleasant

The concept design avoids interfering with the stabilised slip area by widening the road on the down-slope side. Widening on the down-slope is not likely to require extensive stabilisation techniques but would require extension of the existing subsoil drainage network.

The potential for instability as a result of the proposed widening is expected to be very low as the widening would be mainly on the southern side of the highway. Excavation would not intercept the existing drains however, the drains should be located, cleaned and extended to the southern side. Outlet structures would be required which would typically include erosion protection measures such as gabion baskets. The excavation and reuse of material is outlined in Section 8.6.1.

Design and construction of the cuts and embankments should be based on the recommendations made in Section 8.7.2 and Section 8.7.3.

#### 8.8.2 Mount Pleasant to Rose Valley Road

Widening for the existing carriageway of the alignment consists of 1V:2H fill batters and 1V:1H cut batters. Cutting in the latite would have a similar appearance to existing cuttings.
One of the fill sections involves up to 4.2 m high embankment between Ch820 to Ch1080. There are no expected issues with regards to the fill. Placement of underfill drains would be advantageous in terms of maintaining the existing surface and subsoil drainage regimes under the fill.

Deep cuts (up to 4.5 m) would be required to the south of Omega Lane on the northern side of the alignment.

Excavation in the fresh latite would likely require rock breakers or blasting. Alternatively if blasting techniques would cause excessive vibrations to nearby residents Penetrating Cone Fracture (PCF) type techniques or expansive grouts for rock breakage purposes may be used. The excavation and reuse of material is outlined in Section 8.6.2. Design and construction of the cuts and embankments should be based on the recommendations made in Section 8.7.2 and Section 8.7.3.

8.8.3 Rose Valley Road interchange

The interchange requires the highway to be cut in 'slot' over a short length between Ch 1460 and Ch 1580. The slot requires excavation up to 10 m deep in material varying from residual soils to highly weathered latite and sandstone. The ultimate six lane configuration would require a vertical cut face. It is proposed to adopt a near-vertical face in the interim four lane configuration and trim this to vertical in the future to accommodate six lanes. Soil nailing is the proposed solution for retaining the near-vertical cut for the four and six lane configurations with design and construction of the soil nailing based on recommendations made in Section 8.7.5. A greater density of nails would be required in the residual soils. An architectural precast panel would be used to face the entire cut face. Drainage works in the form of strip drains would be required between panels of soil nails. Construction of the soil nailing would involve in staged construction and excavation. The excavation and reuse of materials is outlined in Section 8.6.3.

The cuts before the slot are proposed to be at 1V:1H batter on the eastern side with a 1V:0.4H section at approximately Ch 1280. The cuts before the slot on the western side are proposed to be at 1V:3H batter. The cuts after the slot would be minor.

Settlement is not expected to be a significant issue as construction of the interchange would involve in cutting of a slot for the carriageway. Embankments for the approach roads would involve placement of fill at 1V:2H batters. Based on the geotechnical information there are no significant issues such as stability and settlement expected in the soils underlying the site.

The design and construction of the cuts and embankments should be based on the recommendations made in Section 8.7.2 and Section 8.7.3.

The latite encountered in the investigation at approximately 3.75 m bgl is highly jointed and the top of the unjointed (fresh) Westley Park sandstone layer at about nine metre bgl. Construction of the foundations would require the headstock of the bridge foundation at both abutments to be supported on piles socketed into the underlying unjointed sandstone. The embedment depth of the piles depends on the position of the piles with reference to the face of the cut. However, it may require the piles to be socketed to a significant depth below the highway cut level to satisfy the overall bridge foundation stability requirements. Bored piles would be required.

The design and construction of the bridge pile foundations should be based on the recommendations made in Section 8.7.6.
8.8.4 Omega Flat

An approximately four metres to five metres high embankment is required to provide flood immunity for the proposed alignment across Omega Flat. Due to the variation in the compressibility and thickness of the underlying estuarine deposits construction of the embankment would result in excessive differential settlement and possible instability in the shoulders of the embankment. Ground improvement comprising a combination of pre-loading and wick drains is considered to be the optimum solution in terms of densification of the underlying soils by consolidation and also in terms of accelerating the consolidation rate in order to complete at least 90 per cent of the primary settlement within a time frame appropriate to the project. To avoid future construction difficulties and reduce the risk of differential settlement, the embankment would be constructed to the ultimate six lane width but accommodate four lanes initially. If instead, the embankment is only constructed to the four lane configuration, additional preloading would be required when the road is ultimately extended. The embankment would have batter slopes of 1V:2H. Embankment for the four lane case is benched to satisfy drainage requirements.

Pre-loading would not be required where the existing highway alignment is re-constructed (Ch 2300 - Ch 2800) to become the southbound lanes of the alignment. In these areas the underlying soils have been consolidated under the existing highway embankment.

Details of the concept design for ground improvement is provided in Section 8.7.4. It is intended that no soils would be removed from this site except topsoil from within the footprint of the proposed embankment. However, there is a requirement to provide a shear key along the toe of the embankment on the western side to mitigate against the potential for a deep seated failure in the foundations soils. This would involve excavation of the soils within the toe and replacement with either compacted imported fill (usually crushed rock) or by cement or lime stabilisation of the insitu soils. Alternatively strengthening of the foundation soils may be achieved by construction of a toe buttressing berm. This would be provided as part of the proposed benched batter for the four lane road widening. Construction of a pseudo buttressing berm for the future widening of the road to six lanes may require placement of additional preload fill to reduce the potential effects of differential settlement.

Construction would need to take into consideration the RTA Acid Sulphate Soil Management Plan for the earthworks within this area.

The design and construction of embankments should be based on the recommendations made in Section 8.7.3.

The piers and abutments of the proposed bridges for crossing the watercourses across the alignment and the Fern Street diversion would be supported by deep driven precast piles socketed into the sandstone which is greater than 13 m in depth in this area.

The design and construction of the pile foundations for the Fern Street overbridge and all other bridges in the Omega Flat area, including the service road bridge should be based on the recommendations made in Section 8.8.7. Some of the concept design details of the culvert for crossing some of the water courses are included in Section 8.8.7.
8.8.5  Sims Road junction vicinity - end of Omega Flat to Belinda Street interchange cuts and fills

The existing highly weathered latite cutting in the vicinity of Sims Road to Belinda Street interchange supports a batter slope of steeper than 1V:1H. The proposed cutting in this vicinity would be in the order of 5.5 m deep with a batter slope of 1V:1H. The upper up to one metre of soils would require chamfering at a lesser slope to reduce the potential effects of erosion. Erosion protection may be required for the cuts in this area due to the nature of material present in the cuttings. The cutting between Ch 3540 and Ch 3880 may also require additional stabilisation in the form of soil nailing or teccomesh. The excavation and reuse of materials is outlined in Section 8.6.6.

The design and construction of cuts and embankments should be based on recommendations made in Section 8.7.2 and Section 8.7.3.

8.8.6  Belinda St interchange

The approximately 8.5 m high embankment spanning the Belinda Street interchange is located in an area underlain by shallow alluvial soils over residual soils. To reduce the potential for excessive differential settlement the approximately two metres deep alluvial soils require removal prior to construction of the embankment. Dewatering and undercutting the in situ soils within the existing pond would be also required prior to construction.

Particular attention to the spanning of the EGP will be required. Structural systems such as piled slabs straddling the EGP would assist in avoiding the imposed vertical stresses on the pipe. The piles would require socketing into the latite to reduce the potential for pile settlement.

The embankment batter slope for the ultimate six lane configuration is 1V:2H. In the interim four lane configuration the batter slope is variable and slightly less than 1V:2H.

The design and construction of embankments should be based on the recommendations made in Section 8.7.3.

Some cuttings are required on the proposed service road on the northbound on ramp. These cuttings will involve excavation in shallow alluvial soils and residual soils over moderately to slightly weathered sandstone and would be feasible with conventional excavation machinery. The design and construction of the cutting should be based on the recommendations made in Section 8.7.2.

The abutments of the proposed bridge would be supported by deep bored piles socketed into the latite which is at approximately seven metres in this area. The design and construction of the bridge pile foundations should be based on the recommendations made in Section 8.8.7.

8.8.7  Crooked River bridges and Willowvale Road intersection

The proposed alignment requires a five span bridge over the Crooked River and Baileys Road / Willowvale Road intersection. Baileys Road would be extended under the bridge and connected to the Belinda Street / Willowvale Road service road. A two span bridge would be required for the service road. An underpass for cattle would be provided under the service road bridge. Crooked River would be realigned and would be provided with scour protection.

The design and construction of the pile foundations for Crooked River and the service road bridges should be based on the recommendations made in Sections 8.8.7.
8.8.8  Gerringong Bends cuts

The alignment requires the existing cutting to be deepened at this location to approximately eight metres below the toe of the existing shotcrete stabilised cuts on the northern side of the alignment.

It is proposed to introduce another bench and face to the northern side of the existing cutting. The additional face would be cut at a similar slope to the existing faces at 1V:0.75H. The proposed batter slope is 1V:0.75H.

Northern side

The vesicular latite that would be encountered during cutting is prone to weathering and the additional face would require erosion protection. It is proposed to adopt shotcrete to be consistent with the treatment adopted for the remainder of the cutting on the northern side of the highway.

To achieve the design batter it is recommended that the cut is be made in staged excavation with application of shotcrete and installation of strip drains under the shotcrete facing or bored drains as assessed appropriate. At this stage, it has been assessed that the proposed cutting would not affect the stability of the existing cutting, however, further investigation and assessment would be required during the detailed design stage to confirm the cut stability. It would also be prudent to allow for installation of soil nailing should the material encountered during the excavation be very weak and highly fractured rock and assessed to have a potential for localised instability.

The design and construction of cuts should be based on recommendations made in Section 8.7.2. Excavation and reuse of material is outlined in Section 8.6.10.

Southern side

The results of the geotechnical investigation indicates the ground profile at the southern side of the highway comprises up to 14 m of residual to extremely weathered soils. The steep batter slope of 1V:0.75H is required to limit encroachment into adjacent properties. There is a risk of mobilisation of the strength of the insitu soils which could lead to soil movement. Soil nailing may not satisfy the long-term stability requirements for the cut. An earth retention system would be required to retain the 1V:0.75H cut. An inclined or near vertical embedded retaining structure such as soldier pile or post and panel wall would be required and likely to be the optimum in terms of constructability, cost and achievement of the design objectives.

Design and construction of the retaining wall should be based on recommendations made in Section 8.7.8.

8.8.9  Gerringong Bends fill

The existing embankment on the western end of the Gerringong Bends between Ch 5820 to Ch 6040 requires significant widening. The existing embankment was constructed in 1998 to the south of the old Princes Highway. The old Princes Highway carriageway is still present to the north of the existing embankment. The embankment will be constructed to suit the ultimate six lane configuration to avoid further incremental widening in the future.
The height of the highway surface would be increased by one metre to two metres from existing and the maximum effective fill depth to the south of the existing embankment would be 7.3 m. The proposed embankment would adopt a similar batter slope to the existing slope, which is 1V:2H. Previous earthworks incorporated cut-off and trench drains to intercept seepage on the bedrock surface. Widening of the existing batter would require benching the batter and locating and extending trench drains. Existing cross drainage structures would also need to be extended.

A natural spring emanates from the toe of the existing embankment. Previous embankment widening work avoided interfering with this spring which supplies a dairy at the base of the embankment. It would not be possible to avoid embankment works in the vicinity of the spring with the widening required by the alignment. The spring would be intercepted and piped to the new embankment interface.

Widening on the existing embankment should be carried out by benching into the existing batter, which should enable the trench drains to be located and continued through the batter widening. In any case the widening at bedrock level should include a longitudinal interceptor trench drain with appropriate outlets.

As the existing embankment was constructed more than ten years ago it is expected that the soils would have consolidated. The potential of differential settlement in the existing embankment under the additional stresses resulting from the embankment widening is expected to be minor to moderate. The potential for differential settlement can be reduced by carrying out the work in staged fashion. Allowance should be made for placement of minor additional fill to compensate for the minor settlement that would occur after the embankment construction is completed, which could occur between six months to 12 months from construction.

Due to the proposed embankment widening, the area that is currently providing some attenuation for stormwater on the northern side of the highway would be reduced and the capacity of the existing drains may not be sufficient. In order to reduce the potential for flooding in the area upstream (northern side) of the embankment and subsequent saturation of the embankment material additional drains may be required. The additional pipes may require the use of trenchless technology. Placement of toe drainage blanket and strip drains within the embankment widening on the downstream (southern side) of the embankment would reduce the potential for saturation of the southern shoulder of the embankment.

In summary the design and construction of the embankment widening should be carried out taking into consideration the general recommendations made in Section 8.8.7. In addition:

- Any weak soils within the foundation should be excavated to enable the embankment to be keyed into the stiff to hard residual or extremely weathered rock.
- The existing drains should be located and extended through the embankment widening.
- Construction of a longitudinal interceptor trench drain with appropriate outlets at the bedrock level at the toe of the eastern side.
- Relocation of the inlets and the outlets of the drains would be required.
- All existing sediment traps, rock mattresses and catch drains should be relocated and reinstated.
- Installation of drainage measures such as drainage blanket and strip drains under the embankment widening on the eastern side of the embankment is recommended.
8.8.10  Gerringong Bends to Toolijooa Road flood plain cuts and fills

From Ch 6050 to Ch 6320

Initially it was proposed that a 1V:0.75H cut be made on the northern side to avoid encroachment onto a nearby property. At this cut batter there is a risk of mobilisation of the strength of the insitu materials if unsupported which could lead to unacceptable soil movement. Soil nailing may not satisfy the long-term stability requirements for the cut. An earth retention system would be required to retain the 1V:0.75H cut. An inclined or near vertical embedded retaining structure such as soldier pile or post and panel wall would be required and likely to be the optimum in terms of constructability, cost and achievement of the design objectives.

Design and construction of the retaining wall should be based on recommendations made in Section 8.7.8.

However, we understand that the RTA is considering purchasing the affected property so that earth retention is not required in this area. If this is the case, then a batter slope of 1V:2H would be appropriate for a cut with no retention measures.

The southern side of the cut is at a batter of 1V:1H and should be designed and constructed based on the recommendation in Section 8.7.2. Excavation and reuse of the excavated material is outlined in Section 8.6.12.

From Ch 6320 to 6480

The ground conditions are generally favourable for the approximately 2.1 m high proposed embankment in this area. Design and construction of the embankment should be based on the recommendations in Section 8.7.3.

From Ch 6480 to 6700

In this area, batters of 1V:2H have been proposed however batters of up to 1V:1H are possible. If the steeper batter option is adopted soil nailing would be required. Soil nailing should be designed and constructed based on the recommendation in Section 8.7.5 and cuts should be based on recommendations in Section 8.7.2. Excavation and reuse of the excavated material is outlined in Section 8.6.12.

8.8.11  Toolijooa Road flood plain fill

An up to 4.5 m high embankment is required to span a low lying area from approximately Ch 6700 to Ch 7300. Alluvial deposits in this low lying area extend to about 8.5 m bgl. The upper three metres of the alluvial deposits are soft and very compressible underlain by less compressible soils. Ground improvement by pre-loading would be required to reduce the potential effects of differential settlement on the embankment. Wick drains would not be required as the thickness of the compressible soils is limited to three metres.

Pre-loading would not be required where the existing highway alignment is re-constructed to become the southbound lanes of the alignment. In these areas the underlying soils have been consolidated under the existing highway embankment.

The design and construction of the embankment should be based on recommendations made in Section 8.7.2. Ground improvement should be based on Section 8.7.4.

The design and construction of the pile foundations of the bridge Ch 7050 should be based on the recommendations made in Section 8.7.7.
8.9 Detailed design stage geotechnical input

Additional geotechnical investigation would likely be required for the detailed design stage together with detailed geotechnical analyses and designs. The locations of the areas requiring detailed input and the extent of the input would typically be assessed during the detailed design stage based on the available geotechnical information and the geometrical design of the detailed design stage. The areas and structures that would likely require significant input are summarised below.

- Rose Valley Road interchange.
- Omega Flat and Ferns Street overbridge.
- Belinda Street interchange.
- Crooked River bridges.
- Gerringong cuts.
- Flood Plain, 600 m east of Toolijooa Road.

8.10 Quantities

The development of the concept design is influenced by many sometimes competing objectives. The achievement of an earthworks balance is desirable as the movement of earthworks within the project and the need to import or export material has a significant influence on the cost of the project. At concept design stage it is desirable to attempt to balance cut and fill volumes by adjusting the vertical alignment if necessary. Consideration is also given to the suitability of the material sourced from within the project for use as select material, concrete or asphalt constituents, or erosion protection. A detailed assessment of earthworks quantities, material suitability, bulking factors and mass haul is undertaken in the detailed design phase.

Significant adjustment to the vertical alignment of the concept design was not necessary to achieve an approximate balance on the basis of bank volumes. The total cut volume is estimated as 450,000 cubic metres. The total fill volume is estimated as 360,000 cubic metres. The 90,000 cubic metres excess in cut volume provides an allowance for unsuitable material of 25,000 cubic metres, material for the select material zone of 60,000 cubic metres, and material for preloading of soft soil areas of 5,000 cubic metres. These volumes do not consider the range of bulking factors that will apply to the various material types. The overall estimate for earthworks indicates that a cut / fill balance is achievable for this project.
9 Urban design

The concept urban design for the proposal was undertaken using the urban design objectives and principles following a visual impact analysis and contextual analysis of the surrounding area. The specific urban design treatments resulting from the analysis are presented in this report. The comprehensive analysis can be found in the *Urban Design, Landscape Character and Visual Impact Assessment*.

9.1 Urban design objectives

The six objectives and design principles that make up the urban and regional design framework for the proposal are:

1. Provide a flowing highway alignment that is responsive and integrated with the natural landscape.
2. Protect the natural systems and ecology of the corridor.
3. Protect and enhance the heritage and cultural values of the corridor.
4. Respect the communities and towns along the highway.
5. Provide an enjoyable, interesting highway with strong visual connections to the Pacific Ocean, immediate hinterland and mountains to the west.
6. Develop a simple and unified palette of elements and details that are easily maintained.

The unifying philosophy behind these various objectives is the goal to develop an upgraded highway that not only meets functional and engineering criteria, but one that respects the environment in which it is situated.

9.2 Key features

Key features of the proposal as they relate to the urban and landscape design are:

- New grade-separated interchange at Rose Valley Road including raising Rose Valley Road and a service road to Fern Street.
- New bridge at Fern Street over the railway line.
- Embankments to lift Fern Street access.
- Cutting through knoll adjacent to Gerringong township.
- Deep cutting near Sims Road adjacent to Gerringong township.
- Large embankment and raising of the highway across Omega Flat.
- New grade-separated interchange at Belinda Street combining a service road to Willowvale Road.
- Large embankment approaching Crooked River.
- Deep cutting past Crooked River.

The proposal route and the location of the key elements are illustrated in Figure 9.1.

9.3 Urban design response

The design principles and objectives are addressed in the proposal as outlined in Table 9.1.

Table 9.1: How the urban design principles and objectives are addressed in the proposal design

<table>
<thead>
<tr>
<th>Objective #1</th>
<th>Design principles</th>
<th>Design responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provide a flowing highway alignment that is responsive and integrated with the landscape</td>
<td>Respond to the grain of the landscape in route selection, including following the edge of valleys and hills, and avoiding disruption of stands of vegetation including both natural vegetation and cultural plantings.</td>
<td>The proposal comprises an upgrade, including widening, of the existing highway alignment. The surrounding landscape has developed around the existing road for the past 80+ years. The proposal would therefore have impact on any adjacent stands of cultural vegetation that have evolved over time. At the Rose Valley Road interchange, the alignment has been designed to preserve the most established Moreton Bay Fig tree which has cultural significance for both Aboriginal and non-Aboriginal heritage. The vertical alignment has been designed to improve grades and improve road safety. Nevertheless, the road generally responds to the natural grain of the landscape by following the existing contours through the landscape and utilising the existing road alignment.</td>
</tr>
</tbody>
</table>
### Objective #1
Provide a flowing highway alignment that is responsive and integrated with the landscape

<table>
<thead>
<tr>
<th>Design principles</th>
<th>Design responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>2  Integrate cut and fill embankments with surrounding terrain by grading out and varying slopes.</td>
<td>Cut and fill embankments would integrate with the adjacent landscape and be assessed at a detail level in each case based on geotechnical options, slope, aspect and existing adjacent landscape character.</td>
</tr>
<tr>
<td>3  Consider independently grading carriageways.</td>
<td>Generally, the nature of the landform surrounding the proposal does not require the consideration of independently graded carriageways.</td>
</tr>
<tr>
<td>4  Preservation of cultural patterns in the landscape.</td>
<td>The proposal would include small integrated interventions to cut and fills slopes and revegetation to essentially preserve the cultural patterns. This would be achieved by reinforcing the patterns of the broader landscape context.</td>
</tr>
<tr>
<td>5  The alignment should avoid as much as possible significant features of the areas through which it passes.</td>
<td>The impact of significant features would be minimised as far as practicable without compromising road safety. The interchange at Rose Valley Road has been designed to minimise the impact on a culturally sensitive area comprising mature Moreton Bay Fig trees and Renfrew Park Estate. The healthiest of the three Moreton Bay Fig trees would be preserved and become part of the landscaping 'gateway' introducing motorists to Gerringong.</td>
</tr>
</tbody>
</table>
| 6  Vary the gradient of the earthworks to provide visual interest and reflect the characteristics of the surrounding landform and landscape | Earthworks would be integrated by understanding the opportunities and constraints identified by the geotechnical investigations. A number of embankment strategies have been developed to:  
  • Increase the usability of pasture land adjacent to the road and integrate the highway with the surrounding landscape.  
  • Reduce the visual impact of cuttings and embankments by introducing plantings to the base and top of new batter where practicable. |
| 7  Cuttings and embankments should be graded out, wherever practicable, to best fit the characteristics of the local landform, returning the land to either its former use or replacing vegetation lost to the highway upgrade. | Cuttings and embankments would be graded out to be integrated with the local landform, land coverage and land use. Areas of vegetation lost would be reinstated. |
### Objective #2
**Protect the natural systems and ecology of the corridor**

<table>
<thead>
<tr>
<th>Design principles</th>
<th>Design responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Avoid areas of natural vegetation, particularly those containing threatened species and communities.</td>
<td>Since much of the landscape has been cleared for agricultural purposes, some of the remaining vegetation is within the current road reserve and would be impacted during construction. Impact to threatened species and communities would be minimised and any natural vegetation removed would be replaced and rehabilitated.</td>
</tr>
<tr>
<td>2 Minimise disruption to natural drainage patterns both through route selection and road design.</td>
<td>Existing drainage systems would be retained and improved where appropriate. Undersized existing drainage structures would be upgraded to meet capacities required to minimise disturbance and reduce flooding during peak rain events particularly to the Omega Flat area. New bridges would traverse the Crooked River.</td>
</tr>
<tr>
<td>3 Minimise the number of creek crossings in the study area.</td>
<td>Creek crossings would be kept to a minimum.</td>
</tr>
<tr>
<td>4 Use medians and road verges to maximise habitat value and maintain pollination paths and wildlife movement patterns where feasible.</td>
<td>The areas for planting included the embankments associated with new interchanges at Rose Valley Road, Belinda Street and Willowlane Road, new embankments along Omega Flat and ribbon plantings along property boundaries and waterways. Plantings would also be made at the base of new cuttings where possible. Median widths are not sufficient to support plantings. Generally the median would consist of pastoral grass reestablishment which reinforces the landscape context.</td>
</tr>
<tr>
<td>5 The landscape qualities and characteristics of the highway corridor landscape should respond to and be integrated with the areas through which it passes.</td>
<td>The proposal passes through four landscape unit types. These differ in vegetation type, land use and land form. The highway corridor would reflect the differences in these landscape units and their associated patterns.</td>
</tr>
<tr>
<td>6 Water quality basins should be integrated with the landscape form and character</td>
<td>Water quality basins would be integrated into the landscape to best represent how water bodies appear in the natural landscape. This could be done by creating organic shapes, a low profile form by reducing steep batters, placing naturalistic objects in and around the basins and planting throughout the basin with native grass and ephemeral plant species.</td>
</tr>
</tbody>
</table>
# Objective #3

Protect and enhance the heritage and cultural values of the corridor

<table>
<thead>
<tr>
<th>Design principles</th>
<th>Design responses</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1</strong> Avoid items of identified Aboriginal and non-Aboriginal heritage and cultural value.</td>
<td>The intersection of Rose Valley Road and the proposal is located adjacent to Renfrew Park and close to three mature Moreton Bay Fig trees. Due to safety concerns, the interchange design would impact on two of the fig trees but preserve the most established specimen which has Aboriginal and non-Aboriginal cultural value (to Renfrew Park Estate). Strip acquisition of the Renfrew Park Estate grounds, including one fig tree, would be required to accommodate the new interchange.</td>
</tr>
<tr>
<td><strong>2</strong> Acknowledge and respond to the heritage and cultural values of the rural landscape.</td>
<td>Important values and connections to the cultural landscape would be maintained by using ribbon plantings to emphasise property boundaries and waterways and reducing continuous roadside plantings that restrict broader views. The harmonious balance of the cultural and rural landscape would be reinforced by the urban design related works as outlined in the concept design.</td>
</tr>
<tr>
<td><strong>3</strong> Acknowledge and respond to Aboriginal value placed on the broader landscape.</td>
<td>The design would consider the recommendations of the heritage consultant and the Aboriginal focus group.</td>
</tr>
<tr>
<td><strong>4</strong> Reduce the visual and noise impact of the highway through the design of the proposal.</td>
<td>Visual and noise impact to local residents would not be significant as the upgrade is mostly separated from residents in Gerringong by the rail corridor. The proposal adjacent to the most populated section of Gerringong would be in cutting for some of its length, which would reduce visual and noise impacts on Gerringong. Installation of noise attenuation adjacent to the highway would be considered during detail design to reduce noise impacts for nearby residents with plantings to reduce visual impacts of the noise attenuation.</td>
</tr>
<tr>
<td><strong>5</strong> Consider the important value of the productive landscape within the landscape.</td>
<td>As the proposal is essentially a widening of the existing alignment the amount of productive landscape impacted would be minimised. New works would be integrated with the surrounding landscape to maximise productive use of land, for example, by merging landscape to the road edge, reducing slopes to batters to allow grazing of rural animals on edges.</td>
</tr>
<tr>
<td>Objective #4</td>
<td>Protect and enhance the heritage and cultural values of the corridor</td>
</tr>
<tr>
<td>-------------</td>
<td>---------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Design principles</strong></td>
<td><strong>Design responses</strong></td>
</tr>
</tbody>
</table>
| 1 | Minimise the impact of the highway upgrade on the amenity of residents of Gerringong.  
   The visual impact of the proposal itself on Gerringong would be minimised by providing suitable cultural and indigenous planting, providing a refined, simple bridge connection to Fern Street over the railway line and considering noise attenuation as appropriate. |
| 2 | Provide effective and efficient access to Gerringong.  
   The number of access movements for entering and exiting Gerringong would be increased from seven to eight. The upgraded interchanges would include landscaping and plantings to provide a legible gateway at the Rose Valley Road interchange and at the Belinda Street interchange to include way-finding and visual connectivity. |
| 3 | New town access points to be designed as an important and integral part of the town, ensuring a clear and consistent way showing.  
   The new town access points comprise the largest new footprint associated with the proposal. This space would be part of a combined strategy for providing connection to the towns and would include the use of cultural plantings and locally derived materials (stone and gravels). In the case of Gerringong the strong historical plantings of Norfolk Island Pines are a distinctive identifying feature and would be reiterated at the interchanges and access points. |
| 4 | Minimise the disruption and loss of amenity to rural communities in the study area.  
   There would be a small loss of amenity to rural communities with the increased footprint of the proposal. Access points are provided at Rose Valley Road and Willowvale Road. The revegetation strategy would provide a balance of visual screening and reinforcement of the existing landscape character to minimise the loss of amenity to rural communities. |
**Objective #5**
*Provide a safe, enjoyable and interesting highway with strong visual connections to the Pacific Ocean, immediate hinterland and mountains to the west*

<table>
<thead>
<tr>
<th>Design principles</th>
<th>Design responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Acknowledge the role of this section of Princes Highway as an important part of a longer scenic drive along the NSW South Coast.</td>
<td>The proposal has a visual connection to the ocean, township, rural land and forested escarpment. The descent from Mount Pleasant provides the first real experience of the rural landscape south of Sydney and is a gateway to the rural south coast. The urban design strategy takes advantage of this by maximising broader views, integrating the upgrade with the existing landscape and using planting and design techniques for infrastructure that are culturally and visually relevant within the landscape context.</td>
</tr>
<tr>
<td>2 Maximise opportunities for high quality and varied views of the coast, the rural landscape and adjacent mountain ranges.</td>
<td>The proposal would increase the opportunities for experiencing the coast, rural landscape and adjacent mountain ranges by opening up views across the rural landscape towards the coast and mountain ranges. Views would be directed by ribbons of culturally relevant planting and reducing restrictions such as continuous planting along the road edge and continuous deep cuttings.</td>
</tr>
<tr>
<td>3 Provide visual connections and easy, well marked access to the towns along the route.</td>
<td>The proposal locates the new south bound entrance (north of Gerringong) a further 1.2 km away from town, when compared with the existing entrance. Visual connection with the town is enhanced by reiterating plantings that exist within the town, providing way-finding signage and including ‘gateway’ design plantings at the interchange. The entrance at Belinda Street would improve the visual connection with Gerringong as the highway would no longer dip into the Crooked River catchment as it does currently. This would keep the town in full view on approach from the south.</td>
</tr>
<tr>
<td>4 Use landscape treatments to soften the appearance of the road for the road user without compromising opportunities for key views.</td>
<td>The majority of the proposal elevates the road user (especially across Omega Flat). The landscape treatment would be a balance between reinforcing the existing landscape character and mitigating noise impacts for Gerringong residents. Landscaping would be used particularly around new interchanges and adjacent to potential noise attenuation and new cuttings where possible. Views across the rural landscape to the coast and towns would not be substantially or continuously compromised.</td>
</tr>
</tbody>
</table>
### Objective #5
**Provide a safe, enjoyable and interesting highway with strong visual connections to the Pacific Ocean, immediate hinterland and mountains to the west**

<table>
<thead>
<tr>
<th>Design principles</th>
<th>Design responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>5. Consider the heritage of the highway in the upgrade so that where practicable road users may experience it.</td>
<td>Much of the heritage along the proposal is able to be experienced by the user through the broader visual engagement with the landscape. Heritage values that can be experienced include the road passing in close proximity to Renfrew Park as well as the opportunities for a gateway entrance into this area with the large Moreton Bay Fig trees.</td>
</tr>
</tbody>
</table>

### Objective #6
**Develop a simple and unified palette of elements and details that are easily maintained**

<table>
<thead>
<tr>
<th>Design principles</th>
<th>Design responses</th>
</tr>
</thead>
</table>
| 1. Develop a consistent approach to the development of bridges along the highway upgrade. Urban design principles to be consistent with those outlined in the RTA’s ‘Bridge Aesthetics- Design guidelines to improve the appearance of bridges in NSW’ (RTA 2003). | There would be four important bridges associated with the proposal:  
- The bridge over the highway at Rose Valley Road.  
- The bridge over the existing railway line that joins to Fern Street.  
- The bridge over Belinda Street at the interchange.  
- The bridge over the Crooked River.  
All of these bridges are designed as simple, elegant forms sympathetic to the surrounding landscape rather than as gateway elements. |
| 2. Develop a consistent approach to the design of noise attenuation along the highway upgrade. Urban design principles to be consistent with those outlined in the RTA’s ‘Noise Wall Design Guidelines- Guidelines to improve the appearance of noise walls in NSW’ (RTA 2007). | Noise attenuation during detailed design and plantings would be considered to screen possible elements as appropriate. |
| 3. Develop an integrated strategy for the avoidance, minimisation and improved appearance of shotcrete as outlined in the RTA’s ‘Shotcrete Design Guidelines- Design guidelines to avoid, minimise and improve the appearance of shotcrete’ (RTA 2005). | A detailed geotechnical investigation would be undertaken during detail design to investigate actual need for shotcrete and minimise use where possible. |
| 4. Develop a consistent approach to the design of soft landscape along the highway upgrade. Planting design principles to be consistent with those outlined in the RTA’s ‘Landscape Guideline- Landscape design and maintenance guidelines to improve the quality, safety and cost effectiveness of road corridor planting and seeding’ (RTA 2008). | The proposal includes soft landscaping at the new interchanges, along embankments and at property boundaries and creek crossings, as well as along the upgrade route as appropriate. The proposal does not pass through large stands of existing vegetation but mostly pasture lands with isolated clumps of either remnant or mostly historic cultural plantings. |
10 Public utilities impacted by the project

The proposal interacts with various major and minor utilities. The impact on these utilities and any potential required adjustment was considered in the route identification and assessment stages of the project. Following is a description of the impact and likely adjustment to significant utilities impacted by the proposal. The significant utilities impacted by the proposal are summarised in Table 10.1 and shown in Figure 10.1.

<table>
<thead>
<tr>
<th>Utility</th>
<th>Authority</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>Integral Energy</td>
<td>33 kV and low voltage distribution</td>
</tr>
<tr>
<td>Sewage and water</td>
<td>Sydney Water</td>
<td>375 mm potable water main</td>
</tr>
<tr>
<td>Gas</td>
<td>Jemena</td>
<td>450 mm diameter 15 MPa main (Eastern Gas Pipeline)</td>
</tr>
<tr>
<td>Telecommunications</td>
<td>Optus</td>
<td>Sydney-Melbourne optic fibre</td>
</tr>
<tr>
<td></td>
<td>Telstra</td>
<td>Sydney-Melbourne optic fibre</td>
</tr>
<tr>
<td>Rail</td>
<td>RailCorp</td>
<td>South Coast Rail Line</td>
</tr>
</tbody>
</table>

10.1 Electricity

Integral Energy own and operate significant overhead feeders serving the Gerringong substation on Rowlins Road in Gerringong. One feeder tracks over Mount Pleasant Ridge from Kiama and follows the western side of the existing highway to the Fern Street junction. Between Fern Street and the substation location the feeder tracks the eastern side of the existing highway road reserve. This feeder is significantly impacted by the proposal and would require relocation on the western side of the proposal between the substation site and Rose Valley Road interchange – approximately three kilometres.

A second feeder tracks remote from the proposal in the same easement as the Eastern Gas Pipeline. This feeder crosses the proposal where it enters the substation site and near Belinda Street on its way to Berry. This feeder would require adjustment where it crosses the proposal.
Figure 10.1: Significant utilities impacted by the proposal
10.2 Sewage and water

Sydney Water operates a sewer and water network in Gerringong and Gerroa on the eastern side of the railway line. Water is provided to Gerringong from the Gerringong reservoir located at the northern extremity of the study area. A Sydney Water 375 mm diameter main follows the eastern side of the existing highway from Mount Pleasant to Rose Valley Road. At Rose Valley Road the main splits into two – a branch crosses the existing highway and tracks the western side of the existing highway before crossing back in the vicinity of Fern Street. A new section of main continues to track the eastern side of the existing highway to Fern Street. It is planned that the western side branch becomes redundant when the highway is upgraded. The main continues to follow the eastern side of Fern Street into Gerringong and on to Gerroa.

It is intended that the existing main be protected in the shoulder of the upgraded highway to Omega Lane – a length of approximately 450 m. Relocation will be required over approximately 600 m to accommodate the Rose Valley Road interchange. Relocation or protection will also be required over 300 m to accommodate the southbound on ramp. The development of the southern approach to the Fern Street bridge will also require localised adjustment to the main.

The sewerage network in Gerringong and Gerroa culminates at the Gerringong Gerroa wastewater treatment plant south of Crooked River. The Gerringong Gerroa wastewater treatment plant does not discharge to the ocean. Advanced tertiary treated effluent is pumped to Sydney Water owned grazing land between the railway line and the existing Princes Highway where it is used to irrigate pasture. The effluent re-use irrigation scheme covers a substantial area on the southern side of the highway in the vicinity of the Gerringong Bends to Toolijooa Road. The scheme is operated by Veolia Water. The proposal requires a strip acquisition of the irrigated grazing land but does not interfere with the operation of the irrigation scheme or the sewerage network.

10.3 Gas

The most significant asset impacted by the proposal is the Eastern Gas Pipeline owned and operated by Jemena. The Eastern Gas Pipeline runs from northern Victoria to Western Sydney and is a 450 mm diameter 15 MPa main buried at a depth between 900 mm and 1200 mm. The main crosses the existing highway west of Belinda Street on a similar alignment to the overhead high voltage transmission lines and Optus Sydney-Melbourne optic fibre cable.

The proposal crosses the Eastern Gas Pipeline on an embankment in the order of eight metres high. A service road connecting Belinda Street and Willowvale Road also crosses the pipeline. Consultation with Jemena during the route selection phase indicated that disturbance and relocation of the pipeline was best avoided. Consideration was given to ensuring no design elements required excavation below existing surface on the alignment of the pipeline. Further consultation with Jemena would establish the protection requirements for the pipeline where it is ‘built over’ by the proposal.

10.4 Telecommunications

10.4.1 Optus

A buried Sydney-Melbourne optic fibre cable follows a similar alignment to the Eastern Gas Pipeline and overhead high voltage transmission lines. The proposal interacts with the cable in the vicinity of the Crooked River bridge. Adjustment to the cable would be required where it crosses the proposal.
10.4.2 Telstra

The major Telstra asset located in the vicinity of the proposal is a Sydney-Melbourne optic fibre cable which is generally aligned with the western side of the railway line entering Gerringong. The cable tracks the eastern side of Fern Street through Gerringong and re-joins the eastern side of the railway line in the vicinity of Belinda Street. It then follows the southern side of the railway line to Bomaderry.

The proposal interacts with this cable in the vicinity of the Fern Street bridge and would require adjustment at this location. Drainage amplification works near the junction of Belinda Street and Rowlins Road would also interfere with the cable tracking on the northern side of Belinda Street.

10.5 Rail

The South Coast Rail Line parallels the proposal from Fern Street to Belinda Street. The rail line crosses Fern Street with a signalised level crossing in close proximity to the junction of Fern Street and the existing highway.

The proposal spans the rail line with a bridge – eliminating the need for the level crossing. The bridge allows for a future duplication of the currently single line track. Allowance has also been made for future electrification of the line.

Between Fern Street and Belinda Street the existing highway parallels the rail line. The proposal requires duplication of the existing highway on the western side. Cut and fill embankments associated with the proposal extend to the rail corridor boundary.

The rail line spans Belinda Street on an overpass. The overpass is unaffected by the proposal. It is intended that pedestrian facilities be incorporated on Belinda Street under this bridge.
II Road furniture

11.1 Lighting

The concept design includes consideration of the extent of lighting required for the proposal. An indicative lighting arrangement is shown on the concept design drawings in line with the following criteria:

- The at-grade junction at Sims Road is to be lit to ‘flag’ standard in accordance with AS/NZS 1158 Code of Practice for Public Lighting.
- Rose Valley Road and Belinda Street interchanges are generally to have ramp terminals, merge / diverge, and weaving areas lit.

The proposal is not lit remote from interchange areas and the Sims Road junction.

11.2 Barriers

The concept design indicates a median barrier for the entire length of the proposal. The first 850 m of the proposal adopts a concrete median barrier similar to that used on the Kiama Bends. The concrete barrier is adopted where it is required to limit the median width. The median width incorporating the concrete barrier is 2.6 m. The remainder of the proposal adopts a five metres wide median incorporating a wire rope median barrier. The wire rope barrier does not track the centre of the median, instead it moves towards the inside of curves to maximise sight distance.

For the purpose of concept design, wire rope barrier on the outside of the carriageways has been provided where embankment height is greater than 1.5 m. Further design development may determine that more extensive barrier is required on the outside of carriageways.

Appropriate transitions would be provided from wire rope barrier to bridge barrier.

11.3 Line marking

Line marking design has been developed for the purpose of indicating a possible arrangement to cater for the required design vehicle. All line marking has been prepared in accordance with AS1742, and RTA’s Road Design Guide and model drawings.
12 Terrestrial ecology

12.1 Terrestrial ecology assessment
A terrestrial ecology assessment was undertaken as part of the REF for the proposal.

12.2 Endangered ecological communities
Two vegetarian communities were recorded in the study area: Estuarine Saltmarsh and Subtropical Dry Rainforest.

Estuarine Saltmarsh is commensurate with the Coastal Saltmarsh endangered ecological community (EEC) listed under the TSC Act which occurs in the NSW North Coast, Sydney Basin and South East Corner bioregions.

Subtropical Dry Rainforest is commensurate with the Illawarra Subtropical Rainforest EEC listed under the TSC Act which is confined to the Sydney Basin Bioregion.

12.3 Flora
Based on database search results, a total of 12 plant species listed on the TSC Act and/or Environmental Protection and Biodiversity Conservation Act 1999 (EPBC Act), or their habitat, have been previously recorded within a 10 km radius of the study area. No threatened plant species were recorded in the study area during the current surveys. An assessment of the potential habitat for the 12 threatened plant species was undertaken and included the proximity of previous records, the presence of identified habitat preferences, and potential habitat. The assessment concluded six threatened plant species may exist within the study area and included; Cynanchum elegans, Daphnandra sp. 'Illawarra' Irinopharsus trypherus, Solanum celatum, Syzygium paniculatum and Zieria granulata. Impact assessments were carried out for each of these threatened plant species and determined that the proposal is unlikely to have a significant impact upon any of these species.

12.4 Fauna
Fauna habitat within the study area ranges from predominantly cleared areas which have low to moderate habitat quality in terms of fauna habitat characteristics, to fragmented small patches of native vegetation, including important habitat features such as tree hollows, rocky shelters, riparian vegetation, fallen logs and feeding resources.

A total of 79 animal species listed on the TSC Act and/or EPBC Act, or their habitat, have been previously recorded within a 10 km radius of the study area. One threatened (preliminarily listed) Little Eagle Hieraetus morphnoides, and two migratory species, Latham’s Snipe Gallinago hardwickii and Cattle Egret Ardea ibis, were recorded during the current surveys, all just outside the study area. Based on the proximity of current and previous records and the presence of identified habitat preferences, potential habitat may exist within the study area for 41 threatened and 21 migratory animal species.

Impacts to the potential habitat of 41 threatened species were considered negligible and therefore, significance assessments were not conducted for these species. Impact assessments were carried out for the remaining six threatened animal species and concluded a significant impact by the proposed upgrade to be unlikely.
Impacts to the potential habitat of the 21 migratory species were considered negligible. Individuals of these species that may occur in the study area were not considered likely to be an ecologically significant proportion of the population. Further, potential habitat in the study area was not considered important for the migratory species. As such, no significance assessments under the EPBC Act were carried out for these species.

A species impact statement and/or referral to the Environment Minister is not recommended for any EECs or threatened (or migratory) flora and fauna.

### 12.5 Wildlife corridors and connectivity

Within the study area roadside native vegetation is limited to small discontinuous segments of native and exotic vegetation cover and groundcover. The proposed upgrade is not likely to impact on any local or regional wildlife corridors due to the existing degree of clearing and fragmentation.

### 12.6 Mitigation

Impacts of the proposal are likely to come from a number of sources such as:

- Vegetation clearance / habitat loss.
- Edge effects.
- Mortality of individuals during both the construction and operations phases.
- Introduction and/or spread of weeds.

Early consideration of potential flora and fauna constraints in the initial route selection stage of the project has generally allowed important ecological features in the study area to be avoided (Gerringong to Bomaderry Princes Highway Upgrade, Preferred Option Report, RTA October 2008).

Additional measures relating to construction and ongoing environmental management are documented in the REF.
13 Aquatic ecology and water quality

An aquatic ecology and water quality assessment was undertaken as part of the (REF for the proposal.

The proposal follows the alignment of the existing Princes Highway. It begins at the Mount Pleasant Lookout to the north, descending onto the coastal floodplain, traversing two small coastal catchments, the Ooaree Creek and Crooked River drainages and then ascending a moderate ridge that connects Toolijooa Hill to Currys Mountain, culminating at the Toolijooa Road intersection.

The Ooaree Creek and its tributaries flow in a south easterly direction into the Omega Flat floodplain to the north of Gerringong. The Omega Flat is a lowland marsh that drains into Werri Lagoon, a SEPP 14 wetland that periodically discharges into the ocean at the northern end of Werri Beach. The Omega Flat is known to contain acid sulfate soils (ASS).

The Crooked River drainage lies immediately to the south of Ooaree Creek. The Crooked River crosses the existing highway to the south-west of Gerringong before flowing into a floodplain and eventually the Crooked River estuary. The estuary is more frequently open to the ocean than Werri Lagoon and supports mangrove, seagrass and saltmarsh habitat. Coastal Saltmarsh is listed as an endangered ecological community (EEC) in NSW.

There are two small freshwater wetland areas within the Crooked River drainage. Both are located outside the study area, degraded and composed of small pondages and creek swamp habitat. They are potentially Freshwater Wetlands on Coastal Floodplains which is a listed EEC in NSW under the TSC Act, although both occur at elevations near the upper limit for this community.

The freshwater habitat within the study area was considerably degraded. Riparian vegetation was often absent, banks were unconsolidated, eroded and trampled by livestock and channel substratum was usually dominated by loose accumulations of soft-sediments. In the low-lying floodplain waterways have been highly modified by flood mitigation works. The more ephemeral waterways had poorly defined channels and were often colonised by pasture grasses. Water quality was typical of aquatic ecosystems that have been disturbed by agricultural practices, with elevated nutrient levels and bacterial levels and low dissolved oxygen. The presence of instream macrophyte taxa was recorded and a comprehensive range of macrophyte species present.

A regional inventory of freshwater fish identified a total of 36 species as potentially existing based on potential habitat and regional distribution or having historically existed within the study area. Of these, three are introduced and two are listed as threatened. Macquarie perch Macquaria australasica is listed as endangered under the Fisheries Management Act 1994 (FM Act) and the EPBC Act, and Australian grayling is listed as vulnerable under the EPBC Act.

Of these 36 species however, previous studies recorded only eight freshwater fish species in the study area and only three species were recorded during this study. It is considered likely that this is due to the two catchments of Ooaree Creek and Crooked River being relatively small and with degraded freshwater habitats. The majority of watercourses in the study area were assessed as providing ‘minimal’ to ‘unlikely’ fish habitat. (Class 3 – 4 Waterways), with the exception of Crooked River which provided ‘moderate’ fish habitat (Class 2 Waterway).
Werri Lagoon and Crooked River estuary constitute major fish habitat (Class 1 Waterways) although both were located outside the study area. Previous research has recorded fish from 21 families, representing 33 species, 13 of which were of commercial interest. These estuaries, particularly Crooked River, are possible habitat for Syngnathiformes (which includes Pipefish, Pipehorses, Seahorses, Seadragons, and Ghost Pipefish) and large juvenile Black Cod *Epinephelus daemelii*. Syngnathiformes are afforded protection under the *EPBC Act* and Black Cod are listed as vulnerable under the *FM Act*.

### 13.1 Potential impacts of the proposal

Environmental constraints of the proposal relate primarily to:

- The installation of in-stream drainage structures.
- The mobilisation of sediments into waterways.
- Potential pollution from materials used in the process of road construction.
- Disturbance of acid sulfate soils.
- Presence of invasive species.
- Presence of threatened and protected species and communities.
- Proposed realignment of two waterways.
- Potential changes to hydrology from the operation and construction of the highway upgrade.

#### Realignment of waterways

Realignments have been proposed within the road reserve for the Crooked River at the Princess Highway crossing (Appendix E of the Aquatic Ecology and Water Quality Assessment (see Appendix F of the REF)), and an unnamed waterway approximately 0.5 km east of the Toolijooa Road interchange (Appendix F of the aquatic ecology and water quality assessment (see Appendix F of the REF)). The exact details of the realignments would be determined during the detailed design.

The proposal would realign approximately 100 m of the Crooked River channel at the existing Princes Highway crossing and two short sections of an unnamed watercourse on the north side of the Princes Highway between the Gerringong Bends and Toolijooa Road. The altered creek formations would be designed such that flood flows are contained within the new channel and do not revert back to their previous course of flow.

The existing aquatic habitat and biota in the realigned watercourse sections would be lost. The subsequent realignments can potentially alter channel morphologies and profiles, creating changes to hydrology and geomorphology (including changes to rates of scour, flow rates and existing flood regimes), which can have concomitant effects on aquatic ecology.

The unnamed watercourse on the north side of the Princes Highway between the Gerringong Bends and Toolijooa Road is ephemeral, degraded and considered unlikely fish habitat (Class 4 Waterway). Minor redirection of such waterways is considered unlikely to have a substantial impact on aquatic ecology providing flows are still transferred into original downstream habitats.

Crooked River is considered moderate fish habitat (Class 2 Waterway) although the banks and riparian vegetation have been substantially degraded. Impacts on the Crooked River can be minimised by mimicking the natural channel morphology in the realigned section and restoring riparian habitat.
I&I NSW have a policy of 2:1 environmental compensation for direct loss of aquatic or riparian habitat (Smith and Pollard 1999). Therefore to negate the impacts, the proposal could also include rehabilitation of Crooked River reaches (e.g., restoration of riparian habitat and restrictions on stock access) upstream and downstream of the proposed realignment.

Consultation with DECCW and I&I NSW would be undertaken during detailed design with regard to the proposed creek realignments.

13.1.1 Assessment of impacts and recommendations

Potential impacts from mobilised sediment can be minimised by an erosion and sediment control plan that implements standard sediment control measures. Similarly, potential contamination of waterways with polluted runoff from the highway or accidental spills can be mitigated by proper handling of hazardous substances on site and the channelling of surface runoff into terrestrial vegetation or sediment basins.

Significant changes to hydrology are not anticipated to occur in relation to the construction of an earth embankment and associated culvert structures across Omega Flat or the installation of drainage structures at creek crossings.

Provided the recommended mitigation measures outlined in the REF are adopted it is unlikely that the works and structures associated with the construction and operation of the proposal would have long-term impacts on threatened species, endangered communities or the wider aquatic ecology of the study area. This includes the Freshwater Wetlands of Coastal Floodplains and downstream habitats and biota, such as Coastal Saltmarsh, Syngnathiformes, juvenile Black Cod, seagrass beds, mangroves or the SEPP 14 Werri Lagoon.

Specific recommendations relating to the construction of waterway crossings and the proposed realignment of two waterway are documented in the REF as follows:

- The detailed design of drainage structures would take into consideration the guidelines for the design and construction of waterway crossings to maintain fish passage outlined in ‘Guidelines and Policies for Aquatic habitat management and Fish Conservation’ (Smith and Pollard 1999) and ‘Why do Fish need to Cross the Road? Fish Passage Requirements for Waterway Crossings’ (Fairfull and Witheridge 2003).

- To negate the loss of aquatic habitat and biota from the proposed waterway realignments equivalent biotic assemblages would be restored in the realigned reaches. The rehabilitation program would consider (but not be limited to):
  - Restoration of the natural creek geomorphology. For example:
    - A meandering channel to reduce velocity and scour during high flow events.
    - Natural bed forms, such as an alternating sequence of pools, riffles and runs.
  - Establishment of a complete and broad riparian habitat including removal of exotic species.
  - Stabilised channel bank and bed and the protection of exposed soil until riparian vegetation is completely established.
  - The introduction of engineered log jams to create pooling sections and submerged woody debris (see Brooks et al. 2004).

- Consultation with DECCW and I&I NSW would be undertaken during detailed design with regard to the proposed creek realignments.
These recommendations relate to the detailed design process and additional measures relating to construction and ongoing environmental management are documented in the REF.
14 Noise

A noise assessment has been undertaken for the operation and construction phases with an additional vibration assessment undertaken for the construction phase. The findings are documented in the REF.

Operational road traffic noise has been assessed for the future (2018 and 2028) road traffic conditions at existing residential dwellings. General noise mitigation recommendations have been made where the predicted noise levels exceed the established criteria.

The assessment identifies the construction noise and vibration impacts and sets out recommended mitigation measures to minimise disturbance at sensitive receptors adjacent to the scheme. The results from the assessment identify that construction impacts with mitigation measures may still cause disturbance to properties within close proximity to the works.

A detailed description of the modelling undertaken and the noise criteria applied can be found in the Noise and Vibration Assessment as an Appendix to the REF.

Noise mitigation recommendations

During the daytime the ECRTN noise goal of $L_{Aeq(15hr)}$ 60 dB(A) will be exceeded at 52 residential properties in 2028. During the night-time period, the ECRTN noise goal of $L_{Aeq(9hr)}$ 55 dB(A) will be exceeded at 97 residences in 2028.

Practice Note (iv) in the ENMM provides guidance as to what the RTA considers to be reasonable and feasible mitigation. Feasible mitigation is defined as mitigation that is technically achievable using standard engineering methods. Where the ECRTN noise goals are exceeded there are three instances where it may be considered reasonable to consider mitigation. These are if the design year noise levels at residential properties (2028) are:

1. Greater than two dB(A) above the future existing noise levels;
2. Greater than two dB(A) above the noise goals detailed in the ECRTN; or
3. “Acute” (65 dB(A) $L_{Aeq(15hr)}$ or 60 dB(A) $L_{Aeq(9hr)}$ or above), where future existing noise levels already exceed the noise goals. (Section 2.2 Practice Note (IV) in the Environmental ‘Noise Management Manual’)

Of the residences that are likely to be exposed to noise levels exceeding the ECRTN noise goals, 83 exceed the allowance of two dB(A) over future existing noise levels, exceed the allowance of two dB(A) over the noise goals or, where future existing noise levels already exceed the noise goals, are defined as “Acute”.

The ENMM provides guidance on selecting mitigation measures for receivers. It advises where ‘reasonable and feasible’ if residences are closely grouped together in numbers of three or less, architectural treatments are preferred over noise barriers.

With the exception of Gerringong township the majority of properties that are eligible for consideration of mitigation measures along the proposal are grouped in three or less receivers. Therefore it is considered acceptable and cost effective to provide architectural treatment for facades of these residences facing the proposed redevelopment, rather than the installation of roadside barriers.
There are 22 isolated rural dwellings along the Princes Highway where exceedences are predicted. Noise levels at five of these properties exceed the ECRTN noise goals by more than 10 dB(A), noise levels at nine of these properties exceed the ECRTN noise goals by five to 10 dB(A) whilst noise levels at the remainder of the properties exceed the ECRTN noise goals by up to five dB(A).

For properties where exceedences are up to 10 dB(A) fresh air ventilation, sealing of wall vents and upgraded window and door seals is generally considered appropriate. Where exceedences are over 10 dB(A) additional upgrade of windows and doors may be appropriate.

Within Gerringong township there are 62 properties that are eligible for consideration of mitigation measures. Noise levels at 17 of these properties exceed the ECRTN noise goals by five to 10 dB(A), these properties are all located immediately east of the railway line adjacent to the Princes Highway. Noise levels at the remainder of the properties in Gerringong exceed the ECRTN noise goals by less than five dB(A).

The following mitigation measures would be considered for the proposal. These recommendations relate to the detailed design process and additional measures relating to construction and ongoing environmental management are documented in the REF:

- Noise attenuation would be considered during detailed design to reduce road traffic noise levels at the residential properties located immediately to the east of the railway line adjacent to the Princes Highway. The indicative location of noise attenuation is shown in Appendix G possible attenuation could include a noise barrier, or mound, or combination of both, which would be investigated in more detail during detail design.
- In addition to the noise attenuation, architectural treatments would be considered at the detailed design stage for properties where appropriate eg for isolated properties where a noise barrier would not be feasible. Depending on the level of impact, architectural treatments may include provision of fresh air ventilation, sealing of wall vents, upgraded window and door seals and upgraded windows and doors for more heavily impacted residences.

The mitigation measures would be determined in detailed design where reasonable and feasible and in consultation with property owners.

A minimum reduction of 5 dB(A) is generally required before attenuation such as noise barriers are considered a cost-effective mitigation option. Should noise attenuation such as a barrier be considered appropriate and installed as part of the proposal, it may reflect some noise from passing trains to the residential properties immediately to the east of the railway line. However the increase in railway noise as a result of the construction of the noise barrier would be barely perceptible and is unlikely to cause criteria exceedences. At the remaining 26 properties architectural treatments are recommended for consideration.

The construction of a “quiet” road surface such as Open Graded Asphalt or Stone Mastic Asphalt, may have the effect of reducing noise levels by approximately 2dB(A) to 3dB(A). This may be considered as an alternative to the architectural treatments for properties within the Gerringong township and may reduce the size and scale of the noise attenuation required. This option would be subject to a cost benefit analysis during detailed design.
15 Heritage

The cultural heritage assessment program was undertaken as part of the REF for the proposal and included two main assessment streams; a cultural assessment and an archaeological assessment, as specified by DECCW and RTA policy.

15.1 Aboriginal heritage

Twelve Aboriginal heritage recordings occur within or near the study area. These consist of one with reported subsurface artefact, two sites with surface artefacts, and nine potentially archaeological sensitive areas.

In addition to these recordings, the Aboriginal cultural value of mature fig trees across the Illawarra region is noted. There are five mature fig tree incidences, singly or in groups, in or near to the proposal study area.

Of the 12 Aboriginal heritage recordings, two sites are considered to have low local significance, one is considered to have moderate to high significance in a local context (subject to confirmation by archaeological test excavation), and the significance of the nine potentially archaeological sensitive areas can only be determined following archaeological testing.

15.2 Non-Indigenous heritage

Fourteen non-Aboriginal heritage recordings occur within or near the proposal study area. These consist of one cultural landscape description, and 13 specific site descriptions. The site recordings consist of four with standing structures, three containing archaeological remains of former structures, three disused highway remnants, one surface dump of disused vehicles, one agricultural dry stone wall, and a property driveway entrance.

Of the 14 non-Aboriginal heritage recordings, 12 are considered to be of local heritage significance, while the remaining two are not considered significant.

15.2.1 Potential impacts

Aboriginal

With reference to Appendix H of the REF showing locations, the degree of impact for each of the identified Aboriginal heritage recordings is summarised in Table 15.1.
### Table 15.1: Aboriginal heritage recordings

<table>
<thead>
<tr>
<th>ID</th>
<th>Description</th>
<th>Degree of impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Artefact A5</td>
<td>Reported subsurface artefact distribution</td>
<td>Low impact - the artefact is at the edge of the proposed alignment</td>
</tr>
<tr>
<td>Artefact A6</td>
<td>Isolated find</td>
<td>High impact - proposed alignment lies over the top of the artefact</td>
</tr>
<tr>
<td>Artefact A7</td>
<td>Artefact distribution</td>
<td>High impact - proposed alignment lies over the top of the artefact</td>
</tr>
<tr>
<td>PASA 31</td>
<td>Crest and upper slopes of spurline on eastern fall of Toolijooa Ridge, just north of Toolijooa Road intersection with current highway. PASA located on south side of proposed carriageways and current highway</td>
<td>Medium to high impact - proposed alignment lies over the top of approximately 50 per cent of the PASA</td>
</tr>
<tr>
<td>PASA 32</td>
<td>Banks, flats and adjacent slopes associated with unnamed tributary 500 m east of Toolijooa Road intersection with highway</td>
<td>Low impact - edge of proposed alignment would encroach into the PASA</td>
</tr>
<tr>
<td>PASA 33</td>
<td>Banks, flats and adjacent slopes associated with unnamed tributary immediately west of former Toolijooa Public School, and slightly elevated margin of valley floor coastal plain (former possible wetland basin)</td>
<td>Low impact - edge of proposed alignment would encroach into the PASA</td>
</tr>
<tr>
<td>PASA 34</td>
<td>Crest of locally elevated ridgeline, 250 m west of Willowvale Road intersection with highway</td>
<td>High impact - proposed alignment lies over the top of the PASA</td>
</tr>
<tr>
<td>PASA 35</td>
<td>Banks, flats and adjacent slopes associated with Crooked River</td>
<td>High impact - proposed alignment lies over the top of the PASA</td>
</tr>
<tr>
<td>PASA 36</td>
<td>Banks, flats and adjacent slopes associated with unnamed tributary crossing 500 m south of Sims Road intersection with highway. PASA located on western side of current highway</td>
<td>Medium impact - alignment encroaches into PASA</td>
</tr>
<tr>
<td>PASA 37</td>
<td>Basal slopes on southern margin of former Omega swamp basin</td>
<td>Low to medium impact - edge of proposed alignment would encroach into the PASA</td>
</tr>
<tr>
<td>PASA 38</td>
<td>Ridgeline crest, and basal and mid slopes on northern margin of former Omega Flat swamp basin</td>
<td>High impact - proposed alignment lies over the top of the PASA</td>
</tr>
<tr>
<td>PASA 39</td>
<td>Crest and upper slopes of a spurline just north of ‘Dunoon’ Dairy. PASA is located on west side of the current highway</td>
<td>Low to medium impact - edge of proposed alignment would encroach into the PASA</td>
</tr>
</tbody>
</table>
Non-Aboriginal

The proposal would have the potential to impact on non-Aboriginal heritage to varying degrees in the following ways:

- Destruction or disturbance to: above and below-ground structures and relics, ground relief features, and archaeological deposits present within the construction footprint. This can be expected to involve up to 100 per cent within the footprint, although there may be some limited potential for site remnants to survive outside of the footprint.
- Destruction or disturbance to above and below-ground structures and relics, ground relief features, and archaeological deposits present within the construction footprint and storage depots and other ancillary areas situated outside of the footprint.
- Destruction or disturbance to a strip of land which forms part of the associated grounds or a property block within which a heritage item / place is situated, such as a homestead building, or associated tree(s).
- Indirect impacts (such as to the contextual values of place(s) and/or item(s)) which are now adjacent to or closer to the upgraded highway; or to the overall values of the landscape through which the upgrade passes.
- Indirect impact to items of movable heritage which may have been moved to avoid direct impact and as a consequence lost contextual integrity.

With reference to Appendix H of the REF showing locations, the degree of impact for each of the non-Aboriginal heritage recordings that are identified as having some heritage significance, are summarised in Table 15.2.

<table>
<thead>
<tr>
<th>ID</th>
<th>Description</th>
<th>Level of significance</th>
<th>Degree of impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>H31</td>
<td>Homestead site</td>
<td>Local heritage significance on the draft Kiama Heritage Inventory (DKHI) 2007</td>
<td>Located immediately adjacent to the upgrade, and although not directly impacted by earthworks, existing property boundaries may be affected to a minor extent by land acquisition depending on the width of the easement required</td>
</tr>
<tr>
<td>H32</td>
<td>Former Toolijooa Public School</td>
<td>Local heritage significance on the draft Kiama Heritage Inventory (DKHI) 2007</td>
<td>Marginally impacted by earthworks conducted within existing property boundaries, but in areas where the risk of impacting heritage values would be low</td>
</tr>
<tr>
<td>H34</td>
<td>Aorangi homestead and grounds</td>
<td>Local heritage significance on the draft Kiama Heritage Inventory (DKHI) 2007</td>
<td>Directly impacted but to a limited extent, within existing property boundaries</td>
</tr>
<tr>
<td>H36</td>
<td>Agricultural dry stone wall</td>
<td>Local heritage significance on the draft Kiama Heritage Inventory (DKHI) 2007</td>
<td>Directly impacted but to a limited extent, within existing property boundaries</td>
</tr>
<tr>
<td>ID</td>
<td>Description</td>
<td>Level of significance</td>
<td>Degree of impact</td>
</tr>
<tr>
<td>-----</td>
<td>--------------------------------------------------</td>
<td>-----------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>H37</td>
<td>Site of Stationmaster's residence at Gerringong</td>
<td>Local heritage significance on the draft Kiama Heritage Inventory (DKHI) 2007</td>
<td>Situated outside of the direct construction footprint but within a possible construction traffic and ancillary facility area</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H38</td>
<td>Renfrew Park Estate and grounds</td>
<td>Local heritage significance on the draft Kiama Heritage Inventory (DKHI) 2007</td>
<td>Directly impacted but to a limited extent, within existing property boundaries</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H39</td>
<td>1940s highway remnant</td>
<td>Local heritage significance on the draft Kiama Heritage Inventory (DKHI) 2007</td>
<td>Marginally impacted by earthworks conducted within existing property boundaries, but in areas where the risk of impacting heritage values would be low</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>H40</td>
<td>Former Omega Public School</td>
<td>Local heritage significance on the draft Kiama Heritage Inventory (DKHI) 2007</td>
<td>Located immediately adjacent to the upgrade, and although not directly impacted by earthworks, existing property boundaries may be affected to a minor extent by land acquisition depending on the width of the easement required</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H41</td>
<td>1940s Highway remnant</td>
<td>Local heritage significance on the draft Kiama Heritage Inventory (DKHI) 2007</td>
<td>Directly impacted but to a limited extent, within existing property boundaries</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H42</td>
<td>Site of Homeleigh homestead</td>
<td>Local heritage significance on the draft Kiama Heritage Inventory (DKHI) 2007</td>
<td>Directly impacted but to a limited extent, within existing property boundaries</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H43</td>
<td>Innisfail property entrance</td>
<td>Local heritage significance on the draft Kiama Heritage Inventory (DKHI) 2007</td>
<td>Fully impacted and would require removal</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Southern Illawarra Coastal Plain and Hinterland Cultural Landscape</td>
<td>Local heritage significance on the draft Kiama Heritage Inventory (DKHI) 2007</td>
<td>The identified cultural landscape would be impacted, but moderated by the already dominant presence of the highway, and the small proportion of land effected relative to the whole</td>
</tr>
</tbody>
</table>
15.2.2 Cultural heritage issues and the Rose Valley Road interchange

See Appendix G of the REF for further details.

The proposed interchange at Rose Valley Road would be constructed in close proximity to two items of cultural heritage significance. The existing carriageway separates Renfrew Park and two established specimens of *Ficus macrophylla* (Moreton Bay Fig trees), both of which are part of cultural value to the local Aboriginal community.

A number of options for the interchange design have been considered with specific regard to their varying degrees of impact on both Renfrew Park and the fig trees following feedback from the Aboriginal focus group (AFG). A comparative analysis of the value of these two items was undertaken for the proposal.

The optimal cultural heritage management strategy would be to conserve both the Moreton Bay Fig trees to the west of the highway as well as the remaining Renfrew Park grounds and garden plantings. However, following extensive investigation of design options, the optimal strategy cannot be realised.

The required footprint for the proposal would necessitate either the removal of the larger eastern fig tree on the western side of the highway, or the smaller of the two figs plus a section of the grounds of Renfrew Park, including the fig located near the south western corner and the current formal entrance posts and gate. Both Aboriginal and non-Aboriginal heritage values would be affected regardless of which alignment option is selected.

It was concluded that an alignment that conserves, at least the larger of, the two Moreton Bay Fig trees on the western side of the highway, and which as a consequence must impact the western portion of the Renfrew Park homestead grounds and plantings, would be a justifiable management solution on the following grounds:

- Strong Aboriginal cultural values are associated with the larger tree on the west side of the highway.
- The continuing integrity of this tree as a healthy and vigorous tree, and as a central axis tree in relation to the homestead.
- The larger of the two fig trees on the western side of the highway has the longer SULE of the two fig trees of the homestead and therefore should be preserved over the smaller of the western trees.
- The combined Aboriginal and non-Aboriginal values of this tree.
- The already compromised nature of the Moreton Bay Fig tree in the south western corner of the Renfrew Park gardens (given the loss of its pair at the former north-west corner of the homestead grounds, and its impacted and vulnerable root system).
- The already compromised nature of the western portion of the homestead grounds, due to previous highway widening and the recent construction of a new vehicle driveway and entrance.
- Renfrew Park is typical of rural domestic houses of the era and locality. They are well represented currently on Kiama Municipal Council’s LEP. The relevance of the curtilage, fronting the highway would be maintained and therefore impacts to the heritage item would not change the significance of the item ie it would retain its local significance on the draft Kiama Heritage Inventory (DKHI) 2007.
A fig tree of this age and Aboriginal cultural significance is not as common in the locality. Its rarity lies in the cultural activity associated with the tree by Aboriginal people.

The potential to mitigate the impact to the homestead grounds by re-location of the formal entrance way and remodelling of the front garden and its planting to re-establish symmetry around the central axis.

Strategies for managing the potential impacts on each Aboriginal and non-Aboriginal heritage site or features are reflected in the recommendations below. These recommendations relate to the detailed design process and additional measures relating to construction and ongoing environmental management are documented in the REF.

Safeguard and management measures

With regard to the management of mature fig trees within the proposal area:
- Wherever feasible, direct impact to mature fig trees would be avoided.
- The continued and sustainable health of near or adjacent trees would be considered in the detailed design of the upgrade.
- In cases where direct impact to mature fig trees is unavoidable:
  - Wherever feasible, trees with reduced health, condition or vigour are impacted in preference to examples displaying good condition, health and vigour.
  - Establish a management and impact mitigation program in consultation with the AFG. This action is relevant to the anticipated removal of the fig trees at Rose Valley Road.
- Consultation with Aboriginal stakeholder groups would be conducted with regard to all incidences of anticipated impact to mature fig trees.

An appropriate means of commemorating the traditional Aboriginal culture of the country being traversed by the upgrade would be adopted where and as feasible. This may take the form of signage, adopted nomenclature for built structures or wayside stops, the use of motifs in any incorporated artwork, or the erection of commemorative markers and/or monuments. The development, source material, and approval of any such proposal would be the subject of continuing consultation with Aboriginal stakeholders.

Where feasible, direct impact to known sites and features with assessed heritage significance would be avoided, and where not feasible, that impact would be minimised and mitigated.

Consideration would be given to reducing the extent of the cuts required adjacent to Aorangi (H34) and the dry stone wall (H36), with the objectives of avoiding or reducing the extent of direct impact (including the loss of mature garden plantings at Aorangi), and the width of the required easement and consequential property acquisition.

The boundary of the upgrade easement would be defined so that land acquisition is minimised in the area of the following sites:
- H31 (site of Harding tenant farm)
- H32 (former Tooljooa Public School)
- H34 (Aorangi)
- H36 (dry stone wall)
- H38 (Renfrew Park)
- H40 (former Omega Public School)
With regard to site H37 (site of Omega Stationmasters residence), disturbance to the deposit would be avoided below a depth of around 100 cm. If the area is required for ancillary activities (not associated with substantial ground disturbance), then additional hard stand gravels would be applied to protect any remaining archaeological deposits. In the event that excavations below a depth of 100 cm are anticipated and unavoidable, then an archaeological test excavation would be conducted with approval from Heritage Branch, to ascertain the nature, significance and management requirements of any potentially occurring archaeological deposits.

With regard to the Renfrew Park property (H38), it is recommended that the following actions be undertaken in addition to the archival record outlined above:

- Ensure that the palm tree remains undisturbed and viable.
- Develop and instigate, in consultation with the landowner and a heritage garden specialist, a landscaping plan for the remaining portion of the homestead front enclosure. The objective of the plan would be to integrate the upgrade batter and easement requirements with the redevelopment of the homestead frontage. Subject to owner and Kiama Municipal Council heritage requirements, it is recommended that the plan seek to retain the palm tree, to re-establish the formal and symmetrical garden schema, and to reposition the existing entrance posts and gateway in a new location along the central axis.
- Integrate the retained fig tree on the west side of the highway with any planned, northbound exit, gateway installation for the Gerringong area.

With regard to site H39 (1940s highway remnant north of Renfrew Park), impact to this feature would be minimised where feasible, and adjacent landscaping and other treatments within the easement adjacent to the site would take into account the desirability of maintaining the ability of the public to view the feature either from the road during travel, and/or via a pedestrian path.

With regard to the Innisfail property entrance feature (site H43), and in addition to the archival record outlined above, the following actions would be conducted subject to agreement by stakeholders:

- The feature would be appropriately dismantled.
- Temporarily stored (if necessary).
- Re-installed, and restored to its original form, at a new entrance location along the Innisfail property driveway.

A program of revegetation along the upgrade easement and associated works would be conducted with the aim of mitigating the impact to the cultural values of the immediate and larger surrounding landscape. The program would include the use of both native and exotic species in accordance with the landscape plan. The latter would be representative of those already present in the landscape and be established in the proximity of towns, historical estates or where dictated by the surrounding landscape.
16 Property impacts

The proposal essentially involves widening the existing highway alignment to accommodate the design cross section. Generally widening is undertaken to one side of the existing alignment. This allows the proposal to be constructed whilst traffic remains on the existing highway and limits the majority of property acquisition to one side of the existing highway.

The proposal improves the vertical and horizontal alignment of the existing highway. Improvements in the vertical alignment introduces cuts and fills which have a greater ‘footprint’ than the existing highway which more closely follows the natural surface. Hence property acquisition may be required on the non-widened side of the existing highway. Improvements in the horizontal geometry introduces larger radius curves which tends to ‘pull’ the upgrade alignment to the inside of existing curves.

Widening the highway alignment generally requires ‘strip’ acquisitions of relatively large rural lots. In some instances an acquisition of a whole lot is required.

16.1 Determining the road boundary

More area than the earthworks footprint is required to accommodate the proposal. Additional land is required to accommodate access ways for maintenance vehicles, basins to capture and treat stormwater from the road, and width to provide for future widening to three lanes in each direction (where required).

The following rationale was used as a guide for determining the road boundary. Where only minor adjustments were required, the boundary was adjusted so that a better fit with existing property boundaries was achieved.

The permanent road boundary does not allow for any additional area required to facilitate construction. Construction may require temporary works to provide for public or construction traffic and temporary facilities such as compounds, stockpiles, or batch plants. It is assumed that any area required in addition to that permanently acquired will be temporarily leased from the property owner following negotiation.
17 Constructability and staging

17.1 Constructability

Generally widening or duplication of an existing highway poses greater construction and road user management challenges than deviation or ‘green field’ construction. The highway must be kept open to traffic throughout construction, often in circumstances where space is limited and temporary diversions are necessary. The potential for conflict between highway traffic and construction traffic is high, and delays may be frequent. Under these conditions, phased construction must be implemented to reduce delay to road users while maintaining high levels of safety for motorists, residents, and the construction workforce.

Construction traffic would generally use the cleared footprint to transport materials adjacent to the highway traffic. Construction traffic exit and entry points would be minimised and controlled.

17.2 Staging of the proposal

The proposal can be constructed in two broad stages:

- The northbound lanes and associated earthworks and median can be constructed with two-way traffic remaining on the existing highway.
- The southbound lanes and associated earthworks can be constructed with two-way traffic shifted to the completed northbound lanes.

Exceptions to this broad strategy are Rose Valley Road and Belinda Street interchanges and the Gerringong Bends. The possible staging strategy is discussed in greater detail below with reference to the ‘staging’ drawings in the concept design drawing set.

### Mount Pleasant to Rose Valley Road interchange

| Stage 1 | Two-way traffic to remain on the existing highway northbound carriageway with construction of the southbound lanes from Chainage 0 - 500.  
Two-way traffic to be switched to the existing southbound carriageway at Chainage 500 with construction of the northbound lanes from Chainage 500 – 1150. |
| Stage 2 | Two-way traffic transferred to the constructed southbound lanes with construction of northbound lanes Chainage 0 – 500.  
Two-way traffic to be switched to the constructed northbound lanes Chainage 500 – 1150. |

### Rose Valley Road interchange

| Stage 1 | Two-way traffic to remain on the existing highway.  
Construct all western-side ramps, bus interchange, and adjustments to Rose Valley Road. A temporary sidetrack is required to allow the northbound traffic stream to be taken via the off and on ramps in Stage 2.  
Construct southbound off ramp and tie to existing highway ready to take the southbound traffic stream in Stage 2. The ramp cannot be constructed to finished surface level between Chainage 1150 and 1320. Further work will be required following stage 2 to complete the ramp to final level. |
### Rose Valley Road interchange

**Stage 2**
- Southbound traffic transferred to the southbound off ramp.
- Northbound traffic transferred to the northbound off ramp and northbound on ramp with temporary connecting track.
- Construct Rose Valley Road overbridge and full upgrade cross-section from Chainage 1150 – 1600.

### Rose Valley Road interchange to Fern Street

**Stage 1**
- Two-way traffic to remain on the existing highway.
- Construct full upgrade cross-section to the western side of the existing highway from Chainage 1600 – 2100.

**Stage 2**
- Two-way traffic transferred to the completed northbound lanes. Southbound traffic on switch from existing highway in vicinity of Chainage 1750.
- No access available to and from Fern Street. All grade-separated movements to and from Gerringong available at the partially constructed Belinda Street interchange.
- Construct southbound on ramp and Fern Street bridge.

### Fern Street to Belinda Street interchange

**Stage 1**
- Two-way traffic to remain on the existing highway.
- Construct northbound lanes to the western side of the existing highway from Chainage 2100 – 4000.

**Stage 2**
- Two-way traffic transferred to the completed northbound lanes.

### Belinda Street interchange

**Stage 1**
- Two-way traffic to remain on the existing highway.
- Construct northbound on ramp, service road (including connection to the existing highway at Belinda Street junction), and off ramp. On and off ramps will need to be configured to take temporary two-way traffic. A temporary protected right turn treatment will be required at the Belinda Street connection.

**Stage 2**
- Two-way traffic transferred to the western side ramps and service road.
- Construct full carriageway formation, eastern side off and on ramps, and Crooked River bridges from Chainage 4000 – 5200.

### Belinda Street interchange to tie-in at Toolijooa Road

**Stage 1**
- Two-way traffic to remain on the existing highway.
- Construct southbound lanes adjacent to existing highway from Chainage 5200 – 6050.
- Construct northbound lanes and on ramp from future Toolijooa Road interchange from Chainage 5850 – 7650.
**Belinda Street interchange to tie-in at Toolijooa Road**

| Stage 2 |  
|---------|---|
| • Two-way traffic transferred to the southbound lanes between Chainage 5300 – 6000.  
• Traffic switch at Chainage 6000 with two-way traffic transferred to the completed northbound lanes.  
• Construct northbound lanes from Chainage 5300 – 6000.  
• Construct southbound lanes from Chainage 6025 – 7500. Southbound lanes to terminate with a stub at Chainage 7500.  
• Construct southbound off ramp to Toolijooa Road to enable u-turn at Toolijooa Road.  
• Once traffic has been shifted to the completed southbound lanes a temporary switch would connect the southbound lanes to the existing highway. Northbound traffic would remain on the northbound on ramp until construction of the next downstream highway upgrade project was completed. |
18 Construction resources

18.1 Material demand

The availability of raw and manufactured materials has a significant influence on the cost of the proposal. The cost estimate includes assumptions regarding haul distances drawn from research into local sources of construction materials. Sources for the supply of constituent raw materials such as cement, bitumen and aggregate have also been considered.

18.1.1 Bulk earthworks

The earthworks material demand is heavily influenced by constraints on the vertical geometry of the project alignment. A significant driver for the vertical geometric design was meeting design standards and achieving a desirable alignment. Significant adjustments to the vertical geometry were not required to achieve a reasonable earthworks balance.

North of Gerringong the project alignment moves off the existing alignment and into cutting to create an overpass for Rose Valley Road. This provides an opportunity to win some material for the adjacent crossing of Omega Flat.

The crossing of Omega Flat requires an embankment to be constructed to provide immunity for a target 1 in 100 year storm event. Depending on the soft soil treatment adopted for Omega Flat, it is probable that material will be required to pre-load the foundations of the road embankment. Any pre-load material is expected to be sourced from outside the project.

A significant embankment at the Belinda Street interchange will draw material from cuttings in the vicinity of Sims Road in addition to material extracted from the deepening of the ‘Gerringong Bends’ cutting. Material from the Gerringong Bends will also be transported to the low lying area towards the southern extent of the project.

Significant adjustment to the vertical alignment of the concept design was not necessary to achieve an approximate balance on the basis of bank volumes. The total cut volume is estimated as 450,000 cubic metres. The total fill volume is estimated as 360,000 cubic metres. The 90,000 cubic metres excess in cut volume provides an allowance for unsuitable material of 25,000 cubic metres, material for the select material zone of 60,000 cubic metres, and material for preloading of soft soil areas of 5,000 cubic metres. These volumes do not consider the range of bulking factors that will apply to the various material types. The overall estimate for earthworks indicates that a cut / fill balance is achievable for this project.

Table 18.1 summarises the significant material requirements.

18.1.2 Pavement materials

A semi-rigid pavement has been assumed. This pavement is similar to that adopted for North Kiama Bypass and Oak Flats to Dunmore Princes Highway upgrades. This pavement comprises approximately 100 mm of asphalt over 300 mm of blast furnace slag and 300 mm of select material.
Table 18.1: Significant material requirements

<table>
<thead>
<tr>
<th>Material</th>
<th>Quantity (cubic metres)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Earthworks</strong></td>
<td></td>
</tr>
<tr>
<td>Cut</td>
<td>450,000</td>
</tr>
<tr>
<td>Fill</td>
<td>360,000</td>
</tr>
<tr>
<td><strong>Pavement</strong></td>
<td></td>
</tr>
<tr>
<td>Blast furnace slag</td>
<td>60,000</td>
</tr>
<tr>
<td>Asphalt</td>
<td>20,000</td>
</tr>
</tbody>
</table>

* Earthworks includes 60,000 cubic metres of select material assumed sourced within the proposal.

18.2 Material sources

The south coast region has plentiful resources of easily accessible hard rock for concrete and asphalt production. Most significant quarries and batch plants are located to the north of the project site at Shell Harbour, Dunmore, Albion Park, and Bombo. The region is also well serviced by major asphalt and concrete suppliers. Depending on demand in the region at the time of construction it may be economical to establish a mobile asphalt batch plant dedicated to the project.

Blast furnace slag is a co-product of steel production. The slag product is distributed by Australian Steel Mill Services (ASMS) located in Port Kembla. Sufficient lead time would be required to allow stockpiling of the required quantities for the proposal.

18.3 Haulage of materials

Heavy industry in the region has established a reliable on-road haulage fleet. Although the South Coast Rail Line is located in close proximity to the proposal it is not economically viable to haul by rail. The majority of raw and manufactured materials would be hauled from the region to the immediate north of the proposal. Some specialist pre-cast concrete elements would be sourced from the Sydney metropolitan area. Materials would be transported on the Princes Highway.
19 Temporary infrastructure

19.1 Temporary infrastructure requirements

Temporary infrastructure is required for two purposes:

- To support or facilitate the construction of the proposal – such as batching plants or site compounds.
- To divert traffic or services around various construction stages.

The required location of compounds, batch plants, and stockpile sites is dependent on the work packages identified by the construction contractor. Work packages are differentiated according to the location, the nature of the work, and the timing of the activity. It is likely that cleared land would be leased from adjacent land holders for temporary infrastructure.

Following is a description of the required pieces of temporary infrastructure which may be required to construct the proposal.

19.1.1 Site compounds

The establishment of administration and construction compounds would form part of the site establishment works. Site compound establishment would include the erection of site fencing and clearing and levelling the site. Hard stand areas would be constructed and offices and storage sheds would be erected. Temporary utility connections to these sites would be established.

Compounds would comprise prefabricated sheds or purpose built temporary buildings for the proposal. It may be possible to utilise an existing dwelling to be acquired by the proposal if the dwelling is located such that it is not affected by the earthworks for the majority of the project duration.

Two types of compound are required for the proposal:

- Administration compounds are the centre for works coordination and communication and provide for employee and visitor parking.
- Construction compounds vary in size and provide a supporting role to the administration compounds. They are used to enclose machinery and materials to be incorporated in the works.

The location and layout of site compounds would be designed with consideration for the natural and built environment and the location of near and sensitive receivers. Impacts include the noise, vibration, and dust generated by traffic and site activities. Traffic Management and Noise and Vibration Sub Plans would be established, implemented, and monitored throughout the course of the project.

19.1.2 Batching plants

The scale of the project is such that temporary concrete and asphalt batching plants may be required. Concrete batching plants are required to service the construction of bridges. Asphalt batching plants are required for construction of temporary and permanent pavement.
Prior to construction it is proposed that a set of constraints and a procedure be established for
the construction contractor to follow in selecting, developing and managing batching plant sites.

It is anticipated that the operation and location of temporary batching plants will be considered
in the environmental assessments for the project. All batching plants will therefore be required
to comply with relevant environmental requirements, including dust collection equipment, hours
of operation, and management of waste materials.

A number of criteria have been stipulated in the Conditions of Approval for the establishment
of construction facilities on similar projects in the past. These criteria are:

- Sites to be located on residues of land purchased for the road works.
- Sites to be located within the road corridor assessed in the EIS and Representations
  Report to the greatest extent possible.
- Sites to be located so as to facilitate effective transport of concrete and asphalt to the
  worksites.
- Sites to be located to allow efficient access for constituent materials.
- Sites to be located such that they have direct access to the project alignment so that
  there is no need for haulage of concrete and asphalt on the existing road network.
- Sites to be relatively level and have sufficient area to permit effective operation,
  preferably at least 1 ha.
- Sites to be separated from the nearest residence by at least 200 m unless it can be
  demonstrated that there will be no adverse noise, visual and air quality impacts.
- Sites to be separated from creeks or watercourses by at least 50 m conditional upon
  the provision of adequate erosion and sedimentation controls.
- Sites to have low conservation significance for flora, fauna or aboriginal or non-
  aboriginal heritage.
- Sites to be already cleared of native vegetation.
- Sites not to be located within 100 m of, or drain directly to, SEPP 14 wetlands.
- Sites not to be located within 100 m of waterways unless adequate erosion and
  sediment controls are implemented to protect water quality.
- Sites must be above the 20 ARI flood level unless a contingency plan to manage
  flooding issues is prepared and implemented.
- Sites to be selected so that the operation of the plants does not impact on the land
  use of adjacent properties current at the time the plant is established.
- Concrete batching sites to have at least town water and power supply. Asphalt
  batching plants to have at least power supply.

19.1.3 Casting yards

Concrete elements will be either cast in place, pre-cast off site, or cast on-site. The following
concrete elements are required:

- Pits, pipes, culverts, and headwalls for drainage works.
- Barriers, noise attenuation, and other road furniture.
- Bridge girders, piles, and abutments.

It is anticipated that most concrete elements will be either cast insitu or pre-cast off site. If
required, casting yards can be accommodated within the concrete batch plant sites.
The need to transport concrete from concrete batch plants to casting yards is eliminated by locating casting yards within the concrete batch plant sites. All cast elements can be transported off-road from the casting yard directly to the work site.

### 19.1.4 Stockpile sites

Stockpiles are required for the temporary storage of materials delivered to the construction site or generated from within the construction site. Materials would include the constituents of concrete and asphalt and stripped topsoil for use in final landscaping work.

Proposed selection criteria for determination of stockpile sites are as follows:

- Sites to be located on residues of land purchased for the road works.
- Sites to be located at regular intervals to minimise haulage.
- Sites to be located such that they have direct access to the project alignment so that there is no need for haulage on the existing road network.
- Sites to have sufficient area to permit the storage of topsoil and the movement of scrapers.
- Sites to be separated from creeks or watercourses where possible, conditional upon the provision of adequate erosion and sedimentation controls.
- Sites to have low conservation significance for flora, fauna or aboriginal or non-aboriginal heritage.
- Sites to be already cleared of native vegetation.
- Sites not to be located within 200 m of, or drain directly to, SEPP 14 wetlands.

### 19.1.5 Side tracks

Where the new works interact with the existing road network, there is a need to incorporate traffic diversions to enable ‘off-line’ construction of the permanent works. Side tracks would be constructed with asphalt pavement and temporary line marking and traffic control devices to maintain existing road network functionality during construction.

### 19.1.6 Temporary traffic facilities

It is important that construction vehicles accessing the site and compounds do not create unacceptable disruption to traffic on adjacent roads. Where significant volumes of traffic are generated by site activities, temporary traffic facilities may be needed to ensure safe and efficient entry and egress of construction vehicles. These facilities could include right turn bays, traffic signals, and round-a-bouts on the existing road network.

### 19.1.7 Temporary utility diversions

Construction staging may be such that utilities will need to be removed from their current alignment and placed on a temporary alignment for a significant duration of the works. Utilities would be installed in their new permanent alignment when this suited construction staging.

The contractor would carry out a detailed survey and identify all utilities affected prior to the commencement of the construction. Modifications to the affected utilities would be in accordance with the design and construction methods approved by the relevant service authorities.
19.1.8 Haulage roads / pre-loading embankments

Where possible, it is proposed to utilise the project alignment for mass haulage of materials. Once the alignment is cleared of vegetation a haulage route will be established to link borrow sites, construction compounds, and concrete batching plants. Where the new alignment utilises the existing road corridor, a haulage route will need to be accommodated.

19.1.9 Sedimentation basins

Sedimentation basins are required at the time that the project alignment is cleared of vegetation. Sedimentation basins would be excavated at low-lying areas adjacent to the formation. They would be situated close to natural watercourses and may be incorporated as a permanent part of the drainage works.
20 Road safety audit

20.1 Audit purpose

A concept design (Stage 2) road safety audit of the proposal was undertaken. The audit was conducted to ascertain potential road safety issues for all road users. The full audit report is included in Appendix A.

Given the current development of the design, the audit was limited to consideration of elements identifiable from the audited plans. As design development proceeds, further design elements would be developed and be subject to a detail design (Stage 3) road safety audit. Issues considered during the audit were:

a. Road alignment and cross-section.
b. General arrangement of interchanges.
c. Local and property access.
d. Provision for pedestrian and cycle movements.
e. Potential staging and construction issues.

Issues to be addressed in the Stage 3 audit may include:

i. Lighting.
ii. Physical objects.
iii. Drainage;
iv. Road pavement.
v. Traffic control devices.
vi. Roadside safety barriers.

The objective of the audit was to identify potential safety issues for all road users and to ensure that these are recognised and considered. The following matters were considered:

- Have all of the permitted movements of all of the various road users been catered for in a safe way?
- Are the appropriate operational and control mechanisms in place to promote safety?
- Would the system operate to an acceptable level of safety in all situations, such as poor weather and during darkness?
- Are there opportunities to reduce the occurrence or severity of crashes?

Although the audit reviewed and identified safety issues, the responsibility for assessing and implementing the recommendations remains with the designers, project managers and asset owners. It is not the role of the auditor to provide solutions to the identified safety issues; however identification of potential safety concerns may assist the designer in developing alternative remedial solutions.

Table 20.1 shows the designer’s response to the audit findings.
Table 20.1: Road safety audit findings and design team response

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| 1    | The relative steep grade together with the horizontal curves and restricted alignment of the Kiama Bends, just beyond the northern extent of works may contribute to potential crashes at the interface between the upgrade and existing highway. The northern tie-in occurs just to the south of a small radius horizontal curve, (estimated at approximately 120 m radius) with an existing advisory speed sign for 65 km/h. The relationship of the horizontal curve to the crest vertical curve, some eight per cent upgrade, speed zone and relationship / compatibility to the upgraded section of the highway, particularly for northbound travel direction is not evident from the audited plans. However it is important that drivers accelerating on the upgrade appreciate the horizontal curve ahead and have adequate warning to adjust speed. Increased speeds in the southbound travel direction may occur due to the downgrade, with potential rear end crashes with vehicles decelerating to enter properties. | • Posted speed for northbound carriageway will be 80 km per hour to match the speed zoning on the Kiama Bends.  
• Progressive reduction in design elements adopted for northbound traffic on approach to 150 m radius curve include: eight per cent upgrade, retention of two 320 m radius curves, auxiliary lane merge 300 m before the 150 m radius curve, narrowing of median from five metres to 2.6 m, switch from wire rope median barrier to concrete .  
• Consideration of speed camera for northbound traffic prior to 150 m radius curve.  
• Solid median barrier will minimise head-on crashes reducing the severity of crashes in this zone.  
• Minimum 2.5 m wide shoulder available for vehicles decelerating to enter properties with an additional lane to overtake if necessary. |
| 2    | Construction staging of the northern tie-in will be potentially hazardous due to the proximity of the horizontal curve (sub-standard for a 100 km/h speed zone) to the start of the works and grades / superelevation within the works area. Traffic switches, in particular to the northbound carriageway, to permit completion of the northern section of work would require careful design of alignment / transitions / pavement crossfall / superelevation and consideration of speeds zones / advance warning. | • For consideration during detailed design and construction planning.  
• Road work speed reduction will extend beyond the extent of the work.  
• Construction approaching the northern tie-in involves extending the existing pavement with crossfall correction to curves so traffic will continue to use the existing lanes and switch to newly constructed pavement as it is built. The median to be constructed after traffic is separated. |
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<td>3</td>
<td>A gap between existing and proposed median barriers may contribute to unsafe u-turn / right turn movements at the northern extremity of the proposed work. Details of the proposed barriers and terminal treatments do not form part of the audit plans however, the concept design indicates a significant gap between the two barriers / terminal. The proposed median barrier (Ch 00) starts some 60 m to the south of the end of the existing concrete median barrier / crash barrier. Northbound drivers may attempt u-turn movements, given the length of travel to the north / South Kiama before an interchange permits a u-turn. Drivers exiting the Mount Pleasant Lookout to the southbound carriageway may also attempt u-turns at the median opening. An existing property access driveway junctions with the northbound carriageway near Ch 00. Attempted right turn entry exit movements at this driveway would be hazard, with sight lines affected by the horizontal curve and median barriers.</td>
<td>• Gap in median barrier is not intended. Solid median barrier will extend from the Kiama Bends to a wire rope transition 500 m north of Rose Valley Road.</td>
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<td>4</td>
<td>Drivers entering the northbound carriageway from minor side roads and properties, north of Rose Valley Road and wanting to turnaround to proceed southbound may attempt to use the exit driveway to the southbound carriageway at some 500 m north of the end of the works. For drivers exiting to the northbound carriageway between Rose Valley Road and the end of the works and wanting to proceed southbound on the highway, the next turnaround opportunity would be in front to the median barrier, which ends opposite the exit driveway for an existing lay-by / truck stop, approximately 500 m north of the end of the works.</td>
<td>• All previous gaps in median barrier on Kiama Bends have since been closed and are anticipated to remain closed.</td>
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| 4 cont’d | The ability to turn at this location would be governed by traffic conditions at the time, e.g., gaps in the opposing traffic, following traffic etc. However, the location is potentially hazardous due to deceleration in northbound (median side) travel lane, potential conflict with vehicles exiting the lay-by; and turning in front of median barrier may be unexpected for northbound drivers. The alternative is to travel through the Kiama Bends to the Weir Street interchange at South Kiama, approximately 2.5 km beyond the northern extent of the works. | **To be addressed during development of detailed design sign posting strategy.** Expected that “One Way” or “Left Only” signs will be installed at property accesses and Sims Road junction.  
**Opposing carriageway will be clearly visible beyond the narrow median with wire rope barrier. Low vegetation is proposed.** |
| 5 | **There is potential for unfamiliar drivers to exit the local property accesses via a wrong way turn onto the highway (this applies to local property access along the entire route)**  
Drivers exiting local properties and unfamiliar with the location may mistake the two lane carriageways as operating for two-way movements. Poor weather and lighting conditions would exacerbate this potential. | - To be addressed during development of detailed design sign posting strategy. Expected that “One Way” or “Left Only” signs will be installed at property accesses and Sims Road junction.  
- Opposing carriageway will be clearly visible beyond the narrow median with wire rope barrier. Low vegetation is proposed. |
| 6 | **Potential loss of control crashes due to sheeting of water on road surface with Type ‘F’ median barrier, six per cent cross fall towards median**  
Details of proposed drainage provisions are not included in the audit plans however the proposed Type F median barrier and six per cent crossfall at the northern extremity of the works may contribute to water across the southbound lane (2), despite the eight per cent downgrade on the through alignment. | • Median drainage is incorporated with Type F barrier to capture water and minimise width of flow against the barrier. Flow under barrier will not be permitted. |
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| 7    | The proposed Omega Lane junction at Ch 600 is located in a section of deep cut with 1:1 batter slopes, where the provision of adequate sight distance and approach grades on the lane will be important for exiting drivers to safely junction / merge with northbound traffic.  
The Omega Lane junction is also located towards the end of the merge lane for the Rose Valley Road northbound on-load ramp. The potential for slow moving farm trucks using the access will require adequate sight distance to safely junction, accelerate on the upgrade and merge with northbound traffic.  
Grading of the lane approaching the highway should facilitate drivers stopping prior to the junction. | • Omega Lane to be retained at the current location to reduce excavation  
• Omega Lane services a very limited number of properties and traffic volumes are correspondingly low.  
• Sight distance requirements (SISD) have been met for this junction for a 80km/hr design speed. |
| 8    | Horizontal curves (R320m) near Ch 340 and Ch 660 within the section of eight per cent grade may contribute to poor lane discipline or vehicles leaving the carriageway.  
For the proposed 80 km/h design speed at the northern end of the project, the R320 curves are within the range where drivers may be misled regarding the appropriate negotiation speed. The curves are deceptive in that they appear to the driver to be capable of being safely negotiated at higher speeds than is actually possible.  
The eight per cent grade (upgrade in the northbound direction and downward in the southbound direction) would further increase the potential for drivers to approach at too higher speed. | • The proposed geometry is similar to the existing geometry but with improved superelevation. A review of the accident history for this section does not indicate a high frequency of the type of issues highlighted.  
• Solid median barrier will minimise head-on crashes |
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|      | In the northbound direction, the smaller radius curves may assist in reducing speeds approaching the start of the Kiama Bends, providing the visual clues for the driver are adequate to achieve a speed reduction. The end of the northbound merge lane (approximately Ch 600 to Ch 300) is also located between these curves, which may contribute to side swipe type / merge crashes with a left to right merge on the outside of a R320 and eight per cent upgrade. In the southbound travel direction, drivers would be transitioning from the Kiama Bends to the new section of work, with an expectation of a higher standard alignment and downgrade contributing to increased speeds. | • Only low grasses are proposed for the median.  
• No R320 curves are proposed where wire rope safety barrier is used.  
• Wire rope barrier to be offset to inside of curves provides minimum stopping sight distance for 100 km/h standard  
• Barrier transition detail will be developed in detail design phase.  
• Concrete barrier and wire rope barrier will overlap in the transition area to avoid direct impact with terminals. Appropriate deflection will be provided between barriers to ensure they operate independently. |
<p>| 9    | Wire rope safety barrier is proposed in the median to separate opposing traffic from Ch 850 southward. While drivers would have a view through the barriers for the majority of the route, sight distance may be affected in the section of small(er) radius horizontal curves (eg R320/ R600) and straight. Vegetation may further impact on sight distance. Details of the proposed treatment of the depressed median are not provided, however growth of vegetation in the median would further impair sight distance. |                                                                                                                                                                                                                  |
| 10   | Sections where the wire rope barrier transitions to Type F barrier, eg Ch 850, should take into account the deflection of the wire rope to avoid vehicles being led onto the concrete barrier terminal |                                                                                                                                                                                                                  |</p>
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| 11   | Potential for side swipe crashes at merge of Rose Valley Road northbound on-load ramp on upgrade | • The merge lane would extend beyond the northern limit of the project and involve extensive earthworks in unstable terrain if the full grade-corrected length was adopted. The design team believes that the 600 m length provided is satisfactory as an interim solution pending a future realignment of the Kiama Bends.  
• The eight per cent grade will slow heavy vehicles so that their merge intentions are predictable for faster traffic.  
• Very few trucks will load northbound from Rose Valley Road due to the load restriction on Fern Street, but slow vehicles will move from the mainline to the auxiliary lane. |
| 12   | Horizontal and vertical alignment between Ch 230 to 1150 | • Due to the intention to match the existing alignment within this section, the existing broken-back curves were unavoidable without significant changes to the alignment. The alternative is to replace the 2 x 320 m radius curves with one 600 m radius curve, but this would encourage higher speeds approaching the 150 radius curve at Kiama Bends.  
• There were no opportunities available to lessen the eight percent grade. It is expected that this grade will be addressed in future projects addressing the alignment of the Kiama Bends. |
<p>| 13   | The entry to slip lane for the Fern Street / Rose Valley Road southbound off-load ramp at Ch 1050 is located downstream of an R320 horizontal curve, over a crest and on the outside of a reverse R900 curve, which limits approach sight distance and decision time for drivers to appreciate the exit location | • The geometry at this location has been constrained by the interchange alignment at Rose Valley Road and the preceding alignment at Mount Pleasant (existing alignment matched). The diverge length has since been increased from 120 m to 145 m to improve sight distance and decision time. |</p>
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| 14   | Potential for rear-end crashes from vehicles decelerating in the through lane to the Rose Valley Road off-load ramp due to the short length of the right turn bay (some 40 metres including taper) for the right turn to Rose Valley Road overpass (Ch 1450) | • Due to the location and geometry of the Rose Valley Road overpass, a right turn bay length that caters for full deceleration length was not achievable. Partial deceleration will be required in the adjacent through lane but vehicles can store clear of the through traffic.  
• The right turn movement to Rose Valley Road is a low frequency movement servicing approximately 30 properties in Rose Valley and u-turns for properties on the eastern side between Weir St and Rose Valley Road. |
| 15   | Drivers exiting a local property near Ch 1080 at the start of the Rose Valley Road slip lane may attempt to drive across the slip lane onto the main southbound carriageway with potential conflict with southbound traffic | • This movement is possible but it would be much safer to load onto the highway by turning left to the southbound offload ramp, following the Fern Street extension and loading at the Fern Street southbound onload ramp. Moving the access or extending the ramp is not practical. |
| 16   | Potential for wrong way through movement for northbound traffic on Fern Street (Gerringong) access road approaching off-load ramp junction at Rose Valley Road overbridge at Ch 1450  
The current intersection design relies on pavement arrows to indicate to drivers on the northbound traffic lane that only left turn movements to Rose Valley Road overbridge are permitted. At night and poor weather conditions drivers may assume the road continues as a two-way road. | • Need to provide a raised concrete median detail which will direct traffic left with the addition of a left turn only sign  
• Flag lighting to be provided in conjunction with a raised median to highlight the turn movement |
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<td>17</td>
<td>Headlight glare for northbound traffic on Fern Street (Gerringong) access road approaching off-load ramp junction at Rose Valley Road overbridge at Ch 1450. Similarly, headlight glare from northbound Fern Street ramp traffic may also confuse drivers of the main southbound carriageway, due to opposing headlights on the left. Headlight glare at night from northbound traffic on the local road and southbound traffic on the off-load ramp may affect drivers’ appreciation of the road ahead and potential conflict, with drivers’ braking on the off-load ramp. Headlight glare may also affect drivers on the main southbound carriageway with the Fern Street ramp aligned parallel to the main southbound carriageway.</td>
<td>• Detailed design to consider the extent of screens or planting between the highway and service road.</td>
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<td>18</td>
<td>Potential for intersection crashes due to drivers on Rose Valley Road northbound not expecting the unusual priority for the right turning traffic from Fern Street to on-load to the highway northbound (Ch 1450 at the junction on the western side of the of the Rose Valley Road overbridge)</td>
<td>• The junction layout shown is indicative for the purpose of concept design. This junction requires further consideration during detailed design. • Low volume movement catering for local traffic. • Pavement marking, signposting and lighting will highlight the stop or give-way priority</td>
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<td>19</td>
<td>Drivers of larger vehicles (truck and buses) exiting the indented turnaround on Rose Valley Road and wanting to execute a u-turn to on-load to the highway northbound may cross the centreline of Rose Valley Road (Ch 1450 on the main highway alignment)</td>
<td>• Rose Valley Road is a very low volume local road. • Detail design will ensure that turning movements for all types of vehicles using the facility are contained within the appropriate lane.</td>
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<td>20</td>
<td>A local property access junctions to the Fern Street ramp some 20 metres south of the overbridge (Ch 1500). Drivers exiting the property may attempt to turn right or cross the median to access the overbridge and the highway northbound on-load ramp</td>
<td>• This access and one approximately 120 m north, service the same property. These accesses will be consolidated into a single point opposite the Rose Valley Road / Fern Street junction. Right turn from Fern St south will need to cross the overbridge and use the turnaround facility.</td>
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<td>21</td>
<td>Potential for aquaplaning in section of flat grade and horizontal curves (Ch 1580-2800)</td>
<td>• A 0.5 per cent longitudinal grade has since been introduced over this length. Aquaplaning to be investigated further during detail design.</td>
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<td>An extended length of very flat grade (longitudinal grade of zero percent) is proposed between approximately Ch 1580 and 2600, which coincides with horizontal curves.</td>
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<td>22</td>
<td>Potential for errant vehicles to be led onto the concrete barrier terminal at culvert due to deflection of wire rope barrier at Fern Street / Rose Valley Road southbound on-load ramp at approximately Ch 2400</td>
<td>• Appropriate barrier transition details will be developed in the detailed design phase.</td>
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<td>The wire rope fencing is provided in approach and departure to the concrete barriers at the culvert. Deflection of the wire rope may contribute to errant vehicles being directed into the barrier terminal. Details of the proposed barriers and terminal treatments do not form part of the audited plans.</td>
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<td>23</td>
<td>Potential conflicts between drivers merging from the Fern Street / Rose Valley Road southbound on-load ramp with the highway southbound at approximately Ch 2570. Hazards on the western edge of the ramp will increase the crash severity for errant vehicles</td>
<td>• Wire rope barrier has since been incorporated in the design. Appropriate transitions with bridge barriers will be considered in detailed design.</td>
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<td>Drivers merging from the ramp may not have sufficient length to accelerate, judge gaps in highway traffic and merge. The length of the merge is some 240 m. Wire rope fencing is proposed adjacent to the merge due to the culvert at Ch 2450 and steep 1:2 embankment with a height of some 4.5 m. Errant vehicles at this location may run behind or through the barrier with potential for roll-over or impacts with the culvert headwall.</td>
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| 24   | Potential hazard for errant vehicles due bridge abutments and barrier protection at Omega Flat bridge(s) and culverts  
The location of the Omega Flat Bridge abutments within the gore area for the northbound off-load ramp to Rose Valley Road and between the main carriageway and southbound Gerringong access road at approximately Ch 1700 may limit the ability to locate abutments / barriers outside clear zone or provide terminal flares on approach barriers. Similar safety issues may arise with bridges / culverts at Ch 1900, Ch 2080, Ch 2300 and Ch 2450.  
The bridge at Ch 2300 has a minor local access road junction near the southern approach on the northbound carriageway, which will preclude continuous barrier protection on this approach; detailed design of bridges and culverts will clarify the proposed treatments.  
The proximity of the bridges / culverts will mean the barrier type transitioning from wire rope barrier to bridge barrier to wire rope to barrier, etc. Deflection of the wire rope barrier should avoid errant vehicles being led onto other rigid terminals. The overall treatment of barriers and terminal treatments for the whole section should be reviewed to minimise potential hazards. | - Barrier transition details to be developed in the detailed design phase. The location of bridges / culverts is fixed.  
- Property accesses have been placed where they correspond to the current ‘driveway’ location. The road safety audit findings will be considered in the final positioning of property accesses during finalisation of the concept design. |
| 25   | Local property accesses are located in areas of significant cut (some five metres at Ch 3100) and fill (2.6 metres at Ch3300) which hampers the provision of adequate sight distance and a level standing area for drivers exiting to the highway | - Property access locations still to be finalised in concept design.  
- Adequate sight distance will be considered when finalising property access locations. |
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| 26   | Potential lane changing / merge crashes due to closure of Lane 1 of the northbound or southbound carriageway would be required to construct the future widening illustrated on the typical cross section in cut (near Simms Road Ch 3150)  
Future staged construction of the works is not detailed, however the extent of excavation illustrated suggests an extended duration of the works and associated lane closure would be required. | • One lane in each direction will be available at all times during construction.  
• In the vicinity of Ch 3150, traffic will remain on the existing highway whilst the ultimate northbound carriageway is excavated. Two-way traffic will then be transferred to the completed northbound carriageway whilst the ultimate southbound carriageway is excavated. |
| 27   | The proposed Sims Road junction at Ch 3550 is located in a section of deep cut with 1:1 batter slopes, where the provision of adequate sight distance and approach grades on the side road will be important for exiting drivers to safely junction / merge with northbound traffic  
Grading of the lane approaching the highway should facilitate drivers stopping prior to the junction. | • Sims Road junction has adequate SISD. |
| 28   | Drivers' appreciation of the road alignment ahead would be affected particularly at night by the alternating appearance of headlights due to the vertical alignment near Ch 4080  
The vertical alignment creates sufficient height difference between crest and sag to obscure an oncoming vehicle in the dip near Ch 4080 from view. Drivers' appreciation of the road alignment ahead would be affected particularly at night by the alternating appearance of headlights. | • This issue is not considered to warrant a revision in the alignment.  
However, further design development to address cross drainage issues may improve the alignment by eliminating the sag to overcome cross drainage issues.  
• Minimum vertical curves lengths for headlight criteria have been met. |
| 29   | Sight distance is restricted for drivers exiting at the junction of Sims Road to the northbound carriageway, with the junction located some 170 metres over the crest at Ch 3737  
Similarly drivers travelling over the crest would have limited time to appreciate the junction location, decelerate and turn left on entry, with potential for rear-end crashes. | • Sims Road is used primarily by residents who will be familiar with the arrangement.  
• A minimum 3.0 m wide shoulder is available for decelerating vehicles on approach to Sims Road.  
• Sight distance requirements have been achieved (SISD, ASD and 5 seconds gap acceptance from Sims Road) |
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| 30   | Headlight glare from southbound traffic on the Belinda Street to Willow Vale service road may mislead northbound drivers on the Willow Vale off-load ramp, contributing to braking and rear-end crashes. Similarly headlights from the service road may be visible to drivers on sections of the northbound highway carriageway contributing to driver error due to opposing traffic being visible to the left of the carriageway | • Lighting proposed at the intersection of the service road and Willowvale Road will assist driver appreciation of the configuration.  
• Signage to be considered in detailed design could include advance warning for off-load ramp traffic of ‘intersection’ and ‘two-way traffic’ ahead.  
• There is good sight distance for motorists to view the lane / intersection arrangement. To be investigated further during detail design.  
• There is a considerable height variation between the highway and service road that may reduce this possible issue. To be investigated further during detail design. |
| 31   | Potential conflict between entering and exiting traffic at the Baileys Road underpass. The narrow width of the underpass and approach alignment will restrict mutual sight distance of opposing traffic. Similarly, limited pavement width may contribute to conflict on the horizontal curves to the east of the underpass and at the service road junction to the west of the underpass | • Baileys Road services a single property with very low traffic movements.  
• Safe intersection sight distance is adequate.  
• Detailed design to investigate widening adjacent to the bridge abutment                                                                                                                                  |
| 32   | Errant vehicles may reach the steep batter slopes, due to deflection of the wire rope barriers in the vicinity of the Belinda Street underpass. Wire rope barriers in front of a 1.5 metre verge are proposed to protect the high non-traversable embankment (approximately eight metres height with a maximum 2:1 batter slope). The proximity of the barrier to the top of the embankment would increase the risk for errant vehicles of running down the batter slope. The barriers may fail to perform adequately with a consequent secondary hazard to vehicles on the Willow Vale Road and southbound on-load ramp below. | • Adequate verge width is provided to allow full deflection of the wire rope barrier in accordance with design standards for wire rope barrier.  
• The likelihood of such an event occurring is relatively low. The 3.0 m wide shoulder provides opportunity to regain control of an errant vehicle. |
<table>
<thead>
<tr>
<th>Ref.</th>
<th>Audit finding</th>
<th>Designer response</th>
</tr>
</thead>
</table>
| 33   | Potential hazard for cyclists riding adjacent to wire rope/ high embankment, near Belinda Street interchange  
Cyclists are proposed to use the 2.5 m shoulder, which is widened to three metres adjacent to wire rope barrier. The wire rope may have limited impact in containing an errant cyclist, with the cyclist overtopping the barrier and rolling down the batter slope. | • This risk is considered acceptable given the small number of cyclists and the short length of the hazard.  
• A 1.5m wide verge is provided behind the wire rope barrier |
| 34   | Drivers may have difficulty in maintaining lane discipline due to short lengths of horizontal curves, near approximate Ch 5580-5700, 5860-5960 and crest near Ch 5550  
For southbound drivers, the R600 at Ch 5580 will be hidden over a crest at Ch 5550.  
For drivers travelling in the northbound direction, the start of the R600 curve is some 130 m over the crest which allows limited time to adjust speed. Drivers accelerating on the downgrade may exceed desirable speeds for the 600 m radius horizontal curves. However, this radius meets the minimum horizontal curve criteria adopted for sections where the existing highway alignment is retained. | • Alternative alignments were investigated along the Gerringong Bends to improve geometry coordination, however the associated impacts were considered excessive and not in accordance with the project objectives.  
• The R600 curve at Ch 5580 although over a crest is defined well in advance by the walls of the deep cutting and wire rope median barrier. 3D animation demonstrates that horizontal curve visibility is not a problem at this location.  
• Lane discipline on short arc length R600m curves is not considered to be a problem |
| 35   | Driver may attempt late lane changes due to the start of the slip lane (Ch 5540) to Willow Vale Road for northbound being located just over the crest at Ch 5550  
Approach sight distance to the start of the slip lane is severely restricted, given the combination of crest vertical curve, exit on the inside of R600 curve and downgrade. The overall length of the slip lane (some 180 m to the diverge gore area) provides limited decision time in addition to diverge requirements to allow drivers to safely exit. | • The length of this lane has since been extended to address this situation by providing 7 seconds (215 m) to diverge to the ramp. |
<table>
<thead>
<tr>
<th>Ref.</th>
<th>Audit finding</th>
<th>Designer response</th>
</tr>
</thead>
<tbody>
<tr>
<td>36</td>
<td>Sight lines (minimum requirement for safe intersection sight distance) for property access near Ch 6050 may be diminished by the cut embankment and horizontal curve to the south</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• This property access has since been relocated (to approx Ch5780) to address sight distance issues.</td>
<td></td>
</tr>
<tr>
<td>37</td>
<td>Sight lines for property access near Ch 6250 may be diminished by median barrier; the access will introduce a discontinuity in the outside barrier reducing the effectiveness of the barrier and requiring a terminal treatment. Sight distance will be important for exiting drivers given the access is some 200 m beyond the end of the merge on the southbound carriageway, where drivers may still be accelerating from the merge on a downgrade for the through alignment.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• There is no outside barrier proposed here.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• 100 km/h safe intersection sight distance past the wire rope median barrier has been provided.</td>
<td></td>
</tr>
<tr>
<td>38</td>
<td>Poor lane discipline and run off the road type crashes may be generated by compound curves at the temporary southern tie-in of the proposed works to the existing highway at approximately Ch 7500. The Toolijooa Road junction may be subject to increased intersection crashes due to u-turning traffic and intersection movements. Details of the tie-in (if required, dependent on staging of Sections 1 and 2) are not clear and would be resolved in further stages of work. However the alignment for the southbound travel direction appears likely to require successively smaller radii, if required to tie back to the existing carriageway. Drivers may be mislead into selecting a higher approach speed than achievable to safely negotiate the successive curves. For drivers exiting to the southbound carriageway south of Belinda Street, Toolijooa Road provides the next turn opportunity. The proposed transition from the proposed works to the existing highway / Toolijooa Road or continuation to Section 2 of the upgrade is not clear. However additional turning movements and potential conflict may be generated at Toolijooa Road.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• A tie-in arrangement using a single R500 curve has since been developed.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• The southbound off-load ramp to be included in the concept design to separate left turn traffic to Toolijooa and provide the opportunity to U-turn using Toolijooa Road.</td>
<td></td>
</tr>
<tr>
<td>Ref.</td>
<td>Audit finding</td>
<td>Designer response</td>
</tr>
<tr>
<td>------</td>
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<td>-------------------</td>
</tr>
<tr>
<td>39</td>
<td><strong>Construction staging</strong>&lt;br&gt;The proposed alignment follows the existing highway corridor with sections of significant level changes from the existing carriageway. The design and location of traffic switches and protection at level changes will be important for the safety of road users during construction. (Mitigation measures may temporarily require works outside the future road reservation).&lt;br&gt;The design of temporary access for local properties will also need to maintain adequate sightlines in areas of significant level differences between existing and proposed carriageways, eg Ch 3070, Ch 3300, Sims Road, Ch 4700, Ch 6030, Ch 6250.</td>
<td>• A concept level construction staging strategy has since been developed to indicate a potential staging strategy. The strategy has not considered every aspect – including individual property accesses. It is likely that property access will be restricted to left-in-left-out during construction.</td>
</tr>
</tbody>
</table>
21 Proposal cost estimate

21.1 Scope of work

The cost estimate of the proposal is derived from cost estimates for each of the major work element of the proposal, including:

- Project development
- Investigation and design
- Property acquisitions
- Public utility adjustments
- Construction, and
- Handover

21.2 Concept cost estimate

The concept cost estimate has been compiled in accordance with the RTA’s Project Estimating Manual, Version 2.0 (31 March, 2008). The concept cost estimate figure is reported with a 90 per cent probability of being achieved – this is known as a P90 estimate. The P90 estimate for the proposal is $232M ($2009).

The concept cost estimate has been derived using probabilistic estimating techniques. This technique requires a risk matrix to be compiled with the likelihood and consequence of each risk expressed in dollars. A large number of potential combinations of risks are run using simulation software. A range of combined risk outcomes are plotted in a bell curve and the 90 per cent probability figure is reported.
22 Actions arising from the value engineering workshop

A value engineering workshop for the proposal was held on 11 December 2009. The workshop brought together a range of stakeholders to review the concept design and highlight issues, concerns, potential improvements and risks associated with various aspects of the proposal.

The objectives of the workshop were:

- Clarify the objectives of the project.
- Review the Gerringong upgrade design developed to meet the project objectives.
- Identify issues influencing value for money.
- Propose solutions or actions to address the issues identified.

A summary of the actions arising from the workshop is provided in Table 22.1 below.
## Table 22.1: Value engineering issue register

<table>
<thead>
<tr>
<th>No.</th>
<th>Checklist Item</th>
<th>Applicable to</th>
<th>Recommended action</th>
<th>Responsible party</th>
<th>Timetable</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>Existing Kiama Bends heading southbound speed limit is to remain 80kph. Is 80kph a practical expectation?</td>
<td>X</td>
<td>Is it possible to increase speed limit to 100kph?</td>
<td>RTA</td>
<td>Review accident statistics and recent incident occurrence for this stretch of road.</td>
<td>Grant Campbell to provide accident history from Mt Pleasant to Rose Valley Rd</td>
</tr>
<tr>
<td>1b</td>
<td>Existing Kiama Bends heading southbound speed limit is to remain 80kph. Is 80kph a practical expectation?</td>
<td>X</td>
<td>Do we consider different speed limits southbound (100kph), northbound (80kph)?</td>
<td>AECOM</td>
<td>Is the introduction of a solid median barrier sufficient to reduce accidents (head-on)?</td>
<td>Different speed limits likely outcome. Concrete barriers proven to prevent head-on accidents (Kiama Bends and Mount Osmond)</td>
</tr>
<tr>
<td>1c</td>
<td>If southbound speed limit is 100kph what are the consequences?</td>
<td>X</td>
<td>The following issues are to be reviewed: - Curve radius - Higher cross fall - Sight distance - Impact of central barrier - High wind area? - Pavement surface - Heavy vehicles heading southbound (8% grade and tight bends) - Need for higher median barriers for heavy vehicles - Land take - Public utilities (e.g. water main) - Safe access (left-in, left-out) property access - Understanding of nature of accidents - Space for side basins - 8% grade in the section - Cost of staking for 100kph southbound, staging impacts on construction</td>
<td>RTA / AECOM</td>
<td>Review accident report before considering treatments</td>
<td></td>
</tr>
<tr>
<td>1d</td>
<td>Impact on the downgrade of the 8% grade along with the small radius bends. Will this cause problems for heavy vehicles even if speed limit is not increased to 100kph?</td>
<td>X</td>
<td>Alter alignment to reduce curves. Is this an option? Consider tall boy median rather than standard.</td>
<td>AECOM</td>
<td>Is this practical - consider additional property acquisition cost and loss of agricultural land.</td>
<td>Review accident report before considering treatments</td>
</tr>
<tr>
<td>1e</td>
<td>Review significance of vegetation on south side of bend (CH 600)</td>
<td>X</td>
<td>AECOM</td>
<td>Additional vegetation would be impacted if a 100kph alignment was adopted.</td>
<td>No alignment changes proposed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Review potential drainage and erosion (construction phase as well as operation).</td>
<td>X</td>
<td>AECOM</td>
<td>The required operational sedimentation controls are still to be confirmed. It is possible that additional land may need to be leased from land holders for the purpose of construction sedimentation basins.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2a</td>
<td>What treatments are being proposed to create driver perception of 80kph?</td>
<td>X</td>
<td>Sign posting and progression of bends. Further work required on geometric design (sign posts are not enough)</td>
<td>AECOM</td>
<td>Extension of Type F barrier, narrow 2.6m median, signposting, lower level of service force by merging traffic 250m before bends. Permanent speed camera.</td>
<td></td>
</tr>
<tr>
<td>3a</td>
<td>Constructability, staging, safe separation with existing road and new road overlapping.</td>
<td>X</td>
<td></td>
<td>AECOM</td>
<td>A suitable construction staging sequence is to be demonstrated for the design adopted. Travelling public and road worker safety will be a consideration.</td>
<td></td>
</tr>
<tr>
<td>3b</td>
<td>Reconsider north bound method of slowing traffic as approaching Kiama Bends.</td>
<td></td>
<td></td>
<td>AECOM</td>
<td>Northbound traffic will be slowed by the 8% upgrade. Type F barrier, narrow 2.6m median, signposting, lower level of service force by merging traffic 250m before bends. Permanent speed camera.</td>
<td></td>
</tr>
<tr>
<td>3c</td>
<td>Is it possible to alter the design to coincide with proposed future RTA project to straighten out Kiama Bends?</td>
<td>X</td>
<td></td>
<td>RTA / AECOM</td>
<td>Current design accommodates a potential Kiama Bends project proposed by RTA. This was a driver for adopting the lower 80kph alignment from the Rose Valley Road interchange north. The old bends alignment will need to be maintained for access and transport of hazardous materials. Connection arrangements at each end has not been considered.</td>
<td></td>
</tr>
</tbody>
</table>
### Rose Valley Road interchange

<table>
<thead>
<tr>
<th>No.</th>
<th>Checklist Item</th>
<th>Applicable to</th>
<th>Recommended action (include estimated saving for significant items)</th>
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<th>Timetable</th>
<th>Comment</th>
<th>RTA Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>7a</td>
<td>The north bound entrance/acceleration lane is a conventional design - is it possible to reduce the length and have the traffic join the highway earlier?</td>
<td>X</td>
<td></td>
<td>RTA / AECOM</td>
<td></td>
<td>This comment has been superseded / addressed by the later adoption of the 'loop' option. Loop option superseded by staggered 'T' which addresses main fig tree preservation, ramp length, bus bay and safety concerns of the loop option.</td>
<td></td>
</tr>
<tr>
<td>7b</td>
<td>Confidence of northbound exit ramp being able to fit between the two fig trees' impact of the upgrade on the living conditions / environment of both the trees.</td>
<td>X</td>
<td></td>
<td>RTA / AECOM</td>
<td></td>
<td>This comment has been superseded / addressed by the later adoption of the 'loop' option. Railer above.</td>
<td></td>
</tr>
<tr>
<td>7c</td>
<td>How will vertical walls be constructed? Review impact of construction on fig trees. Design / construction concerns over how the road would be built around the trees (impact on water table, ground conditions etc.)</td>
<td>X</td>
<td>Review method for building the embankments used to manage the risk. Adjust alternative design of cutting / slot to manage the risk. Faster slope to be used rather than vertical wall.</td>
<td>RTA</td>
<td></td>
<td>Seek advice from arborist regarding the potential impact of the 'loop' on the health of the trees. Arborist report has been requested.</td>
<td></td>
</tr>
<tr>
<td>7d</td>
<td>Review constructibility (staging) / maintaining traffic flow and impacts on Renfrew Park.</td>
<td>X</td>
<td></td>
<td>AECOM 1st</td>
<td></td>
<td>How much room is required during construction? Considering we still need to provide Renfrew Park with access during construction? Review highway operation during construction period.</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Undertake comparative assessment of fig tree versus Renfrew Park property.</td>
<td>X</td>
<td></td>
<td>RTA / AECOM</td>
<td></td>
<td>Archaeological Report received 4/12/20 with recommendation that large fig tree be retained with consequential impact on the Renfrew Park grounds and planting.</td>
<td></td>
</tr>
</tbody>
</table>

### Rose Valley Road interchange to Fern Street

<table>
<thead>
<tr>
<th>No.</th>
<th>Checklist Item</th>
<th>Applicable to</th>
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<th>Timetable</th>
<th>Comment</th>
<th>RTA Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Conflicting headlights on service road for cars traveling in the opposite direction.</td>
<td>X</td>
<td>Consider using landscaping. Development plan.</td>
<td>RTA</td>
<td></td>
<td>Additional separation of the two alignments to satisfy cross drainage requirements may alleviate this potential issue. Incorporate in detail design landscaping brief.</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Review value for money / costs options for realigning interchange at Fern Street rather than Rose Valley Road (due to constraints of fig trees and Renfrew Park).</td>
<td>X</td>
<td>Review: - Moving interchange further south closer to the residents near Burnett Ave. - Compare the footprint of a four way intersection at Fern Street and the most recent design of Rose Valley Road. - Review the estimated cost of the Rose Valley Road and Fern Street interchanges (challenge was made as to the actual difference in cost suggested between the two). - Alternative to remove bridge options and upgrade level crossing (is this a long term solution?).</td>
<td>AECOM</td>
<td></td>
<td>Need to address soft soil issues and urban design problems of providing a four way interchange at Fern Street. Post meeting Mark Bennett issued an example of a similar bridge over rail from Albury. The example used a partial arrangement to set columns outside rail clearance requirements. No further design options to be progressed. Ensure costing of interchanges can withstand scrutiny. Portal arrangement has lower visual impact than blade plates required to meet Railcorp requirements. Soft plastic soils 15m deep - best avoided.</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Does the road speed (50kph) drive the need for a larger bridge over the railway than may be needed?</td>
<td>X</td>
<td>Do we need the larger 50m bridge at Fern Street? Consider minimal impact bridge at entrance to Gerringong (consider reduced speed limit). Use of blade supports and planks (to ensure safety from train accidents) and to reduce height of bridge.</td>
<td>AECOM</td>
<td></td>
<td>50m design affects the length of embankment but has little impact on length of bridge. Need to investigate bridge length where embankment would be constructed on soft soils.</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Compare (e.g. multicriteria analysis) current proposal against a combined single interchange closer to Gerringong urban area.</td>
<td>X</td>
<td></td>
<td>AECOM</td>
<td></td>
<td>Not required.</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Does Belinda Street need to be fully operational before Fern Street upgrade can commence?</td>
<td></td>
<td>Cost / time savings if Belinda Street and Fern Street could be constructed together.</td>
<td>AECOM</td>
<td></td>
<td>Large social benefit of not closing Fern Street. Belinda St needs to be operational before Fern St can be closed. Difficult to commence piling work before closure as alignment is over existing pavement.</td>
<td></td>
</tr>
<tr>
<td>No.</td>
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<td>Comment</td>
<td>RTA Comment</td>
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</tr>
<tr>
<td>16</td>
<td>Look at 3D impact to ensure it will work.</td>
<td>X</td>
<td>AECOM</td>
<td>The current drive through demonstrates the 3D impact.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Reconsider space requirements / noise attenuation solutions within the road reserve. Identify preferred method of treatment at each location.</td>
<td>X</td>
<td>Identify preferred method of treatment at each location.</td>
<td>AECOM</td>
<td></td>
<td></td>
<td>Review exceedances and develop strategy for wall/paving treatments and residential treatments.</td>
</tr>
<tr>
<td>18</td>
<td>Use low cost mound as an alternative to a sound wall. Review sound mitigation through Gerringong.</td>
<td>X</td>
<td>Select future funding to be examined Acceptance of local residents to a sound wall - rural environment. Consider alternative noise mitigation e.g. low noise pavement. Consider moving noise wall in between residents and rail line rather than road and rail line. Investigate noise treatment within the road reserve. Review industrial versus resident occupancy along road reserve.</td>
<td>AECOM</td>
<td></td>
<td></td>
<td>Review exceedances and develop strategy for wall/paving treatments and residential treatments. The adoption of noise mounds would most likely require the upgrade design to shift further westward.</td>
</tr>
<tr>
<td>19</td>
<td>What considerations have been made for school pick-ups?</td>
<td>X</td>
<td>Check Ministry of Transport requirements / limits on distance to be travelled by parents to take their children to the school bus pick-up point. Review possibility of underpass facility at Sims Road - safety issue.</td>
<td>AECOM</td>
<td></td>
<td></td>
<td>Bus parking at Belinda Street and Rose Valley road will be provided. Accept the need for some financial assistance to travel to bus stops (minor) Review pedestrian access at Sims Road Review pedestrian access at railway underpass in Belinda St.</td>
</tr>
<tr>
<td>20</td>
<td>Review the impact of flooding remediation underneath Belinda Street interchange.</td>
<td>X</td>
<td>Check staging of drainage construction at Belinda Street interchange. Watercourse, underpasses and soft soils at Belinda Street. Vill need careful consideration of construction staging.</td>
<td>AECOM</td>
<td></td>
<td></td>
<td>Report on investigation.</td>
</tr>
<tr>
<td>21</td>
<td>Identify if the Eastern Gas Pipeline location / requirements will change at the Belinda Street interchange.</td>
<td>X</td>
<td>Review structures, impacts and requirements.</td>
<td>AECOM</td>
<td></td>
<td></td>
<td>Report on investigation, particularly the service road.</td>
</tr>
</tbody>
</table>

**Roywill Road intersection to Doonhead Road**

<table>
<thead>
<tr>
<th>No.</th>
<th>Checklist Item</th>
<th>Concept/EA phase</th>
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<th>Timetable</th>
<th>Comment</th>
<th>RTA Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>22</td>
<td>Check safety issue of approach to Willowvale Road from northbound off-ramp.</td>
<td>X</td>
<td>Reassess Willowvale Road intersection on service / access road from road safety (speed of approach) perspective.</td>
<td>AECOM</td>
<td></td>
<td></td>
<td>Check left turn Willowvale Road to Service Road - high speed downhill approach from northbound off-ramp - recommend treatments.</td>
</tr>
<tr>
<td>23</td>
<td>Review ongoing maintenance requirements and ease of maintenance on cuttings and embankments (2/1) and long term costs and safety (all locations).</td>
<td>X</td>
<td>Review ease of maintenance. Ability to establish planting and growth.</td>
<td>AECOM</td>
<td></td>
<td></td>
<td>Report on investigation.</td>
</tr>
<tr>
<td>24</td>
<td>Check grades where existing existing road (e.g. Ch 6900) crosses the proposed road for construction staging.</td>
<td>X</td>
<td>AECOM</td>
<td></td>
<td></td>
<td></td>
<td>Report on investigation.</td>
</tr>
<tr>
<td>25</td>
<td>Review drainage and staging to suit construction and take water away (e.g. Ch 6705 area).</td>
<td>X</td>
<td>RTA subsoil drainage is installed along this length of road and needs to be considered Potential stockpile site - consideration of run-off required Control flow through properties or bring down side of highway and channel through amended cut-off.</td>
<td>AECOM</td>
<td></td>
<td></td>
<td>Report on investigation.</td>
</tr>
<tr>
<td>26</td>
<td>Make provision for crossover for incident management (all locations).</td>
<td>X</td>
<td>AECOM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>Avoid shallow embankments and cuts</td>
<td>X</td>
<td>Shallow embankments require extensive ground preparation, avoid where possible.</td>
<td>AECOM</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>Provision for slowing traffic as it exits high speed new road and enters old road at southern end (southbound traffic).</td>
<td>X</td>
<td>Remove climbing lane Take back to one lane further down the upgraded section.</td>
<td>AECOM</td>
<td></td>
<td></td>
<td>Safety concern - 7km of fast road and approaching Foxground Blends. Concept design to show reduction to 1 lane SB/E on existing climbing lane with traffic separated by a wide median.</td>
</tr>
</tbody>
</table>
### Terms and acronyms used in this report

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>AADT</td>
<td>Annual average daily traffic</td>
</tr>
<tr>
<td>ARI</td>
<td>Average recurrence interval</td>
</tr>
<tr>
<td>ASD</td>
<td>Approach sight distance</td>
</tr>
<tr>
<td>ASS</td>
<td>Acid sulfate soil</td>
</tr>
<tr>
<td>ASSMP</td>
<td>Acid sulfate soils management plan</td>
</tr>
<tr>
<td>ATC</td>
<td>Automatic traffic count</td>
</tr>
<tr>
<td>bgl</td>
<td>Below ground level</td>
</tr>
<tr>
<td>DECCW</td>
<td>Department of Environment, Climate Change and Water</td>
</tr>
<tr>
<td>DOS</td>
<td>Degree of saturation</td>
</tr>
<tr>
<td>ECRTN</td>
<td>Environmental Criteria for Road Traffic Noise</td>
</tr>
<tr>
<td>EEC</td>
<td>Endangered ecological community</td>
</tr>
<tr>
<td>EGP</td>
<td>Eastern Gas Pipeline</td>
</tr>
<tr>
<td>EIA</td>
<td>Environmental impact assessment</td>
</tr>
<tr>
<td>EMP</td>
<td>Environmental management plan</td>
</tr>
<tr>
<td>EP&amp;A Act</td>
<td>Environmental Planning and Assessment Act 1979. Provides the legislative framework for land use planning and development assessment in NSW</td>
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<tr>
<td>FM Act</td>
<td>Fisheries Management Act 1994</td>
</tr>
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<td>GFR</td>
<td>Geotechnical factual report</td>
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<td>GIR</td>
<td>Geotechnical interpretive report</td>
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<tr>
<td>I&amp;I NSW</td>
<td>NSW Department of Industry and Investment</td>
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<tr>
<td>km/h</td>
<td>Kilometres per hour</td>
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<tr>
<td>LCSC</td>
<td>Level Crossing Strategy Council</td>
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<tr>
<td>LGA</td>
<td>Local government area</td>
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<tr>
<td>LoS</td>
<td>Level of service. A qualitative measure describing operational conditions within a traffic stream and their perception by motorists and/or passengers.</td>
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<tr>
<td>PCF</td>
<td>Penetrating cone fracture</td>
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<td>PPV</td>
<td>Peak particle velocity</td>
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<tr>
<td>RCE</td>
<td>Riparian channel and environment</td>
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<td>REF</td>
<td>Review of Environmental Factors</td>
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<td>RTA</td>
<td>Roads and Traffic Authority</td>
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<tr>
<td>SISD</td>
<td>Safe intersection sight distance</td>
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<td>SPT</td>
<td>Standard penetration test</td>
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<td>SSD</td>
<td>Stopping sight distance</td>
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<td>SWTC</td>
<td>RTA scope of works and technical criteria</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Description</td>
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<td>--------------------------------------------------</td>
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<td>TSC Act</td>
<td>Threatened Species Conservation Act 1995</td>
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<td>VMP</td>
<td>Vegetation management plan</td>
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<td>WBNM</td>
<td>Watershed bound network model</td>
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<td>WRSB</td>
<td>Wire rope safety barrier</td>
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Appendix A

Road Safety Audit
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Please refer to separate report