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Discount Rate Sensitivity Tests: Tables 5.4 and 5.5 below provide summary results for the preferred option utilising discount rates of 10% and 4% respectively.

Table 5.4: Proposal RUCBA - 10% Discount Rate

Present Value Cost \$M			Benefit	RUCBR			NPV \$M		
-20%	Base	+20%	\$M	-20%	Base	+20%	-20%	Base	+20%
12.81	16.02	19.22	24.75	1.93	1.55	1.29	11.93	8.73	5.53

Table 5.5: Proposal RUCBA – 4% Discount Rate

Present Value Cost \$M			Benefit	RUCBR			NPV \$M		
-20%	Base	+20%	\$M	-20%	Base	+20%	-20%	Base	+20%
19.63	24.53	29.44	75.45	3.84	3.08	2.56	55.83	50.92	46.01

5.4 Geotechnical Conditions

Construction of the highway Proposal would be influenced by the prevailing geotechnical conditions in the area, particularly in relation to the stability of major cuttings and embankments and the suitability of material for fill embankments.

A detailed geotechnical, acid sulphate and contaminated land investigation was undertaken during the production of this EIS and is provided in Appendix K. The following section summarises the main findings of this report.

5.4.1 Sub-surface Conditions

The sub-surface soil profile encountered along the proposed alignment can be divided into:

- Residual soils weathered from underlying rock and situated in the rounded hillside areas
- Alluvial soils that have been deposited over the lower flood plain areas of the site
- Fill associated with the existing road embankments

Sub-surface conditions in the hillside areas comprise mostly high plasticity clay soils over weathered claystone, siltstone and sandstone rock of the Triassic Age Camden Haven Beds. The soil depth is variable and the rock comprises mostly extremely weathered siltstone while some sandstone is exposed in the existing road cuttings near Two Mile Creek Road. A deep weathering profile with clay soils and decomposed very low strength claystone and siltstone (to depths in excess of 10m) occurs in the proposed cuts south of Forest Road.

Sub-surface conditions in the lowland areas comprise clay soils of medium to high plasticity interbedded with some sandy clay to sand layers to depths up to 15m. The clays are generally stiff with some localised firm clay and silt materials near the surface. As a result settlement of soils is unlikely to be a significant problem.

Sub-surface conditions encountered in the existing fill embankments comprise road pavement gravels in the upper layers over clay and gravelly clay layers.

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5.4.2 Groundwater Levels

Groundwater levels in the hillside areas were encountered within 2 m to 5 m of the surface. Drainage blankets may be required in cuts 3 and 4 to address the potential for groundwater inflow. Local residents have also recognised the occurrence of groundwater springs west of Moorland (South). Groundwater levels across the lowland areas are expected to occur within 0.5m to 1m of the surface depending on weather conditions.

5.4.3 Subgrade Conditions

Subgrade conditions in the hillside areas mostly comprise high plasticity expansive clays of low CBR strength (2.5% to 10%). Final pavement design would need to consider measures to minimise expansive soil effects, such as establishing a cover of non-reactive materials, drainage and subgrade stabilisation.

Subgrade preparation in the lowland sections would be dependent upon weather conditions and final design embankment levels. This would be expected to require the stripping of nominal depths of soil, placement of a layer of geofabric and a bridging layer to facilitate placement and compaction of subsequent layers of embankment fill materials. The embankment thickness required beneath the pavement to provide a suitable base for pavement construction is likely to range from 0.5m to 1.5m depending on the subgrade strength and weather conditions. The expansive and potentially softening nature of the clay fill would need to be considered in final design (ie. thickness of select layer may need to be increased).

5.4.4 Stability of Embankments and Cut Batter Slopes

Stability of embankments is not expected to be a constraint in terms of limiting embankment heights. Maximum batter slopes ranging from 2H:1V to 2.5H:1V (for clay fills over 4m in height) are appropriate. Settlement of the proposed high embankments south of Forest Road is expected to be minimal (ie. <100mm) as are expected settlements along the majority of the alignment for which low embankments are proposed.

Suitable cut batter slopes are 2H:1V in soil and weathered rock with maximum batter slopes up to 1.5H:1V in the competent rock profile. Material won from cuts would mostly comprise high plasticity reactive clays of low CBR strength with moisture contents in excess of optimum for standard compaction. Appropriate specification of compaction moisture criterion potentially accompanied by spreading and drying would be required for the use of this material. Some select material may be available from the weathered rock profile in cuts in the southern end of the work.

5.4.5 Foundation for Structures

Foundations for lightly loaded structures such as culverts and cattle/farm machinery underpasses can be founded on high level footings situated in the near surface stiff to very stiff clays. Suitable foundations for bridges at Two Mile Creek and the North Coast Railway would comprise bored piers socketed into weathered sandstone and siltstone rock at depths in the order of 5m to 10m.

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5.4.6 Other Geotechnical Factors

The presence of halloysite clay has been identified by x-ray diffraction in clays to be won from cuts throughout the study area. This clay mineral is prone to irreversible material property changes (density, plasticity) on drying and can result in problems with earthworks control testing. The material is suitable as general earthwork fill however its properties need to be considered in control and specification of earthworks.

Acid sulphate soils were not encountered during the investigation and are not expected to pose constraints to the project.

Soil contamination levels in the soils tested along the proposed alignment are low with no detectable hydrocarbons or pesticides, with arsenic and lead levels well within recommended guidelines. Groundwater tested at 3 locations indicated low levels of nitrate, arsenic and hydrocarbons.

Groundwater lead levels (0.009 – 0.032mg/l) were less than the criteria of 0.05mg/l (Schedule 2 Clean Waters Act) for waters leaving or discharging from the sites, however the levels were high by comparison to ANZECC Guidelines for fresh surface waters (0.005mg/l). It is not uncommon for lead levels in groundwater to exceed surface water guidelines as lead can be naturally occurring in some geological environments. Alternatively, as the bores are close to the existing road, the lead levels could be associated with runoff and infiltration of road surface water.

5.5 Construction Methods

The detailed construction methods would be developed by the successful Contractor in response to the contract documentation. The documentation would incorporate the design features and other measures such as the environmental safeguards highlighted in Section 9.

5.5.1 Construction Overview

In general, the following road construction methods would be applied to the project:

- Utility adjustments would be undertaken
- Site compounds, boundary fencing, ancillary facilities and access tracks would be established
- Erosion and sedimentation controls would be put in place at the start of road construction according to a Soil and Water Management Plan component of the Construction Environmental Management Plan
- A traffic management plan would be prepared and implemented to reduce conflict between highway users and construction plant and haul trucks
- The bridge sites and road alignment would be cleared to the width required for construction purposes, the topsoil would be generally stripped and stockpiled, and catch drains would be established
- Drainage structures would be installed, particularly those where substantial box culverts are necessary to allow floodwater to pass below the proposed embankments
- Installation of cattle/farm machinery underpass structures
- Earthworks would be excavated using excavators, bulldozers, scrapers and trucks
- Excavated material would be hauled directly to fill areas
- The fill material would be compacted by rollers and vibrating compactors and then graded
- Concrete or bitumen batching plants would be established as necessary

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- Pavement would be constructed on completed embankments and cuttings
- Installation of traffic management devices, signage and roadside furniture
- The completion of work would require a range of rehabilitation and landscaping activities

Specific elements of the construction process are further described below and in Appendix K. These include:

- Embankment construction
- Settlement
- Foundations of structures
- Pavements

5.5.2 Embankment Construction

Embankment construction in different environments including adjacent existing embankments has been discussed in Appendix K. In particular settlement is not expected to be significant in lowland areas.

5.5.3 Pavement Construction

Sub-grade conditions are discussed in Section 6.3 and Section 6.4 of Appendix K. These conditions indicate that areas of high plasticity clays and low strength clays may be expected in cuttings south of Forest Road. Management measures such as the control of moisture ingress and the stabilisation of the surface of the clay with lime or gypsum may be considered to strengthen the sub-grade.

The occurrence of natural springs and high groundwater levels would require attention in pavement design and construction. This would include drainage measures in cuts such as a free draining rock layer below the select layer.

5.5.4 Construction Monitoring and Inspection

The geological conditions encountered in the hillside area are variable ranging from sandstone rock to deep clay soil profiles. The description and discussion of site conditions together with engineering analysis involves both interpolation between field data points and interpretation of results. Consequently, concept design recommendations must be viewed as best estimates at this stage of the project. During construction the prevailing geotechnical conditions would be more fully revealed and considering the geological nature of the site, some variation can be expected.

On-site geotechnical input should be maintained during construction as the prevailing geotechnical conditions are more fully revealed.

5.6 Construction Material Sources

5.6.1 Topsoil

The depth of topsoil and root affected materials encountered in the hillside areas ranged from about 50mm to 300mm (refer Appendix K). Topsoil is generally comprised of a clay and silt