4. Topography, geology and soils

This section describes the existing environment and potential impacts related to topography, geology and soils within the proposed MLARP area. The assessment has been based on a review of available information and field investigations. This section addresses the following:

- The topography of the project area is detailed showing the significant features of the landscape.
- The geology of the project area is outlined with particular reference to the physical and chemical properties of surface and sub-surface materials and geological structures within the proposed areas of disturbance.
- The physical and chemical properties of the soils are detailed, identifying any influences on land contamination, erosion potential, stormwater runoff quality, rehabilitation and agricultural productivity of the land.
- The depth and quality of soil that is appropriate for use in accordance with the standards outlined in the *Planning Guidelines: The Identification of Good Quality Agricultural Land* (DPI, DHLGP 1993), which supports the State Planning Policy 1/92: Development and the Conservation of Agricultural Land.
- Identification of Good Quality Agricultural Land (GQAL) within and adjacent to the disturbance zone of the Project and any land contamination from existing and historical use, based on land use history and the nature and quantity of any contaminants.
- Preventative strategies and mitigation measures relevant to topography, geology and soils issues.

For the purpose of describing the topography, geology and soils the project area has been divided into the following five sections:

- Aldoga Rail Yard
- North Coast Line/East End Mine Branch Line (NCL/EEMBL)
- Moura Link North
- Moura Link Eastern Option
- Moura Link Western Option

These areas are illustrated in Figure 4.1. It should be noted that sites TP23, TP27, TP29 and TP30 have been used for both the Aldoga Rail Yard section and NCL/EEMBL section because these sites are located within or close to both sections.

This section describes the existing environment and potential impacts related to topography, geomorphology, geology and soils within the project area. The assessment has been based on a review of available information and field investigations.

4.1 Methodology

4.1.1 Topography and landforms

The topographical and landform patterns within the project area were investigated through a combination of reviewing the relevant aerial photographs and maps, and by undertaking a landform survey in accordance with the principles and intent of the guidelines outlined in Gunn *et al* 1988. Observations recorded during the landform survey were described in accordance with McDonald *et al* 1990. Field inspections were undertaken by the project team during March and April 2008.

The assessment of the existing environmental values for the topography and landforms involved the following activities:

- Review of existing information, including relevant maps, aerial photographs and previous reports.

- Field inspection and landform survey of the project area was completed during March 2008, which included surface, landform and vegetation structure observations and soil profile descriptions at selected locations.

4.1.2 Geology and geomorphology

Geological descriptions were identified using the Australia 1:100,000 Geological Series – Gladstone Sheet 9150 and the Queensland Government Natural Resources and Mines 1:100,000 Geological Series map.

Geotechnical investigations for the project area have been undertaken (PB 2008). The investigation and findings from the geotechnical investigation are discussed below.

4.1.3 Soils, good quality agricultural land and contaminated land soils

A desktop assessment was completed in order to identify and assess the risks associated with:

- Soil erosion
- Intercepting and disturbing Acid Sulfate Soil (ASS) material
- Intercepting and disturbing potentially contaminated land
- Loss of GQAL
- Disturbance within a Red imported fire ant restricted area

Soils

Soil profile descriptions have been recorded in accordance with McDonald, R.C. *et al* 1990 *Australian Soil and Land Survey Field Handbook* and Isbell, 2002 *Australian Soil Classification*.

A desktop assessment included a review of the following information:

- DPI's Land Systems of the Capricornia Coast – Map 3 Calliope Area
- Calliope Shire GQAL mapping
- Geotechnical findings
- Ross D.J. 2004 Acid Sulfate Soils Tannum Sands – Gladstone Area Central Queensland Coast and Acid Sulfate mapping
- Topographical and geological characteristics of the project area
- Aerial photographs

Good quality agricultural land

GQAL is land that has been identified as capable of supporting sustainable use for agriculture and is defined as land used for crop and/or animal production, excluding intensive animal/plant production systems, such as feedlots, piggeries, poultry farms and plant nurseries based on hydroponics or imported growth media (DPI/DHLGP 1993).

The presence of GQAL within the project area was assessed against the Agricultural Land mapped in the Calliope Shire Council Planning Scheme. Field observations were also assessed in accordance with the principles of the State Planning Policy 1/92 *Development and Conservation of Agricultural Land* and the Planning Guidelines: *The Identification of Good Quality Agricultural Land*.

Contaminated land

A review of existing information has been undertaken, which is consistent with Section 7.2 of Appendix 7 in the *Draft Guidelines for the Assessment and Management of Contaminated Land in Queensland* (Department of Environment 1998) in order to identify potential areas of contaminated land, which included:

- A review of historical and existing land use in the project area.
- A search of the EPA Environmental Management Register (EMR) and Contaminated Land Register (CLR) database to identify sites that are currently or have been subject to Notifiable Activities and have been listed (it is noted that this information is to be used as a guide only and consideration must be given to areas that may not be included on the EMR or CLR as they may also be subject to contamination).
- A review of selected historical aerial photographs along the extent of the corridor for the purpose of identifying potentially contaminating activities occurring within the project area that may not have been listed on the EMR/CLR, such as areas previously utilised for dumping, material storage and/or landfill areas.

It is noted that the extent of the contaminated land investigation undertaken for the EIS was limited to a desktop review and did not include the following:

- Field soil delineation investigations
- Groundwater investigations
- Detailed surface water quality investigations

The desktop investigation identified the likelihood of finding contaminated soil material within the project area based on current known/recorded information.

Red imported fire ants

A search of the Restricted Area Search Engine (RASE) maps for the project area was conducted to identify any Fire Ant Restricted Areas. Red Imported Fire Ants (Fire ants) *(Solenopsis invicta*) are notifiable species under the *Plant Protection Act 1989*.

4.2 Description of Environment Values

4.2.1 Topography and landforms

The project area contains a range of topographical elevations and landform features. Topographical elevations range between approximately 10 m Australian Height Datum (AHD) and 200 m AHD. Topographical features are illustrated in Figure 4.2.

Review of *Land Systems of the Capricornia Coast Map 3 Calliope Area* (DPI 1995) indicated that a number of land systems occur within the project area. The land systems identified are listed in Table 4.1 and are illustrated in Figure 4.3.

Table 4.1 Land systems of the Capricornia Coast Map 3 Calliope Area

Land System Features	Land System	Map Code	Landform and Geology	Major Soils	Remnant Native Vegetation (refer Section 5)
Hills Eucalypt open forest and woodland Sedimentary rocks	Wycheproof	Wf	Undulating to rolling low hills and rises on sedimentary rocks and greenstone; saline outbreaks on lower slopes and drainage flats	Shallow, stony, brown and black, massive loams and clay loams; shallow, red and brown, structured gradational clay loams	Eucalypt woodland (narrow-leaved ironbark, gum-topped bloodwood and Moreton Bay ash)
Hills Eucalypt open forest and woodland Sedimentary rocks	Carrara	Cr	Undulating to rolling low hills and rises on sedimentary rocks	Shallow brown and black, massive loams and clay loams, bleached sandy and loamy surface, brown and grey, alkaline sodic duplex soils	Eucalypt woodland (narrow-leaved ironbark, gum-topped bloodwood, pink bloodwood)
Hills Eucalypt open forest and woodland Sedimentary rocks	Nagoorin	Ng	Undulating to rolling low hills and fans on fine grained sedimentary rocks and unconsolidated sediments	Bleached clay loamy and silty surface, brown and grey, alkaline sodic duplex soils	Gum topped box woodland
Hills Eucalypt open forest and woodland Sedimentary rocks	Rundle	Ru	Steep rocks to rolling hills on steeply dipping sedimentary rocks	Shallow, stony brown and black, massive loams and clay loams	Eucalypt open forest (lemon-scented gum, narrow-leaved ironbark, pink bloodwood, Queensland peppermint) with mixed understorey
Hills Eucalypt open forest and woodland Volcanic rocks	Chalmers	Ch	Rolling to steep hills on acid and intermediate volcanic rocks and steeply dipping sedimentary rocks	Bleached massive sands and loams; shallow, stony brown and black, structured uniform clays and gradational clay loams	Eucalypt woodland (narrow-leaved ironbark, lemon-scented gum, pink bloodwood, ghost gum)
Old alluvial plains and alluvial fans Duplex soils	Nulgi	Nl	Broad, level to gently undulating alluvial plains on silty and fine textured alluvium	Bleached silty surface, brown and grey, alkaline sodic duplex soils	Gum-topped box woodland
Hills Vine forest Sedimentary rocks	Moore	Mo	Steep to rolling hills and rises or sedimentary rocks	Shallow, stony brown, red and dark, structured gradational clay loams and uniform clays	Vine Forest

Land System Features	Land System	Map Code	Landform and Geology	Major Soils	Remnant Native Vegetation (refer Section 5)
Undulating rises and plains Eucalypt woodland Volcanic rocks	Sleipner	Sl	Undulating footslopes and rises, and gently undulating fans below hills on intermediate and acid volcanic rocks, and small areas of granitic rocks	Bleached loamy and clay loamy surface, brown and grey, alkaline sodic duplex soils	Eucalypt Woodland (blue gum, narrow leaved ironbark)
Floodplains and local alluvial plains Duplex soils	Calliope	Cp	Broad, level alluvial plains along the Calliope River and tributaries	Clay loamy surface, black and brown duplex soils, black and grey, alkaline cracking clays with moderate melonhole	Eucalypt woodland (Moreton Bay ash, blue gum, narrow-leaved ironbark

Source: DPI 1995

The major landform patterns observed during the field inspection within and surrounding the project area are summarised as follows:

- Mountains, hills, low hills and rises
- Alluvial plains
- Made land (road and rail)

The landform survey observation summary is listed in Table 4.2 and survey locations are illustrated on Figure 4.4. Full landform survey observation sheets are provided in Appendix D1.

Table 4.2 Landform survey findings

Site (Project area)	Landform pattern	Slope	Dominant vegetation
BH02/TP03 (MLWO) 	Low Hills	Moderately inclined	Tallest stratum is trees (12.01 – 20 m) with a sparse crown and foliage cover class. Mid stratum are trees (1.01 – 3 m) with an isolated plants crown and foliage cover class. Ground cover is sod grass (0.51 – 1 m) with crown and foliage cover class of dense (>70%)
BH12 (MLEO) 	Low Hills	Very Steep	Tallest stratum is trees (12.01 – 20 m) with a sparse crown and foliage cover class. Mid stratum are trees and shrubs (1.01 – 3 m) with a very sparse crown and foliage cover class. Ground cover is tussock grass (0.51 – 1 m) with crown and foliage cover class of dense (>70%)

Site (Project area)	Landform pattern	Slope	Dominant vegetation
BH21 (NCL/EEMBL) 	Hills	Steeply inclined	Tallest stratum is trees (12.01 – 20 m) with a sparse crown and foliage cover class. Mid stratum are trees and shrubs (3.01 – 6 m) with a sparse crown and foliage cover class. Ground cover is tussock grass (0.51 – 1 m) with crown and foliage cover class of mid dense (30-70%)
LF 01 (NCL/EEMBL) 	Hills	Very steeply inclined	Tallest stratum is trees (12.01 – 20 m) with a very sparse crown and foliage cover class. Mid stratum are trees and shrubs (3.01 – 6 m) with an isolated clumps crown and foliage cover class. Ground cover is tussock grass (0.26 – 0.5 m) with crown and foliage cover class of mid dense (30-70%)
TP02 (MLWO) 	Low Hills	Moderately inclined	Tallest stratum is trees (12.01 – 20 m) with an isolated plants crown and foliage cover class. Ground cover is tussock grass (0.26 – 0.5 m) with crown and foliage cover class of dense (>70%)
TP05 (MLWO) 	Low Hills	Moderately inclined	Tallest stratum is trees (12.01 – 20 m) with an isolated plants crown and foliage cover class. Ground cover is tussock grass (0.26 – 0.5 m) with crown and foliage cover class of dense (>70%)
TP06 (MLEO) 	Rises	Gently inclined	Tallest stratum is trees (12.01 – 20 m) with a sparse crown and foliage cover class. Mid stratum are trees (6.01 – 12 m) with a very sparse crown and foliage cover class. Ground cover is tussock grass (0.51 – 1 m) with crown and foliage cover class of mid dense (30-70%)

Site (Project area)	Landform pattern	Slope	Dominant vegetation
TP07 (MLEO) 	Rises	Very gently inclined	Tallest stratum is trees (12.01 – 20 m) with a mid dense and sparse crown and foliage cover class. Mid stratum are trees (1.01 – 3 m) with a very sparse crown and foliage cover class. Ground cover is tussock grass (0.26 – 0.5 m) with crown and foliage cover class of mid dense (30-70%)
TP08 (MLEO) 	Rises	Steeply inclined	Tallest stratum is trees (12.01 – 20 m) with an isolated clumps crown and foliage cover class. Mid stratum are trees (3.01 – 6 m) with an isolated clumps crown and foliage cover class. Ground cover is tussock grass (0.51 – 1 m) with crown and foliage cover class of dense (>70%)
TP10 (LF) (MLEO) 	Rises	Moderately inclined	Tallest stratum is trees (12.01 – 20 m) with a sparse crown and foliage cover class. Ground cover is tussock grass (1.01 – 3 m) with crown and foliage cover class of dense (>70%)
TP12 (MLEO) 	Rises Made Land (road corridor)	Moderately inclined	Tallest stratum is trees (20.01 – 35 m) with a sparse crown and foliage cover class. Mid stratum are trees (3.01 – 6 m) with a very sparse crown and foliage cover class. Ground cover is tussock grass (0.51 – 1 m) with crown and foliage cover class of mid dense (30 - 70%)
TP13 (MLN) 	Rises	Moderately inclined	Tallest stratum is trees (12.01 – 20 m) with a very sparse crown and foliage cover class. Mid stratum are trees (3.01 – 6 m) with an isolated clumps crown and foliage cover class. Ground cover is tussock grass (0.26 – 0.5 m) with crown and foliage cover class of dense (>70%)

Site (Project area)	Landform pattern	Slope	Dominant vegetation
TP14 (MLN) 	Rises Made Land (road corridor)	Gently inclined	Tallest stratum is trees (12.01 – 20 m) with a sparse crown and foliage cover class. Mid stratum are trees (1.01 – 3 m) with a very sparse crown and foliage cover class. Ground cover is tussock grass (0.51 – 1 m) with crown and foliage cover class of dense (>70%)
TP16 (NCL/EEMBL) 	Low Hills Made Land (rail corridor)	Moderately inclined	Tallest stratum is trees (12.01 – 20 m) with a very sparse crown and foliage cover class. Mid stratum are trees (3.01 – 6 m) with an isolated clumps crown and foliage cover class. Ground cover is tussock grass (0.26 – 0.5 m) with crown and foliage cover class of dense (>70%)
TP17 (MLN) 	Low Hills Made Land (road corridor)	Moderately inclined	Tallest stratum is trees (12.01 – 20 m) with a sparse crown and foliage cover class. Mid stratum are trees (1.01 – 3 m) with an isolated plants and foliage cover class. Ground cover is tussock grass (0.26 – 0.5 m) with crown and foliage cover class of dense (>70%)
TP22 (MLN) (NCL/EEMBL) 	Rises Made Land (rail corridor)	Gently inclined	Tallest stratum is trees (>35.01 m) with a mid dense crown and foliage cover class. Mid stratum are trees (3.01 – 6 m) with a sparse crown and foliage cover class. Ground cover is tussock grass (1.01 –3 m) with crown and foliage cover class of dense (>70%)
TP23 (ARY) (NCL/EEMBL) 	Rises Made Land (rail corridor)	Moderately inclined	Tallest stratum is trees (12.01 – 20 m) with a sparse crown and foliage cover class. Mid stratum are trees (3.01 – 6 m) with a sparse crown and foliage cover class. Ground cover is tussock grass (0.26 – 0.5 m) with crown and foliage cover class of dense (>70%)

Site (Project area)	Landform pattern	Slope	Dominant vegetation
TP24 (ARY) (NCL/EEMBL) 	Rises Made Land (rail corridor)	Moderately inclined	Tallest stratum is trees (12.01 – 20 m) with a sparse crown and foliage cover class. Mid stratum are trees (1.01 – 3 m) with a sparse crown and foliage cover class. Ground cover is tussock grass (0.26 – 0.5 m) with crown and foliage cover class of dense (>70%)
TP25 (ARY) (NCL/EEMBL) 	Rises	Moderately inclined	Tallest stratum is trees (12.01 – 20 m) with a sparse crown and foliage cover class. Mid stratum are trees (1.01 – 3 m) with a sparse crown and foliage cover class. Ground cover is tussock grass (0.51 – 1 m) with crown and foliage cover class of dense (>70%)
TP27 (ARY) (NCL/EEMBL) 	Low Hills	Gently inclined	Tallest stratum is trees (12.01 – 20 m) with a very sparse crown and foliage cover class. Mid stratum are trees (1.01 – 3 m) with a very sparse crown and foliage cover class. Ground cover is tussock grass (0.51 – 1 m) with crown and foliage cover class of dense (>70%)
TP28 (ARY) (NCL/EEMBL) 	Rises	Gently inclined	Tallest stratum is trees (6.01 – 12 m) with a mid dense crown and foliage cover class. Mid stratum are trees (1.01 – 3 m) with a very sparse crown and foliage cover class. Ground cover is sod grass (1.01 – 3 m) with crown and foliage cover class of mid dense (30-70%)
TP29 (ARY) (NCL/EEMBL) 	Stagnant Alluvial Plain	Gently inclined	Tallest stratum is trees (6.01 – 12 m) with a mid dense crown and foliage cover class. Mid stratum are trees (1.01 – 3 m) with a very sparse crown and foliage cover class. Ground cover is sod grass (1.01 – 3 m) with crown and foliage cover class of mid dense (30-70%)

Site (Project area)	Landform pattern	Slope	Dominant vegetation
TP30 (ARY) (NCL/EEMBL) 	Stagnant Alluvial Plain Made Land (rail and road corridor)	Gently inclined	Tallest stratum is trees (6.01 – 12 m) with an isolated plants crown and foliage cover class. Ground cover is sod grass (1.01 – 3 m) with crown and foliage cover class of dense (>70%)
TP31 (ARY) (NCL/EEMBL) 	Alluvial Plain	Very gently inclined	Tallest stratum is trees (12.01 – 20 m) with an isolated clumps crown and foliage cover class. Mid stratum are trees (3.01 – 6 m) with a very sparse crown and foliage cover class. Ground cover is tussock grass (0.51 – 1 m) with crown and foliage cover class of dense (>70%)
TP32 (ARY) (NCL/EEMBL) 	Mountains Made Land (rail and road corridor)	Very gently to moderately inclined	Tallest stratum is trees (12.01 – 20 m) with a mid dense crown and foliage cover class. Mid stratum are trees (1.01 – 3 m) with a very sparse crown and foliage cover class. Ground cover is tussock grass (0.51 – 1 m) with crown and foliage cover class of mid dense (30-70%)
TP33 (ARY) (NCL/EEMBL) 	Mountains Made Land (rail corridor)	Level to steeply inclined	Tallest stratum is trees (12.01 – 20 m) with a mid dense crown and foliage cover class. Mid stratum are trees (1.01 – 3 m) with a sparse crown and foliage cover class. Ground cover is tussock grass (0.51 – 1 m) with crown and foliage cover class of mid dense (30-70%)
TP34 (NCL/EEMBL)	Rises Made Land (road corridor)	Moderately inclined	Tallest stratum is trees (12.01 – 20 m) with an isolated clumps crown and foliage cover class. Mid stratum are trees (3.01 – 6 m) with an isolated clumps crown and foliage cover class. Ground cover is tussock grass (0.51 – 1 m) with crown and foliage cover class of mid dense (30-70%)

Site (Project area)	Landform pattern	Slope	Dominant vegetation
TP35 (NCL/EEMBL) 	Rises	Moderately inclined	Tallest stratum is trees (12.01 – 20 m) with a sparse crown and foliage cover class. Mid stratum are trees (3.01 – 6 m) with a very sparse crown and foliage cover class. Ground cover is tussock grass (0.51 – 1 m) with crown and foliage cover class of mid dense (30-70%) and lantana (1.01 – 3 m) with crown and foliage cover class of sparse (10-30%)
TP36 (NCL/EEMBL) 	Low Hills Made Land (rail corridor)	Moderately inclined	Tallest stratum is trees (12.01 – 20 m) with a sparse crown and foliage cover class. Mid stratum are trees (3.01 – 6 m) with a very sparse crown and foliage cover class. Ground cover is tussock grass (0.51 – 1 m) with crown and foliage cover class of mid dense (>70%)
TP37 (NCL/EEMBL) 	Low Hills Made Land (rail corridor)	Very steeply inclined	Tallest stratum is trees (12.01 – 20 m) with a mid dense crown and foliage cover class. Mid stratum are trees (6.01 – 12 m) with a sparse crown and foliage cover class. Ground cover is tussock grass (1.01 – 3 m) with crown and foliage cover class of mid dense (>70%)
TP38 (NCL/EEMBL) 	Rises Made Land (rail corridor)	Moderately inclined	Tallest stratum is trees (12.01 – 20 m) with a very sparse crown and foliage cover class. Mid stratum are trees (3.01 – 6 m) with an isolated plants crown and foliage cover class. Ground cover is tussock grass (0.51 – 1 m) with a crown and foliage cover class of dense (>70%)
TP39 (NCL/EEMBL) 	Rises Made Land (rail bridge and embankment)	Gently to Very Steeply inclined	Tallest stratum is trees (12.01 – 20 m) with a very sparse crown and foliage cover class. Mid stratum are trees (3.01 – 6 m) with an isolated plants crown and foliage cover class. Ground cover is tussock grass (0.51 – 1 m) with crown and foliage cover class of mid dense (30-70%) and sod grass (<0.25 m) with a crown and foliage cover class of dense (>70%)

Site (Project area)	Landform pattern	Slope	Dominant vegetation
TP40 (NCL/EEMBL) 	Rises Made Land (rail bridge and embankment)	Gently inclined	Tallest stratum is trees (12.01 – 20 m) with an isolated clumps crown and foliage cover class. Mid stratum are trees (1.01 – 3 m) with an isolated clumps crown and foliage cover class. Ground cover is tussock grass (0.51 – 1 m) with crown and foliage cover class of mid dense (30-70%)

Table notes:
ARY: Aldoga Rail Yard
NCL/EEMBL: North Coast Line/East End Mine Branch Line
MLN: Moura Link North
MLEO: Moura Link Eastern Option
MLWO: Moura Link Western Option

Field observations for the project area are summarised below.

Aldoga Rail Yard

The topography within this section ranges between approximately 48 m AHD adjacent to Larcom Creek and approximately 197 m AHD at Mount McCabe west of Larcom Creek as assessed in April 2008, based on survey information as at 1982. This area is part of the GSDA and currently is leasehold land for grazing, forestry plantations and includes the NCL rail corridor. The slopes associated with the Mount McCabe are moderately inclined (10 to 32%) between the existing crest of the hill and the surrounding alluvial plains. Slopes within the alluvial plains area around Larcom Creek tend to be relatively level to gently inclined (1% to 9%) with the steeper slopes being associated with the well defined stream channel of Larcom Creek that crosses this area.

The dominant landform elements within and surrounding this area is a hillcrest, surrounded by hillslopes and footslopes moving into valley flats and plains.

NCL and EEMBL

The topography within this section ranges between approximately 22 m AHD adjacent to Sandy Creek in east of the area and approximately 200 m AHD at the footslopes of Mount Larcom Ranges assessed in April 2008, based on survey information as at 1982. This area is part of the GSDA and currently is leasehold land for grazing, forestry plantations and includes both the NCL and EEMBL rail corridors. The slopes associated with the Mount Larcom Ranges are steeply inclined (32-56%) between the hillslopes and the surrounding alluvial plains. Slopes within the alluvial plains area around Larcom Creek tend to be relatively level to gently inclined (1% to 9%) with the steeper slopes being associated with the well defined stream channel of Larcom Creek that crosses this area.

The dominant landform elements within and surrounding this area are hillcrests, surrounded by hillslopes and footslopes moving into valley flats and plains.

Moura Link North

The topography within this section ranges between 40 m AHD adjacent to Larcom Creek and approximately 150 m AHD at hills to the north and south of Larcom Creek as assessed in April 2008, based on survey information as at 1982. This area is part of the GSDA and currently is leasehold land for grazing and includes the Bruce Highway road corridor. Slopes associated with the hills north and south of Larcom Creek are moderately inclined (10 to 32%) between the crest of the hill and the alluvial plain flats of Larcom Creek. Slopes within the alluvial plains area around Larcom Creek tend to be relatively level to gently inclined (1% to 9%) with the steeper slopes being associated with the well defined stream channel that crosses this area.

The dominant landform elements within and surrounding this area are low hills and rises intersected by a plain.

Moura Link Eastern Option

The topography within this section ranges between 10 m AHD adjacent to the Calliope River and approximately 128 m AHD at hills to the south of the Calliope River as assessed in April 2008, based on survey information as at 1982. This area is freehold land used for grazing. Slopes associated with the hills south of the Calliope River are moderately inclined (10 to 32%) between the crest of the hill and the alluvial plain flats around Farmer Creek and the Calliope River. Slopes within the alluvial plain adjacent to Farmer Creek and the Calliope River tend to be relatively level to gently inclined (1% to 9%) with the steeper slopes being associated with the well defined stream channels that cross this area.

The dominant landform elements within and surrounding this area are low hills and rises intersected by a plain.

Moura Link Western Option

The topography within this section ranges between 20 m AHD adjacent to the Calliope River and approximately 150 m AHD at hills to the south of the Calliope River as assessed in April 2008, based on survey information as at 1982. This area is freehold land used for grazing. Slopes associated with the hills south of the Calliope River are moderately inclined (10 to 32%) between the crest of the hill and the alluvial plain flats around the Calliope River. Slopes within the alluvial plain adjacent the Calliope River tend to be relatively level to gently inclined (1% to 9%) with the steeper slopes being associated with the well defined stream channels that cross this area.

The dominant landform elements within and surrounding this area are low hills and rises intersected by a plain.

4.2.2 Geology and geomorphology

As mapped by the Australia 1:100,000 Geological Series – Gladstone Sheet 9150 and the Queensland Government Natural Resources and Mines 1:100,000 Geological Series map (refer Figure 4.5), the geological formations which occur within the project area are presented in Table 4.3.

Table 4.3 Geological characteristics within the project area

Morphostratographic Unit	Symbol	Description
Erebus Beds SEDIMENTARY ROCK	SDe	Formed during the period Silurian - Devonian periods and comprises dacitic to rhyolitic volcaniclastic sandstone and conglomerate, minor siltstone, fossiliferous limestone and marble.
Erebus Beds CARBONATES (LIMESTONE OR DOLOMITE)	SDe/L	Formed during the Silurian – Devonian periods and comprises fossiliferous limestone, marble.
Mount Alma Formation ARENITE-MUDROCK	DCa	Formed during the late Devonian – Early Carboniferous periods and comprises thinly interbedded fine-grained sandstone and siltstone and thick beds of conglomerate with andesitic to dacitic clasts and siltstone rip-up-clasts.
Rockhampton Group SEDIMENTARY ROCK	Cr	Formed during the Early Carboniferous period and comprises dark grey mudstone, siltstone, felsic volcaniclastic sandstone, polymictic conglomerate, ooid-bearing sandstone and conglomerate with mudstone rip-up clasts; oolitic and pisolitic limestone and minor skeletal limestone; rare rhyolitic ignimbrite.
Rockhampton Group/ Berserker Group SEDIMENTARY ROCK	Cr, Pk	Formed during the Carboniferous – Permian periods and comprises mudstone, siltstone, felsic volcaniclastic sandstone, ooid-bearing sandstone and conglomerate with mudstone rip-up clasts, minor limestone and rhyolitic ignimbrite; siltstone, sandstone, intrusive and extrusive domes, volcanic breccia.
Chalmers Formation MIXED SEDIMENTARY ROCKS AND FELSITES	Pkc	Formed during the Permian period and comprises siltstone, lithic sandstone, rhyolitic to andesitic volcaniclastic breccia, rhyolitic and dacitic tuff, minor andesitic tuff.
Lakes Creek Formation ARENITE-MUDROCK	Pkl	Formed during the Permian period and comprises siltstone and lithic sandstone
GRANITOID	PRg/b	Formed during the late Permian – Early Triassic periods and comprises pink medium-grained hornblende-biotite quartz monzonite
The Quaternary Period deposits include:		
COLLUVIUM	TQr	Deposited in the Tertiary - Quaternary periods and comprises of clay, silt, sand, gravel and soil: colluvial and residual deposits
ALLUVIUM	TQa	Deposited during the Tertiary – Quaternary periods and comprises of clay, silt, sand and gravel: high-level alluvium and colluvium
COLLUVIUM	TQr/r	Deposited during the Tertiary – Quaternary periods and comprises red soil; colluvial and residual deposits derived from mafic rocks
ALLUVIUM	Qa	Deposited during the Quaternary periods and comprises of clay, silt, sand, gravel: flood plain alluvium

Source: Geological Series – Gladstone Sheet 9150

The geological characteristics in each area is summarised below.

Aldoga Rail Yard

- The Rockhampton/Berserker Group
- Lakes Creek Formation
- Late Permian-Early Triassic Gratinoid
- Tertiary/Quaternary Alluvium and Colluvium

North Coast Line and East End Mine Branch Line

- Chalmers Formation, Lakes Creek Formation
- Late Permian-Early Triassic Gratinoid
- Tertiary/Quaternary Alluvium and Colluvium

Moura Link North

- The Mount Alma Formation
- The Rockhampton Group
- Quaternary Alluvium

Moura Link Eastern Option

- The Mount Alma Formation
- Quaternary Alluvium

Moura Link Western Option

- The Mount Alma Formation
- The Erebus Beds
- Quaternary Alluvium

The structural geology of the study area is observed to consist of various blocks which comprise the Coastal, Yarrol, Calliope and Berserker Blocks with post tectonic igneous intrusions.

The Coastal Block comprises the Devonian to Carboniferous aged continental slope sediments and minor volcanic geological units, with the Yarrol Block consisting of the Early Carboniferous marine shelf sediment. The Calliope Block is made up of Early to Middle Devonian island arc sediments and acid volcanic deposits with the Berserker Block comprising early Permian volcanic and sediments.

The contact between the Coastal Block and the Yarrol, Calliope and Berseker Block is faulted by the Boyne River Fault. This fault trends in a north west to south east direction through the region. The geological unit within these blocks have been described in Table 4.3. The various sedimentary and volcanic geological units are observed to have gentle folding and foliation present.

4.2.3 General geotechnical properties

The investigation encountered various soil and rock strata throughout the project area. These results have been interpreted to provide a sub-surface profile for each of the rail infrastructure sections. Further geotechnical investigations will be required during detailed design to determine the suitability of the material for the proposed construction activities. This investigation will also assist in determining whether material will need to be sourced from other sites within the region, including licensed quarries.

The fieldwork investigation results for the proposed Moura Link (including the Moura Link North, Moura Link Eastern and Western Options) and for the planned upgrading of the EEMBL, Aldoga Rail Yard and NCL are described under the following sub-headings. For each of the rail sections encountered sub-surface strata have been described in sequence from the ground surface level. The encountered ground conditions are likely to vary along the length of the rail section. The described profiles are provided as an outline only and as previously highlighted further investigation must be undertaken to assess the ground conditions at specific locations.

Aldoga Rail Yard

The ground investigation encountered varied sub-surface conditions through the Aldoga Rail Yard area. The investigation comprised boreholes BH07 and BH08 with test pits TP23 to TP33 completed. Groundwater was recorded in borehole BH08 at a 5.80 m depth next to Larcom Creek. The sub-surface conditions encountered are discussed below.

Topsoil

A thin layer of topsoil was generally encountered throughout this area to a depth of 0.30 m. Although borehole BH07, located west of where the EEMBL connects into the yard, recorded topsoil to a maximum depth of 0.60 m. The topsoil was noted to vary from black organic to clayey silty sand or sandy silty clay with rootlets present.

Alluvium

This material was encountered to the far west of the yard in test pits TP23 and TP24. These pits were located close to a creek and encountered alluvium to depths of 0.60 m and 0.80 m, respectively. The alluvium comprised brown, high plasticity, very stiff, silty clay with a sand and gravel content. Other test pits TP29, TP30, TP31 and TP32 along with borehole BH08 all within the vicinity of Larcom Creek encountered alluvium. At Larcom Creek borehole BH08 encountered the alluvium to a 2.80 m depth with TP29 close to the western creek bank recording a 1.70 m depth. Test pits TP30 and TP31 slightly east of the creek recorded a 1.20 m and 1.40 m depth, respectively. To the far east of the creek the alluvium thinned out to 0.50 m in depth where test pit TP32 was located. The test pits and the single borehole recorded the alluvium as comprising brown high plasticity, generally stiff to very stiff, silty clay with sand and gravel content. The alluvium in BH08 was noted to grade from the high plasticity, very stiff, clay into a low plasticity, very stiff sandy clay at a 1.20 m depth with this soil profile terminating at 2.80 m depth. The Dynamic Cone Penetrometer (DCP) test completed at TP29 next to Larcom Creek recorded a firm silty clay between depths of 0.30 m and 0.90 m with the test at TP30 indicating a firm silty clay between a 0.30 m and 1.00 m depth.

Colluvium

This soil profile was only encountered in borehole BH07 positioned on GSDA land adjacent to Mount Larcom Road. The purpose of this borehole was to assess the sub-surface conditions for a potentially deep rail cutting proposed towards the western end of the yard. At this location the colluvium comprised very dense, medium grained, clayey gravel consisting of fragments of intermediate to mafic igneous rock. The Standard Penetration Test (SPT) attempted at a 1.20 m depth terminated at commencement of the test.

Residual soil

Residual soil derived from the weathering of the underlying bedrock was encountered in the majority of test pits along the Aldoga Rail Yard section. Test pits TP24, TP25, TP27, TP28 and TP29 to the west of Larcom Creek and TP30, TP31, TP32 and TP33 located to the east of the creek all encountered residual soil at shallow depths between 0.20 m and 1.70 m. The recorded profile comprised either sandy or silty clay with gravel content and varied from low to high plasticity and generally from stiff to hard. The soil was recorded up to a depth of 3.50 m to the west and east of the yard. The DCP tests completed for TP32 recorded the silty clay to be firm between depths of 0.50 m and 1.20 m. Borehole BH08 located at Larcom Creek encountered residual soil from 2.80 m to 8.80 m in depth. The recorded profile graded from low to medium plasticity, stiff to very stiff, sandy to silty clay with some gravel content.

Sandstone, siltstone and volcaniclastic breccia bedrock

The bedrock encountered through the Aldoga Rail Yard section generally appear to be derived from the Chalmers and Rockhampton formation. Borehole BH07 cored through extremely to slightly weathered, very low to high strength, volcaniclastic breccia with volcanic clasts from 2.00 m below the surface level to termination depth of 5.50 m. Borehole BH08 at Larcom Creek encountered extremely weathered, extremely low strength siltstone with medium to high plasticity, stiff to very stiff clay bands and friable siltstone fragments to a 20.0 m depth. SPTs were completed in the extremely weathered siltstone with N values (blows/0.3m) of 37 and 58 recorded and other tests terminating before completion. Test pit TP23, TP25, TP27, TP28, TP32 and TP33 all excavated through extremely to highly weathered, highly fractured, very low to low strength sandstone with clay, sand and gravel bands. The test pits all terminated at depths between 1.60 m to 3.50 m upon encountering moderately weathered, low to medium strength sandstone.

NCL and EEMBL

The ground investigation along the existing NCL corridor consisted of three boreholes and eight test pits. Borehole BH06 and test pit TP22 are located to the west of the proposed Aldoga Rail Yard following the existing NCL route towards the township of Mount Larcom. To the east of Aldoga Rail Yard in the direction of the township of Yarwun, boreholes BH10 and BH11 and test pits TP34, TP35, TP36, TP37, TP38, TP39 and TP40. Borehole BH11 recorded groundwater at a 3.20 m depth next to the Calliope River Road with test pit TP37 near Yarwun quarry encountering groundwater at a 1.70 m depth.

Geotechnical properties for BH07 and BH08 with test pits TP23 to TP33 were described above in Aldoga Rail Yard section.

The EEMBL connects the proposed Moura Link and the Aldoga Rail Yard. Borehole BH05 and test pit TP16 were completed within this rail section. Groundwater was encountered at a 2.60 m depth in borehole BH05 where the EEMBL and Moura Link are proposed to join. The sub-surface conditions encountered are provided below.

Topsoil

To the west of the NCL corridor a topsoil profile was encountered to a depth of 0.40 m and comprised medium plasticity, stiff, silty clay. At the eastern end of the NCL the topsoil was present to a 0.40 m depth.

A thin layer of topsoil to a depth of 0.30 m was encountered in test pit TP16 which was excavated adjacent to the existing EEMBL railway cutting.

Fill

Borehole BH06 located at the far western end of the NCL route intercepted fill material comprising clayey sandy gravel to a 2.10 m depth with 20 mm to 30 mm gravel fragments. Borehole BH11 was positioned close to the Calliope River Road at Yarwun township towards the eastern end of the NCL corridor and recorded a firm, gravelly clay fill material to a 0.20 m depth. Test pit 39 also located next to the Calliope River Road encountered fill to a depth of 0.60 m comprising gravelly sandy clay. Fill was present along both the existing road and rail lines within the eastern end of the NCL corridor. The fill in test pits TP34 and TP36 comprised sandy gravel to a 0.30 m depth. Test pit TP37 on the NCL rail line, located next to the quarry owned by Earth Commodity, encountered 0.80 m of fill. This fill comprised clayey gravel with coal fragments and occasional steel pieces. Fill comprising clayey gravel was logged to a 0.90 m depth in test pit TP40 next to Sandy Creek at the east end of the NCL corridor.

Fill was encountered at the southern end of the EEMBL where borehole BH05 was completed. At this location the railway passes across an embankment and continues northwards through a cutting in the direction of Aldoga Rail Yard. It is likely that the excavated material from the cutting was used to construct the embankment. Borehole BH05 was positioned at the embankment toe and encountered 1.40 m of fill from ground surface. The fill comprised firm clay with sandstone gravel. Following inspection the cutting appears to have been excavated through inter-bedded sandstone and siltstone.

Alluvium

Borehole BH11 at the Calliope River Road encountered high plasticity, stiff to very stiff sandy clay to a 1.20 m depth with the sand content diminishing at a 1.90 m depth. After 1.90 m the clay changed to low plasticity, stiff to very stiff and became silty to 2.50 m below the surface. Test pit TP37 located on the NCL rail line adjacent to Sandy Creek and the operating quarry encountered very loose sand with a clay and silt content to a 2.20 m depth. The DCP testing completed with TP37 indicated that the sand was very loose to loose with the majority of blows being 0.00 m and 1.00 m to a 2.20 m depth. Below 2.20 m the alluvium comprised black, high plasticity, stiff clay to termination depth of 2.60 m. During excavation of TP37 the test pit collapsed due to the sand being very loose. Groundwater was recorded at a 1.70 m depth and was observed to continuously flow into the pit during the excavation. Test pit TP40 was located where Sandy Creek crosses the end of the NCL corridor. Alluvium was encountered to an approximate 2.00 m depth in this excavation and comprised high plasticity, silty clay with some fine gravel content. The associated DCP test completed at TP40 indicated that the silty clay was soft to firm between depths of 0.90 m and 2.20 m.

This material was present in borehole BH05 and was encountered between depths of 1.40 m and 2.80 m below the ground surface. As BH05 was excavated in a low lying area at the southern end of the EEMBL this area is likely to be on the edge of the Larcom Creek floodplain. The alluvium comprised yellow-brown high plasticity firm clay.

Colluvium

Both borehole BH05 and test pit TP16 encountered colluvium from depths of 2.80 m and 0.40 m, respectively. The colluvium comprised varying profiles with depth and TP16 encountered brown and grey medium plasticity, very stiff to hard, sandy gravelly clay to a depth of 1.30 m. Between 1.30 m and 2.80 m this colluvium profile had a cobble scree content comprising weathered siltstone and quartzite which is typical of the area according to the geological map. From 2.80 m the colluvium comprised pale grey to white, dense gravel within a low plasticity, very stiff, clay matrix to termination depth of 3.40 m. Borehole BH05 recorded the same profile to a depth of 4.20 m with a registered SPT N value of 32 indicating dense gravel.

Residual soil

This soil profile is recorded in test pit TP22 along the west end of the NCL corridor and comprises low plasticity, stiff clay with calcrete gravel and cobbles to a 0.80 m depth. After this depth the soil altered to a medium plasticity, stiff to very stiff, sandy gravelly clay with the calcrete gravel and cobble content increasing at a 2.00 m depth. The test pit terminated at 2.60 m below surface level without determining the boundary depth of this soil profile. To the east of the NCL corridor this soil profile is encountered in borehole BH11 from a 2.50 m depth to 8.80 m below the surface. This comprised medium dense clayey gravel of fine to coarse, sub angular sandstone fragments to approximately 5.00 m and became dense at 6.00 m and very dense at a 7.00 m depth. The density was reflected in the recorded SPT N values of 22 at 4.50 m and 45 at 6.00 m. Test pits TP35, TP39 and TP40 encountered low and high plasticity, stiff sandy clay with some gravel content to depths of 2.00 m, 3.60 m and 3.50 m, respectively. The DCP test at TP40 indicated that the silty clay was of a firm to stiff consistency to a 3.50 m depth.

This soil profile was encountered in borehole BH05 at a 4.20 m depth and was derived from weathering of the siltstone bedrock beneath. The residual soil comprised grey, low plasticity, stiff, silty clay with friable siltstone fragments that increased with depth. An SPT N of 15 was recorded and the soil profile terminated at a 5.9 m depth.

Siltstone and sandstone bedrock

At the western end of the corridor near the township of Mount Larcom borehole BH06 augured through extremely to highly weathered, extremely low strength siltstone from 2.10 m below surface level to a depth of 4.10 m. The siltstone had sandstone gravel fragments present at a 3.00 m depth. The borehole then reverted to coring through highly to moderately weathered, low to medium strength siltstone with inter-bedded fine grained sandstone to a 7.40 m completion depth. Siltstone was logged in borehole BH11 at the Calliope River Road near the township of Yarwun between depths of 8.80 m to 13.40 m. The siltstone was logged as a meta-siltstone meaning the sedimentary rock had been subjected to low grade metamorphism altering the physical properties of the rock. The meta-siltstone was recorded as extremely weathered and extremely low in strength to a depth of 9.70 m. Below 9.70 m the meta-siltstone was noted to be generally highly to moderately weathered although some extremely weathered zones were present. The strength of this meta-siltstone varied due to the weathering and ranged from extremely low to medium strength to a depth of 11.30 m. After this depth the metasiltstone was encountered as fresh and of very high strength to borehole termination depth of 13.40 m. Siltstone bedrock was excavated at Flynn Road in test pit TP35 between 2.00 m and 2.30 m and was moderately weathered and of medium strength. Test pit TP38 was proposed to be excavated through the rail cutting on the NCL line near the township of Yarwun. Excavation of the pit was attempted on the mid slope bench of the rock cutting and terminated at surface level. As a result the cutting slope was locally mapped by the PB site engineering geologist. The exposed rock in the slope face was a meta-siltstone and comprised fresh and extremely high strength rock.

Borehole BH05 recorded sandstone bedrock between depths of 5.90 m and 10.00 m and had a varied weathering and strength profile. The sandstone was pale grey, fine to medium grained, with occasional fracture zones, extremely to slightly weathered and of very low to high strength.

Granitoid bedrock

Borehole BH10 was positioned where the Gladstone-Mount Larcom Road passes beneath the existing NCL rail line and encountered pink, medium grained granitoid at a shallow depth of 0.95 m below the surface. The granitoid was extremely to moderately weathered with depth and a very low to medium strength encountered.

Test pit TP34 recorded extremely to highly weathered, extremely low to very low strength granitoid. The extremely weathered granitoid had the consistency of clayey gravel between depths of 0.30 m and 0.80 m. After 0.80 m the granitoid became moderately weathered and of low to medium strength to termination depth at 1.40 m. Test pit TP36 terminated at a 0.40 m depth upon encountering fresh, very high strength granitoid. This granite bedrock was interpreted to be a localised igneous intrusion as interpreted from the local geology map.

Moura Link North

Where the Moura Link Eastern Option and Moura Link Western Option join to the south of the Bruce Highway, the Moura Link continues northwards to the township of Mount Larcom. Boreholes BH03 and BH04 along with test pits TP6, TP13, TP14 and TP17 were completed through the remainder of the corridor. The investigation encountered the following sub-surface conditions. During the fieldwork no groundwater was recorded in any of the boreholes or test pits through this corridor.

Topsoil

A thin layer of topsoil was generally encountered along the remainder of the Moura Link. This topsoil layer was recorded as being between 0.10 m and 0.40 m in thickness.

Fill

Fill was present at the Bruce Highway and was encountered where borehole BH03 was drilled to a depth of 1.00 m below surface level. The fill comprised gravel and cobbles of sandstone in a sandy clay matrix.

Alluvium

Alluvium was encountered on the floodplain between the Calliope River and the Bruce Highway. Test pit TP06 was excavated at the northern end of the proposed Moura Link Eastern and Western Options and encountered alluvium to a depth of 2.50 m below surface level. The alluvium comprised yellow brown, high plasticity, silty clay with a trace of sand and gravel and some ferruginous nodules. The silty clay was observed to a varying consistency that ranged from soft to firm to a 1.00 m depth, stiff to very stiff to 1.70 m and very stiff to hard to a 2.50 m depth. The DCP results for TP06 indicated blows of 1 to 3 between depths of 0.40 m to 1.20 m. This alluvium deposit was also encountered at Larcom Creek and comprised pale brown, low plasticity, firm to stiff, gravelly clay to a 1.25 m depth.

Colluvium

At Larcom Creek borehole BH04 encountered colluvium deposits. The colluvium comprised various soil profiles with the first being a yellow-red, low plasticity, stiff gravelly clay to a 2.50 m depth with an SPT N value of 14. The gravelly clay encountered sandstone and siltstone gravel bands at a depth of 3.80 m and became very stiff with an SPT N value of 18 being recorded. From 3.80 m depth the colluvium became dense sandy gravel with a clay matrix and an SPT N value of 34 being recorded, this profile terminated at 6.50 m. Test pit TP17 approaching the end of the Moura Link, towards the township of Mount Larcom, encountered colluvium from depths of 0.30 m to 1.00 m with the profile comprising low plasticity gravely clay with a trace of cobbles.

Sandstone and siltstone bedrock

Siltstone bedrock was present at a 1.00 m depth beneath the Bruce Highway where borehole BH03 was drilled. The siltstone was generally highly to moderately weathered and of medium to high strength, although at a 3.40 m depth the siltstone became slightly weathered and of high strength with the borehole terminating at a 4.10 m depth. Test pit TP13 excavated on high ground just north of the Bruce Highway encountered siltstone bedrock at a shallow depth of 0.20 m below the ground surface. The siltstone was extremely to highly weathered and of very low to low strength and was recovered as a siltstone gravel in clay matrix during excavation. The test pit terminated at a depth of 1.40 m upon encountered moderately weathered low to medium strength siltstone.

At Larcom Creek from a 6.50 m depth siltstone was encountered in borehole BH04 to termination depth of 9.70 m. The siltstone varied in weathering profile and generally was moderately to slightly weathered, although an extremely weathered zone existed between depths of 7.20 m and 7.80 m. As expected the strength of the siltstone corresponded with the weathering profile. For the extremely weathered zone the siltstone was of extremely low strength but generally was recorded to be of medium to high strength. Test pit TP14 was excavated on a gentle ridge slope just south of Larcom Creek and adjacent to the Bruce Highway. During excavation sandstone bedrock was encountered at a shallow depth of 0.10 m and was extremely to highly weathered and of extremely low to very low in strength. The sandstone was recovered as hard clayey sandy gravel and terminated at a 1.30 m depth. Sandstone with inter-bedded siltstone was present in test pit TP17 near the township of Mount Larcom and was moderately weathered and of medium strength between depths of 1.00 m and 1.50 m.

Moura Link Eastern Option

Investigation for the Moura Link Eastern Option has been targeted along the general rail alignment and where key structures are proposed. Boreholes BH09 and BH12 together with test pits TP07, TP08, TP09 and TP12 have been excavated for this option the sub-surface conditions encountered are discussed below. Groundwater was not encountered during the fieldwork within this section of the Project.

Topsoil

A layer of topsoil was encountered where the railway is required to cross the Calliope River and within the floodplain area. The topsoil comprised either grey-brown, firm to stiff, sandy and silty clay to a 0.30 m depth or dark brown fine grained loose sand to 0.30 m below the ground surface.

Fill

Fill material was encountered close to the Dawson Highway. At this location a bridge is proposed to allow the eastern rail option to cross over the Dawson Highway and connect into the MSL. This material was present in borehole BH09, located on the Dawson Highway, and comprised compacted road base material. The road base consisted of sandstone gravel and cobbles within a sandy matrix to a 0.40 m depth. Test pit TP12 positioned at Scrubby Creek just off the Dawson Highway found fill comprising of gravelly sandy Clay of medium plasticity to a depth of 0.20 m.

Alluvium

Alluvium was present to varying depths along the eastern rail option. Around the Dawson Highway the alluvium, as recorded in borehole BH09 at Scrubby Creek, consisted of black, high plasticity, very stiff, silty clay to a 0.70 m depth and became orange-brown, medium to high plasticity, very stiff silty clay with sand and a trace of fine rounded gravel to a 2.60 m depth.

At the Calliope River, where borehole BH12 is located, the alluvium was encountered to a 2.85 m depth and comprised dark brown, stiff to very stiff clay of medium plasticity with some gravel present. An SPT N value of 20 recorded in the alluvium indicated very stiff clay.

To the north of the river, where test pits TP07 and TP08 are located within the floodplain, the alluvium consisted of black and dark brown, high plasticity, very stiff silty clay with a trace of sand to a 0.90 m depth. Test pit TP08 recorded alluvium to a depth of 3.60 m which comprised orange-brown medium plasticity very stiff to hard sandy clay with some fine to medium grained sand. The DCP testing next to test pits TP07 and TP08 indicated that the alluvium was stiff to very stiff clay.

Residual soil

Residual soil derived from weathering of the underlying sedimentary bedrock was encountered within the Calliope River floodplain to a depth of 1.80 m. The residual soil comprised orange-brown mottled brown very stiff to hard silty clay with some fine to coarse grained sand. The DCP test results in the residual soil indicated a very stiff to hard consistency in the silty clay.

Sandstone and siltstone bedrock

Inter-bedded sandstone and siltstone rock was encountered during the fieldwork along the Moura Link Eastern Option. The fieldwork results confirm the regional geology as outlined in Section 4.2.2 with the sandstone and siltstone being from the Mount Alma formation. At the Dawson Highway the borehole BH09 encountered highly weathered siltstone at 0.40 m below the ground surface. This highly weathered unit comprised friable siltstone that was recovered as gravel and cobble size material in a firm to stiff clay matrix to a depth of 2.70 m. Beneath a 0.20 m layer of moderately weathered fine to medium grained sandstone highly weathered siltstone was encountered at 2.90 m depth and had thin inter-bedded sandstone layers. At 3.95 m the siltstone became moderately weathered and was noted to have numerous fractures to borehole termination depth of 4.70 m. Test pit TP12 located at Scrubby Creek recorded highly weathered very low to low strength sandstone with clay in filled fractures between depths of 2.60 m to 3.60 m. During the fieldwork the sandstone was recovered as sub-angular gravel with a stiff clay matrix. Within the Calliope River region test pit TP09 found highly weathered very low to low strength siltstone present from 0.20 m below ground surface to termination depth at 1.10 m. The excavated siltstone was recovered as gravel and cobble size material due to the friable nature. Borehole BH12 encountered extremely weathered sandstone at 2.85 m below surface level with SPT N values of 37 and 27 indicating extremely low strength rock. At 5.95 m the sandstone was inter-bedded with siltstone and was generally extremely to highly weathered with numerous fractures to borehole termination depth at 13.45 m. To the north of the river extremely to highly weathered, extremely low to very low strength siltstone was encountered between depths of 1.80 m to 2.20 m termination depth.

Moura Link Western Option

Along the Moura Link Western Option the majority of the boreholes and test pits were completed at the proposed bridge locations at Dawson Highway and the Calliope River with other test pits completed within the general corridor. Boreholes BH01 and BH02 along with test pits TP01, TP02, TP03 and TP05 were completed along the western rail option with the following subsurface conditions being encountered. Groundwater was encountered only in borehole BH01 next to the Dawson Highway at a 4 m depth.

Fill

Fill material was encountered within the MSL rail corridor to a depth of 1.80 m below surface level. The fill generally appeared to be a mixture of sandy clay with gravel, cobbles and boulders of sandstone and was observed to be well compacted.

Topsoil

Generally a thin layer of topsoil was recorded along the western rail option and comprised either silty clay or silty sand. Although at the Calliope River the depth slightly increased to between 0.40 m and 0.70 m.

Alluvium

Alluvium was encountered at the Calliope River to a depth of 1.7 m and comprised medium plasticity silty clay which was interpreted from field observations as having a soft to firm consistency. Test pit TP05 approximately 1.5 km north of the Calliope River recorded alluvium to a 0.60 m depth which comprised brown, high plasticity, very stiff silty clay with a trace of fine to medium grained sand. At the MSL rail corridor near the Dawson Highway borehole BH01 encountered alluvium to a depth of 4 m which comprised fine grained dense silty sand.

Sandstone and siltstone bedrock

As encountered along the Moura Link Eastern Option the inter-bedded sandstone and siltstone of the Mount Alma formation was present along this option corridor. The weathering and strength of the sandstone along the corridor appeared to vary with depth. At the MSL rail corridor grey to pale red, fresh and very high strength sandstone is recorded between depths of 4.00 m and 5.80 m in borehole BH01. The sandstone then appeared to change and become moderately weathered and of medium strength to borehole termination depth at 6.20 m. Test pit TP02 slightly north of the Dawson Highway encountered very shallow sandstone bedrock at a depth of 0.10 m. This unit was recorded as highly weathered, very low to low strength sandstone which was highly fractured and recovered as angular sandstone gravel within a clayey sandy matrix. The sandstone became moderately weathered and of low to medium strength at a 0.60 m depth. Sandstone bedrock was encountered close to the near surface within the Calliope River region. Borehole BH02 recorded moderately to slightly weathered medium to high strength sandstone from a 1.7 m depth to 5.10 m below the ground surface. Test pit TP03 encountered highly weathered very low to low strength sandstone at a 0.40 m depth. To the north of the river siltstone bedrock was located at a 0.60 m depth and was highly weathered, highly fractured and of a very low to low strength. At termination depth of 1.50 m the siltstone became moderately weathered and of low to medium strength.

4.2.4 General soil properties

The soils investigation was completed in conjunction with the geotechnical investigations.

Investigations within the project area included the following activities:

- Reconnaissance survey and site inspections within the extent of the project area
- Surface observations and soil profile descriptions at selected locations
- Survey observations recorded in accordance with the recommendations contained in the *Australian Soil and Land Survey Field Handbook* (McDonald *et al* 1990) and *Australian Soil Classification* (Isbell 2002)

Geotechnical and soil investigation included the excavation of 33 test pits and three boreholes where soil and land survey information were collected. In addition it should be noted that soil samples were not collected at TP14, TP34, and TP38 due to rock being encountered within the first 0.1 m below ground level.

Soil samples collected from 13 sites were selected for laboratory analysis which is detailed in Tables 4.4, 4.6, 4.8 and 4.9.

Table 4.5 outlines the Emerson Aggregate Test (EAT) class number definitions as detailed in AS 1289.3.8.1-2006 Method of testing soil for engineering purposes- Method 3.8.1: Soil classification tests – Dispersion – Determination of Emerson class number of a soil.

Soil and land survey locations are shown on Figure 4.4.

Aldoga Rail Yard

Soil surface and profile descriptions for the Aldoga Rail Yard were recorded during the soil investigation completed by Connell Hatch. Soils within this section were observed to be dominated by clayey sands and loamy material associated with slopes and elevated areas, and silts and clays associated with the alluvial plains and low lying areas surrounding Larcom Creek.

The soil samples collected from TP23, TP27, TP29 and TP30 were classified under the Australian Soil Classification (Isbell 1996). Table 4.4 summarise sampling locations, soil classification and a brief classification description for each test pit site. Full soil classification descriptions, laboratory analysis results and borehole logs are provided in Appendices D2, D3 and D4.

Table 4.4 Aldoga Rail Yard soil classifications

Sampling location	Soil classification	Description
TP23	Brown-Orthic Tensol	Generally has a weak pedologic organisation apart from the A horizon and the dominant colour class in the upper 0.5 m of the solum is brown
TP27	Melanic, Eutrophic, Brown Dermosol	This soil has a structured B2 horizon and lacks strong texture contrast between A and B horizons. There is a dark surface or near surface horizon that has insufficient organic carbon to qualify as a humose horizon, and has little if any evidence of stratification. This soil class has all of the following properties: • Moist colour is black throughout (ie value 3 or less and chroma 2 or less) and dry colour value is 5 or less. • A minimum thickness of 0.2 m (in soils with a clear or abrupt textural B horizon the minimum thickness must be present within the A horizon) • The major part of the horizon has more than a weak grade of structure in which the most common ped size is 0.01-0.02 m or less. This condition may be waived for an Ap horizon or when dry consistence strength is weak or less. • pH (1:5 H_2O) is 5.5 or greater throughout the major part of the horizon. The major part of the B2 horizon is eutrophic (Base status is greater than 15 cmol (+) per kg clay.) but the B and BC horizons are not calcareous. The dominant colour class is brown.
TP29	Endohypersodic, Massive Black Vertosol	Clay soils with shrink-swell properties that exhibit strong cracking when dry and at depth have slickensides and/or lenticular structural aggregates. May have gilgai microrelief. • A clay field texture or 35% or more clay throughout the solum except for thin, surface crusty horizons 0.03 m or less thick • When dry, open cracks occur at some time in most years. These are at least 0.005 m wide and extend upward to the surface or to the base of any plough layer, self-mulching horizon, or thin, surface crusty horizon • Slickensides and/or lenticular peds occur at some depth in the solum A subhorizon of the solum below 0.5 m has an Exchangeable Sodium Percentage (ESP) of 15% or greater and has a massive or weak blocky (usually > 0.05 m peds) A horizon, and there is no surface crusty horizon with the dominant colour class being black.
TP30	Acidic-Sodic, Mesotrophic, Brown Kandosol	This soil lacks strong texture contrast, has massive or only a weakly structured B horizons, and is not calcareous throughout. The major part of the B2 horizon is strongly acid and at least the lower part of the B horizon is sodic. The major part of the B2 horizon is mesotrophic (base status is between 5 and 15 cmol (+) per kg clay inclusive). The dominant colour class is brown.

Source: Isbell 2002

Soil surface and profile descriptions for the proposed Aldoga Rail Yard were recorded during the soil investigation completed by Connell Hatch. Soils within this section were observed to be dominated by clayey sands and loamy material associated with slopes and elevated areas and silts and clays associated with the alluvial plains and low lying areas surrounding Larcom Creek.

The soil samples collected from TP23, TP27, TP29 and TP30 were classified under the Australian Soil Classification (Isbell 2002). Table 4.4 summarise sampling locations, soil classification and a brief classification description for each test pit site. Full soil classification descriptions, laboratory analysis results and borehole logs are provided in Appendices D2, D3 and D4.

Exchangeable sodium percentages (ESP) were calculated and EAT were performed on each sample analysed as an indicator of soil dispersivity and the likely risk of soil erosion potential. Samples collected from TP29 and TP30 had ESP values greater than 15% throughout most of the profile and are considered to be sodic. EAT results for these sample sites were recorded as Class 1, 2 or 3 (refer Table 4.5). TP23 and TP27 samples recorded ESP values below 15% and displayed minimal dispersive properties in the EAT. Results indicated soils at TP29 and TP30 have dispersive and sodic properties which increases soils susceptibility to erosion. Full laboratory results are provided in Appendix D3.

Microrelief refers to relief up to a few metres about the plane of the land surface. Gilgai is surface microrelief associated with soils containing shrink-swell clays. Gilgai consists of mounds and depressions showing varying degrees of order. (McDonald *et al* 1990). Gilgai were observed around the Larcom Creek floodplain around TP28, TP29 and TP30.

Table 4.5 Emerson aggregate test class number definitions

Emerson Class Number	Definition
Class 1	Air dried crumbs of soil show a strong dispersion reaction, ie, a colloidal cloud covers nearly the whole of the bottom of the beaker, usually in a very thin layer. The reaction should be evident within 10 min. In extreme cases all the water in the beaker becomes cloudy leaving only a coarse residue in a cloud of clay.
Class 2	Air-dried crumbs of soil show a moderate to slight reaction. A moderate reaction consists of an easily recognisable cloud of colloids in suspension, usually spreading ht thin steak on the bottom of the beaker. A slight reaction consists of the bare hint of cloud in water at the surface of the crumbs
Class 3	The soil remoulded at the plastic limit disperses in water
Class 4	The remoulded soil does not disperse in water. Calcium carbonate (calcite)or calcium sulfate (gypsum) is present
Class 5	The remoulded soil does not disperse in water and the 1:5 soil/water suspension remains dispersed after 5 min
Class 6	The remoulded soil does not disperse in water and the 1:5 soil/water suspension begins to flocculate within 5 min
Class 7	The air-dried crumbs of soil remain coherent in water and swells
Class 8	The air-dried crumbs of soil remain coherent in water and do not swell

Source: AS 1289.3.8.1-2006

NCL and EEMBL

Soil surface and profile descriptions for the NCL and EEMBL were recorded during the soil investigation completed by Connell Hatch. Soils within this section were observed to be dominated by clayey sands and loamy material associated with slopes and elevated areas and silts and clays associated with the alluvial plains surrounding Larcom Creek and areas of lower elevations near the township of Yarwun and on the footslopes of the Mount Larcom Ranges.

The soil samples collected from BH21, TP23, TP27, TP29, TP30 and TP33 were classified under the Australian Soil Classification (Isbell 2002). Table 4.6 summarises sampling locations, soil classification and a brief classification description for each sampling location. Full soil classification descriptions, laboratory analysis results and borehole logs are provided in Appendices D2, D3 and D4.

Table 4.6 NCL and EEMBL soil classifications

Sampling Location	Soil Classification	Description
BH21	Haplic, Mesotrophic, Brown Ferrosol/ Kandosol	This soil lacks strong texture contrast, has massive or only a weakly structured B horizon, and is not calcareous throughout. The major part of the B2 horizon is whole coloured. The major part of the B2 horizon is mesotrophic (base status is between 5 and 15 cmol (+) per kg clay inclusive). The dominant colour class is brown. The colour of this soil was observed to be a reddish brown so based on colour there is a possibility that it may have a high enough free iron oxide content to be classed as a ferrosol but due to no free iron oxide analysis being completed as part of the analysis it can not be determined beyond reasonable doubt that this is the case.
TP23	Brown-Orthic Tensol	Refer to Table 4.4
TP27	Melanic, Eutrophic, Brown Dermosol	Refer to Table 4.4
TP29	Endohypersodic, Massive Black Vertosol	Refer to Table 4.4
TP30	Acidic-Sodic, Mesotrophic, Brown Kandosol	Refer to Table 4.4
TP33	Manganic, Mesotrophic, Brown Kandosol	This soil lacks strong texture contrast, has massive or only a weakly structured B horizons, and is not calcareous throughout. This soil contains a manganic horizon within the solum and the major part of the B2 horizon is mesotrophic (base status is between 5 and 15 cmol (+) per kg clay inclusive).The dominant colour class is brown.

Source: Isbell 2002

ESPs were calculated and EATs were performed on each sample analysed as an indicator of soil dispersivity and the likely risk of soil erosion potential. Samples collected from TP29, TP30 and TP33 had ESP values greater than 15% throughout most of the profile and are considered to be sodic. EAT results for these sample sites were recorded as Class 1, 2 or 3(refer Table 4.5). BH21, TP23 and TP27 samples recorded ESP values below 15% and displayed minimal dispersive properties in the EAT. Results indicated soils at TP29, TP30 and TP33 have dispersive and sodic properties which increases soils susceptibility to erosion. Full laboratory results are provided in Appendix D3.

Gilgai were observed around the Larcom Creek floodplain around TP28, TP29 and TP30, and at TP23 and 25.

The report Land Suitability Assessment and Soils of the Calliope and Yarwun Areas, Queensland (DNR 1999) details the studies of the soil types in the vicinity of townships of Yarwun and Targinie. The map Calliope Area Soils (refer Appendix D5) included in the DNR report shows the study area and soil types encountered. Table 4.7 summarises the soil types found in this study which intersect the project area and the brief description provided in the report.

Table 4.7 Soil identified within the project area from Land suitability assessment and soils of the Calliope and Yarwun areas, Queensland (DNR 1999)

Soil type	Description
Grey or Brown Sodosol	Loamy surface with bleached subsurface over alkaline mottled grey or brown sodic clay subsoil
Grey Kurosol	Very thick loamy surface with bleached subsurface over acid mottled grey clay subsoil
Orthic Tenosol	Loamy surface with brown or red loamy subsoil
Brown Sodosol	Gravely clay loamy surface with bleached subsurface over yellowish brown sodic clay subsoil
Red Kandosol or OthicTenosol	Coarse sandy or loamy surface grading to a red or brown clay loamy subsoil or coarse sandy throughout
Red or Brown Dermosol	Shallow to moderately deep, gravely clay loamy or clayey surface grading to a red or brown structure clay subsoil
Brown Sodosol	Bleached clay loamy surface over yellowish brown sodic clay subsoil
Leptic Tenosol	Stony loamy brown soil; Occasional rock outcrop
Black or Brown Vertosol	Deep black to brown cracking clay; normal gilgai

Source: DNR 1999

During excavation for the soil sampling the material being extracted were inspected for any signs of ASS material (ie sulphur smell or jarosite). At TP37 a sulphur smell was noted in the underling layers and two samples were collected for pH field and pH field oxidised testing. The result obtained from this analysis did not meet the characteristics of an ASS and were not submitted for further ASS testing.

Moura Link North

Soil surface and profile descriptions for the Moura Link North were recorded during the soil investigation completed by Connell Hatch. Soils within this section were observed to be dominated by sandy and loamy material associated with sloped and elevated areas and silts and clays associated with the alluvial plains surrounding Larcom Creek and areas of lower elevations around near the township of Mount Larcom.

The soil samples collected from TP13, TP17 and TP22 were classified under the Australian Soil Classification (Isbell 2002). Table 4.8 summarises sampling locations, soil classification and a brief classification description for each sampling location. Full soil classification descriptions, laboratory analysis results and borehole logs are provided in Appendices D2, D3 and D4.

Table 4.8 Moura Link North soil classifications

Sampling location	Soil classification	Description
TP13	Leptic Tenosol	Generally has a weak pedologic organisation apart from the A horizon and is underlain within 0.5 m of the surface by a calcrete pan; hard unweathered rock or other hard materials; or partially weathered or decomposed rock or saprolite.
TP17	Mottled, Mesotrophic, Brown Kandosol	This soil lacks strong texture contrast, has massive or only a weakly structured B horizon, and is not calcareous throughout. It has a horizon in which mottle abundance is greater than 10% (visual abundance estimate) and contrast between colours is distinct to prominent. The major part of the B2 horizon is mesotrophic (base status is between 5 and 15 cmol (+) per kg clay inclusive). The dominant colour class is brown.

Sampling location	Soil classification	Description
TP22	Reticulate, Hypercalcic, Brown Kandosol	This soil lacks strong texture contrast, has massive or only a weakly structured B horizon, and is not calcareous throughout. Below the B2 horizon it has strongly developed reddish, yellowish and greyish or white, more or less reticulately mottled horizons that can be hand-augured or cut with a spade. It contains less than 2% soft finely divided carbonate, and have less than 20% hard carbonate nodules or concretions. The dominant colour class is brown.

Source: Isbell 2002

ESPs were calculated and EATs were performed on each sample analysed as an indicator of soil dispersivity and the likely risk of soil erosion potential. Samples collected from TP13 had ESP values greater than 15% throughout most of the profile and are considered to be sodic. EAT results for these sample sites were recorded as Class 1 or 3 (refer Table 4.5). TP17and TP22 samples recorded ESP values below 15% and displayed minimal dispersive properties in the EAT. Results indicated soils at TP13 have dispersive and sodic properties which increases soils susceptibility to erosion. Full laboratory results are provided in Appendix D3.

Gilgai were observed in the floodplains of Larcom Creek during field visits.

Moura Link Eastern Option

Soil surface and profile descriptions for the Moura Link Eastern Option were recorded during the soil investigation completed by Connell Hatch. Soils within this section were observed to be dominated by clayey sands and loamy material associated with slopes and elevated areas and clays associated with the alluvial plains surrounding the Calliope River, Farmer Creek and Scrubby Creek.

The soil samples collected from BH12 and TP06 were classified under the Australian Soil Classification (Isbell 2002). Table 4.9 summarises sampling locations, soil classification and a brief classification description. Full soil classification descriptions, laboratory analysis results and borehole logs are provided in Appendices D2, D3 and D4.

Table 4.9 Moura Link Eastern Option soil classifications

Sampling location	Soil classification	Description
BH12	Sodic, Mesotrophic, Brown Kandosol	This soil lacks strong texture contrast, has massive or only a weakly structured B horizon, and is not calcareous throughout. It has a B horizon in which at least the lower part is sodic (the ESP of the fine earth soil material is 6 or greater).The major part of the B2 horizon is mesotrophic (base status is between 5 and 15 cmol (+) per kg clay inclusive). The dominant colour class is brown.
TP06	Mottled-Sodic, Eutrophic, Brown Dermosol	This soil has a structured B2 horizon and lacks strong texture contrast between A and B horizons. The major part of the B2 horizon is mottled and at least the lower part of the B horizon is sodic. The B2 horizon is eutrophic (base status is greater than 15 cmol (+) per kg clay) but the B and BC horizons are not calcareous. The dominant colour class is brown.

Source: Isbell 2002

ESPs were calculated and EATs were performed on each sample analysed as an indicator of soil dispersivity and the likely risk of soil erosion potential. Samples collected from TP06 had ESP values greater than 15% throughout most of the profile and are considered to be sodic. EAT results for these sample sites were recorded as Class 3 (refer Table 4.5). The surface sample collected from BH12 had and ESP value considered sodic and an EAT results of Class 3 but the samples collected below 0.1 m have ESP values below 15% and displayed minimal dispersive properties in the EAT. Results indicated soils at TP06 and BH12 have dispersive and sodic properties which increases soils susceptibility to erosion. Full laboratory results are provided in Appendix D3.

Review of *Land Systems of the Capricornia Coast Map 3 Calliope Area* (DPI 1995) indicated the Calliope land system group (refer Table 4.1) has moderate Melonhole Gilgai as a major soil characteristic. Landform survey observations were consistent with the DPI mapping with Gilgai being observed at BH12, TP10 and TP08.

Moura Link Western Option

Soil surface and profile descriptions for the Moura Link Western Option were recorded during the soil investigation completed by Connell Hatch. Soils within this area were observed to be dominated by sandy and loamy material associated with slopes and elevated areas and clays associated with the alluvial plains surrounding the Calliope River.

The soil samples collected from TP03/BH02 and TP06 were classified under the Australian Soil Classification (Isbell 2002). Table 4.10 summarises sampling location, soil classification and a brief classification description. Full soil classification descriptions, laboratory analysis results and borehole logs are provided in Appendices D2, D3 and D4.

Table 4.10 Western Option Soil Classifications

Sampling location	Soil classification	Description
BH02/ TP03	Reticulate, Mesotrophic, Grey Dermosol	This soil has a structured B2 horizon and lacks strong texture contrast between A and B horizons. Below the B2 horizon it has strongly developed reddish, yellowish and greyish or white, more or less reticulately mottled horizons that can be hand-augured or cut with a spade. The B2 horizon is mesotrophic (base status is between 5 and 15 cmol (+) per kg clay inclusive). The dominant colour class is grey.
TP05	Mesotrophic, Mottled-Mesonatric, Red Sodosol	This soil has a clear or abrupt textural B horizon and in which the major part of the upper 0.2 m of the B2 horizon (or the major part of the entire B2 horizon if it is less than 0.2 m thick) is sodic and not strongly acid. The major part of the B2 horizon is mesotrophic (base status is between 5 and 15 cmol (+) per kg clay inclusive). The major part of the upper 0.2 m of the B2 horizon is mottled and has an ESP between 15 and 25%.

Exchangeable sodium percentages (ESP) were calculated and Emerson Aggregate Tests (EAT) were performed on each sample analysed as an indicator of soil dispersivity and the likely risk of soil erosion potential. Samples collected from TP05 had ESP values greater than 15% throughout most of the profile and are considered to be sodic. EAT results for these sample sites were recorded as Class 1 or 3 (refer Table 4.5). BH02/TP03 samples recorded ESP values greater than 15%. EAT was not completed for BH02/TP03. Results indicated soils at BH02/TP03 and TP05 have dispersive and sodic properties which increases soils susceptibility to erosion. Full laboratory results are provided in Appendix D3.

Review of *Land Systems of the Capricornia Coast Map 3 Calliope Area* (DPI 1995) indicated the Calliope land system group (refer Table 4.1) has moderate Melonhole Gilgai as a major soil characteristic. Landform survey observations were consistent with the DPI mapping with Gilgai being observed at BH02/TP03.

4.2.5 Acid sulfate soils

ASS are a characteristic feature of low lying coastal environments in Queensland, particularly where landform elevations are below 5 m AHD. ASS are comprised of iron sulfides generally in the form of pyritic material that is a product of the natural interaction between iron rich organic matter and sulfate rich seawater present in anaerobic low energy estuarine environments. Undisturbed, these soils are generally present in an anaerobic state within the subsurface profile (below the water table) of Holocene marine muds and sands in the form of Potential Acid Sulfate Soil (PASS). Actual Acid Sulfate Soil (AASS) are the oxidised (disturbed) form, which may occur as the result of natural or anthropogenic disturbance from changes in groundwater levels and/or exposure to oxygen (Powell, B. & Ahern, C.R. *Nature, Origin and Distribution of Acid Sulfate Soils: Issues for Queensland* 1999).

ASS in an undisturbed environment may have a pH of neutral or slightly alkaline and no visual appearances indicating its acidic potential. However, when exposed to air either by direct excavation or by indirect changes to the surrounding water table, pyritic material inherent in the soil matrix is oxidised by sulfur oxidising bacteria leading to the formation of sulfuric acid. Following rainfall, sulfuric acid associated with soil oxidation can then be released into surface runoff and receiving waters and mobilised in groundwater, resulting in mortality of aquatic flora and fauna and deterioration in ecosystem health as well as impacts on structures and existing infrastructure.

In addition to acidification of receiving waters, the acidic environment of the soils and/or receiving waters have the potential to mobilise metal contaminants (particularly aluminium and iron). These metals become soluble under acidic conditions and are readily leached from the soil profile by catchment runoff or groundwater flows. Therefore runoff or drainage water from uncontrolled or inadequately managed exposed ASS has the potential to significantly impact upon flora, fauna and ecosystem health.

The geomorphic and site description criteria that are used to determine if ASS are likely to be present include:

- Land with elevation less than 5 m AHD
- Soil and sediment of recent geological age (Holocene)
- Marine or estuarine sediments and tidal lakes
- Low lying coastal wetlands or back swamp areas, waterlogged or scalded areas, Stranded beach ridges and adjacent swales, interdune swales or coastal sand dunes
- Coastal alluvial valleys
- Areas where the dominant vegetation is tolerant of salt, acid and/or waterlogging conditions (eg mangroves, salt couch, swamp tolerant reeds, rushes, grasses (eg *Phragmites australis*), paperbarks (*Melaleuca* spp.) and swamp oak (*Casuarina* spp.)
- Areas identified in geological descriptions or in maps as:
  - Bearing sulfide minerals
  - Coal deposits or marine shales/sediments
  - Deep older estuarine sediments below ground surface of either Holocene or pre-Holocene age

The DNRM - Acid Sulfate Soils - Tannum Sands Gladstone Area Central Queensland Coast (2004) found the ASS encountered in the study was almost exclusively associated with tidal lands or the tidal zone (refer Figure 4.6). The area where ASS was encountered in the DNRM report were all outside the project area.

Field observations, the Gladstone Regional Council (Calliope Shire Council) mapping and DNRMW mapping indicate that there is a low risk of the soils and sediment within this area being affected by ASS material, therefore minimal sampling for ASS was conducted.

4.2.6 Good quality agricultural land

Under the Calliope Shire Council (CSC) Planning Scheme, agricultural land suitability within each area has been mapped as follows:

- Aldoga Rail Yard
  - C2 Pasture land suitable for native pastures
- North Coast Line and East End Mine Branch Line
  - A Land suitable for plantation , tree and vine crops with minor or moderate limitations
  - C1 Land suitable for sown pasture with moderate limitations
  - C2 Pasture land suitable for native pastures
  - C2 Land marginal for sown pasture with sever limitations
  - C3 Land suitable for grazing of native pasture in accessible areas
- Moura Link North
  - C2 Pasture land suitable for native pastures
- Moura Link Eastern Option
  - C1 Pasture land suitable for sown pastures
  - C2 Pasture land suitable for native pastures
- Moura Link Western Option
  - C2 Pasture land suitable for native pastures

Soil profile samples were collected during the soil and land survey from the project area (refer Section 4.2.4). These areas are mapped under the CSC Planning Scheme as suitable for agricultural purposes (Class A, C1, C2, C3). The sample analysis results are provided in Appendix D3.

The Agricultural Land Classes identified in the CSC Planning Scheme are illustrated in Figure 4.7.

The land survey findings are summarised for each area in Table 4.2.

The dominant agricultural land uses in the surrounding areas were observed to be grazing pastures.

4.2.7 Land contamination

This section contains a preliminary contaminated site investigation of the project area generally in accordance with Section 7.2 of Appendix 7 in the *Draft Guidelines for the Assessment and Management of Contaminated Land in Queensland* (EPA 1998) to identify potential background contamination levels. The limitations to this investigation are contained in Appendix D8.

Site description

The preliminary contaminated land investigation was conducted for affected properties within the project area.

Current land uses

Table 4.11 provides a summary of the existing land uses within and adjacent to the project area.

Table 4.11 Summary of existing land uses

Precinct	Current land use
Aldoga Rail Yard	Rural land use. Rail corridor and existing rail line with grazing pasture
North Coast Line/East End Mine Branch Line	Rural land use. Rail corridor and existing rail line with grazing pasture
Moura Link	Rural land use, agricultural grazing pasture
Moura Link Eastern Option	Rural land use, agricultural grazing pasture
Moura Link Western Option	Rural land use, agricultural grazing pasture

Existing land uses within and adjacent to the project area are discussed further in Section 3.

Hydrology and local groundwater uses

A search of the DNRW groundwater database was conducted. A summary of the findings is provided in Section 9. No groundwater quality information relevant to potential groundwater contamination from current or historical land use activities is provided in the database and 10 groundwater bores have been identified within a 3 km radius of the project area (refer Figure 9.1).

4.2.8 Site history review

The sources of information associated with the site history review for the project area include:

- Interviews with QR representatives
- Search the EPA's EMR and CLR database
- Review of historical aerial photography between 1959 and 2007
- Review of a Soil Contamination Report for the assessment of contaminated soil relocated to the rail corridor during the Yarwun Railway Station Yard Remediation
- Review of information compiled for the WICT EIS (Connell Hatch 2006)

Interviews

QR's Principal Scientific Advisor was contacted to seek further information relating to the low level contaminated soil stockpile located on Lot 72 on SP122249. This soil was relocated during remediation activities at the former Yarwun Railway Station Yard, and the soil contains low levels of some heavy metals such as arsenic and copper. The source of this contamination was reported by QR as being sodium arsenate, which was formerly used by QR as a herbicide. It is understood that this herbicide was formerly stored in a goods shed at the former Yarwun Railway Station Yard. The soil contamination report (refer Appendix D6) indicates that some samples from the stockpile contained arsenic levels above the EPA Environmental Investigation Levels, but below the Health-based Investigation Level for Standard Residential land use. Other analytes - copper, lead, zinc, mercury and cyanide, were below the relevant EPA Environmental Investigation Levels and Health-based Investigation Levels.

QR advised that it was common practice during the 1940s and 1950s to apply an arsenic based herbicide to the railway tracks to control the growth of vegetation in the railway corridor. Herbicide was generally applied was approximately 3 m either side of the track centreline. It is understood that assessments conducted by QR have indicated that concentrations of arsenic based herbicide residues of significance are generally not found more than 5 m from the track centreline.

QR advised that hydrocarbon contamination of rail track areas (from locomotives) is typically surficial and minor, except at older refuelling facilities or at diesel locomotive depots where units stand for long periods of time.

Aerial photograph review

A selection of historical aerial photographs of the project area held by the DNRW Sunmap Department were reviewed, with the results summarised in Table 4.12.

Table 4.12 Summary of historical aerial photograph observations

Year	Summary of Observations
1 July 1959 Run 4, Ref: Q926 No. 69, 71, 73, 75 and 77	• Township of Yarwun, Gladstone-Mount Larcom Road and NCL have been established • Very limited clearing of vegetation along NCL from the township of Yarwun to approximately 2.5 km west of the township of Yarwun • Significant clearing of vegetation north along NCL from 2.5 km west of the township of Yarwun to the township of Mount Larcom • Two patches of agricultural land approximately 250 m x 200 m in area north of NCL 2.5 km west of the township of Yarwun • Land in the project area from Gladstone-Mount Larcom Road to approximately 400 m south of Gladstone-Mount Larcom Road has been cleared • Land approximately 400 m south to the project area boundary remains vegetated, gradually decreasing in tree cover towards the Bruce Highway • There are about six rural homesteads apparent within and adjacent to the project area
1 July 1959 Run 8 Ref: Q928 No. 24 and 25	• The parcel of land 1.5 km east of Larcom Creek and 1 km north of Dawson Highway has been cleared for agricultural purposes
1 May 1961 Run 9, Ref: CAB 189-5090	• Approximately 25 m of vegetation borders the east of the Bruce Highway until the Highway intersects with Farmer Creek (outside the project area). Land after 25 m east of the Bruce Highway has been cleared for the next 500 m approximately • There has been significant clearing in the Moura Link Western Option section north of the Calliope River to the Bruce Highway, with two small patches of vegetation remaining in the area
25 May 1965 Run 8, Ref: Q1447 No. 155, 157. 159, 161 and 163 (for Aldoga/East Mine Branch Line) Run, 8, Ref Q1447 No. 27 (for Western Option)	• There has been tree regrowth in the area north of Gladstone-Mount Larcom Road and east of Larcom Creek to the project area boundary north and property boundary fence approximately 1 km east of Larcom Creek
26 July 1977 Run 1 Ref: Q3362 No 0234 and 0235	• The MSL has been established and runs parallel to the Dawson Highway. There has been limited impact on the surrounding vegetation
11 July 1979 Run 9 Ref: Q3066 No. 8667	• There has been extensive clearing throughout the project area south of Gladstone-Mount Larcom Road to the EEMBL section boundary, with approximately one-third of vegetation remaining compared to 1965
29 July 1979 Run 10, Ref Q3074 No. 9625 and 9630	• The NCL is extended north of the township of Yarwun • There has been extensive clearing north of NCL from approximately 1 km to 2.5 km west of the township of Yarwun. The corresponding south section of NCL remains vegetated with only small patches of clearing

Year	Summary of Observations
19 August 1986 Run 1, Ref: Q4580 No. 114	• A road has been established in a northerly direction from the Dawson Highway where the direction of the Dawson Highway changes from east to west into a southerly direction. • There have been private roads established in the project area between the Bruce Highway and the Dawson Highway but have had limited impact on the surrounding tree density
28 September 1989 Run 10, Ref: QC4831 No. 44 and 49	• Mount Larcom Yarwun Road has been established • The NCL and Gladstone Mount Larcom Road are separate features • There has been extensive tree regrowth in the area south of the township of Mount Larcom cleared in 1979
11 October 1989 Run 13, Ref: QC 4842 No. 95	• The area south of Farmer Creek and north of the Calliope River has been cleared with the exception of 200 m directly north of the Calliope River • The project area south of the Bruce Highway and North of the Dawson Highway has been largely cleared with the exception of the following – 600 m x 250 m area approximately 120 m west of Farmer Creek and directly south of the Bruce Highway – 350 m x 850 m area directly and west of the project area boundary.
2 August 1996 Run 1, Ref: QC5440 No 7	• There has been further clearing of the project area east of the Calliope River and north of the Dawson Highway • Some tree regrowth is evident in the area cleared north of Dawson Highway observed in 1986 • The area between the MSL and Dawson Highway, bordering Scrubby Creek to approximately 400 m west of Scrubby Creek has been cleared • The area east of Scrubby Creek in the project area has been cleared for approximately 150 m • There has been some regrowth in the area approximately 600 m west of Scrubby Creek and approximately 500 m north of the Dawson Highway, that was cleared in 1986
27 April 1999 Run 11, Ref: QAP 5713	• The EEMBL has been established
2 May 1999 Run 10 Ref: QAP5719 No. 107 and 137	• Tree growth has been re-established south of Mount Larcom Yarwun Road
18 July 2007 Run 10 Ref: QAP6264 No. 199	• The area between the MSL and Dawson Highway, bordering Scrubby Creek to approximately 400 m west of Scrubby Creek observed to have been cleared in 1999 has now been converted into agricultural land. • There has been tree clearing in the area from the Calliope River to 500 m south of Calliope River

Environmental management register and contaminated land register searches

CLR and EMR searches were conducted for land parcels contained within the project area. Over 70 land parcels were supplied by QR for the search. Properties listed on the EMR are displayed in Figure 4.8 and full search results for all properties with the project area are provided in Appendix D7.

Table 4.13 provides a summary of the land parcels listed on the EMR database. There was no land parcels listed on the CLR database from the project area searched.

Land parcels listed on the EMR were noted in the Aldoga Rail Yard and NCL sections of the project area only.

Table 4.13 Summary of Land Parcels Listed on EMR Database

Property description	Status on EMR	Notes and reason for listing	Current ownership/lessee details
Lot 30 on SP130898[2]	Listed on EMR	Notifiable Activity[1] 374 – Railway Yards – operating a railway yard including goods-handling yards, workshops and maintenance areas.	State of Queensland represented by Queensland Transport
Lot 72 on SP122249[3]	Listed on EMR	Notifiable Activity[1] 374 – Railway Yards – operating a railway yard including goods-handling yards, workshops and maintenance areas.	State of Queensland represented by Queensland Transport
Lot 75 on SP122249[4]	Listed on EMR	Notifiable Activity[1] 374 – Railway Yards – operating a railway yard including goods-handling yards, workshops and maintenance areas.	State of Queensland represented by Queensland Transport
Lot 91 on SP122250[2]	Listed on EMR	Notifiable Activity[1] 374 – Railway Yards – operating a railway yard including goods-handling yards, workshops and maintenance areas.	State of Queensland represented by Queensland Transport
Lot 140 on SP122252	Listed on EMR	Hazardous contaminants - Possible high arsenic levels along railway corridor.	State of Queensland represented by Queensland Transport

Table notes:
1. Notifiable Activity as listed in Schedule 2 of the *Environmental Protection Act 1994*
2. This property recently subdivided from parent parcel Lot 1 on RP601330
3. This property is the result of the recent amalgamation of Lot 4 on CTN1335 and Lot 71 on DS2
4. This property is the result of the recent amalgamation Lot 71 on DS2 and Lot 81on DS2

Historical title search

A titles search of EMR listed properties was conducted as part of the EIS, however this search did not reveal significant historical land use information. A summary of current ownership of EMR listed properties is provided in Table 4.13.

EPA records

A search of EPA records and register for recorded notices, orders or licenses for the project area was not conducted. This record search was not undertaken, as it was considered unlikely that this activity would not reveal significant historical land use information.

Local government records and licenses

A search of local government records was not conducted as it was considered unlikely that this activity would reveal significant historical land use information.

Review of previous reports

Two reports relating to contamination in the project area were identified by QR. Both reports relate to the remediation of Yarwun Railway Station and relocation of contaminated soil from this area and are referenced as follows:

- Site Plan for Queensland Rail Yarwun Railway Station Yard, Yarwun, Central Queensland prepared by Fluor Daniel GTI (1997)
- Additional Soil Testing, Yarwun Yard Issue, prepared by QR (1998)

The findings of these reports are included in the summary of site history and conclusions.

Site observations

Relevant site observations pertaining to Lot 72 on SP122249 were compiled during the completion of the WICT EIS (Connell Hatch 2006). These observations were made during site visits conducted by Connell Hatch staff at various times between April and September 2006 and are included below.

Along the NCL, on Lot 72 on SP122249 which is located to the north of Lot 356 on FTY1160, a stockpile of soil, with a sign "Low Level Contaminated Soil Do Not Remove from this Enclosure", was noted. Information supplied by QR relating to this soil is contained in the Interviews Section below.

Photo 4.1 Contaminated soil at eastern end of NCL section

Summary of site history

Table 4.14 provides a summary of the site history of the project area.

Table 4.14 Site history summary

Period	Summary of project area historical land use activities
Prior to 1959	NCL opened in late 1800s to early 1900s Prior to 1959, the land use in the project area was predominantly rural or open space.
1959-1979	Between 1959 and 1979, further clearing in the GDSA and Aldoga Precinct for grazing pasture and powerline easements was undertaken. East End Branch Line/Aldoga to East End opened in 1968. Moura Branch and MSL opened around 1968.
1979-1989	Grazing pasture was the primary land use within the project area during this period.
1989-1999	Between 1989 and 1999, additional railway lines were constructed on the southern side of the Calliope River, some rail realignments on the NCL also occurred during this period. The Old Yarwun Rail Yard was remediated around 1998 and the NCL realigned to bypass the township of Yarwun.
1999 to present	The project area continues to be used predominantly as grazing pasture, although some increase in tree coverage was observed.

Gaps in the site history

Gaps identified in the site history review include:

- Historical waste management practices and waste disposal practices used by QR
- The identity and specific chemical composition of herbicides and pesticides used within the rail corridor by QR prior to 1968
- The chemicals and oils/fuels (if any) used or stored on properties within the rail corridor
- The existence of cattle dips on the rural properties within the project area
- The waste disposal practices for waste chemicals and oils/fuels (if any) used or stored on rural properties within the project area
- The impact of historical rail realignments on the project area
- Spill and rail/road accident information for the NCL, EEMBL, MSL, Bruce Highway, Gladstone-Mount Larcom Road and the Dawson Highway

Potential areas of environmental concern

Based on the site history, potential areas of environmental concern (AEC) and associated chemicals of concern were identified. These are summarised in Table 4.15.

Table 4.15 Summary of potential areas and chemicals of concern

Potential AEC	Potentially contaminating activity	Chemicals of concern	Likelihood of contamination (based on site history review)[1]	Comments
1. Rail Corridor (NCL and Aldoga Rail Yard)	Herbicide treatment along the rail track and diesel/oil spills/ leakage from locomotives	Arsenic, Heavy Metals and OCPs TPH, PAHs	Low	Refer interviews section QR commented that any rail line that was in operation in the period 1940 to 1960 has the potential for arsenic residue in the formulation
2. Stockpile stored in the Rail Corridor on Lot 72 on SP122249	Storage of relocated low level contaminated soil	Arsenic	Low – Medium	Refer Interviews section
3. Rural properties outside the rail corridor within the project area	Cattle dips, waste oil and fuel storage	Arsenic, organochlorins, organophosphates, carbamates and synthetic pyrethroids Hydrocarbons, BTEX, PAH, Phenols and Lead	Low	Based on current and historical land use and practices
Lot 30 on SP130898[2]	Diesel and oil storage areas, railway maintenance, goods handling	TPH, PAHs, Arsenic, phenolics (creosote), heavy metals, nitrates and ammonia	Low	Eastern boundary of old rail corridor. No longer part of NCL due to deviation which by passed the township of Yarwun. Potential for arsenic residues in old track formation. Refer interviews section

Potential AEC	Potentially contaminating activity	Chemicals of concern	Likelihood of contamination (based on site history review)[1]	Comments
Lot 72 on SP122249[3]	Diesel and oil storage areas, railway maintenance, goods handling	TPH, PAHs, Arsenic, phenolics (creosote), heavy metals, nitrates and ammonia	Low	Contains new and old track alignment as was used to relocate remediation soil from Yarwun yard remediation project. Potential for arsenic residues in track formation and in relocated Yarwun Rail Yard soil. Refer Table 4.13 and site description
Lot 75 on SP122249[3,4]	Diesel and oil storage areas, railway maintenance, goods handling	TPH, PAHs, Arsenic, phenolics (creosote), heavy metals, nitrates and ammonia	Low	Located on old rail corridor but no longer part of the NCL due to deviation which bypassed the township of Yarwun Refer Table 4.13
Lot 91 on SP122250[2]	Diesel and oil storage areas, railway maintenance, goods handling	TPH, PAHs, Arsenic, phenolics (creosote), heavy metals, nitrates and ammonia	Low	Current rail corridor and potential for arsenic residues in track formation. However the current track alignment through this lot may be more recent which would not have the potential for arsenic and an old alignment and track formation may exist which does (*pers comm.* QR) Refer Table 4.13
Lot 140 on SP122252	Diesel and oil storage areas, railway maintenance, goods handling	TPH, PAHs, Arsenic, phenolics (creosote), heavy metals, nitrates and ammonia	Low	Only first 500 m of this lot contains original track alignment with potential to contain arsenic residues (*pers comm.* QR) Refer Table 4.13

Table notes:

1. This is a qualitative assessment of the probability of contamination being detected at the potential AEC based on the history study.
2 This property recently subdivided from parent parcel Lot 1 on RP601330
3 This property is the result of the recent amalgamation of Lot 4 on CTN1335 and Lot 71 on DS2
4 This property is the result of the recent amalgamation Lot 71 on DS2 and Lot 81on DS2
BTEX Benzene, Toluene, Ethylbenzene and Xylene
TPH Total Petroleum Hydrocarbon
PAH Polynuclear Aromatic Hydrocarbon
OCP Organochlorine Pesticide
OPP Organophosphorus Pesticide
Heavy metals include Arsenic, Cadmium, Chromium, Copper, Lead, Zinc, Mercury and Nickel

It is important to note that it is generally accepted that, any rail track formation in eastern Queensland which was in use from 1940 to 1960 has the potential to have had arsenic herbicide applied, regardless of whether it is listed on the EMR or not . The NCL alignment through the project area opened in the late 1800s to early 1900s and therefore fits this criteria.

Additionally it is also important to note that aerial herbicide spraying is conducted in the GSDA to control Giant rats tail grass (refer section 5).

4.2.9 Red imported fire ant

No declared Fire Ant Restricted Areas occur within the project area. However, the project areas is located approximately 0.7 km to the west of a Fire Ant restricted area, Fire Ant Restricted Areas Yarwun Extent (refer Figure 4.9). A Fire Ant restricted area is any past or current treatment area.

This area was declared following the discovery of Fire ants at the Orica Chemical Production Facility and Rio Tinto Yarwun Alumina Refinery in 2006. DPIF instigated an appropriate treatment programme to eradicate the area of Fire ants.

There is potential for movement between the WICT and MLARP construction sites. In these instances the QR Fire Ant Risk Management Plan outlines conditions for Fire ant management on QR properties and the WICT Fire Ant Management Plan will detail site specific management measures for the Yarwun area.

If the species is identified within the MLARP, controls on the movement of materials that may be at risk of transporting Fire ants are required. High risk items, known as restricted items, at risk of spreading Fire ants include:

- Soil
- Potting mixture or organic mulch
- An appliance (vehicle, machinery, equipment or apparatus of any kind) used in agriculture or for moving soil
- Baled hay or straw
- Any other things containing soil or with soil attached

A DPIF Approved Risk Management Plan may also be required.

4.3 Potential impacts

The preliminary design for the Project indicates that the majority of disturbance associated with construction and operation of the Project will be associated with:

- Soil excavation, filling/placement and handling, including erosion and sediment control, and contaminant management
- Preparatory/formation earthworks

A summary of the potential impacts identified relating to topography, geology and soils for the Project construction phase include:

- Loss of GQAL
- Loss of fertile topsoil material
- Increased risk of soil erosion in sensitive/erosion prone areas
- Increased risk of soil contamination resulting from construction related activities and operation of rail facilities
- Potential movement of Fire ant affected soils and restricted items and further spread Fire ants in Yarwun
- Disruption of the existing topography due to the installation of engineered landforms in areas dominated by low hills and rises, and the removal of hills for levelling cut batters and as a source for suitable fill material for embankment structures.

The potential impacts are further discussed for each project section below.

It is important to note that the area is characterised by low rainfall for extended periods, with high rainfall averages during the summer months (refer Section 10). During construction heavy rainfall is likely to increase the potential risk of impact on the existing environmental values of the area. This includes:

- Increased risk of erosion within erosion prone, disturbed and cleared areas
- Increased risk of soil dispersion from localised areas
- Increased risk of scouring and damage to works within watercourses
- Increased pressures on erosion control measures and stormwater management systems
- General operation of machinery

It is therefore, important that the scheduling of the works considers the potential risk associated with bulk earthworks being undertaken within these months.

Aldoga Rail Yard

The proposed infrastructure to be constructed in this area relates to the rail yard facilities.
The proposed construction activities that are likely to impact on topography, geology and soils for this area are described below.

- For the construction of the rail yard it is understood that a potentially deep cutting maybe required close to where the EEMBL connects to the yard. This is due to the steep elevated topography at the foot slopes of Mount Larcom Ranges within the development area.
- Larcom Creek intersects the yard and either a culvert with associated earthworks or a railway bridge crossing will be required in this area.
- It is understood that high embankments will be required either side of the Larcom Creek crossing.
- Rail yard facilities and associated infrastructure.

The proposed works comprise cut and fill areas which are shown on Figure 2.2. The design of the Project will aim to achieve a cut and fill balance. However, further investigations will be undertaken during detailed design to determine the suitability of the material for construction, in addition to reducing the area of earthworks. It is likely that any excess spoil will removed offsite for reuse in other projects, this will be dependent on suitability of the material for the proposed application. If additional material is required it is likely to be sourced locally from licensed quarry operations. This along with a cut and fill balance should reduce the requirement for borrow pits.

The potential impacts for the Aldoga Rail Yard include:

- Loss of the topographical features and associated terrestrial vegetation from excavation and clearing for cutting and filling for embankments.
- Increased risk of soil erosion and exposure of erosion prone soils, particularly in eastern areas of the Aldoga Rail Yard and adjacent to Larcom Creek.
- Potential surface water quality impacts from sediment, contaminants entrained in surface water runoff resulting from construction related activities such as exposed soils, spoil stockpiles, material storage, laydown activities and heavy vehicle movement over the project area.
- Increased sediment and contaminant impacts to Larcom Creek and riparian area.
- Loss of valuable topsoil material resulting from stripping and potential stockpiling for extended periods and erosion.
- Increased risk of soil contamination resulting from rail yard construction related activities and operation.

Land within this area has been identified as Agricultural Land Class C2 (pasture land suitable for native pastures) (CSC Planning Scheme www.calliope.qld.gov.au retrieved 18 February 2008).

Construction works proposed as part of the rail yard development within this area will result in the loss of this land for productive agricultural use. Under Section 4.18 of the *Planning Guidelines: The Identification of Good Quality Agricultural Land* (DPI/DHLGP January 1993) the loss of GQAL within this area has been assessed as not triggering a "potential conflict with adjoining land uses" as the provision of rail infrastructure and services are currently a dominant land use within this area and within the GSDA which is designated for future industrial development.

The key potential geotechnical issues for the Aldoga Rail Yard are detailed below.

- Stability of the cut batters in elevated areas around the foothills of the Mount Larcom Ranges and Mount McCabe
- Settlement of fill embankments at the Larcom Creek bridge crossing
- Increased sub-grade risks around Larcom Creek and heading towards Flynn Road due to presence of firm silty clays with shrink swell properties

NCL/EEMBL

The proposed works to be constructed in this area is rail infrastructure. The proposed construction activities that are likely to impact on topography, geology and soils for this area have been described below.

- For the duplication and upgrading of the existing rail it is understood that a widening of a deep cutting maybe required along the NCL around Mount McCabe and the foothills of the Mount Larcom Ranges.
- Due to the steep elevated topography at the south west end of the EEMBL where the line connects into the Moura Link North, earthworks will be required to widen the existing cuttings and embankments for the railway duplication.
- Larcom Creek intersects the NCL and either a culvert with associated earthworks or a railway bridge crossing will be required in this area.
- At the eastern end of the NCL a railway bridge crossing will be required for Sandy Creek and the Calliope River Road near Yarwun township.
- It is understood that bridge crossings (ie road over rail) will be required for the Gladstone-Mount Larcom Road where it crosses over the NCL near Mount Larcom Ranges.
- At the western end of the NCL quadruplication it is understood that two railway bridges maybe required to allow trains to pass over the Gladstone-Mount Larcom Road near the Mount Larcom township (refer Section 2).
- Filling works associated with the earth formation of the rail embankment, ballast, sleepers and track of the new railway lines along the NCL and EEMBL.

The proposed works comprise cut and fill areas which are shown on Figure 2.2. Further investigations will be undertaken during detailed design to determine the suitability of the material for construction, in addition to reducing the area of disturbance.

The potential issues for this area are:

- Loss of the topographical features and associated terrestrial vegetation from excavation and clearing for cuttings and filling for embankments.
- Increased risk of soil erosion and exposure of erosion prone soils, particularly in eastern areas of the NCL and adjacent to Larcom Creek.
- Potential surface water quality impacts from sediment, contaminants entrained in surface water runoff resulting from construction related activities such as exposed soils, spoil stockpiles, material storage, laydown activities and heavy vehicle movement over the project area.
- Increased sediments and contaminant impacts to Larcom Creek, Sandy Creek and respective riparian area.

- Loss of valuable topsoil material resulting from stripping and potential stockpiling for extended periods and erosion.
- Increased risk of soil contamination resulting from rail line construction related activities and operation.
- Potential spread or increase in the area affected by Fire ants around Yarwun.
- Loss of areas suitable for horticulture on partially cleared, natural pastures (areas around the township of Yarwun).

The majority of land within this area has been identified as Agricultural Land Class C2 (pasture land suitable for native pastures). In area around the township of Yarwun area are classed as Agricultural Land Class A (land suitable for plantation, tree and vine crops with minor or moderate limitations), Class C1 (land suitable for sown pasture with moderate limitations), Class C2 (land marginal for sown pasture with severe limitations) and C3 (land suitable for grazing of native pasture in accessible areas) (CSC Planning Scheme www.calliope.qld.gov.au retrieved 18/02/08).

Construction works proposed as part of the rail infrastructure within this area will result in the loss of this land for productive agricultural use. Under Section 4.18 of the *Planning Guidelines: The Identification of Good Quality Agricultural Land* (DPI/DHLGP January 1993) the loss of GQAL within this area has been assessed as not triggering a "potential conflict with adjoining land uses" as the provision of rail infrastructure and services are currently a dominant land use within this area and within the GSDA which is designated for future industrial development.

The key potential geotechnical issues for the NCL/EEMBL are detailed below.

- Stability of the cut batters in elevated areas around the foothills of the Mount Larcom Ranges, Mount McCabe and EEMBL.
- Settlement of fill embankments within fill areas at the Larcom Creek, Sandy Creek and Calliope River Road crossings.
- Increased sub-grade risks around Larcom Creek, Flynn Road, Sandy Creek and the proposed connection of the EEMBL and Moura Link North due to presence of silty clays.

Moura Link North

The proposed works to be constructed in this area is rail infrastructure. The proposed construction activities that are likely to impact on topography, geology and soils for this area have been described below.

- It is understood that the existing Bruce Highway will require a new bridge to all traffic to pass over the proposed Moura Link.
- The proposed railway will require a bridge crossing over Larcom Creek.
- The existing EEMBL may require a potential bridge crossing over the proposed Moura Link railway.
- Numerous minor earthworks comprising both embankments and cuttings will be required along Moura Link North due to the hilly undulating topography.
- Filling works associated with the earth formation of the rail embankment, ballast, sleepers and track of the new railway lines for the Moura Link.

The proposed works comprise cut and fill areas which are shown on Figure 2.2. Further investigations will be undertaken during detailed design to determine the suitability of the material for construction, in addition to reducing the area of disturbance.

The potential impacts identified in the Moura Link North section include:

- Loss of the topographical features and associated terrestrial vegetation from excavation and clearing for cutting and filling for embankments.

- Increased risk of soil erosion and exposure of erosion prone soils, particularly around the crossing of the Bruce Highway.
- Potential surface water quality impacts from sediment, contaminants entrained in surface water runoff resulting from construction related activities such as exposed soils, spoil stockpiles, material storage, laydown activities and heavy vehicle movement over the project area.
- Increased sediment and contaminant impacts to Larcom Creek and riparian area.
- Loss of valuable topsoil material resulting from stripping and potential stockpiling for extended periods and erosion.
- Increased risk of soil contamination resulting from rail line construction related activities and operation.

Land within this area has been identified as Agricultural Land Class C2 (pasture land suitable for native pastures) (CSC Planning Scheme www.calliope.qld.gov.au retrieved 18 February 2008).

Construction works proposed as part of the rail infrastructure within this area will result in the loss of this land for productive agricultural use. Under Section 4.18 of the *Planning Guidelines: The Identification of Good Quality Agricultural Land* (DPI/DHLGP January 1993) the loss of GQAL within this area has been assessed as not triggering a “potential conflict with adjoining land uses” as the provision of rail infrastructure and services are currently a dominant land use within this area and within the GSDA which is designated for future industrial development.

The key potential geotechnical issues for the Moura Link North section are detailed below.

- Settlement of fill embankments within fill areas at the Larcom Creek crossings
- Increased sub-grade risks around Larcom Creek

Moura Link Eastern Option

The proposed works to be constructed in this area is rail infrastructure. The proposed construction activities that are likely to impact on topography, geology and soils for this area have been described below.

- At the southern end of Moura Link Eastern Option a bridge structure will be required for the proposed railway to pass over the Dawson Highway and connect into the MSL.
- Construction of the bridge and culvert structures over the Calliope River, Farmer Creek and Scrubby Creek.
- Numerous minor earthworks comprising both embankments and cuttings will be required along Moura Link Eastern Option route to the hilly undulating topography.
- Filling works associated with the earth formation of the rail embankment, ballast, sleepers and track of the new railway lines for the Moura Link.
- Excavation works associated with the construction of the mainline for the Moura Link.

The proposed works comprise cut and fill areas which are shown on Figure 2.2. Further investigations will be undertaken during detailed design to determine the suitability of the material for construction, in addition to reducing the area of disturbance.

The potential impacts identified in the Moura Link Eastern Option section include:

- Loss of the topographical features and associated terrestrial vegetation from excavation and clearing for cutting and filling for embankments.
- Increased risk of soil erosion and exposure of erosion prone soils, particularly around the Calliope River in the floodplain area between the river and the Bruce Highway.
- Potential surface water quality impacts from sediment, contaminants entrained in surface water runoff resulting from construction related activities such as exposed soils, spoil stockpiles, material storage, laydown activities and heavy vehicle movement over the project area.

- Increased sediment and contaminant impacts to the Calliope River, Farmer Creek, Scrubby Creek and riparian area.
- Loss of valuable topsoil material resulting from stripping and potential stockpiling for extended periods and erosion.
- Increased risk of soil contamination resulting from rail line construction related activities and operation.

Land within this precinct has been identified as Agricultural Land Class C1 (pasture land suitable for sown pastures) and Class C2 (pasture land suitable for native pastures) (CSC Planning Scheme www.calliope.qld.gov.au retrieved 18 February 2008).

Construction works proposed as part of the rail infrastructure within this area will result in the loss of this land for productive agricultural use. Under Section 4.18 of the *Planning Guidelines: The Identification of Good Quality Agricultural Land* (DPI/DHLGP January 1993) the loss of GQAL within this area has been assessed as not triggering a “potential conflict with adjoining land uses” as the provision of rail infrastructure and services are currently a dominant land use within this area. In areas where proposed construction of rail infrastructure will be carried out in undeveloped areas, detailed design of the Project will implement design principles to minimise the impact of site disturbance activities in order to minimise the land impacted by the Project.

The key potential geotechnical issues for the Moura Link Eastern Option are detailed below.

- Settlement of fill embankments within fill areas around the Calliope River in the floodplain area between the river and the Bruce Highway.
- Increased sub-grade risks around the Calliope River in the floodplain area between the river and the Bruce Highway.

Moura Link Western Option

The proposed works to be constructed in this area is rail infrastructure. The proposed construction activities that are likely to impact on topography, geology and soils for this area have been described below.

- At the southern end of Moura Link Western Option a bridge structure will be required for the proposed railway to pass over the Dawson Highway and connect into the MSL.
- Construction of the bridge and culvert structures over the Calliope River.
- Numerous minor earthworks comprising both embankments and cuttings will be required along Moura Link Western Option route to the hilly undulating topography.
- Filling works associated with the earth formation of the rail embankment, ballast, sleepers and track of the new railway lines for the Moura Link.

The proposed works comprise cut and fill areas which are shown on Figure 2.2. Further investigations will be undertaken during detailed design to determine the suitability of the material for construction, in addition to reducing the area of disturbance.

The potential impacts identified in the Moura Link Western Option section include:

- Loss of the topographical features and associated terrestrial vegetation from excavation and clearing for cutting and filling for embankments.
- Increased risk of soil erosion and exposure of erosion prone soils particularly around the Calliope River in the floodplain area between the river and the Bruce Highway.
- Potential surface water quality impacts from sediment, contaminants entrained in surface water runoff resulting from construction related activities such as exposed soils, spoil stockpiles, material storage, laydown activities and heavy vehicle movement over the project area.
- Increased sediment and contaminant impacts to the Calliope River and riparian area.

- Loss of valuable topsoil material resulting from stripping and potential stockpiling for extended periods and erosion.
- Increased risk of soil contamination resulting from rail line construction related activities and operation.

Land within this area has been identified as Agricultural Land Class C2 (pasture land suitable for native pastures) (CSC Planning Scheme www.calliope.qld.gov.au retrieved 18 February 2008).

Construction works proposed as part of the rail infrastructure within this area will result in the loss of this land for productive agricultural use. However, rehabilitation of areas not required during the post-construction stage (operation and maintenance) will enable much of the land area to be returned to its current use as grazing pasture.

Under Section 4.18 of the *Planning Guidelines: The Identification of Good Quality Agricultural Land* (DPI/DHLGP January 1993) the loss of GQAL within this area has been assessed as not triggering a “potential conflict with adjoining land uses” as the provision of rail infrastructure and services are currently a dominant land use within this area and works are proposed adjacent to existing rail infrastructure developments. In areas where proposed construction of rail infrastructure will be carried out in undeveloped areas of the site detailed design of the Project will implement design principles to minimise the impact of site disturbance activities in order to minimise the land impacted by the Project.

The key potential geotechnical issues for the Moura Link Western Option are detailed below.

- Settlement of fill embankments within fill areas around the Calliope River
- Increased sub-grade risks around the Calliope River

4.3.1 Summary of potential impacts

The key potential impacts relating to topography, geology and soils for the construction and operation of the rail infrastructure are summarised below.

- Change in topography and loss of topographical features (ie excavation of hills/landform and filling of the alluvial plains)
- Increased risk of soil erosion in sensitive/erosion prone areas
- Potential spread or increase in the area affected by Fire ants
- Stability of embankments, cut batters and bridge piles
- Disturbance of contaminants
- Potential surface water quality impacts from sediment, acid leachate and/or contaminants entrained in surface water runoff resulting from construction related activities such as exposed soils, spoil stockpiles, material storage, laydown activities and heavy vehicle movement over the project area
- Increased risk of contamination resulting from construction related activities and operation
- Impacts to the Calliope River, Larcom Creek, Farmer Creek, Scrubby Creek, Sandy Creek and unnamed tributaries channels and riparian areas
- Loss of valuable topsoil material resulting from stripping and stockpiling for extended periods and erosion
- Loss of areas suitable for grazing
- Erosion of exposed vulnerable subsoils from rainfall, overland flow and wind action
- Impacts resulting from inadequate management and handling of construction fill during placement and spoil disposal

Mitigation measures for the potential topographical, geological and soil impacts are outlined in Section 4.4.

4.4 Mitigation measures

The measures proposed to mitigate potential soil, geology and topography impacts of the Project are discussed in Section 20.

4.5 Conclusions

4.5.1 Geology and geotechnical stability

Settlement behaviour of materials in floodplain areas are of higher risk and appropriate ground improvement measures are likely to be required in areas where embankments are proposed to be constructed over low strength soils.

Further detailed investigations are required for the assessment of the geotechnical conditions and constraints within the project area in order to adequately inform project design, particularly for embankments, batter slopes, structure foundations, site access points and construction material specifications.

4.5.2 Soils

A range of potential impacts relating to soil and stockpiled material within the project area are likely to occur as a result of the construction of the Project. These impacts will require suitable design and management initiatives to be implemented to ensure adequate mitigation is achieved. Potential impacts identified during the EIS include erosion affecting slopes, banks, exposed vulnerable soils and subsoils and riparian areas through both the interaction with water and wind. Erosion of project area soils and fill stockpiled for use may result in the release of sediment laden runoff to surface waters, reduction in water quality within receiving waterways, loss of downstream aquatic habitat, dust emissions, loss of fertile topsoil, and bank and embankment instability.

These potential impacts can be adequately mitigated through consideration during the detailed design phase to ensure that specific construction activities that potentially increase erosion risks are carried out in suitable locations within the project area and adequate mitigation/control measures are implemented to protect the surrounding environment and minimise soil loss.

The soil sample observed in the northern end of the Moura Link Western Option was classed as a Sodosol which has highly sodic subsoil that is dispersible and susceptible to erosion. Exposure of the sodic subsoil should be minimised in areas with this soil type. All project sections had some soils with sodic properties present identified by field sampling and land systems mapping. The remaining soils identified in the project area are well structured and fairly resistant to erosion. A Soil Handling and Management Plan which includes erosion and sediment controls will be implemented at the commencement of construction to mitigate any erosion issues.

The Calliope Shire Council Planning Scheme has mapped the agricultural land in the project area. Most sites in the project area were mapped as C2 (pasture land suitable for native pasture) with a small area classed as C1 (pasture land suitable for sown pasture). The NCL/EEMBL area is classed as C1 and C2 as well as A (land suitable for plantation, tree and vine crops with minor or moderate limitation, C2 (land marginal for sown pasture with severe limitations) and C3 (land suitable for grazing of native pasture in accessible areas). While these areas will be lost to agricultural land uses, the impact is minimised due to the isolated nature of the area.

4.5.3 Acid sulfate soils

The potential to disturb in-situ ASS is unlikely. If ASS materials are identified during the detailed geotechnical investigation an ASS investigation will be undertaken. If necessary an ASS management plan will be developed prior to commencing site disturbance.

4.5.4 Contaminated land

The potential risk for land contamination from past and current activities is considered to be relatively low overall. Several past and current site activities that are potential contamination sources will require appropriate management measures to be developed to minimise the potential impacts of contaminated soils.

Contaminated land issues can be adequately managed through the implementation of mitigation measures contained in the Soil Handling and Management Plan to be developed at the detailed design phase of the Project.

4.6 Commitments

- Develop and implement of a Soil Handling and Management Sub Plan during construction which addresses:
  - Erosion and sediment control
  - The movement of actual or potentially contaminated soil (from the existing rail corridor or any properties listed on the EMR (ie Lots 71 and 72 on SP122249) including the application for an EPA Waste Disposal Permit (required for removal of soil from a land parcel which is listed on the EMR))
  - Topsoil management
  - Red imported fire ants from nearby sites in accordance with QR's Fire Ant Risk Management Plan