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Adani Mining Pty Ltd

NORTH GALILEE BASIN RAIL PROJECT

Environmental Impact Statement

Chapter 5 Topography, geology, soils and land contamination

November 2013

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5. Topography, geology, soils and land contamination

5.1 Purpose of chapter

The purpose of this chapter is to assess the potential impacts of the NGBR Project on topography, geology, soils and land contamination. This chapter includes an overview of the existing environment, consideration of potential construction and operation impacts, and the identification of proposed mitigation and management measures. A detailed existing environment report presents the outcome of a desktop assessment on topography, geology, soils and land contamination, and is provided in Volume 2 Appendix E Topography, geology, soils and land contamination.

This chapter summarises the key findings of the existing environment report and provides and assessment of the impacts of the NGBR Project on topography, geology, soils and land contamination .Where impacts occur mitigation and management measures are proposed.

The scope of this topography, geology, soils and land contamination report was defined by the following tasks:

- Description of existing topography
- Description of existing geology
- Description of existing soils
- Quantification of existing agricultural values, including
  - Good quality agricultural land
  - Strategic cropping land
- Identification of potential acid sulfate soils
- Identification of potentially contaminated land
- Assessment of impacts on topography, geology, soils and land contamination
- Propose mitigation and management measures.

This topography, geology, soils and land contamination chapter was prepared in accordance with the Terms of Reference (TOR) for the NGBR Project. A table that cross-references the contents of this chapter and the TOR is included as Volume 2 Appendix A Terms of Reference cross-reference.

All mitigation and management measures identified within this chapter are included within Volume 2 Appendix P Environmental management plan framework.

5.2 Methodology

5.2.1 Study area

The study area for the quantification of agricultural land and potentially contaminated land was defined by the final NGBR Project footprint, incorporating the final rail corridor (nominal width of 100 m) and ancillary infrastructure. The preliminary investigation corridor was considered for broader considerations of topography, geology, soils and land contamination.

5.2.2 Data sources

The topography, geology, soils and land contamination report relied on the following data sources:

- North Galilee Basin Railway Concept Design Report (Aarvee Associates 2013)
- Climatic data from the Bureau of Meteorology
- Topographical data and contour data at one metre intervals
- A digital elevation model, created from light detection and ranging (LIDAR) reconnaissance
- LANDSAT satellite imagery (1999 – 2010)
- Australian Bureau of Agriculture and Resource Economics and Sciences (ABARES)
- The Environmental Management Register (EMR) and Contaminated Land Register (CLR)
- Google imagery
- Geology maps and supporting explanatory notes
- Soil and land system maps and accompanying reports
- Acid sulfate soil information
- Good Quality Agricultural Land (GQAL) mapping
- Strategic Cropping Land (SCL) trigger mapping and associated information.

Specific reports and map sheets used for describing geology, soil and land systems, acid sulfate soils and GQAL are included in Volume 2, Appendix E, Topography, geology, soils and land contamination.

Soil maps

Soil maps are defined by the Australian Natural Resource Atlas (http://www.anra.gov.au/topics/soils/overview/qld.html) as follows:

- Single soil types or associations
- Associated attributes include soil type, soil proportion, land quality and land suitability.

Land system maps

Land system maps are defined by the Australian Natural Resource Atlas (http://www.anra.gov.au/topics/soils/overview/qld.html) as follows:

- Associations of soil, vegetation, geology and geomorphology
- Usually broad in scale (1:250,000 to 1:500,000)
- Associated attributes include soil, vegetation, land condition and land capability.

5.2.3 Legislation and guidelines

The legislation relevant to this topography, geology, soils and land contamination assessment is as follows:

- *Environmental Protection Act 1994* (EP Act)
- *Strategic Cropping Land Act 2011* (SCL Act)

- *Sustainable Planning Act 2009*
- State Planning Policy 1/92 Development and the Conservation of Agricultural Land
- State Planning Policy 1/12: Protection of Queensland's Strategic Cropping Land
- State Planning Policy 2/02: Planning and Managing Development involving Acid Sulfate Soils
- Planning Guidelines: The Identification of Good Quality Agricultural Land (1993)
- Guideline for contaminated land professionals (Department of Environment and Heritage Protection, 2012)
- National Environment Protection (Assessment of Site Contamination) Amendment Measure 2013 (No.1).

Further information regarding legislation relevant to this topography, geology, soils and land contamination assessment is provided in Volume 1 Chapter 20 Legislation and approvals.

5.2.4 Desktop assessment

Topographical maps, Google imagery and contour data generated from LIDAR information were used in the desktop assessment to characterise the main topographical features and understand the relationship between soils and geology. Geology maps were reviewed to identify parent material and likely soil associations.

Three maps and associated reports overlaid the study area. Two of these maps were identified as soil maps, at varying scales of 1:100,000 and 1:1,000,000, with the third map identified as a land system report at 1:250,000 scale.

An assessment of the geological properties relating to erosion risk and impact on stormwater quality and receiving environments has been provided in Section 5.3.2. A high/low risk rating has been allocated for each geological unit that is identified within the available mapping. Geological units classified as high risk are the sedimentary deposits which are more susceptible to erosion. Igneous and metamorphic formations are more stable than sedimentary deposits in general, and have been allocated a lower risk. Weathered igneous and metamorphic materials are less stable, as are Mesozoic and Cainozoic/Quaternary sedimentary deposits, and are therefore given a higher risk.

An assessment of the soil properties has been undertaken and is provided in Volume 2 Appendix E Topography, geology, soils and land contamination. The assessment classified soils as high, moderate or low based on the potential for erosion relating to impact on stormwater quality and receiving environments. This allocation was done following consideration of the expected soil physical and chemical properties. Soils allocated a higher risk are those with poor structure, those susceptible to structural decline following disturbance, and those with naturally high sodium levels.

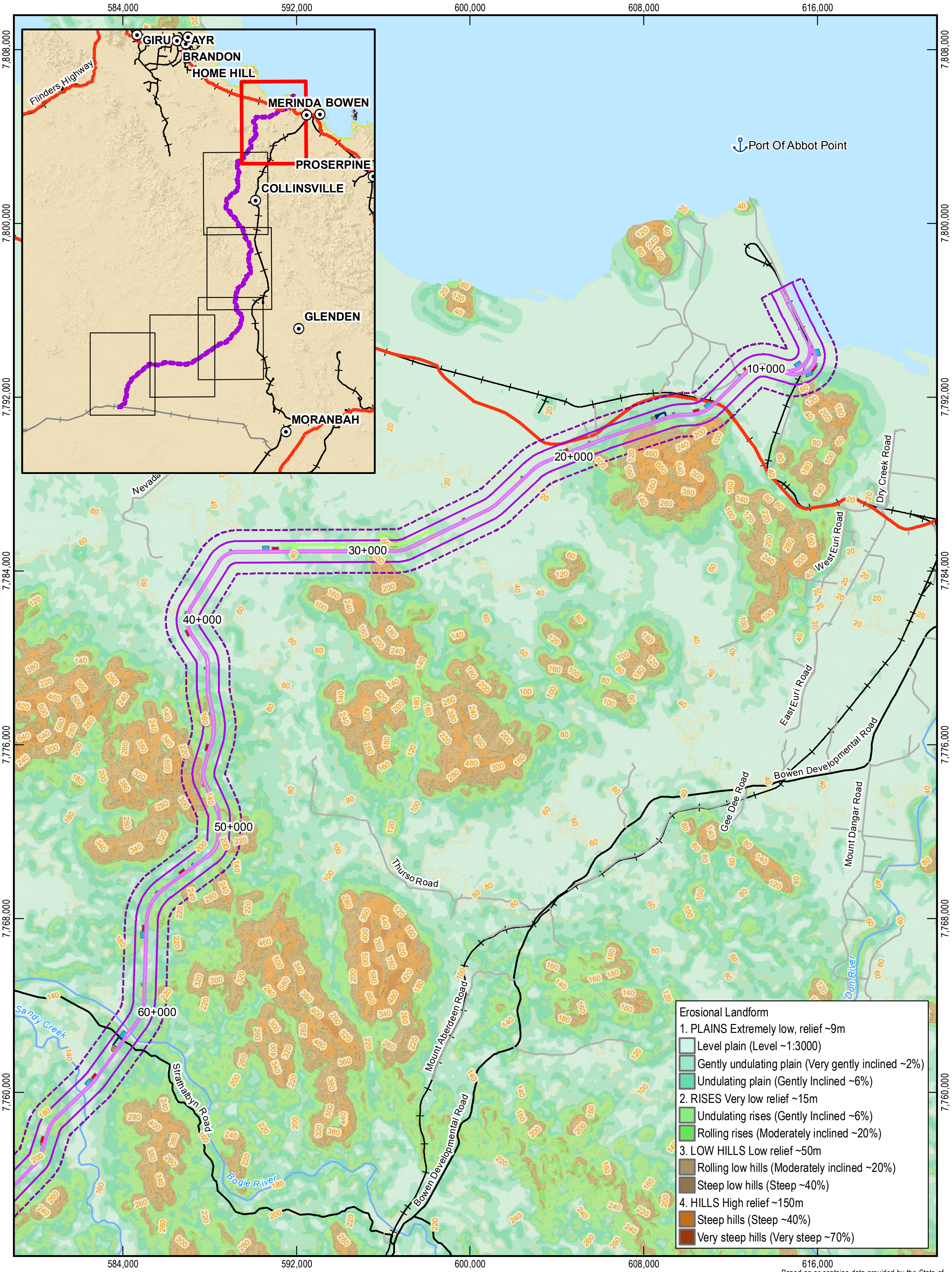
Areas with a risk of acid sulfate soils were identified through a review of topographic and geological mapping. This assessment was supplemented by a review of previous studies conducted in proximity to the study area.

5.3 Existing environment

5.3.1 Topography

Distinctive topographical features from north to south include the coastal floodplain, Clarke Range, Bowen River Valley, Leichhardt Range and the Suttor River floodplain. At the northern end of the NGBR Project (chainage 3.49 km), surface elevation is at its lowest, at three metres Australian Height Datum (mAHD). At the southern end of the NGBR Project (chainage 306.9 km), surface elevation is approximately 300 m AHD.

Elevation and topography undulate in association with mountains and river beds. While the majority of the study area traverses the foothills of mountains, steep low hills are crossed at chainages 71.3 km to 71.7 km, 72.1 km to 72.9 km, 78.0 km to 78.3 km, 80.5 km to 80.9 km and 82.2 km to 82.3 km. Three rivers are crossed by the final rail corridor, including the Bowen River, Suttor River and Bogie River. Numerous creeks are traversed by the final rail corridor, with the largest of these being Pelican Creek and Verbena Creek. An overview of topographical features is provided in Figure 5-1.



LEGEND

- Population Centres
- Major Port
- Highway
- Main Road
- Local Road
- Railway
- Watercourse (Major)
- 20m Contours
- North Galilee Basin Rail Baseline study area (1km buffer)
- North Galilee Basin Rail 1000m Corridor
- North Galilee Basin Rail 100m Corridor

Ancillary Infrastructure Areas
- Bridge Laydown Area
- Concrete Batch Plant
- Construction Camp
- Rolling Stock Maintenance Depot
- Track Laydown Area
- Turning Circle

Based on or contains data provided by the State of QLD (DNRM) [2013]. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for marketing or be used in breach of the privacy laws.

1:250,000 Paper Size A4

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Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

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Adani Mining Pty Ltd
North Galilee Basin Rail Project

Job Number 41-26457
Revision B
Date 29 Aug 2013

Topography and landform

Figure 5-1
Sheet 1 of 6

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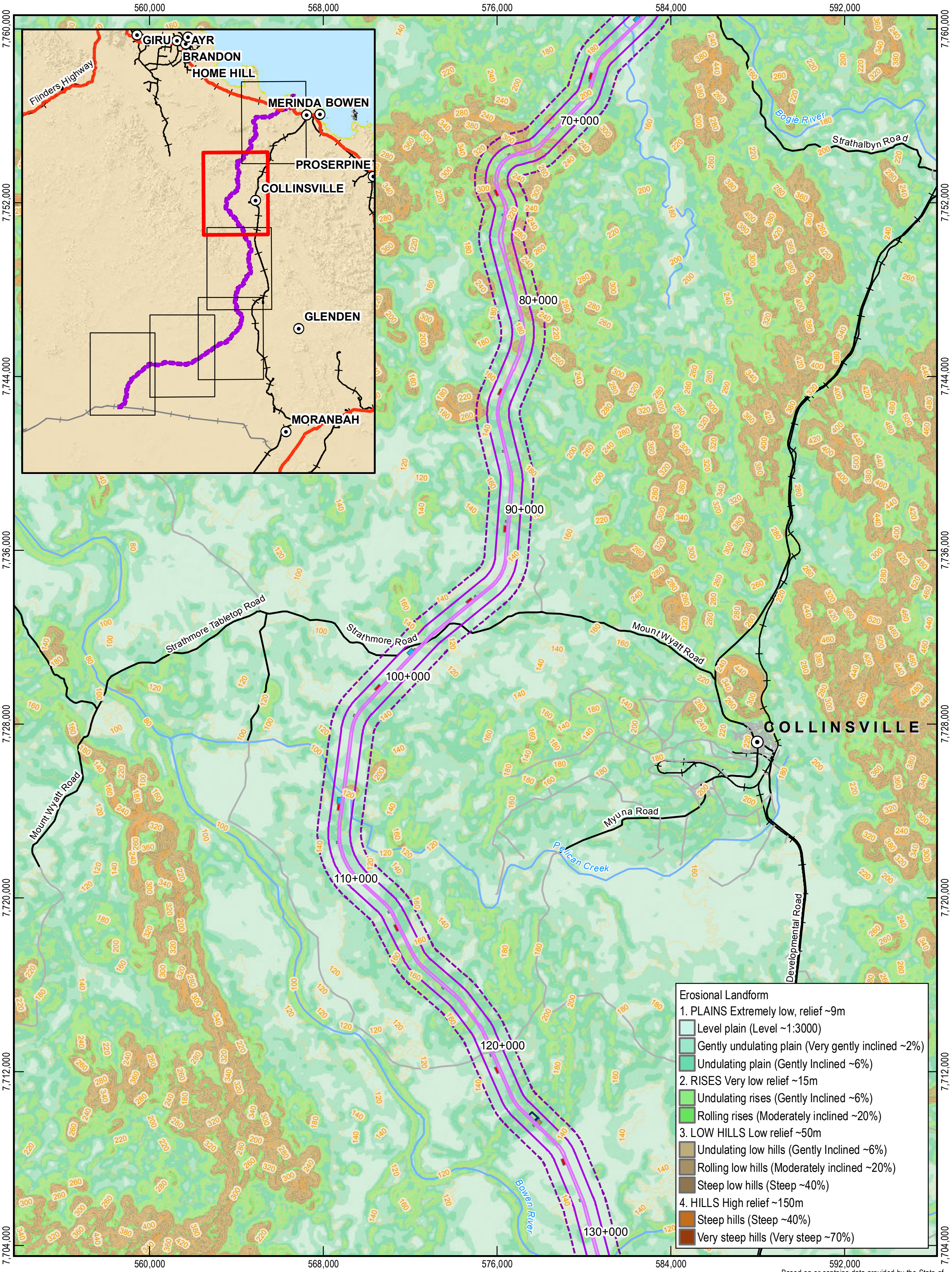
Level 9, 145 Ann Street Brisbane QLD 4000 Australia T 61 7 3316 3000 F 61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data source: GA: Populated Places, Railway, Watercourse/2007; Adani: NGBR Corridor 06/06/2013, NGBR Corridor 13/05/2013, Carmichael Project Rail 23/07/2012, Ancillary Infrastructure 2013; DNRM: Roads/2010, Contour - 10m/2011, Landform/2011. Created by:MS



LEGEND

- Population Centres
- Main Road
- Local Road
- Railway
- Watercourse (Major)
- 20m Contours
- North Galilee Basin Rail Baseline study area (1km buffer)
- North Galilee Basin Rail 1000m Corridor
- North Galilee Basin Rail 100m Corridor
- Ancillary Infrastructure Areas
- Bridge Laydown Area
- Concrete Batch Plant
- Construction Camp
- Track Laydown Area
- Turning Circle

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Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

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Topography and landform

Figure 5-1
Sheet 2 of 6

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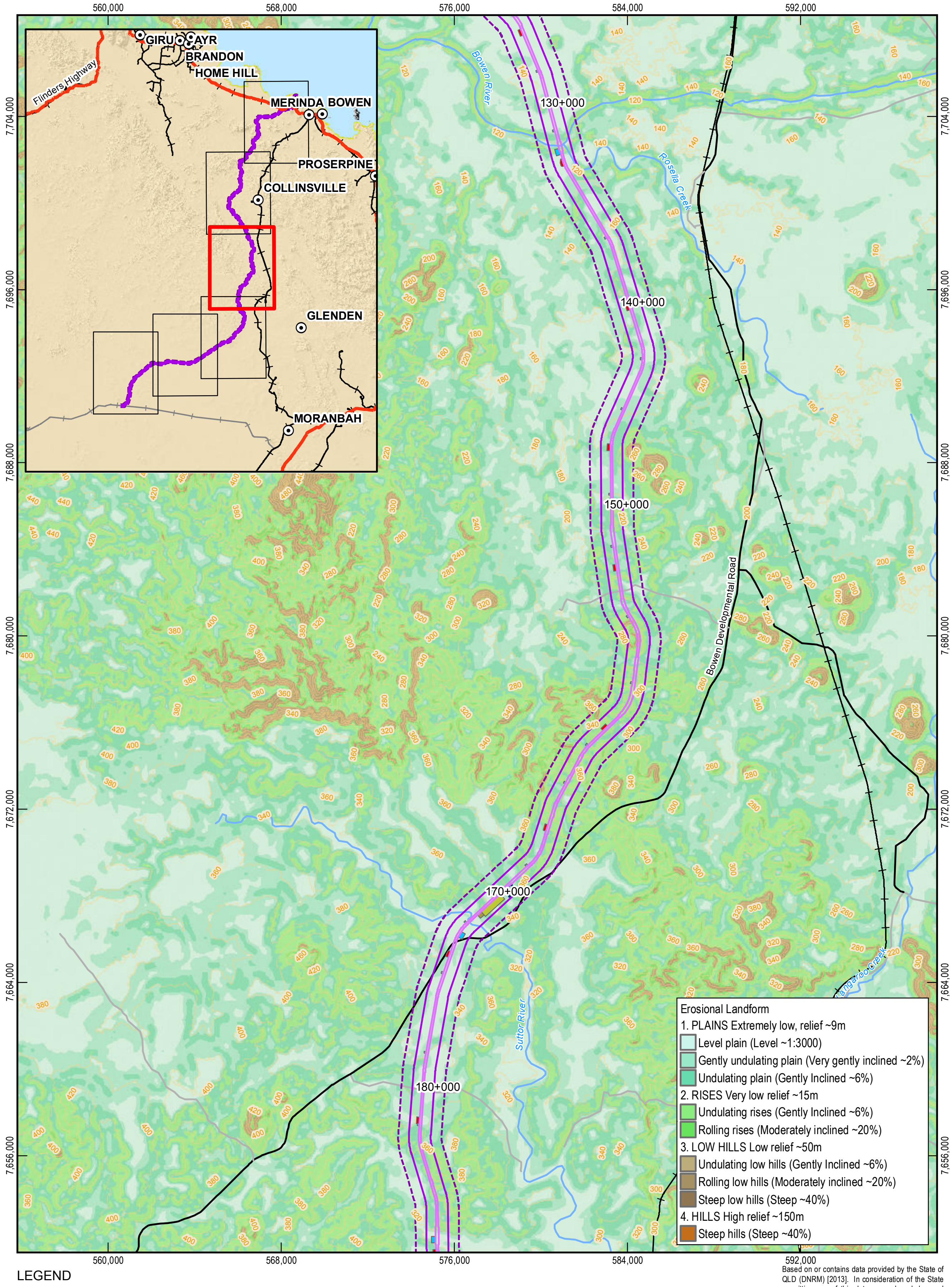

LEGEND

Main Road
Local Road
Railway
Watercourse (Major)
20m Contours
North Galilee Basin Rail Baseline study area (1km buffer)
North Galilee Basin Rail 1000m Corridor
North Galilee Basin Rail 100m Corridor

Ancillary Infrastructure Areas
Bridge Laydown Area
Concrete Batch Plant
Construction Camp
Construction Yard
Track Laydown Area
Turning Circle

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Map Projection: Transverse Mercator
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Grid: GDA 1994 MGA Zone 55

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Revision	B
Date	29 Aug 2013

Topography and landform

Figure 5-1
Sheet 3 of 6

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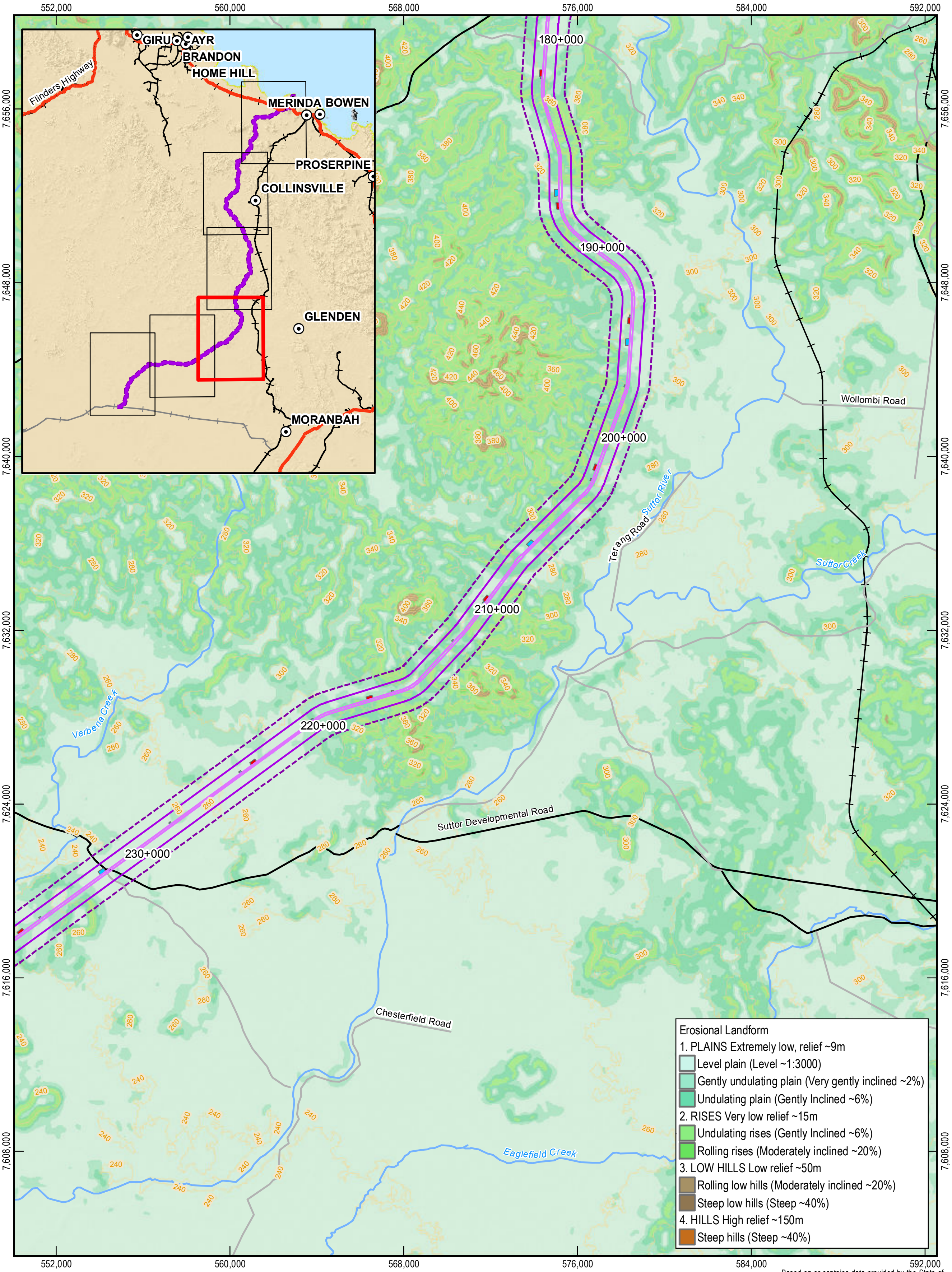

LEGEND

- Main Road
- Local Road
- Railway
- Watercourse (Major)
- 20m Contours
- North Galilee Basin Rail Baseline study area (1km buffer)
- North Galilee Basin Rail 1000m Corridor
- North Galilee Basin Rail 100m Corridor
- Ancillary Infrastructure Areas
- Bridge Laydown Area
- Track Laydown Area
- Turning Circle

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Kilometres

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Grid: GDA 1994 MGA Zone 55

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Revision	B
Date	29 Aug 2013

Topography and landform

Figure 5-1
Sheet 4 of 6

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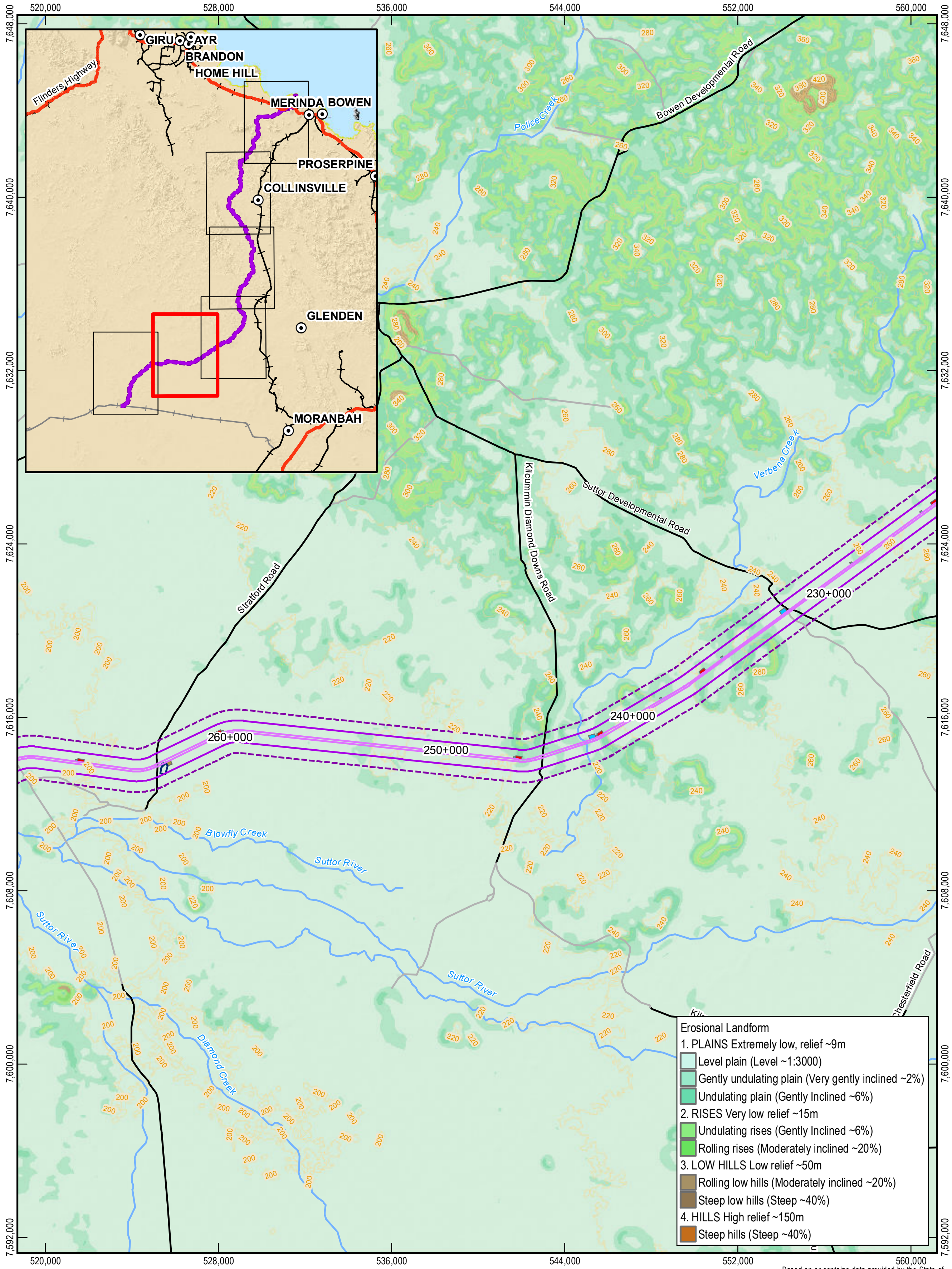

LEGEND

- Main Road
- Local Road
- Watercourse (Major)
- 20m Contours
- North Galilee Basin Rail Baseline study area (1km buffer)
- North Galilee Basin Rail 1000m Corridor
- North Galilee Basin Rail 100m Corridor

Ancillary Infrastructure Areas
- Bridge Laydown Area
- Concrete Batch Plant
- Construction Camp
- Track Laydown Area
- Turning Circle

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Horizontal Datum: GDA 1994
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Topography and landform

Figure 5-1
Sheet 5 of 6

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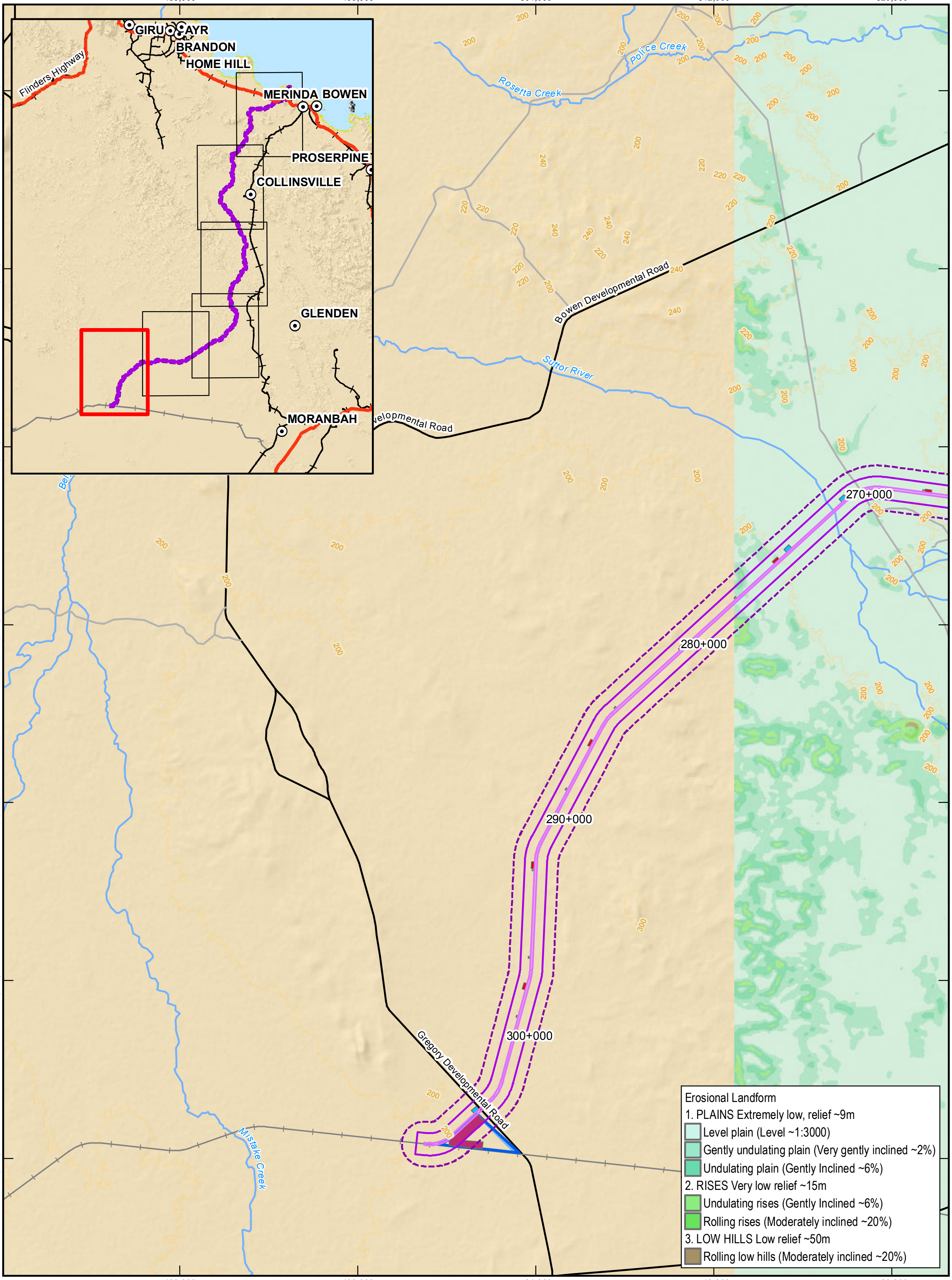
Data source: GA: Populated Places, Railway, Watercourse/2007; Adani: NGBR Corridor 06/06/2013, NGBR Corridor 13/05/2013, Carmichael Project Rail 23/07/2012, Ancillary Infrastructure 2013; DNRM: Roads/2010, Contour - 10m/2011, Landform/2011. Created by:MS



LEGEND

- Main Road
- Local Road
- Carmichael Project (Rail)
- Watercourse (Major)
- 20m Contours
- North Galilee Basin Rail Baseline study area (1km buffer)
- North Galilee Basin Rail 1000m Corridor
- North Galilee Basin Rail 100m Corridor

Ancillary Infrastructure Areas
- Bridge Laydown Area
- Construction Depot Area
- Rail Precinct Area
- Track Laydown Area
- Turning Circle

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Map Projection: Transverse Mercator
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North Galilee Basin Rail Project

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Revision	B
Date	29 Aug 2013

Topography and landform

Figure 5-1
Sheet 6 of 6

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5.3.2 Geology

Overview

Due to the length of the NGBR Project, the underlying geology varies extensively. The NGBR Project crosses four geological regions associated with major rivers, as follows:

- Abbot Point to Bogie River (chainages 3.49 km to 61.1 km)
- Bogie River to Bowen River, including the Herbert and Peter Gordon Ranges (chainages 61.1 km to 132.2 km)
- The ranges and hills between the Bowen River and Verbena Creek (chainages 132.2 km to 242.7 km)
- The Mistake Creek and Suttor River Floodplains (chainages 242.7 km to 306.9 km)

Figure 5-2 shows the mapped geology of the area in terms of the map units. Further information on map units is provided in Volume 2 Appendix E Topography, geology, soils and land contamination.

Abbot Point to Bogie River

The regional geology of Abbot Point to Bogie River is described by the Bureau of Mineral Resources, Geology and Geophysics 1969 1:250,000 Geological Series for Ayr (Sheet SE/55-15) and 1:100,000 Geological Series for Bogie (Sheet 8457), and the accompanying explanatory notes complied by Gregory, and Paine and Cameron (1:250,000) respectively (refer Table 5-1 and Table 5-2).

The study area commences within the Quaternary sand and interbedded silt on the dunes of Abbot Point. As the study area moves south-west, between Mount Little and Mount Roundback, it crosses through an area of Cainozoic-aged stratigraphy on flat to gently undulating land. While some of this material is semi-consolidated, the majority of the lithology is comprised of sand, silt, mud and gravels, having derived by alluvial means. Moving beyond Mount Roundback, the geology becomes mixed, with Upper Carboniferous to Lower Permian-aged geology influenced by sheared or foliated structure (upon which Mount Roundback is based) interspersed by smaller areas of scree, gravel and sand, which occur on scree-slopes.

The study area continues south-west, across Late Carboniferous to Early Permian-aged diorite and Early Permian-aged granodiorite interspersed with Later Tertiary to Quaternary-aged colluvium, with minor areas of Early Creaceous granodiorite. As the study area turns south towards Pine Hill and Mount Abbot Pass, the geology is dominated by granodiorite of varying ages. Quaternary-aged material is not encountered again until the Bogie River is reached.

Table 5-1 Geology from Abbot Point Mount Roundback

Age	Map symbol	Structural/ depositional	Topography	Lithology summary	Potential stability risk
Quaternary	Qa	Outwash fans, essentially stable at present	Colluvial hillslopes	Gravel and sand, semi-consolidated in places	High
	Qr	Ancient and present shore dunes	Low linear dunes up to 7 m	Sand, some interbedded silt	Low
Cainozoic	Cza	Levees, flood plains and deltas	Flat to gently undulating	Sand, silt, mud and gravel, semi-consolidated in places	High
	Czs	Residual soil developed on deeply weathered granitic rocks. Some colluvium	Gently undulating	Soil, sand and rubble, semi-consolidated in places. Unconsolidated[1]	High
				Soil, sand and rubble, semi-consolidated in places. Semi-consolidated	Low
Upper Carboniferous to Lower Permian	C-Pd	Sheared or foliated in places, as is primary layering	Undulating rises, uneven hills and dyke ridges south of Home Hill, Low-lying country south of Guthalungra	Diorite, quartz diorite, tonalite, gabbro, norite, minor granodiorite, adamellite and granite	Low
	C-Pg	Sheared or foliated in places	Coastal inselbergs up to 200 m, uneven hills and undulating country, some dyke ridges	Adamellite, granite, some granodiorite, with minor fine-grained variants.	Low
				Adamellite, granite, some granodiorite, with minor fine-grained variants. Weathered[1]	High

Note: 1. Where geological maps included information regarding the consolidated or weather nature of geology, this information has been included and the potential stability risk assessed

Table 5-2 Geology from Mount Roundback to Bogie River

Age	Map Symbol	Dominant formation type	Formation Name	Lithology Summary	Potential stability risk
Quaternary	Qa	Alluvium	-	Clay, silt, sand, gravel; flood-plain alluvium	High
Late Tertiary to Quaternary	TQr	Colluvium	-	Clay, silt, sand, gravel and soil; colluvial and residual deposits (generally on older land surfaces)	High
Early Cretaceous	Kg/b1	Granodiorite	-	Fine-grained highly porphyritic granite; extensively altered and locally deformed, with minor associated copper and molybdenum mineralisation	Low
	Kgsh?[2]	Granodiorite	Summer Hill Gabbro?	Dark grey to dark greenish-grey, fine to medium-grained, uneven-grained gabbro, norite and subordinate anorthosite, diorite, quartz diorite; minor chromitite	Low
	Kg/b2	Granodiorite	-	Pale pink, medium-grained, slightly porphyritic, leucocratic biotite monzogranite to quartz monzonite	Low
Early Permian	Pgfc	Granodiorite	Fence Creek Granodiorite	Pale pink, fine to medium-grained, uneven-grained to moderately porphyritic biotite-hornblende and hornblende-biotite granodiorite	Low
	Pvk	Acid-intermediate Volcanics	Karungle Volcanics	Andesite, dacite, rhyolite (commonly flow banded and locally brecciated), volcanic breccia, tuff, polymictic conglomerate	Low
	Pg/d	Granodiorite	-	Dark grey, fine-grained, porphyritic biotite-hornblende quartz diorite	Low
Late Carboniferous to Early Permian	CPgsu	Diorite	Sundown Creek Diorite	Grey, fine-grained hornblende- diorite; deeply weathered and poorly exposed	High
	CPg/b5	Granodiorite	-	unit characterised on radiometric images and on aeromagnetic images	Low
	CPgec	Granodiorite	Euri Creek Granodiorite	Pale grey, medium-grained, uneven-grained to slightly porphyritic biotite-hornblende granodiorite to hornblende-biotite tonalite, generally deeply weathered	High[1]
				Pale grey, medium-grained, uneven-grained to slightly porphyritic biotite-hornblende granodiorite to hornblende-biotite tonalite, generally deeply weathered however when unweathered	Low[1]

Age	Map Symbol	Dominant formation type	Formation Name	Lithology Summary	Potential stability risk
	CPggr	Diorite	Glenore Road Quartz Diorite	Grey, medium-grained, slightly uneven-grained pyroxene-hornblende-biotite and cpyroxene-biotite-hornblende quartz diorite; massive; deeply weathered and poorly exposed	High
	CPgmm?[2]	Granodiorite	Mount Mackenzie Granite?	Buff to pale brown, medium-grained, slightly porphyritic, leucocratic muscovite-biotite monzogranite; granophyric.	Low

Note: 1. Where geological maps included information regarding the consolidated or weather nature of geology, this information has been included and the potential stability risk provided

Note: 2. A question mark (?) indicates uncertainty of the classification in original geological mapping dataset. The geology identified is the most likely.

Bogie River to Bowen River

The regional geology adjoining the Bogie and Bowen Rivers is depicted by the Bureau of Mineral Resources, Geology and Geophysics 1972 1:250,000 Geological Series for Bowen (Sheet SF/55-3), 1:100,000 Geological Series for Bogie (Sheet 8457) and the accompanying 1:250 000 Explanatory Notes compiled by Paine and Cameron.

Immediately south of the Bogie River, the geological stratums are materials formed in the Late Carboniferous to Early Permian, with granodiorite and diorite the dominant formations (refer Table 5-3). As the study area crosses Sandy Creek and continues south-west, the underlying formations change to early Permian Lizzie Creek Volcanic groups. Fossil material of flora is common in the sedimentary material within this formation and these sediments can be unstable. This underlying geology is present as the study area intersects the Peter Gordon Ranges to the east and Herbert Ranges to the west. The Lizzie Creek Volcanic group remains the dominant underlying geology until the study area encounters the Bowen River. However, Quaternary alluvial deposits are present at the junction with both Strathmore Creek and Pelican Creek prior to the study area intersecting the Bowen River (refer Table 5-4). Additionally, immediately prior to the Bowen River, lower Cretaceous pockets, surrounded by hills of hornfels and low tors are interspersed along the study area.

The junction of the study area with the Bowen River is characterised by soil covered plains and low rises underlain by various forms of sandstone, siltstone, shale and coal seams derived from the lower to upper Permian. These can prove to be unstable and erodible.

Table 5-3 Geology from Bogie River to Bowen River

Age	Map Symbol	Dominant Formation	Formation name	Lithology	Potential stability risk
Quaternary	Qa	Alluvium	-	Clay, silt, sand, gravel; flood-plain alluvium	High
Early Permian	Pvz	Mafites (lavas, clastics and high-level intrusives)	Lizzie Creek Volcanic Group	Basalt, andesite, and interbedded volcanic breccia; generally subordinate dacite, rhyolite, trachyte; conglomerate, labile arenite, siltstone, calcareous siltstone, shale, carbonaceous shale; minor coal; fossil plant fragments common in sedimentary rocks. Volcanics	Low
				Basalt, andesite, and interbedded volcanic breccia; generally subordinate dacite, rhyolite, trachyte; conglomerate, labile arenite, siltstone, calcareous siltstone, shale, carbonaceous shale; minor coal; fossil plant fragments common in sedimentary rocks. Sediments	High
Early Permian	Pvz/r	Felsites (lavas, clastics and high-level intrusives)	Lizzie Creek Volcanics/r	Mainly dacitic, trachytic to rhyolitic volcanic and intrusive rocks, and associated volcaniclastic sediments	Low
Late Carboniferous to Early Permian	CPg/b7	Granodiorite	-	Unit characterised on radiometric images, and on airborne magnetic images	Low
	CPgga	Granodiorite	Glen Alpine Granite	Pink to brown, medium-grained, slightly to moderately porphyritic, biotite monzogranite; leucocratic; granophyric; deeply weathered and poorly exposed	High
	CPg/b5	Granodiorite	-	Unit characterised on radiometric images, and on airborne magnetic images	Low
	CPgsu	Diorite	CPgsu	Grey, fine-grained hornblende-pyroxene diorite; deeply weathered and poorly exposed	High

Table 5-4 Geology in the vicinity of the Bowen River (raster map)

Age	Map Symbol	Formation name	Topography	Lithology	Potential stability risk
Lower Cretaceous	Ki	-	Pockets surrounded by hills of hornfels; low tors	Granodiorite, diorite, rhyolite, porphyry, gabbro, microdiorite	Low
Upper Permian	Puw	Blackwater Group	Soil-covered plains, some strike ridges. Rugged where hornfelsed	Cross-bedded well-sorted lithic sandstone, siltstone, quartzose sandstone; carbonaceous shale with some coal seams, pebble and cobble conglomerate, dolomitic and calcareous sandstone, tuff. Lithic/quartzose	Low
				Cross-bedded well-sorted lithic sandstone, siltstone, quartzose sandstone; carbonaceous shale with some coal seams, pebble and cobble conglomerate, dolomitic and calcareous sandstone, tuff. Hornfelsed	Low
				Cross-bedded well-sorted lithic sandstone, siltstone, quartzose sandstone; carbonaceous shale with some coal seams, pebble and cobble conglomerate, dolomitic and calcareous sandstone, tuff. Remainder	High
Lower to Upper Permian	Pue	Blenheim Subgroup	Low rises; subdued cuestas	Siltstone, pebbly sublabile sandstone, fossiliferous calcareous siltstone and sandstone, coquinite, limestone (abundance fossils)	High
	Plc	Collinsville Coal Measures	Subdued, some hills	Quartzose sandstone, conglomerate, siltstone, calcareous sublabile sandstone, coal seams, carbonaceous shale (fossiliferous marine horizon)	High
Lower Permian	Plz	Lizzie Creek Volcanics	Gentle rises and black-soil plains in north; high hills in east; some low strike ridges	Basalt, andesite, agglomerate, lithic and tuffaceous sediments, minor acid volcanics	Low

Bowen River to Verbena Creek

The majority of the ranges and hills between the Suttor River flood plain and the Bowen River are mapped in Byerwen Sheet 8455 of the Mount Coolon Sheet SF/55-7, the northern portion, between chainages 132.2 km and 153.7 km, approaching the Bowen River, is mapped in the 1:250,000 Bowen Sheet SF/55-3 and the Bowen Explanatory Notes (Paine and Cameron, 1972).

As the study area progresses southward of the Bowen River, the underlying geology is Late Permian and Permian sedimentary rock formations. Southward of Rosella Creek, the geology is interspersed with Tertiary basalts and sedimentary rocks. As the study area approaches the Suttor River, the geology is dominated by Tertiary arenite and Tertiary and Quaternary-aged colluvium soils (refer Table 5-5). Southward of the Suttor River, the study area crosses Tertiary-aged sedimentary rock formations, interspersed with Permian-aged sedimentary rock, Carboniferous-aged felsites, Tertiary-aged ferricretes and Carboniferous to Permian-aged granitoids. As the study area continues southward, the granitoid geology remains to the west, with Quaternary-aged alluvium soils and Tertiary to Quatenary-aged colluviums present along the final rail corridor and to the east.

At Murray Creek, when the study area heads in a southwest direction, the geology changes to Carboniferous felsites. Prior to the study area intersecting Verbena Creek, the geology shifts again to Quaternary-aged alluvium soils interspersed with Tertiary-aged sedimentary rocks and late Devonian to early Carboniferous-aged felsites (refer Table 5-5).

Table 5-5 Geology encountered between the Bowen River and Verbena Creek

Age	Map symbol	Formation name	Dominant rock type	Lithology summary	Potential stability risk
Quaternary	Qa	-	Alluvium	Clay, silt, sand, gravel; flood plain alluvium	High
	Qr\s	-	Colluvium	Residual soil, colluvium (sandy soils)	High
	Qr\f>Ts,Pb	Overlying Suttor Formation and/or Back Creek Group		Residual soil, colluvium (red soils)	High
	Qr,Pb	Overlying Back Creek Group		Clay, silt, sand, gravel and soil; colluvial and residual deposits	High
	Qr>CPgb	Overlying Bluegrass Creek Granite		Clay, silt, sand, gravel and soil; colluvial and residual deposits	High
Quaternary (Pleistocene)	Qpa	-	Alluvium	Older alluvium	High
Tertiary to Quaternary	TQr>Ts	Overlying Suttor Formation	Colluvium	Older residual soils, colluvium	High
	TQr>Pb	Overlying Back Creek Group		Older residual soils, colluvium	High
	TQr>CPgb	Overlying Bluegrass Creek Granite		Older residual soils, colluvium	High
	TQr>Cub	Overlying Bulgonunna Volcanic Group		Older residual soils, colluvium	High
Tertiary	Ts	Suttor Formation	Sedimentary Rock	Quartz sandstone, clayey sandstone, mudstone and conglomerate; fluvial and lacustrine sediments; minor interbedded basalt Qtz sst	Low

Age	Map symbol	Formation name	Dominant rock type	Lithology summary	Potential stability risk
				Quartz sandstone, clayey sandstone, mudstone and conglomerate; fluvial and lacustrine sediments; minor interbedded basalt. Basalt	Low
				Quartz sandstone, clayey sandstone, mudstone and conglomerate; fluvial and lacustrine sediments; minor interbedded basalt. Remainder	High
	Ts,TQr	Suttor Formation		Quartz sandstone, clayey sandstone, mudstone and conglomerate; fluvial and lacustrine sediments; minor interbedded basalt. Qtz sst	Low
				Quartz sandstone, clayey sandstone, mudstone and conglomerate; fluvial and lacustrine sediments; minor interbedded basalt. Basalt	Low
				Quartz sandstone, clayey sandstone, mudstone and conglomerate; fluvial and lacustrine sediments; minor interbedded basalt. Remainder	High
	Tn	-		Clayey sandstone, sandy claystone, feldspathic sandstone, conglomerate, minor siltstone, rare oil shale	High
	Ts\c	Suttor Formation	Mudrock	Fluvial and lacustrine sediments (clayey)	High
	Ts\s	Suttor Formation	Arenite	Fluvial and lacustrine sediments (sandy)	High
	Td	-	Ferricrete	Duricrusted surfaces/scarps	High
	Td\f	-		Duricrusted surfaces/scarps (ferricrete)	High
Tertiary	Tb		Basalt	Olivine basalt	Low

Age	Map symbol	Formation name	Dominant rock type	Lithology summary	Potential stability risk
Cretaceous	Ki	-	Granitoid	Granodiorite, diorite, rhyolite, porphyry, gabbro, microdiorite	Low
Late Permian	Pwb	Moranbah Coal Measures	Arenite-Mudrock	Labile sandstone, siltstone, mudstone, coal, conglomerate in the east	High
	Pw	Blackwater Group	Sedimentary Rock	Feldspathic and lithic sandstone, silty sandstone, calcareous sandstone, ashstone and cherty mudstone, carbonaceous mudstone and coal; commonly abundant plant fossils and fossil wood	High
Permian	Pb	Back Creek Group	Sedimentary Rock	Quartzose to lithic sandstone, siltstone, carbonaceous shale, minor coal and sandy coquinite. Sst	Low
				Quartzose to lithic sandstone, siltstone, carbonaceous shale, minor coal and sandy coquinite. Remainder	High
Early Permian	Pbc	Collinsville Coal Measures	Sedimentary Rock	Quartzose sandstone, conglomerate, siltstone, coal. Sst	Lo
				Quartzose sandstone, conglomerate, siltstone, coal. Remainder	High
	Pvz	Lizzie Creek Volcanics	Mafites (lavas, clastics and high-level intrusives)	Basaltic to andesitic lava and volcaniclastic rocks (including breccia and arenite), rhyolitic to dacitic lava and volcaniclastic rocks (including ignimbrite); local siltstone, shale and polymictic conglomerate	Low
Carboniferous to Permian	CPgb	Bluegrass Creek Granite	Granitoid	Medium to coarse-grained biotite granite and granodiorite	Low

Age	Map symbol	Formation name	Dominant rock type	Lithology summary	Potential stability risk
Carboniferous	Cub/n	Bulgonunna Volcanic Group	Mafites (lavas, clastics and high-level intrusives)	Andesitic pyroclastic flow deposit	Low
	Cub/po	Bulgonunna Volcanic Group	Felsites (lavas, clastics and high-level intrusives)	Undifferentiated intrusive rhyolite, quartz-feldspar porphyry, feldspar porphyry and microgranite	Low
	Cubl/d	Locharwood Rhyolite		Crystal rich, lithic poor rhyolitic ignimbrite.	Low
	Cubl/b, Cubl/c	-		Crystal rich rhyolitic ignimbrite.	Low
	Cubl/b	-		Crystal rich rhyolitic ignimbrite.	Low
	Cubi	Pinang Rhyolite		Crystal rich rhyolitic ignimbrite.	Low

Mistake Creek and Suttor River floodplains

The regional geology of the Suttor River Flood Plains area and Mistake Creek are depicted by the Bulliwallah Sheet 8354 (Fitzell *et al.,* 2008), Gunjulla Sheet 8354 (Hutton *et al.,* 2011) and Wyena Sheet 8454 (Hutton *et al.,* 2011) 1:100,000 geological map series (Department of Mines and Energy) and the accompanying 1:250,000 Buchannan and Mount Coolon Explanatory Notes compiled by Olgers (1970) and Hutton *et al.* (1998) respectively.

Extending westward from Verbena Creek, the geology is dominated by Pleistocene-aged alluvium soils. This geology is interspersed with Late Tertiary to Quaternary-aged colluvium until the study area crosses the Suttor River. Westwards of the Suttor River, the study area encounters a range of geological features associated with rises and plateaus (refer Table 5-6). These include Tertiary-aged ferricrete, Tertiary to Quaternary-aged colluvium, Early Carboniferous-aged sedimentary rocks and felsites and arenite-rudite and Anakie Metamorphic Group Pelite of uncertain age. The study area ends within Pleistocene-aged alluvium associated with Mistake Creek, with the elevated southern extremity extending into Early Carboniferous mixed sedimentary rocks and arenite-rudite.

Table 5-6 Geology encountered in the Mistake Creek and Suttor River Flood Plain

Age	Map symbol	Dominant rock type	Formation name	Lithology summary	Potential stability risk
Quaternary	Qa	Alluvium	-	Clay, silt, sand, gravel; floodplain alluvium	High
	Qr	Colluvium	-	Clay, silt, sand, gravel and soil; colluvial and residual deposits	High
	Qr,Cs		Overlying Star Of Hope Formation	Clay, silt, sand, gravel and soil; colluvial and residual deposits	High
	Qr,Tu?[1]		Overlying Suttor Formation?	Clay, silt, sand, gravel and soil; colluvial and residual deposits	High
Quaternary (Pleistocene)	Qpa	Alluvium	-	Clay, silt, sand, gravel; flood plain alluvium on high terraces	High
Late Tertiary to Quaternary	TQr	Colluvium	-	Clay, silt, sand, gravel and soil; colluvial and residual deposits (generally on older land surfaces)	High
	TQr\f>Tu		Overlying Suttor Formation	Older residual soils, colluvium (ferruginous soils)	High
	TQr>Ts		-	Clay, silt, sand, gravel and soil; colluvial and residual deposits (generally on older land surfaces)	High
Tertiary	Ts	Arenite-Mudrock	-	Clayey sublabile to quartzose sandstone, sandy claystone, laminated siltstone, and minor conglomerate	High
	Td	Ferricrete	-	Duricrusted palaeosols at the top of deep weathering profiles, including ferricrete and silcrete; duricrusted old land surfaces. Duricrust.	Low
				Duricrusted palaeosols at the top of deep weathering profiles, including ferricrete and silcrete; duricrusted old land surfaces. Remainder	High
Carboniferous	Cvbl/b	Felsites (lavas, clastics and high-level intrusives)	Locharwood Rhyolite	Moderately crystal rich to crystal rich rhyolitic ignimbrite.	Low

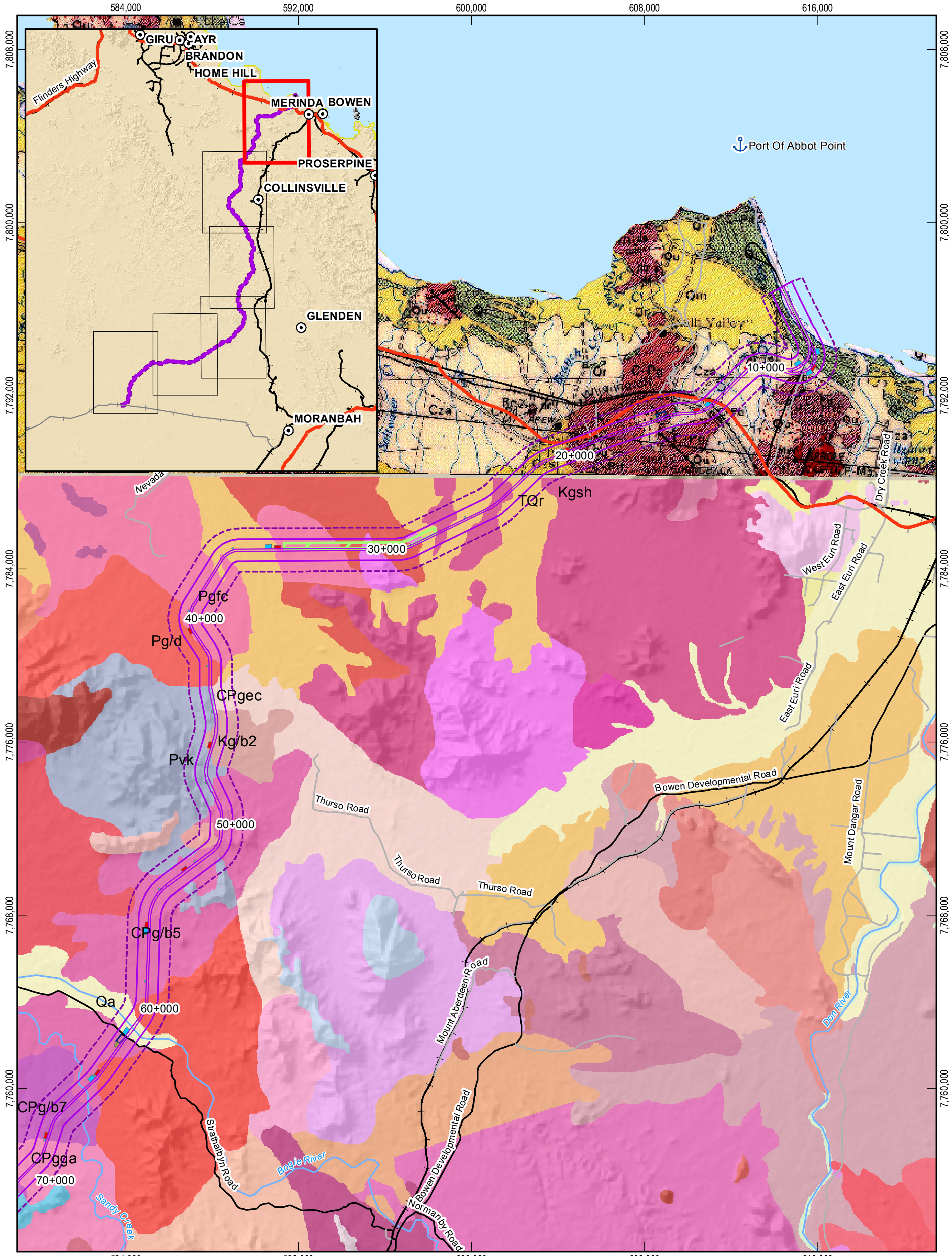
Age	Map symbol	Dominant rock type	Formation name	Lithology summary	Potential stability risk
Early Carboniferous	Cs	Mixed sedimentary rocks and felsites	Star of Hope Formation	Lithic conglomerate, feldspatholithic sandstone, rhyolitic to dacitic ignimbrite and flows, tuffaceous siltstone and rare sinter	Low
	Ch	Arenite-Rudite	Mount Hall Formation	Quartzose to feldspathic sublabile sandstone, quartz-pebble conglomerate, mudstone and red and green siltstone. Qtz sst	Low
				Quartzose to feldspathic sublabile sandstone, quartz-pebble conglomerate, mudstone and red and green siltstone. Remainder	High
Late Devonian to Early Carboniferous	DCs	Felsites (lavas, clastics and high-level intrusives)	Silver Hills Volcanics	Rhyolite, dacite, rhyolitic ignimbrite, volcaniclastic sediments, sinter, minor sandstone and siltstone	Low
Neo-proterozoic to Cambrian?	PLEa	Pelite	Anakie Metamorphic Group	Siltstone, fine sandstone, phyllite, schist.	Low

Note: 1. A question mark (?) indicates uncertainty of the classification in original geological mapping dataset. The geology identified is the most likely.

Fossil presence

In Queensland, fossils are typically found in sedimentary rocks, commonly shale, sandstone, and limestone. The types of rock that normally lack fossils are metamorphic rocks and igneous rocks due to the harsh manner in which they form, which usually destroys or severely deforms any remains of biological organisms.

The study area traverses the Blackwater Group formation between chainages 130.4 km to 158.3 km. This Late Permian-aged sedimentary rock is reported to have an abundance of fossil presence (Paine and Cameron 1972). Formations in the Blenheim subgroup and Collinsville Coal Measures, from chainage 113.2 km to chainage 130.4 km may give rise to fossil remains. Fossil material of flora is common in sedimentary material within the Lizzie Creek Volcanic Group formation immediately south of Pelican Creek.



LEGEND

- Population Centres
- Major Port
- Highway
- Main Road
- Local Road
- Railway
- Watercourse (Major)
- North Galilee Basin Rail 1000m Corridor
- North Galilee Basin Rail 100m Corridor
- North Galilee Basin Rail Baseline study area (1km buffer)

Ancillary Infrastructure Areas

- Bridge Laydown Area
- Concrete Batch Plant
- Construction Camp
- Rolling Stock Maintenance Depot
- Track Laydown Area
- Turning Circle

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1:250,000 Paper Size A4

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Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

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Adani Mining Pty Ltd
North Galilee Basin Rail Project

Job Number	41-26457
Revision	A
Date	30 Aug 2013

Mapped geology

Figure 5-2
Sheet 1 of 7

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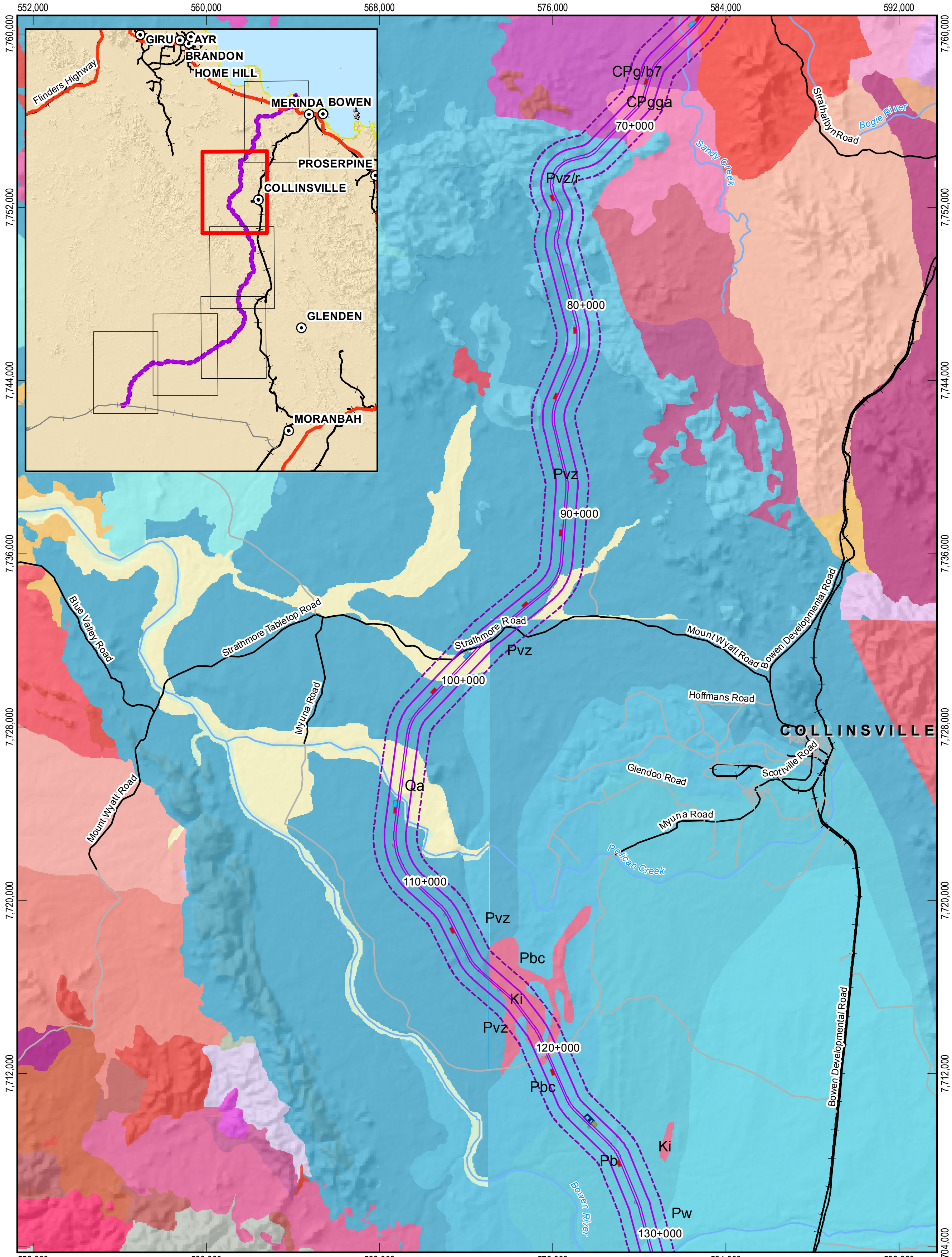

LEGEND

Population Centres | Local Road | Main Road | Railway | Watercourse (Major)

North Galilee Basin Rail 1000m Corridor

North Galilee Basin Rail 100m Corridor

North Galilee Basin Rail Baseline study area (1km buffer)

Ancillary Infrastructure Areas

- Bridge Laydown Area
- Concrete Batch Plant
- Construction Camp
- Track Laydown Area
- Turning Circle

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Figure 5-2
Sheet 2 of 7

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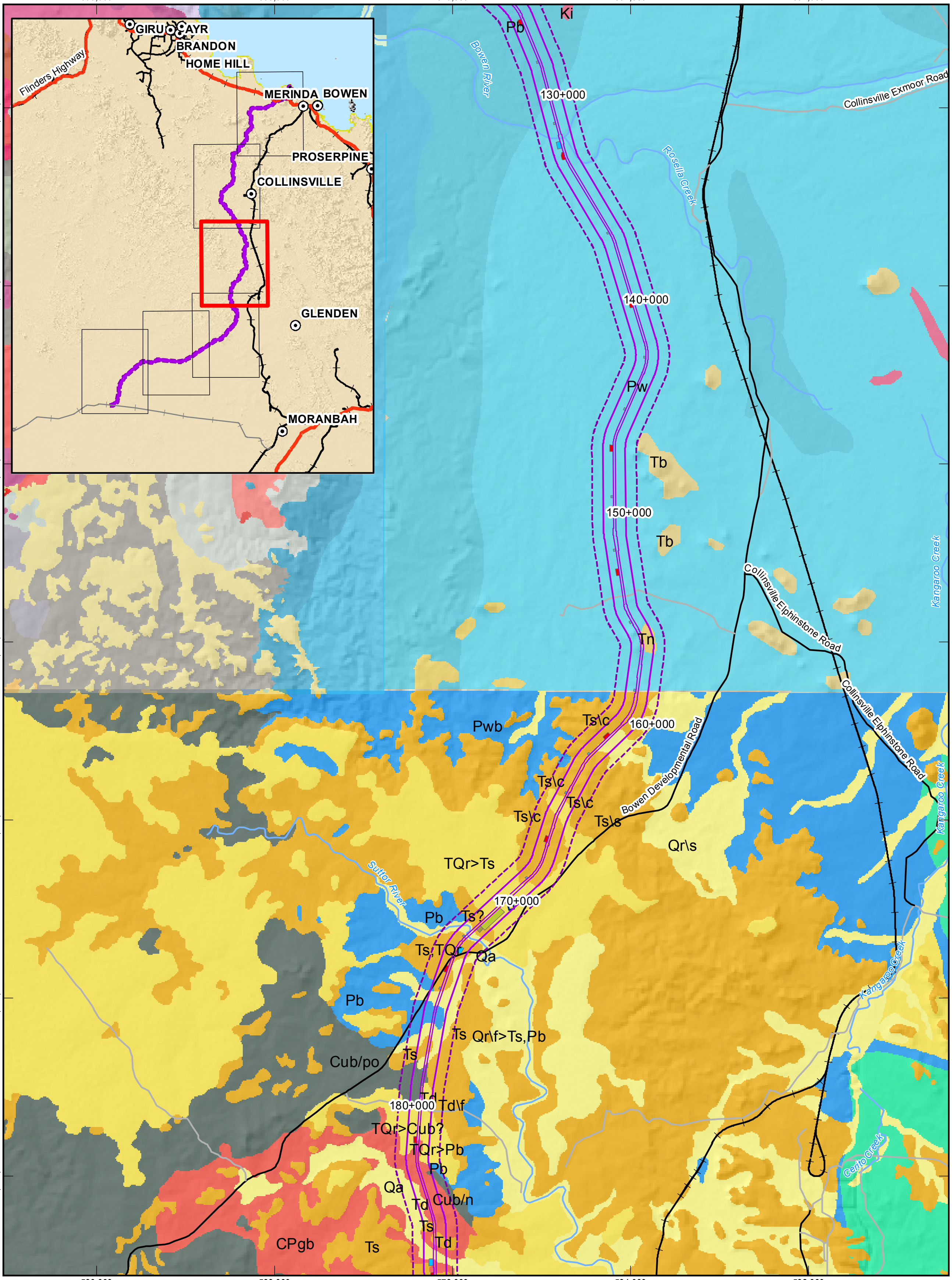

LEGEND

- Main Road
- Local Road
- Railway
- Watercourse (Major)
- North Galilee Basin Rail 1000m Corridor
- North Galilee Basin Rail 100m Corridor
- North Galilee Basin Rail Baseline study area (1km buffer)

Ancillary Infrastructure Areas

- Bridge Laydown Area
- Concrete Batch Plant
- Construction Camp
- Construction Yard
- Track Laydown Area
- Turning Circle

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Figure 5-2
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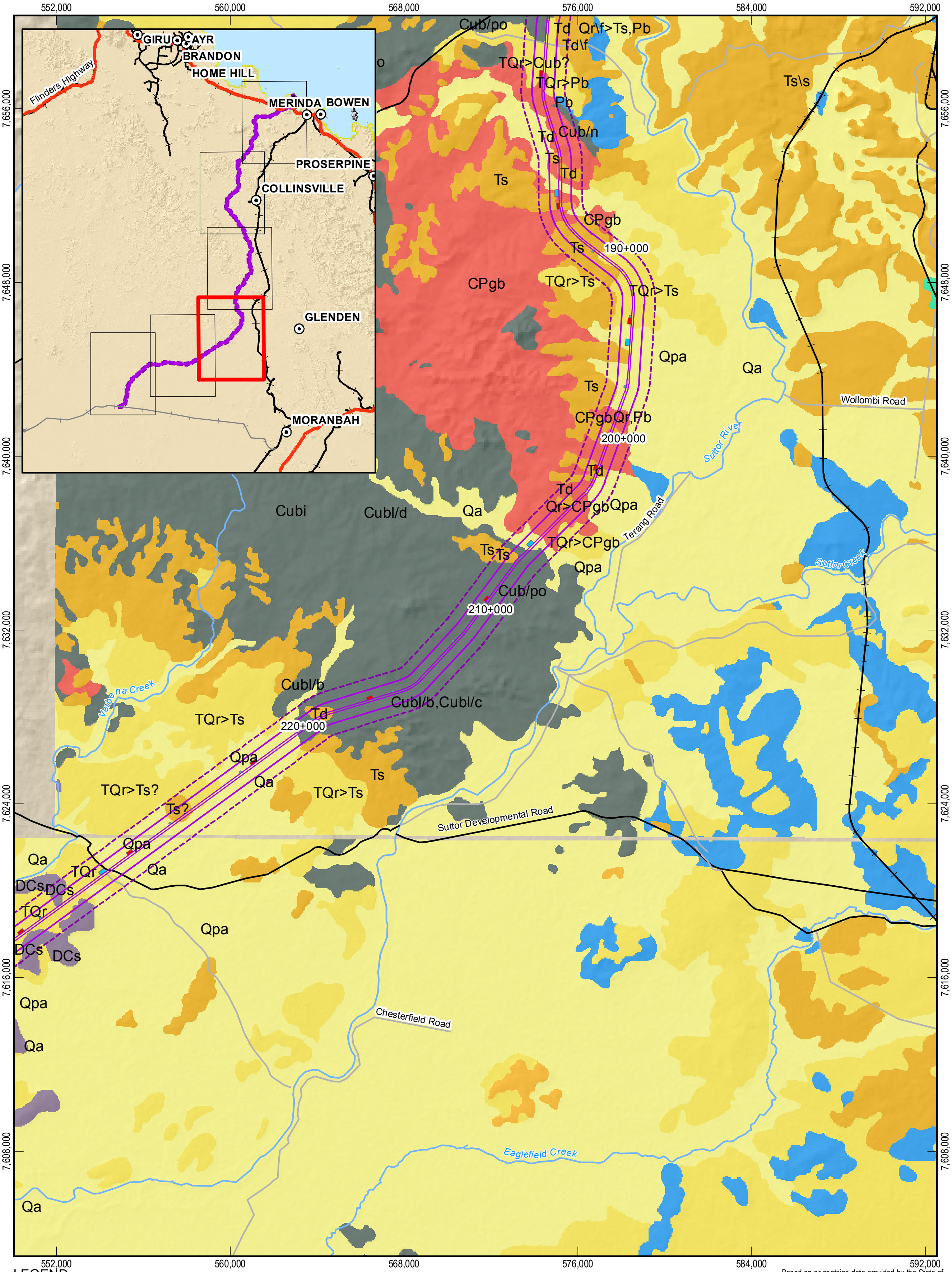

LEGEND

Main Road	North Galilee Basin Rail 1000m Corridor
Local Road	North Galilee Basin Rail 100m Corridor
Railway	North Galilee Basin Rail Baseline study area (1km buffer)
Watercourse (Major)	Ancillary Infrastructure Areas
Bridge Laydown Area	Track Laydown Area
Turning Circle	

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Sheet 4 of 7

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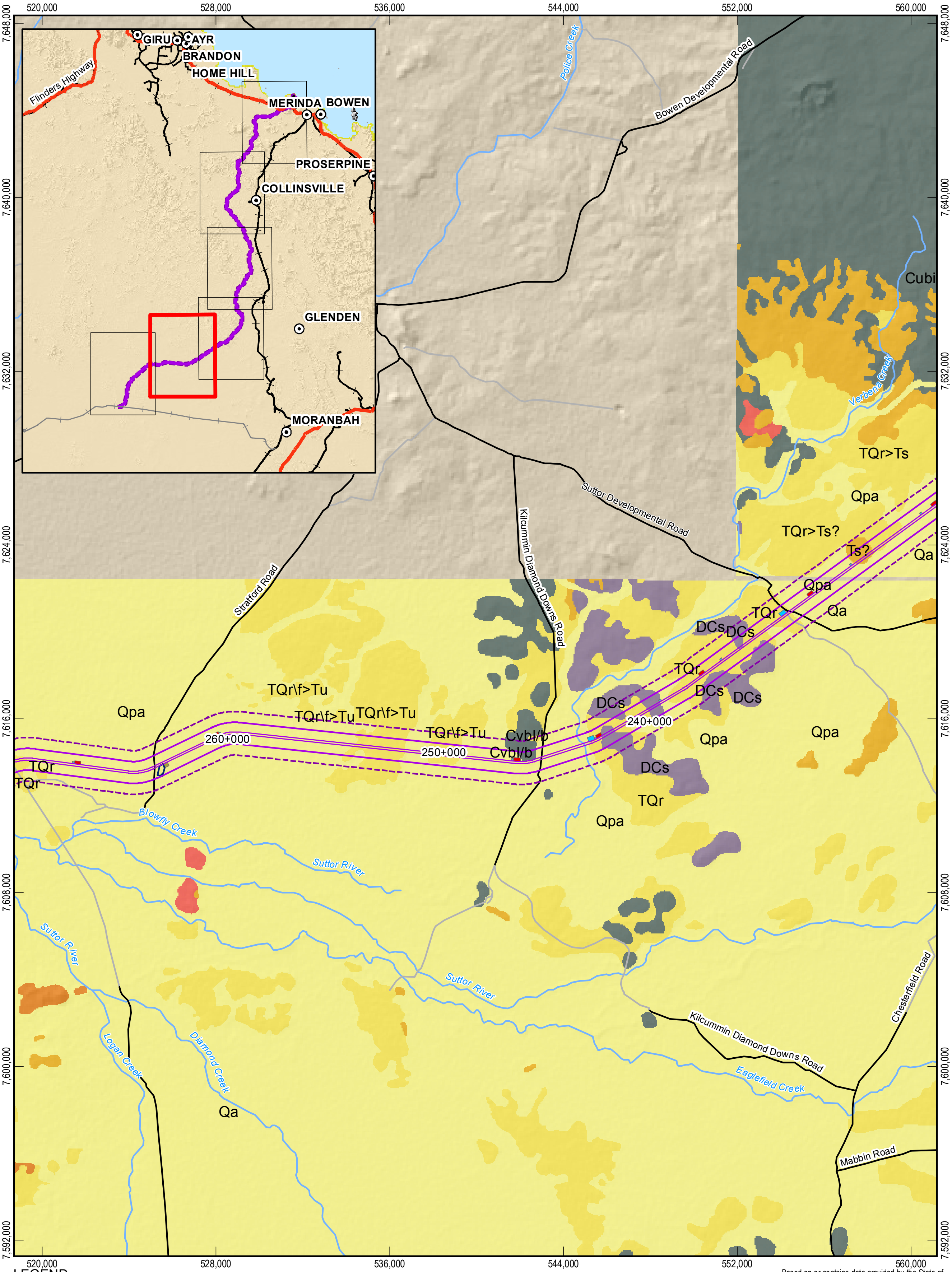

LEGEND

- Main Road
- Local Road
- Watercourse (Major)
- North Galilee Basin Rail 1000m Corridor
- North Galilee Basin Rail 100m Corridor
- North Galilee Basin Rail Baseline study area (1km buffer)

Ancillary Infrastructure Areas

- Bridge Laydown Area
- Concrete Batch Plant
- Construction Camp
- Track Laydown Area
- Turning Circle

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North Galilee Basin Rail Project

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Job Number	41-26457
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Figure 5-2
Sheet 5 of 7

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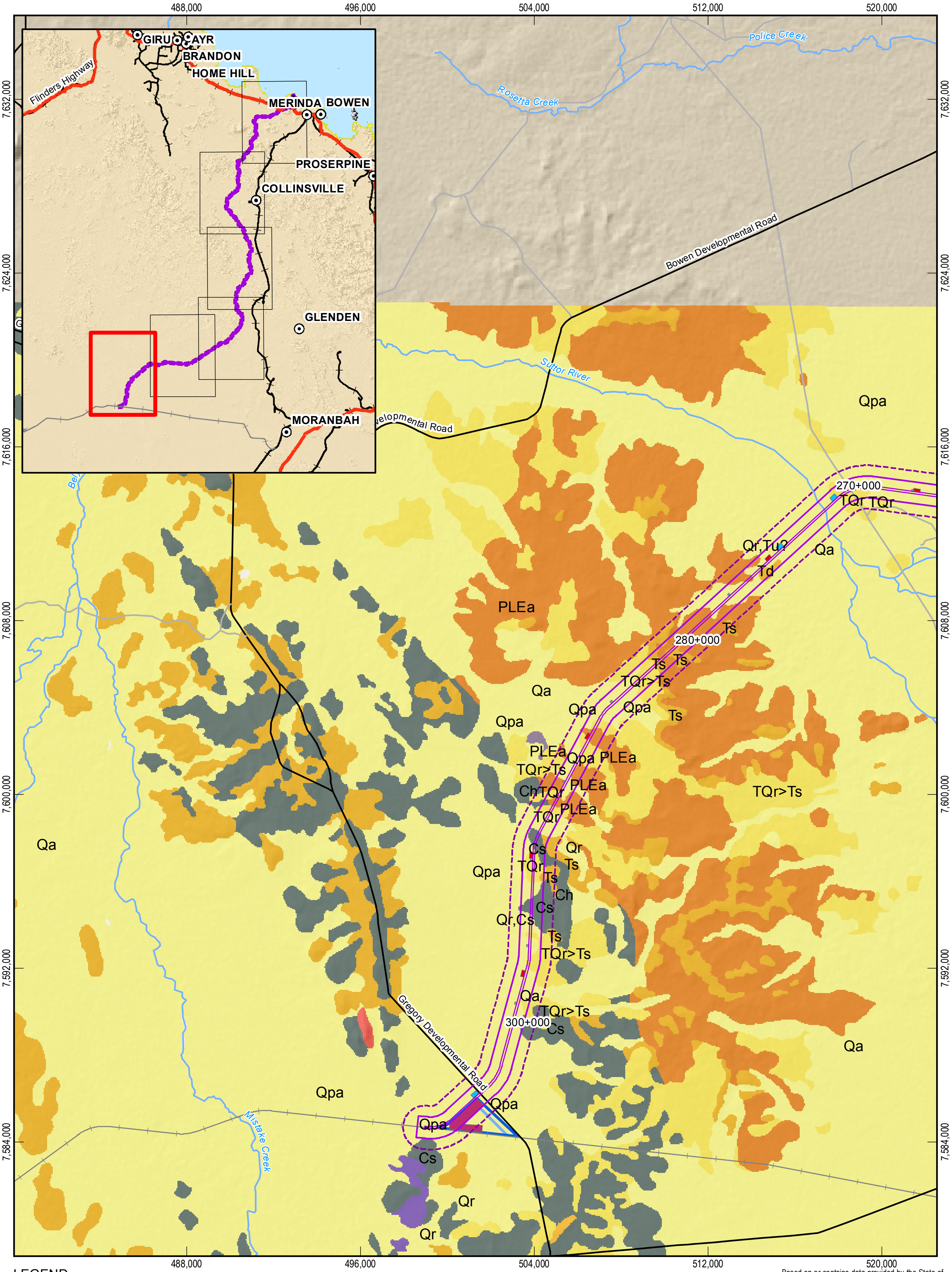

LEGEND

Main Road	Local Road	Carmichael Project (Rail)	North Galilee Basin Rail 1000m Corridor	Ancillary Infrastructure Areas
	Watercourse (Major)		North Galilee Basin Rail 100m Corridor	Bridge Laydown Area
			North Galilee Basin Rail Baseline study area (1km buffer)	Construction Depot Area
				Rail Precinct Area
				Track Laydown Area
				Turning Circle

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1:250,000 Paper Size A4

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Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

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North Galilee Basin Rail Project

Mapped geology

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Figure 5-2
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WATER BODIES
- Water body (unspecified)

HOLOCENE
- Qha-QLD
- Qhh-QLD

QUATERNARY
- Qa-QLD
- Qcr-QLD
- Qct-QLD
- Qr-QLD
- Qr\b-QLD
- Qr\s-QLD

LATE TERTIARY - QUATERNARY
- TQa-QLD
- TQr-QLD

TERTIARY
- Suttor Formation
- Suttor Formation?
- Tb-QLD
- To-8557
- To?-8557
- Ts-QLD

CRETACEOUS
- Griman Creek Formation

CRETACEOUS (Intrusive)
- Hecate Granite/1
- Hecate Granite/2
- Hecate Granite/3
- Hecate Granite/4
- Hecate Granite/5
- Hecate Granite/6
- Hecate Granite/7

EARLY CRETACEOUS? (Intrusive)
- Summer Hill Gabbro
- Summer Hill Gabbro?

EARLY CRETACEOUS (Intrusive)
- Ben Lomond Granite
- Blackwall Quartz Diorite
- Devlins Pocket Quartz Diorite
- Elliot River Granodiorite
- Flagstaff Hill Granite
- Kg/1-8557
- Kg/1?-8557
- Kg/2-8557
- Kg/3-8557
- Kg/4-8557
- Kg/5-8557
- Kg/6-8557
- Kg/7-8557
- Kg/b1-NCON
- Kg/b2-NCON
- Kg/b3-NCON
- Kg/d?-NCON
- Kg/f-8557
- Kg/x-8557
- Kgd/x-8557
- Kgd/y-8557
- Kgd/z-8557
- Monte Christo Granite
- Mount Abbot Igneous Complex/1
- Mount Abbot Igneous Complex/2
- Mount Pring Granite
- Mount Roundback Granodiorite
- Pretty Bend Quartz Monzodiorite
- Pretty Bend Quartz Monzodiorite?
- Selina Creek Granodiorite
- Selina Creek Granodiorite?
- Seventy Creek Granite
- Seventy Creek Granite/f
- Ward Creek Granodiorite

MIDDLE TRIASSIC (Intrusive)
- Gloucester Granite

EARLY TRIASSIC? - MIDDLE TRIASSIC? (Intrusive)
- Passage Islet Granite

PERMIAN
- Mount Wickham Rhyolite
- Mount Wickham Rhyolite?

PERMIAN (Intrusive)
- CPn-8555
- Mamelon Quartz Monzodiorite
- Thunderbolt Granite

EARLY PERMIAN
- Carmila beds
- Carmila beds?
- Collinsville Coal Measures
- Karungle Volcanics
- Lizzie Creek Volcanic Group
- Lizzie Creek Volcanic Group/f
- Lizzie Creek Volcanic Group/f?
- Lizzie Creek Volcanic Group/s
- Lizzie Creek Volcanic Group?
- Lizzie Creek Volcanics/a
- Lizzie Creek Volcanics/r
- Lizzie Creek Volcanics/r?
- Mount Aberdeen Volcanics

EARLY PERMIAN (Intrusive)
- Adaluma Tonalite
- Alick Creek Tonalite
- Beckford Granodiorite
- Dartmoor Granodiorite
- East Creek Tonalite
- Easter Granodiorite
- Ernest Creek Granodiorite
- Expedition Pass Granite
- Fence Creek Granodiorite
- First Pocket Igneous Complex/1
- First Pocket Igneous Complex/2
- Goldbeetle Creek Granodiorite
- Grant Creek Granite
- Highlanders Bonnet Granodiorite
- Humbug Creek Granite
- Lady Norman Granodiorite
- Marlborough Pocket Granodiorite
- Massey Granite
- Mount Cauley Granite
- Nostone Creek Granodiorite
- Nostone Creek Granodiorite?
- Pbr-8557
- Perch Creek Granodiorite
- Pg-8556
- Pg/d-NCON
- Pg/l?-NCON
- Pgd-8556
- Pickhandle Tonalite
- Pla Creek Granodiorite
- Salitros Granite
- Scrubby Top Granite
- Starvation Creek Complex
- Turn Back Granite
- Viola Creek Granodiorite

LATE CARBONIFEROUS? - EARLY PERMIAN? (Intrusive)
- Glenmore Creek Granodiorite

LATE CARBONIFEROUS - EARLY PERMIAN
- Arundel Rhyolite/1
- Arundel Rhyolite/2
- Collins Creek Rhyolite
- Collins Creek Rhyolite?
- McGregors Bonnet Volcanics
- McGregors Bonnet Volcanics?
- The Tableland Volcanics
- The Tableland Volcanics?

LATE CARBONIFEROUS - EARLY PERMIAN (Intrusive)
- Billy-can Creek Granite
- Binbee Quartz Monzodiorite
- Black Pinnacle Igneous Complex/1
- Black Pinnacle Igneous Complex/2
- Black Pinnacle Igneous Complex/3?
- Black Pinnacle Igneous Complex/v1
- Black Pinnacle Igneous Complex/v2
- Bluestone Creek Granodiorite
- Brawl Creek Granite
- Brown Creek Rhyolite
- CPd/b1-NCON
- CPg-QLD
- CPg/1-8356
- CPg/10-8356
- CPg/2-8356
- CPg/2?-8356
- CPg/8-8356
- CPg/9-8356
- CPg/b-NCON
- CPg/b1-NCON
- CPg/b2-NCON
- CPg/b2?-NCON
- CPg/b3-NCON
- CPg/b4-NCON
- CPg/b5-NCON
- CPg/b6-NCON
- CPg/b7-NCON
- CPg/b8-NCON
- CPg/b9-NCON
- CPg/h-NCON
- CPg/i-Leichhardt Range
- CPg/l?-NCON
- CPg/mg-NCON
- CPg/mg?-NCON
- CPg/w1-NCON
- CPg/w2-NCON
- CPg/w3-NCON
- CPg/w4-NCON
- CPg/w5-NCON
- CPg/w5?-NCON
- CPg/w6-NCON
- CPg/w7-NCON
- CPg/y2-NCON
- CPgaa-NCON
- CPgl-NCON
- CPm-8356
- CPr/1-8356
- CPr/1?-8356
- CPr/2-8356
- CPr/2?-8356
- CPr/3-8356
- CPr/3?-8356
- CPr/4-DRUM
- CPr/4?-DRUM
- CPx-8356
- Charlie Creek Microgranite
- Dozer Creek Granite
- Dozer Creek Granite?
- Eight Mile Station Granite
- Euri Creek Granodiorite
- Glen Alpine Granite
- Glen Easter Leucogranite
- Glen Easter Leucogranite/1
- Glendon Granodiorite
- Glenella Creek Granite
- Glenore Road Quartz Diorite
- Glenroy Creek Granodiorite
- Greentop Granite
- Isabella Creek Rhyolite?
- Joe-De-Little Granite
- Joe-De-Little Granite/m
- Joe-De-Little Granite/m?
- Joe-De-Little Granite?
- Lagoon Creek Granite
- Leichhardt Range Granite
- Leichhardt Range Granite?
- Lionel Diggings Granite
- Molongle Creek Granite
- Morer Granite
- Mount Mackenzie Granite
- Mount Mackenzie Granite?
- Mount Magnus Granite
- Oaky Creek Monzogranite
- Panhandle Granite
- Peak John Well Granite/a
- Peak John Well Granite/b
- Peak John Well Granite/c
- Peak John Well Granite/d
- Peak John Well Granite/e
- Percy Douglas Tonalite
- Pine Creek Granite
- Pine Creek Granite?
- Red Hill Creek Granodiorite
- Roscow Granite/1
- Roscow Granite/2
- Roscow Granite/3
- Shannon Vale Gabbro
- Smoko Creek Granite
- Smoko Creek Granite?
- Springlands Gabbro
- Stony Creek Granite
- Stuart Pocket Granite
- Sunbeam Granodiorite
- Sundown Creek Diorite
- Swans Lagoon Granite
- Teatree Creek Gabbro
- Terry Creek Quartz Monzodiorite
- The Three Brothers Gabbro
- Upper Rosetta Creek Granite
- Upper Rosetta Creek Granite/a
- Upper Rosetta Creek Granite?
- Wynne Creek Diorite

CARBONIFEROUS - PERMIAN (Intrusive)
- CPd-NCON
- CPd?-NCON
- CPm?-NCON
- CPp-NCON
- CPp?-NCON
- Lulu Pocket Igneous Complex/2
- Lulu Pocket Igneous Complex/3

CARBONIFEROUS - EARLY PERMIAN (Intrusive)
- CPg-DRUM/BULG
- CPg?-QLD

LATE CARBONIFEROUS
- Bobby Dazzler Rhyolite
- Bobby Dazzler Rhyolite?
- Bulgonunna Volcanic Group/10
- Bulgonunna Volcanic Group/10?
- Bulgonunna Volcanic Group/12
- Bulgonunna Volcanic Group/13
- Bulgonunna Volcanic Group/14
- Bulgonunna Volcanic Group/14?
- Bulgonunna Volcanic Group/15
- Bulgonunna Volcanic Group/15?
- Bulgonunna Volcanic Group/17
- Bulgonunna Volcanic Group/18
- Bulgonunna Volcanic Group/19
- Bulgonunna Volcanic Group/20
- Bulgonunna Volcanic Group/21
- Bulgonunna Volcanic Group/21?
- Bulgonunna Volcanic Group/22
- Bulgonunna Volcanic Group/23
- Bulgonunna Volcanic Group/27
- Bulgonunna Volcanic Group/27?
- Bulgonunna Volcanic Group/28
- Bulgonunna Volcanic Group/7
- Bulgonunna Volcanic Group/7?
- Bulgonunna Volcanic Group/8
- Bulgonunna Volcanic Group/8?
- Bulgonunna Volcanic Group/rh?
- Bulgonunna Volcanic Group/s
- Bulgonunna Volcanic Group/s?
- Conway Volcanics
- Conway Volcanics?
- Earlscliffe Dacite/1
- Earlscliffe Dacite/2?
- Earlscliffe Dacite/3
- Earlscliffe Dacite/3?
- Pyramid Rhyolite
- Pyramid Rhyolite?
- Smedley Dacite
- Smedley Dacite?
- Whitestone Creek Dacite

LATE CARBONIFEROUS (Intrusive)
- Amelia Creek Tonalite
- Birds Nest Granodiorite
- Cg-NCON
- Cg/l1-NCON
- House and Kitchen Granite
- McGains Gossan Granodiorite
- McGains Gossan Granodiorite?
- Milwarra Quartz Diorite
- Milwarra Quartz Diorite?
- Mount Crompton Granodiorite
- Mount Hector Granite
- Mount Nutt Granite
- Tommy Roundback Granodiorite
- Tommy Roundback Granodiorite?

CARBONIFEROUS
- Locharwood Rhyolite
- Locharwood Rhyolite?
- Saint Anns Formation/b
- Scartwater Formation
- Scartwater Formation?

CARBONIFEROUS (Intrusive)
- Bootooloo Gabbro
- Bootooloo Gabbro?
- Cgd-8557

EARLY CARBONIFEROUS
- Cs-8556
- Edgecumbe beds
- Edgecumbe beds?
- Key Creek Gneiss
- Mount Cavana beds
- Star of Hope Formation
- Star of Hope Formation?

LATE DEVONIAN - EARLY CARBONIFEROUS
- Bimurra Volcanics
- Bimurra Volcanics/d?
- Bimurra Volcanics/r
- Bimurra Volcanics?
- Mount Wyatt Formation
- Rosetta Creek Formation
- Rosetta Creek Formation/m
- Rosetta Creek Formation/mv
- Rosetta Creek Formation?
- Saint Anns Formation
- Stones Creek Volcanics
- Stones Creek Volcanics/1
- Stones Creek Volcanics/2
- Stones Creek Volcanics/3
- Stones Creek Volcanics/4
- Stones Creek Volcanics?

DEVONIAN
- Ukalunda Formation?

EARLY DEVONIAN - MIDDLE DEVONIAN
- Ukalunda Formation

LATE SILURIAN - EARLY DEVONIAN (Intrusive)
- Kedumba Granodiorite
- Mount Cuthbert Granodiorite
- Rangeview Station Tonalite
- Rangeview Station Tonalite?
- SDg/1-8357
- SDg/2-8357

SILURIAN - EARLY DEVONIAN (Intrusive)
- Dalmore Granodiorite

ORDOVICIAN (Intrusive)
- Carse Creek Complex
- Elbow Creek Granodiorite
- Og/a-8357
- Og/a-Ravenswood Batholith
- Og/a?-8357
- Og/a?-Ravenswood Batholith
- Two Creek Granodiorite

CAMBRIAN - ORDOVICIAN
- Les Jumelles beds
- Les Jumelles beds/q
- Mount Windsor Volcanics

CAMBRIAN
- Mount Windsor Volcanics?

ORDOVICIAN - PERMIAN (Intrusive)
- Landers Igneous Complex/2

ORDOVICIAN - DEVONIAN (Intrusive)
- ODg/d-8357
- ODg/d-Ravenswood Batholith
- ODg?-Ravenswood Batholith

NEOPROTEROZOIC? - CAMBRIAN
- PLEm-8357

NEOPROTEROZOIC - CAMBRIAN
- Charters Towers Metamorphics?

NEOPROTEROZOIC? - EARLY CAMBRIAN?
- Anakie Metamorphic Group/s

LEGEND

1:1,000,000 Paper Size A4

0 4.5 9 18

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

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Adani Mining Pty Ltd

North Galilee Basin Rail Project

Mapped geology - legend

Job Number	41-26457
Revision	A
Date	29 Aug 2013

Figure 5-2
Sheet 7 of 7

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145 Ann Street Brisbane QLD 4000 Australia T 61 7 3316 3000 F 61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data source: 250k Geology/2011. Created by:MS

5.3.3 Soils

Soil information for the study area ranges in precision. At the northern end, approaching Abbot Point, a detailed soil map has been published at 1:100,000 scale. This detailed mapping is considered to be fairly accurate; however, the majority of the study area is covered by exploratory scale soil mapping of 1:1,000,000 scale. This mapping coarsely identifies the predominant expected soil type of the area. At the southern end, land system mapping of 1:250,000 scale is present. The associated land system report connects soils with landform and vegetation and provides a land suitability assessment for each soil unit. Land system mapping defines the major soil type, but does not incorporate the finer details associated with landform and vegetation. For consistency and comparison purposes, the mapped polygons across all maps have also been identified using the Australian Soil Classification so that soil types can be compared with other maps.

Multiple soil types are intersected by the study area (refer Figure 5-3). These soil types and a brief definition of each are listed below:

- Rudosols: soils with limited structural development, commonly associated with hill tops
- Tenosols: soils with less than 15 per cent clay, with limited structure, commonly associated with hill tops and upper slopes
- Kandosols: soils with greater than 15 per cent clay, with a massive or weakly structured subsoil
- Hydrosols: soils where a greater part of the profile is saturated for at least several months of the year
- Chromosols: soils with a clear or abrupt texture change between the upper sandy material and lower clayey material. The underlying clay is not acidic (pH>5.5) and not sodic (exchangeable sodium percentage less than 6).
- Sodosols: soils with a clear or abrupt texture change between the upper sandy material and underlying clay material. The underlying clay material is sodic (dispersive) and not strongly acidic (pH>5.5).
- Dermosols: structured soils which do not have a strong texture change between topsoil and subsoil. These soils are commonly described as uniform or gradational soils.
- Vertosols: colloquially known as cracking clays, these soils swell when wet and shrink when dry. They are typically impassable when wet.

Sodic soils

Sodic soils are characterised by a disproportionately high concentration of sodium that causes the soil to swell excessively when wet. This weakens the aggregates in the soil, causing structural collapse and closing-off of soil pores, limiting water and air movement through. Soils are classified as being sodic when the exchangeable sodium percentage is from six to 14 per cent, and are considered strongly sodic when ESP is greater than 15 per cent (The State of Queensland DNR 1997). Dispersion of sodic soils may lead to surface crusting, low infiltration, low hydraulic conductivity, compaction of subsoils and increased susceptibility to erosion (Hazelton & Murphy 2007).

Occurrence of sodicity in 1:100,000 soil mapping have been identified within the final rail corridor between chainage 3.49 km and 42.9 km (Aldrick 1998) (refer Figure 5-3 and Table 5-7). Other 1:100,000 soil mapping (Isbell and Murtha 1970) and 1:250,000 soil mapping (Gunn et al

1967) intersected by the final rail corridor did not identify chemical limitations. Hence, soil units displaying sodic properties cannot be surmised for the remainder of the final rail corridor.

Table 5-7 Soil units with sodic properties

Soil unit	Comment	Number of occurrences within the final rail corridor
Carew (Vertosol)	Sodic lower B horizons	7
Dillion (Dermosol)	Sodicity	1
Glenroc (Dermosol)	Sodic subsoils	7
Glenroc stony phase	Sodic subsoils	1
Goodbye (Dermosol)	Strongly sodic subsoils	7
Greentop (Dermosol and Sodosol)	Sodicity	2
Kailla (Tenosol)	Moderate sodicity	1
Kangaroo (Dermosol)	Sodicity	8
Maiden (Hydrosol)	Sodicity	3
Roundback (Kandosol)	Strongly sodic in lower B horizon	7
Salisbury (Dermosol)	Minor B horizon sodicity	1
Seven Sisters (Dermosol)	Sodicity	2
Sixmile (Tenosol, Dermosol and Vertosol)	Sodicity	5
Splitters (Kandosol)	Sodic lower B horizon	1
Tabletop – Gumlu complex (Vertosol)	Sodic lower B horizon	2
Thurso (Dermosol and Chromosol)	Sodicity	4
Wathana (Kandosol)	Very strongly sodic	1
Wathana heavier textured variant (Dermosol)	Very strongly sodic	1
Wilmington (Tenosol)	Very strongly sodic	2
Wygong (Dermosol)	Minor B horizon sodicity	2

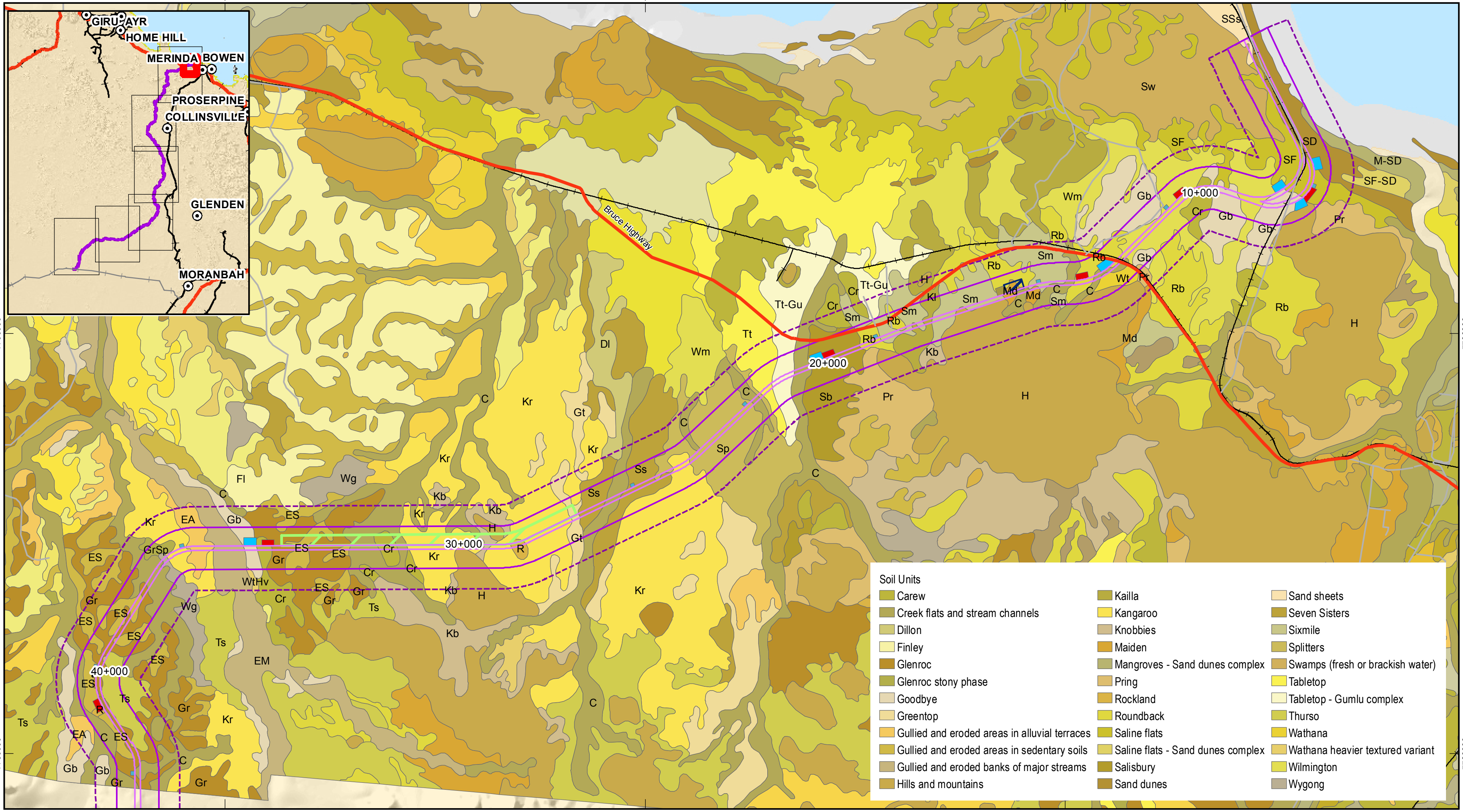
Gilgai microrelief

Gilgai country is present in central Queensland and is associated with expansive (cracking) clay soils (NCST, 2009), referred to as Vertosols (Isbell, 2002). Gilgai are repeated mounds and depressions of varying size and shape, commonly called “crabholes” or “melonholes” (NCST, 2009). The depressions accumulate soil nutrients and salts as water drains into these areas. Consequently, chemical properties of depressions may differ to that of mounds (NRCS, 1993), possibly complicating topsoil stripping.

Available soil mapping has identified areas of gilgai microrelief that will be intersected by the final rail corridor (refer Volume 2, Appendix E Topography, geology, soils and land contamination). In particular, the following soil units / land system display gilgai characteristics:

- 1:100,000 soil mapping (Aldrick 1998)
  - Carew, Salisbury, Tabletop and Wygong
- 1:100,000 soil mapping (Isbell and Murtha 1970)
  - Cc 18, Cc 5, Cd 15, Cf 17, Gf 5 and Ye
- 1:250,000 land systems (Gunn et al., 1967)
  - Blackwater, Islay and Somerby.

Figure 5-3 shows the location of these soil units and land systems along the final rail corridor.



1:125,000 (at A4)

0 1,000 2,000 3,000

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

LEGEND

- Highway
- Local Road
- Railway
- North Galilee Basin Rail 100m Corridor
- North Galilee Basin Rail 1000m Corridor
- North Galilee Basin Rail Baseline Study Area (1km buffer)

Ancillary Infrastructure Areas

- Bridge Laydown Area
- Concrete Batch Plant
- Construction Camp
- Rolling Stock Maintenance Depot
- Track Laydown Area
- Turning Circle

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North Galilee Basin Rail Project

Job Number 41-26457
Revision A
Date 30-08-2013

Land systems and soils

Figure 5-3
Sheet 1 of 7

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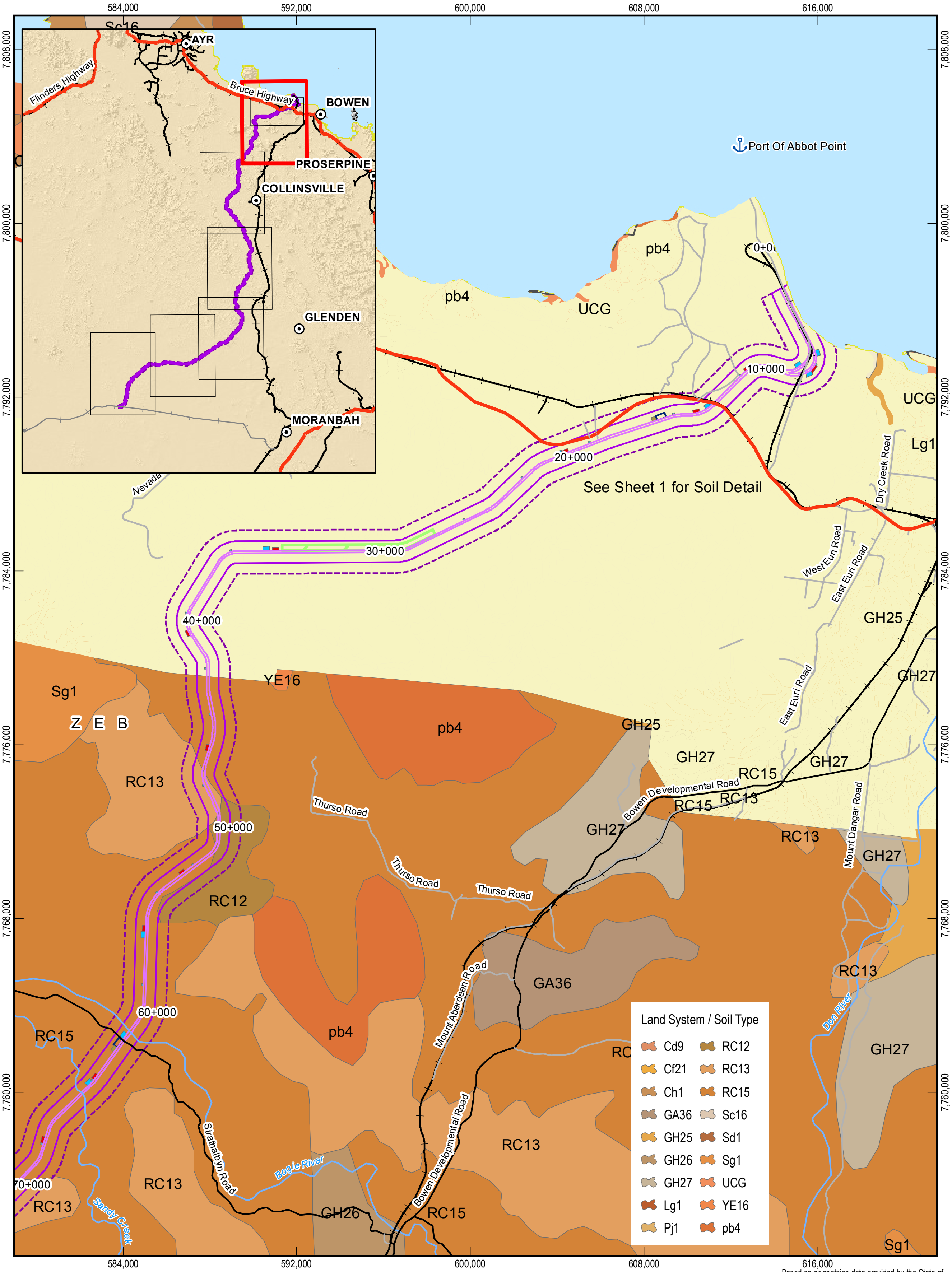
Level 9 145 Ann St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data source: DNRM: DEM (2008), © Commonwealth of Australia (Geoscience Australia): Localities, Railways, Roads, Watercourse (2007); Adani: Project Rail Alignment, Camp Sites, Alignment Functional Areas (2013). Created by: MS



LEGEND

- Population Centres
- Major Port
- Highway
- Main Road
- Local Road
- Railway
- Watercourse (Major)
- North Galilee Basin Rail Baseline Study Area (1km buffer)
- North Galilee Basin Rail 1000m Corridor
- North Galilee Basin Rail 100m Corridor
- Ancillary Infrastructure Areas
- Bridge Laydown Area
- Concrete Batch Plant
- Construction Camp
- Rolling Stock Maintenance Depot
- Track Laydown Area
- Turning Circle

1:250,000 Paper Size A4

0 2 4 8

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

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North Galilee Basin Rail Project

Land systems and soils

Job Number	41-26457
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Figure 5-3
Sheet 2 of 7

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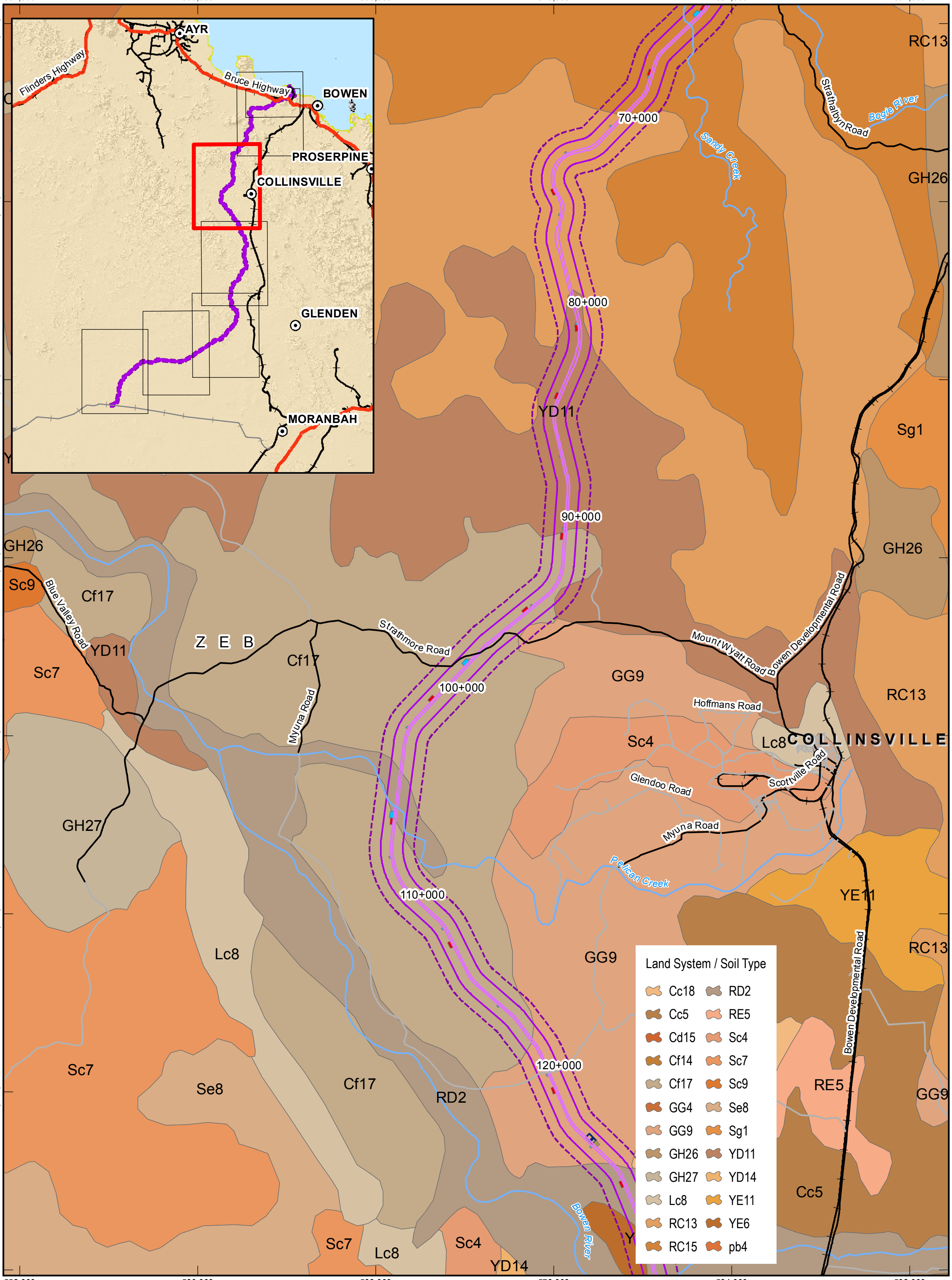
Level 9, 145 Ann Street Brisbane QLD 4000 Australia T 61 7 3316 3000 F 61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data source: GA: Populated Places, Railway, Watercourse/2007; Adani: NGBR Corridor 06/06/2013, NGBR Corridor 13/05/2013, Carmichael Project Rail 23/07/2012, Ancilliary Infrastructure 2013; DNRM: Roads/2010; Conbined Soils/2010. Created by:MS



LEGEND

- Population Centres
- Main Road
- Local Road
- Railway
- Watercourse (Major)
- North Galilee Basin Rail Baseline Study Area (1km buffer)
- North Galilee Basin Rail 1000m Corridor
- North Galilee Basin Rail 100m Corridor
- Ancillary Infrastructure Areas
- Bridge Laydown Area
- Concrete Batch Plant
- Construction Camp
- Track Laydown Area
- Turning Circle

1:250,000 Paper Size A4

0 2 4 8

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

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North Galilee Basin Rail Project

Land systems and soils

Job Number	41-26457
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Date	30 Aug 2013

Figure 5-3
Sheet 3 of 7

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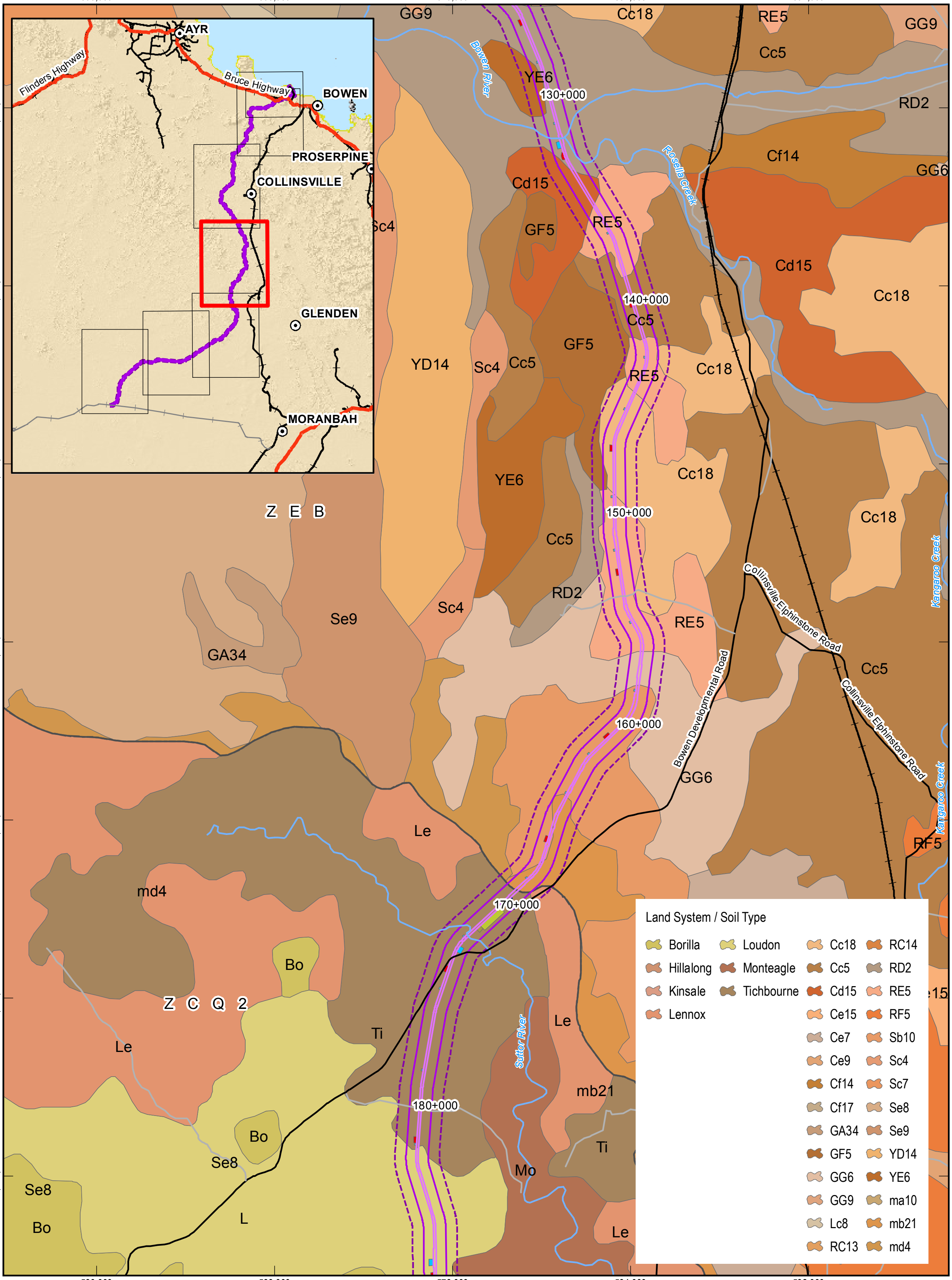
Data source: GA: Populated Places, Railway, Watercourse/2007; Adani: NGBR Corridor 06/06/2013, NGBR Corridor 13/05/2013, Carmichael Project Rail 23/07/2012, Ancilliary Infrastructure 2013; DNRM: Roads/2010; Conbined Soils/2010. Created by:MS



LEGEND

- Main Road
- Local Road
- Railway
- Watercourse (Major)
- North Galilee Basin Rail Baseline Study Area (1km buffer)
- North Galilee Basin Rail 1000m Corridor
- North Galilee Basin Rail 100m Corridor

Ancillary Infrastructure Areas

- Bridge Laydown Area
- Concrete Batch Plant
- Construction Camp
- Construction Yard
- Track Laydown Area
- Turning Circle

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1:250,000 Paper Size A4

0 2 4 8

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

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North Galilee Basin Rail Project

Job Number 41-26457
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Land systems and soils

Figure 5-3
Sheet 4 of 7

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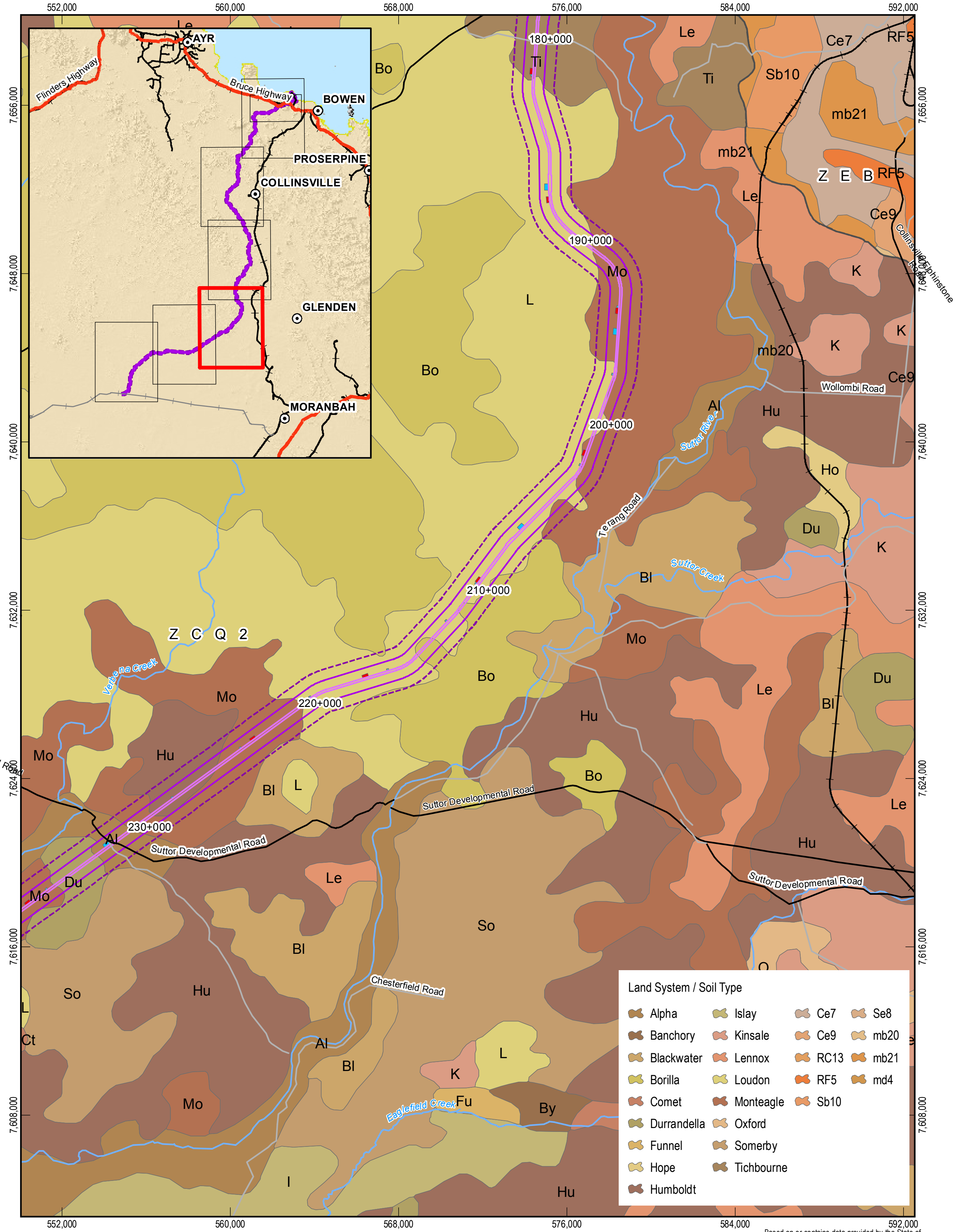
Data source: GA: Populated Places, Railway, Watercourse/2007; Adani: NGBR Corridor 06/06/2013, NGBR Corridor 13/05/2013, Carmichael Project Rail 23/07/2012, Ancilliary Infrastructure 2013; DNRM: Roads/2010; Conbined Soils/2010. Created by:MS



LEGEND

- Main Road
- Local Road
- Railway
- Watercourse (Major)
- North Galilee Basin Rail Baseline Study Area (1km buffer)
- North Galilee Basin Rail 1000m Corridor
- North Galilee Basin Rail 100m Corridor
- Ancillary Infrastructure Areas
- Bridge Laydown Area
- Track Laydown Area
- Turning Circle

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1:250,000 Paper Size A4

0 2 4 8

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

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Adani Mining Pty Ltd
North Galilee Basin Rail Project

Job Number	41-26457
Revision	A
Date	30 Aug 2013

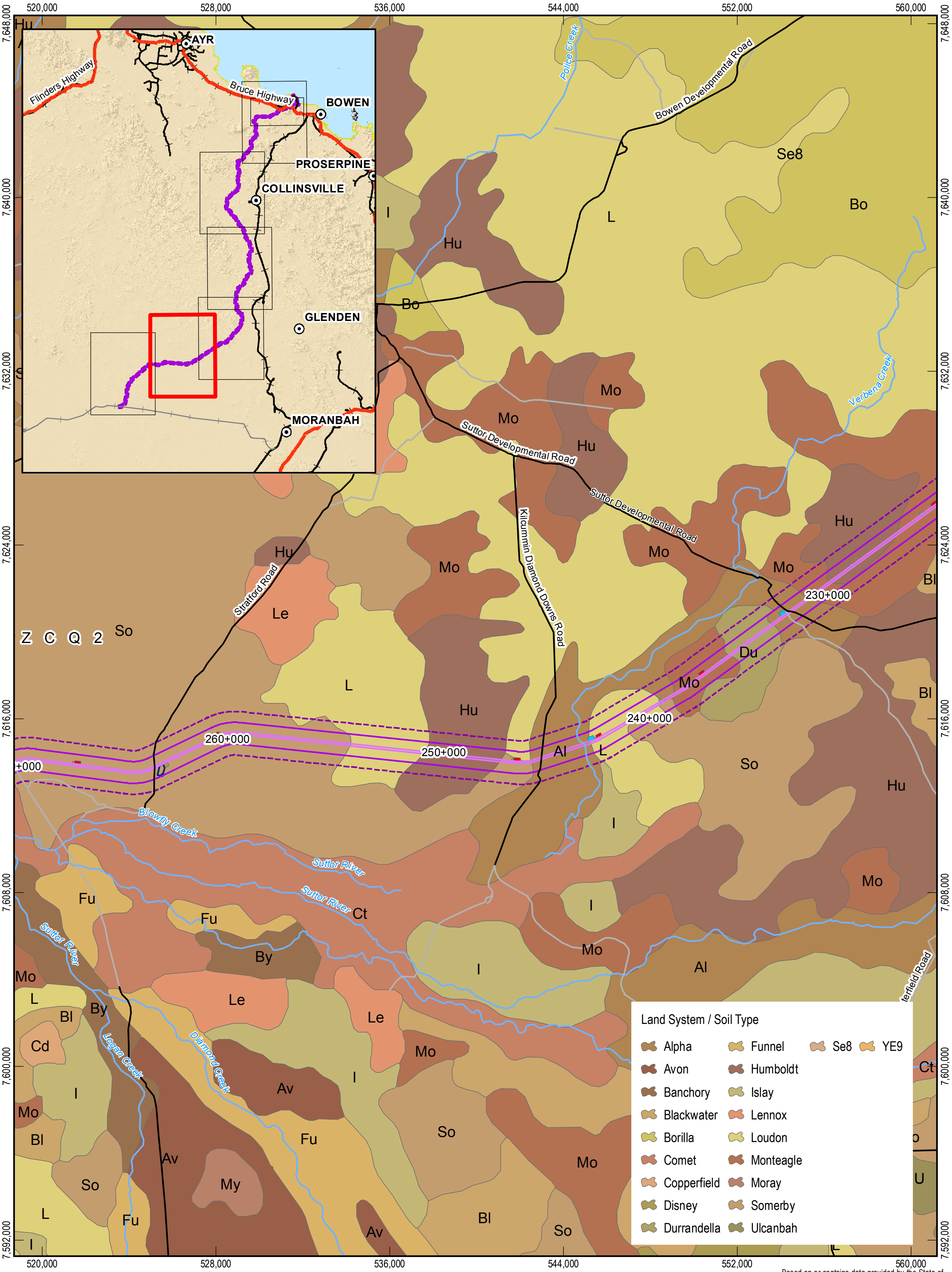
Land systems and soils

Figure 5-3
Sheet 5 of 7

G:\41\26457\06 GIS\Maps\MXD\0400_Geology_Soils\41_26457_0426_rev_a.mxd

Level 9, 145 Ann Street Brisbane QLD 4000 Australia T 61 7 3316 3000 F 61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data source: GA: Populated Places, Railway, Watercourse/2007; Adani: NGBR Corridor 06/06/2013, NGBR Corridor 13/05/2013, Carmichael Project Rail 23/07/2012, Ancillary Infrastructure 2013; DNRM: Roads/2010; Conbined Soils/2010. Created by:MS



LEGEND

- Main Road
- Local Road
- Watercourse (Major)
- North Galilee Basin Rail Baseline Study Area (1km buffer)
- North Galilee Basin Rail 1000m Corridor
- North Galilee Basin Rail 100m Corridor
- Ancillary Infrastructure Areas
- Bridge Laydown Area
- Concrete Batch Plant
- Construction Camp
- Track Laydown Area
- Turning Circle

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1:250,000 Paper Size A4

0 2 4 8

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

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Adani Mining Pty Ltd

North Galilee Basin Rail Project

Land systems and soils

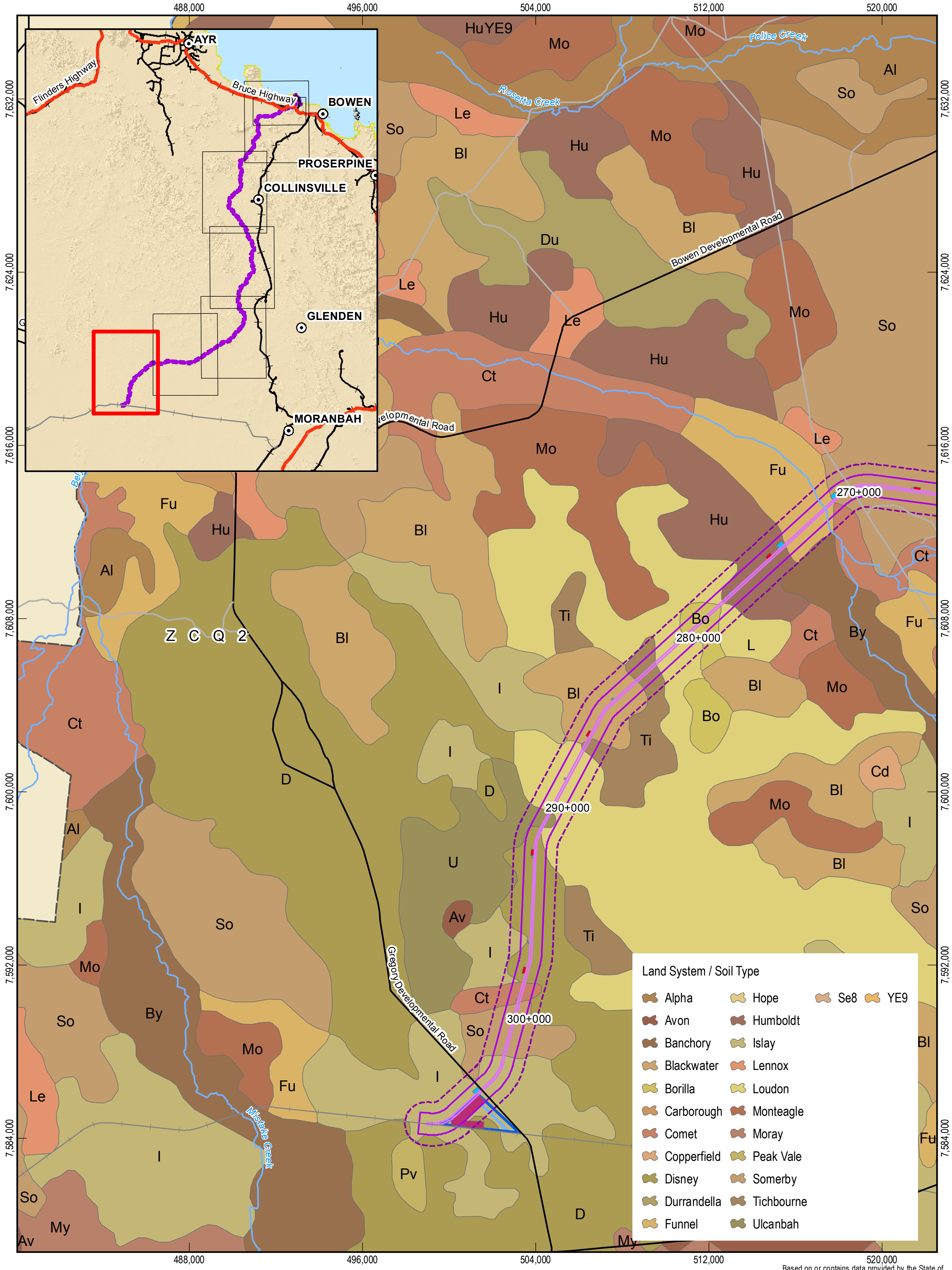
Job Number	41-26457
Revision	A
Date	30 Aug 2013

Figure 5-3
Sheet 6 of 7

G:\41\26457\06 GIS\Maps\MXD\0400_Geology_Soils\41_26457_0426_rev_a.mxd

Level 9, 145 Ann Street Brisbane QLD 4000 Australia T 61 7 3316 3000 F 61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data source: GA: Populated Places, Railway, Watercourse/2007; Adani: NGBR Corridor 06/06/2013, NGBR Corridor 13/05/2013, Carmichael Project Rail 23/07/2012, Ancilliary Infrastructure 2013; DNRM: Roads/2010; Conbined Soils/2010. Created by:MS



LEGEND

- Main Road
- Local Road
- Carmichael Project (Rail)
- Watercourse (Major)
- North Galilee Basin Rail Baseline Study Area (1km buffer)
- North Galilee Basin Rail 1000m Corridor
- North Galilee Basin Rail 100m Corridor
- Ancillary Infrastructure Areas
- Bridge Laydown Area
- Construction Depot Area
- Rail Precinct Area
- Track Laydown Area
- Turning Circle

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1:250,000 Paper Size A4

0 2 4 8

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

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North Galilee Basin Rail Project

Job Number 41-26457
Revision A
Date 30 Aug 2013

Land systems and soils

Figure 5-3
Sheet 7 of 7

G:\41\26457\06 GIS\Maps\MXD\0400_Geology_Soils\41_26457_0426_rev_a.mxd

Level 9, 145 Ann Street Brisbane QLD 4000 Australia T 61 7 3316 3000 F 61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data source: GA: Populated Places, Railway, Watercourse/2007; Adani: NGBR Corridor 06/06/2013, NGBR Corridor 13/05/2013, Carmichael Project Rail 23/07/2012, Ancilliary Infrastructure 2013; DNRM: Roads/2010; Conbined Soils/2010. Created by:MS

5.3.4 Good quality agricultural land

The term GQAL applies to any set of agricultural land classes that are determined by a local government to have agricultural characteristics important to the local economy. Agricultural land classes are defined in Table 5-8.

The majority of the final rail corridor is located with the Whitsunday Regional Council, with only 35.75 km of the 306.9 km final rail corridor positioned within the Isaac Regional Council. The Isaac Regional Council considers class A, B and C1 as GQAL, whereas the Whitsunday Regional Council considers class A and B as GQAL

Table 5-8 Agricultural land classes

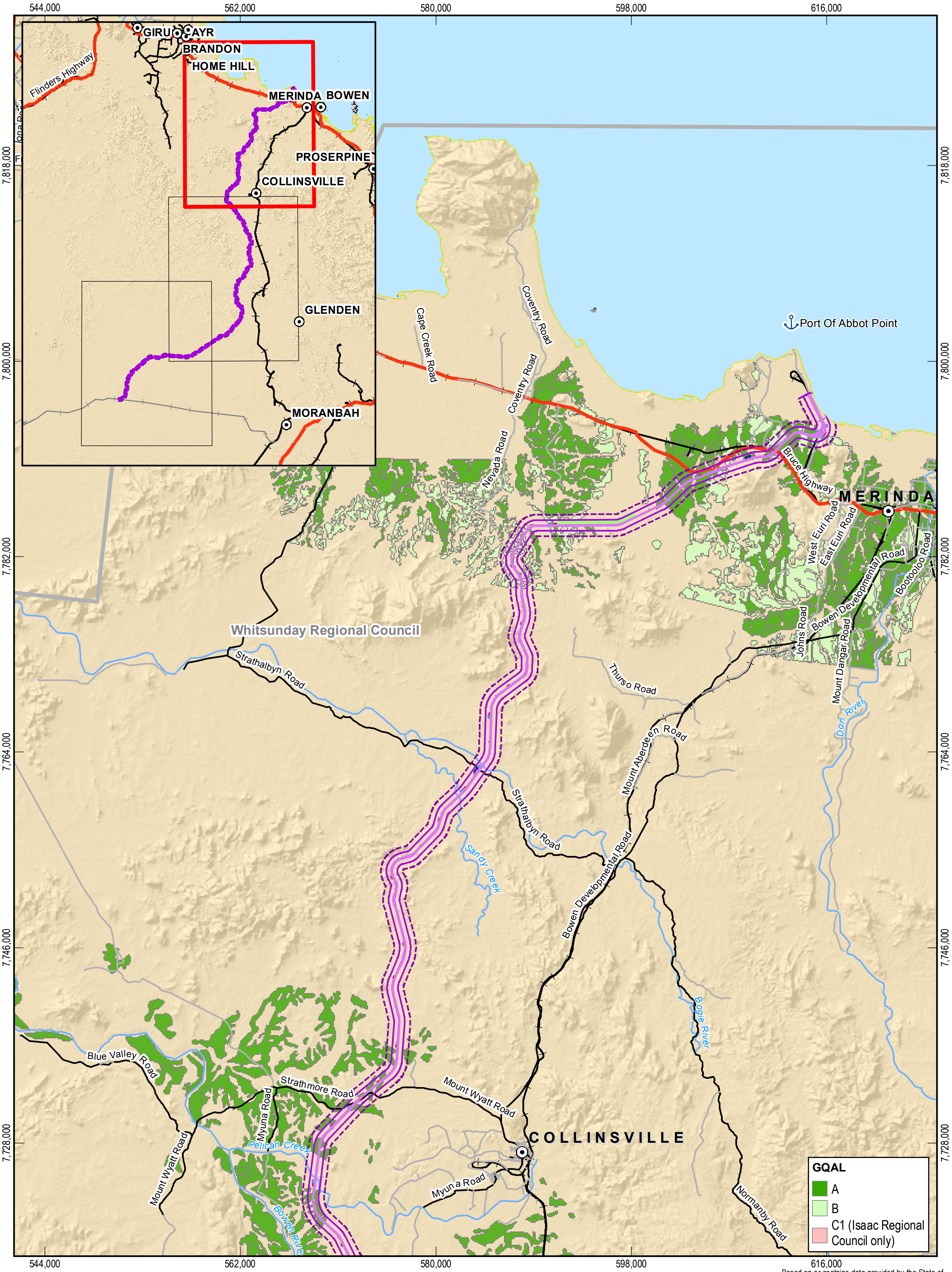
Class	Definition
A	Crop land - land that is suitable for current and potential crops with limitations to production that ranges from none to moderate.
B	Limited crop land - land that is marginal for current and potential crops due to severe limitations; and suitable for pastures. Engineering and/or agronomic improvements may be required before the land is considered suitable for cropping.
C1	Pasture land – suitable for grazing high quality pastures, either sown pastures where ground disturbance is possible for pasture establishment or native pastures on higher fertility soils. Land that is suitable only for pastures due to limitations which preclude continuous cultivation for crop production.
C2	Pasture land – suitable for grazing native pastures with or without the addition of pasture species introduced without ground disturbance. Land that is suitable only for pastures due to limitations which preclude continuous cultivation for crop production.
C3	Pasture land – suitable for light grazing of native pastures in accessible areas, otherwise very steep land more suited to forestry, conservation or catchment protection. Land that is suitable only for pastures due to limitations which preclude continuous cultivation for crop production.
D	Non-agricultural land - land not suitable for agricultural uses due to extreme limitations. This may be undisturbed land with significant habitat, conservation and/or catchment values or land that may be unsuitable because of very steep slopes, shallow soils, rock outcrop or poor drainage.

Source: DPI 1993

A total of 1,669.52 ha of land intersected by the final rail corridor is classified as GQAL, Class A, B and C1 (refer Figure 5-4). The coverage of GQAL within the study area will be confirmed in accordance with a specific field survey methodology (refer to Table 5-9 for distribution of GQAL according to class, regional council and footprint).

Table 5-9 Distribution of areas of GQAL within relevant regional councils

Regional council	Footprint	GQAL	Area (ha)
Whitsunday	Final rail corridor	A	314.64
		B	609.7
	Ancillary infrastructure footprint	A	93.59
		B	119.43
Isaac	Final rail corridor	A	0
		B	58.54
		C1	129.24
	Ancillary infrastructure footprint	A	0
		B	3.05
		C1	341.33



LEGEND

- Population Centres
- Major Port
- Highway
- Main Road
- Local Road
- Railway
- Watercourse (Major)
- Local Government Area
- North Galilee Basin Rail Baseline study area (1km buffer)
- North Galilee Basin Rail 1000m Corridor
- North Galilee Basin Rail 100m Corridor
- Ancillary Infrastructure Areas
  - Bridge Laydown Area
  - Concrete Batch Plant
  - Construction Camp
- Rolling Stock Maintenance Depot
- Track Laydown Area
- Turning Circle

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1:500,000 Paper Size A4

0 4.5 9 18

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

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Good quality agricultural land

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Figure 5-4
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Level 9, 145 Ann Street Brisbane QLD 4000 Australia T 61 7 3316 3000 F 61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

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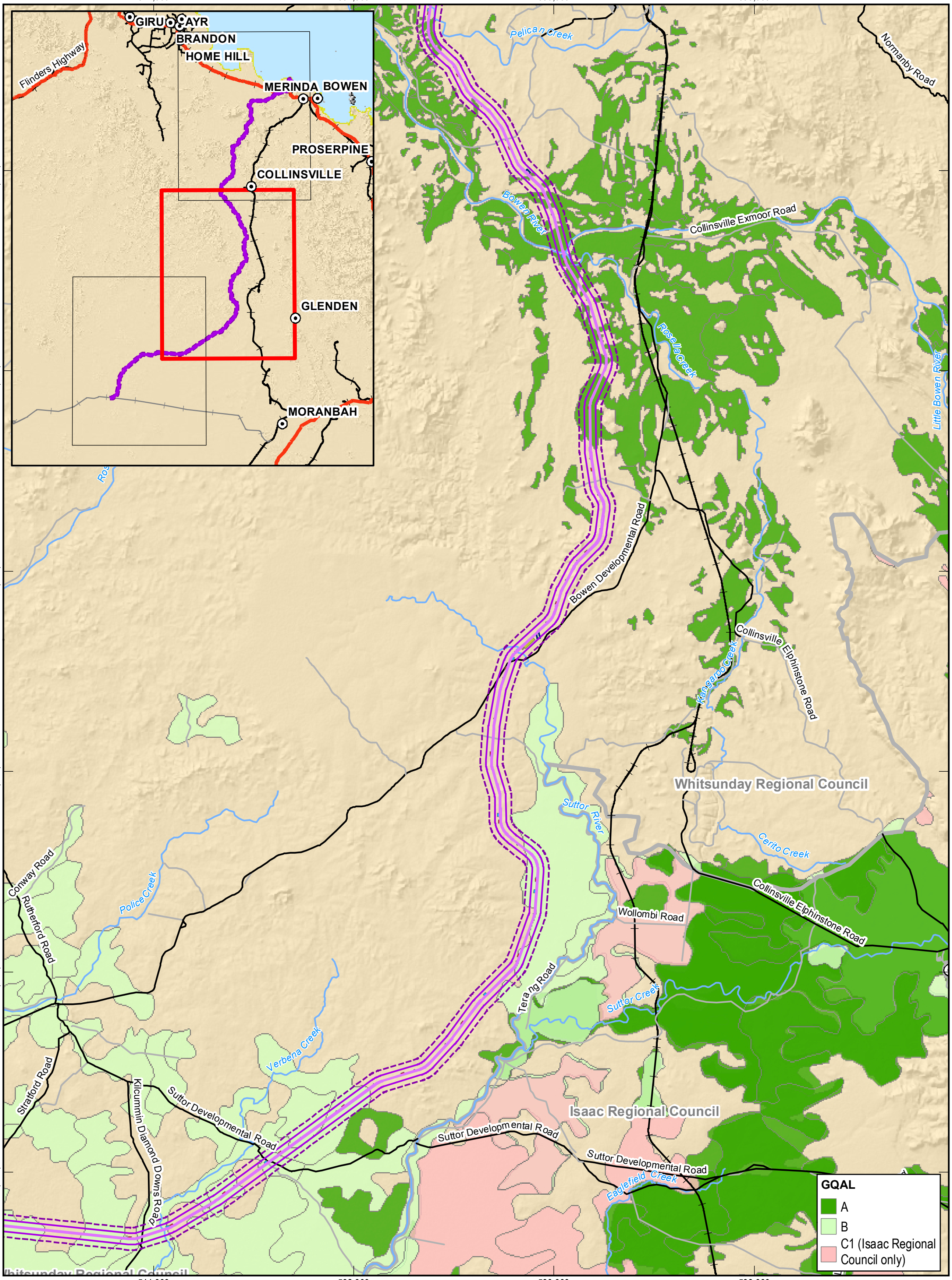

LEGEND

- Population Centres
- Main Road
- Local Road
- Railway
- Watercourse (Major)
- Local Government Area
- North Galilee Basin Rail Baseline study area (1km buffer)
- North Galilee Basin Rail 1000m Corridor
- North Galilee Basin Rail 100m Corridor
- Ancillary Infrastructure Areas
- Bridge Laydown Area
- Concrete Batch Plant
- Construction Camp
- Construction Yard
- Track Laydown Area
- Turning Circle

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Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

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North Galilee Basin Rail Project

Good quality agricultural land

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Figure 5-4
Sheet 2 of 3

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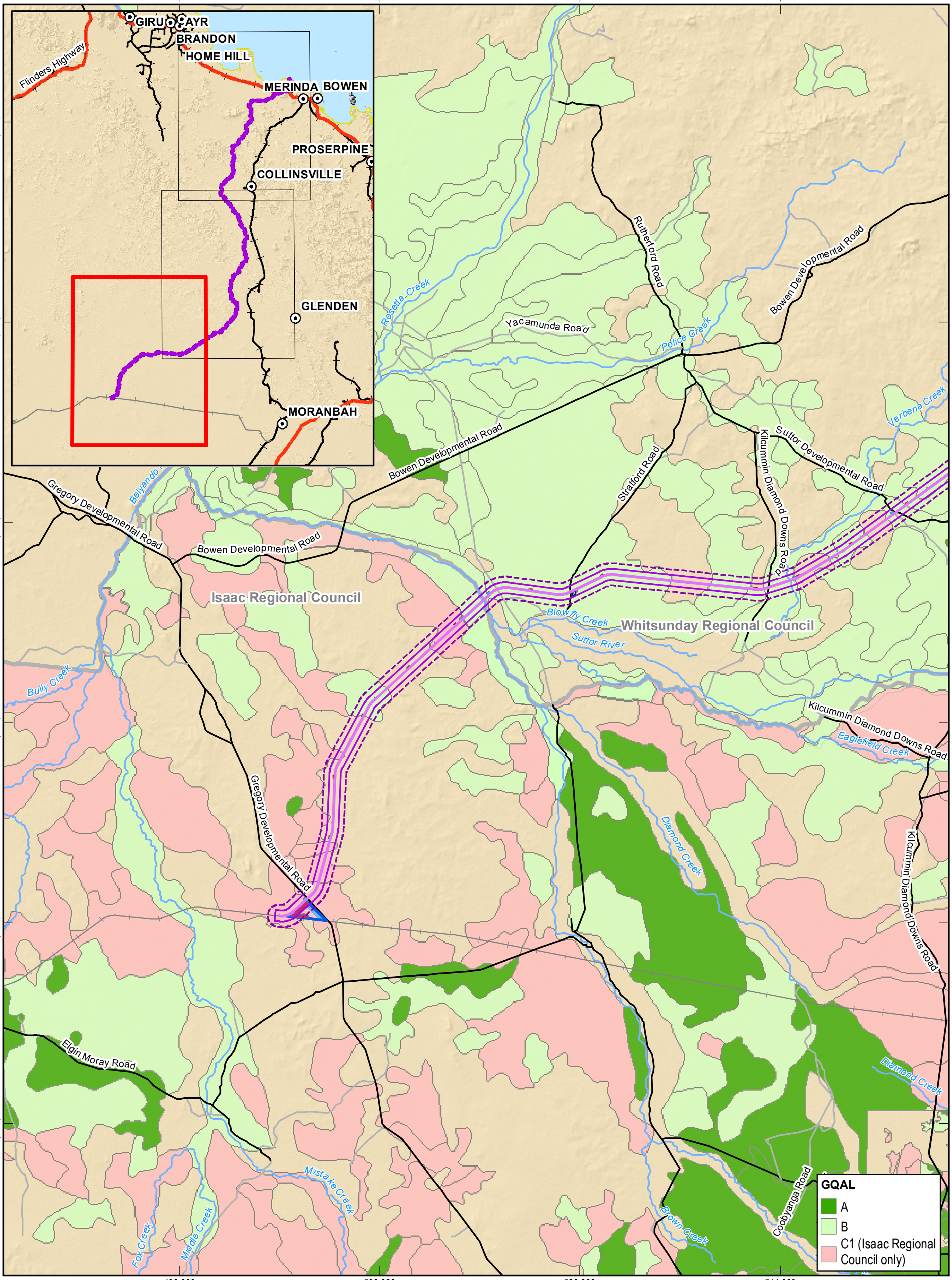
Level 9, 145 Ann Street Brisbane QLD 4000 Australia T 61 7 3316 3000 F 61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data source: GA: Populated Places, Railway, Watercourse/2007; Adani: NGBR Corridor 06/06/2013, NGBR Corridor 13/05/2013, Carmichael Coal Rail EIS 23/07/2012; DNRM: Roads/2010, GQAL/2010. Created by:MS



LEGEND

- Main Road
- Local Road
- Carmichael Project (Rail)
- Watercourse (Major)
- Local Government Area
- North Galilee Basin Rail Baseline study area (1km buffer)
- North Galilee Basin Rail 1000m Corridor
- North Galilee Basin Rail 100m Corridor

Ancillary Infrastructure Areas

- Bridge Laydown Area
- Concrete Batch Plant
- Construction Camp
- Construction Depot Area
- Rail Precinct Area
- Track Laydown Area
- Turning Circle

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1:500,000 Paper Size A4

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Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

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Good quality agricultural land

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Figure 5-4
Sheet 3 of 3

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5.3.5 Strategic cropping land

Strategic cropping land (SCL) is an important, finite resource that is subject to competing land uses from the agriculture, mining and urban development sectors. The *Strategic Cropping Land Act 2011* (SCL Act) aims to strike a balance between these sectors to help maintain the long-term viability of food and fibre industry and support economic growth in regional communities.

The purposes of the SCL Act are to:

(a) protect land that is highly suitable for cropping; and

(b) manage the impacts of development on that land; and

(c) preserve the productive capacity of that land for future generations.

The Act seeks to achieve these objectives by:

- Identifying potential SCL
- Providing criteria to decide whether or not land is SCL
- Establishing protection and management areas
- Providing for development assessment
- Imposing conditions on development
- Preventing permanent impacts on SCL in protection areas (unless the development is in exceptional circumstances)
- Requiring mitigation to be paid by developers if SCL is permanently impacted in the management area, or by a development in exceptional circumstances.

The SCL assessment identified 18 individual polygons within the final rail corridor and eight polygons within the ancillary infrastructure footprints encompassed by ten properties within the Western Cropping zone and Coastal Queensland zone (refer Figure 5-5).

In accordance with the SCL Act, SCL areas within a management zone are required to pass the history of cropping (HOC) test. If the SCL area fails this test, the site does not qualify as SCL. Sections 46, 49 and 50 of the SCL Act set out the requirements for demonstrating whether or not a property has the required HOC. A HOC assessment requires that at least three cropping events occurred on the property from 1 January 1999 to 31 December 2010. A HOC test was undertaken using available LANDSAT imagery and Google imagery on those properties that contained mapped SCL polygons intersected by the study area.

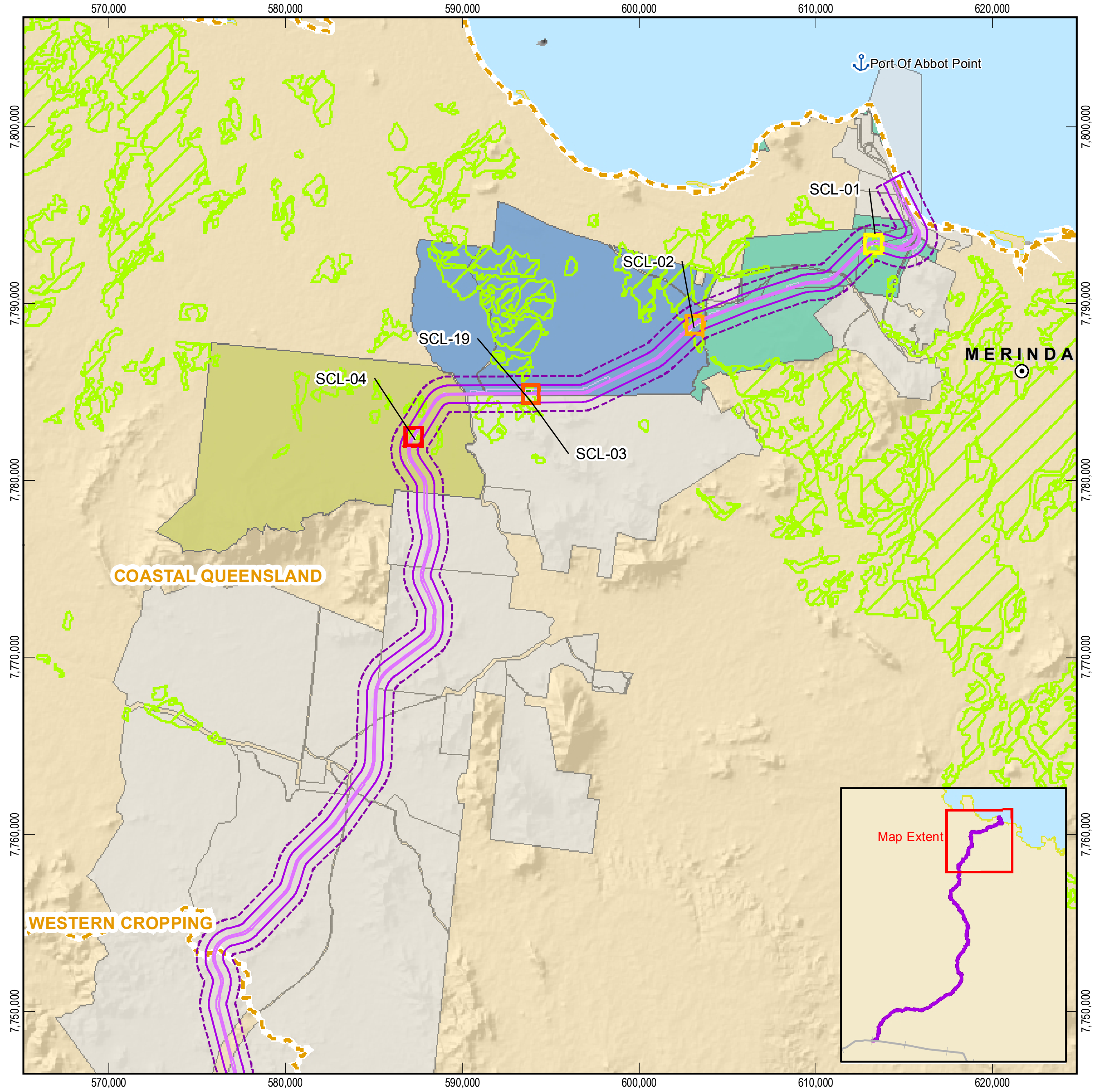
The HOC analysis indicated that nine of the ten properties fail the HOC analysis, with Birralee the only property to have cropping identified from LANDSAT and Google Imagery. Six SCL polygons, four within the final rail corridor and two within ancillary infrastructure footprints, were confined to the Birralee property. A total of 12.01 ha of SCL passed the HOC within the final rail corridor, and 5.09 ha of SCL passed the HOC within the ancillary infrastructure footprints.

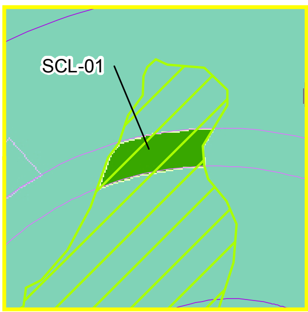
SCL is divided in five zones across Queensland, which reflects regional differences in climate, land forms and cropping systems. These zones are sub-divided into management areas and protection areas. The NGBR Project study area intersects two of the five zones, the Western Cropping and Coastal Queensland zones. The criteria for assessing SCL are slightly different between the Western Cropping and Coastal Queensland zones, and are provided in Table 5-10.

Table 5-10 SCL field criteria for western cropping and coastal Queensland

Criteria	SCL zone	
	Western cropping	Coastal Queensland
Slope	Less than or equal to 3 %	Less than or equal to 5 %
Rockiness	Less than or equal to 20 % for rocks greater than 60 mm in diameter	
Gilgai microrelief	Greater than 50 % of land surface being gilgai microrelief of greater than 500 mm in depth	
Soil depth	Greater than or equal to 600 mm	
Soil wetness	Has favourable drainage	
Soil pH	For non-rigid soils, the soil at 300 mm and 600 mm soil depth must be greater than pH 5.0. For rigid soils, the soil at 300 mm and 600 mm soil depth must be within the range of pH 5.1 to pH 8.9 inclusive.	
Salinity	Chloride content less than 800 mg/kg within 600 mm of the soil surface	Electrical conductivity (one part soil to five parts water) less than 0.56 dS/m within 600 mm of the soil surface
Soil water storage	Greater than or equal to 100 mm to a soil depth or soil physico-chemical limitation of less than or equal to 1,000 mm	Greater than or equal to 75 mm to a soil depth or soil physico-chemical limitation of less than or equal to 1,000 mm

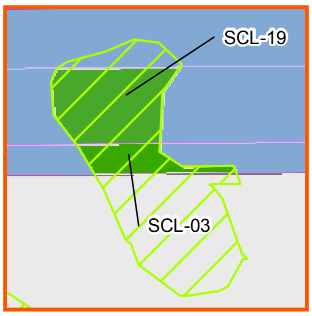
An assessment of the SCL trigger mapping of the relevant zones and constituent management and protection areas was conducted to identify potential SCL in the study area. As LIDAR data was available across the study area, a slope analysis was derived on a 20 m grid. The slope analysis was applied to the Birralee property and indicates these polygons pass the first of the eight verification criteria (i.e. slope). The remaining seven criteria are required to be assessed as part of a field assessment.





Property: MIDQ

Property: Salisbury Plains



Property: Salisbury Plains

Property: Nevada

LEGEND

- Population Centres
- Major Port
- Strategic Cropping Land within Project Footprint
- Strategic Cropping Land

Slope criteria
- <5%
- >5%
- Strategic Cropping Land Zones

Intersected Properties
- MIDQ
- Nevada
- Salisbury Plains

- No Impact
- North Galilee Basin Rail Baseline study area (1km buffer)
- North Galilee Basin Rail 1000m Corridor
- North Galilee Basin Rail 100m Corridor
- Ancillary Infrastructure

1:350,000 Paper Size A4
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Kilometres
Horizontal Datum: GDA 1994
Grid: GCS GDA 1994

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North Galilee Basin Rail Project

Slope analysis on Strategic Cropping Land

Job Number	41-26457
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Date	30 Aug 2013

Figure 5-5
Sheet 1 of 4

G:\41\26457\06 GIS\Maps\MXD\0400_Geology_Soils\41_26457_0434c_rev_c.mxd

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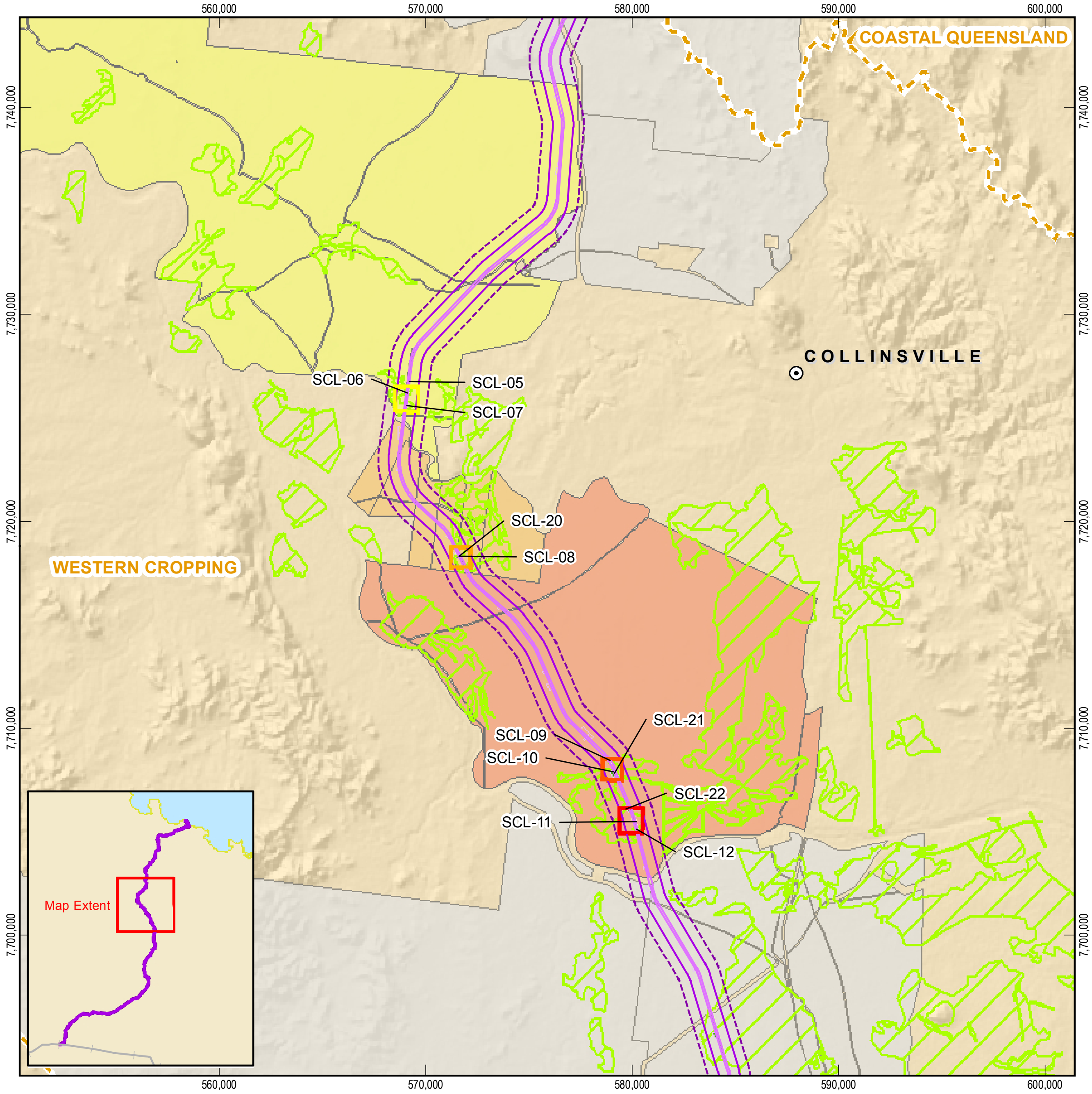
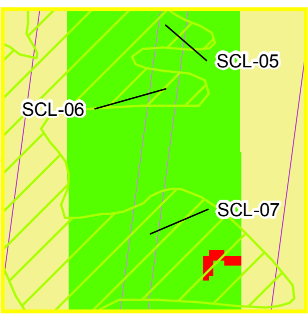
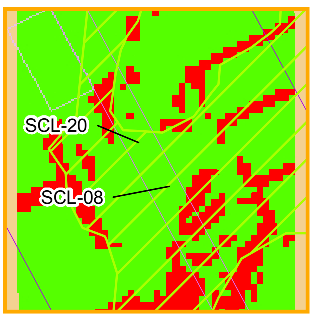
Data source: GA: Populated Places/2007; Adani: NGBR Corridor 06/06/2013, NGBR Corridor 13/05/2013, Ancilliary Infrastructure/2013;
DNRM: Strategic Cropping Land Zones/2012, Stategic Cropping Land/2012, Cadastre/2013. Created by:MS

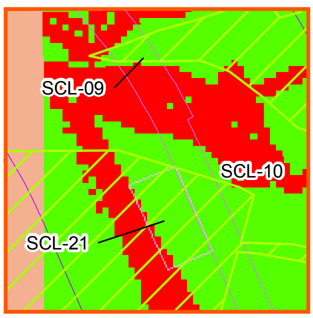




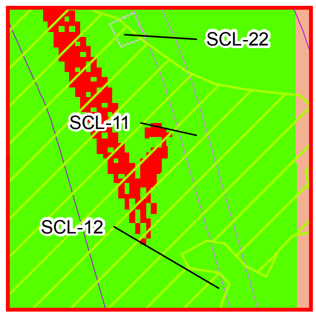
Property: Strathmore



Property: Myuna



Property: Birralee



Property: Birralee

LEGEND

- Population Centres
- Strategic Cropping Land within Project Footprint
- Strategic Cropping Land

Slope
- <3%
- >3%
- Strategic Cropping Land Zones

Intersected Properties
- Birralee
- Myuna (Pt)
- Strathmore

- No Impact
- North Galilee Basin Rail Baseline study area (1km buffer)
- North Galilee Basin Rail 1000m Corridor

- North Galilee Basin Rail 100m Corridor
- Ancillary Infrastructure

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1:300,000 Paper Size A4

0 2.5 5 10

Kilometres

Horizontal Datum: GDA 1994
Grid: GCS GDA 1994

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Adani Mining Pty Ltd
North Galilee Basin Rail Project

Slope analysis on Strategic Cropping Land

Job Number	41-26457
Revision	B
Date	30 Aug 2013

Figure 5-5
Sheet 2 of 4

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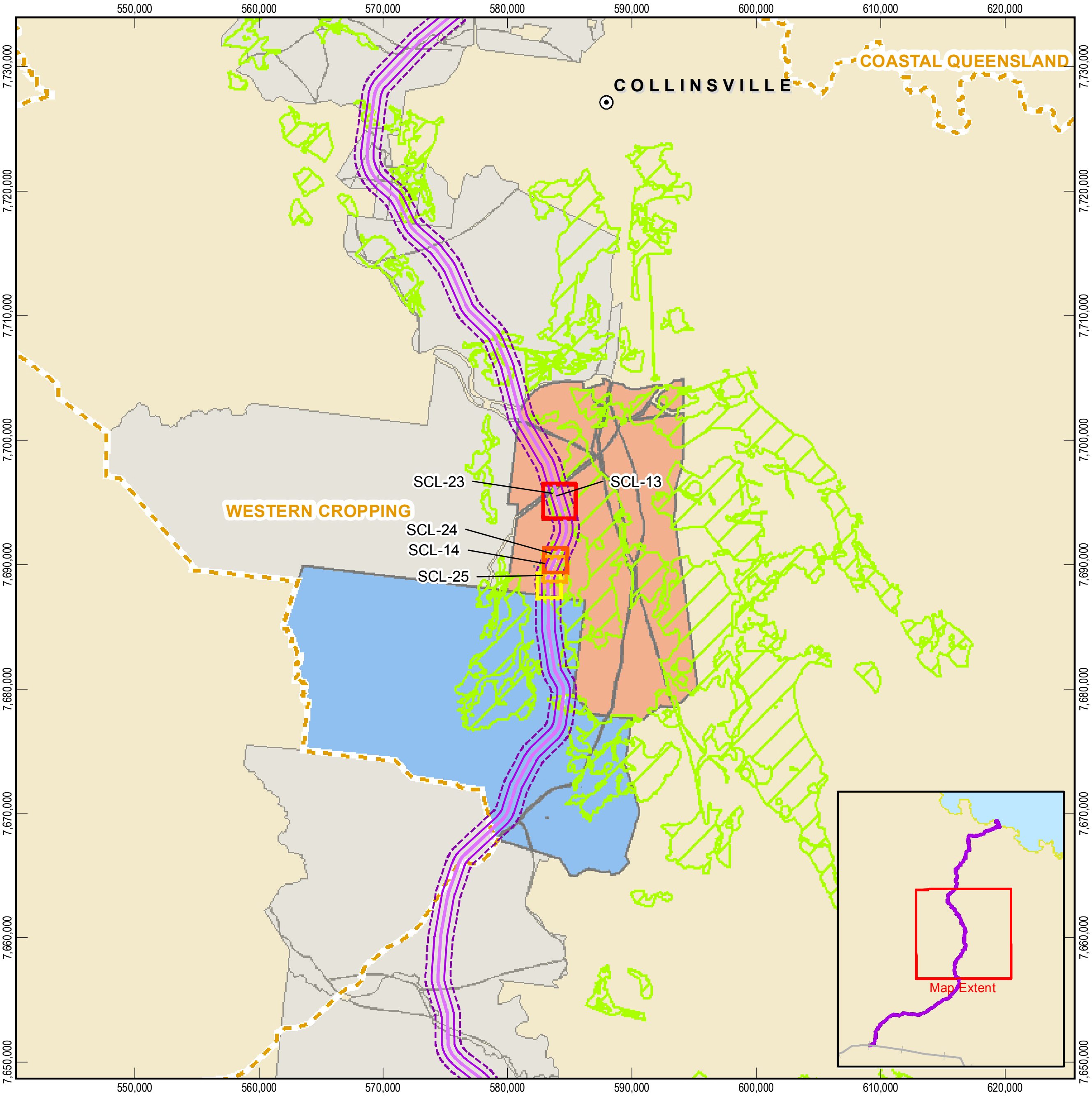
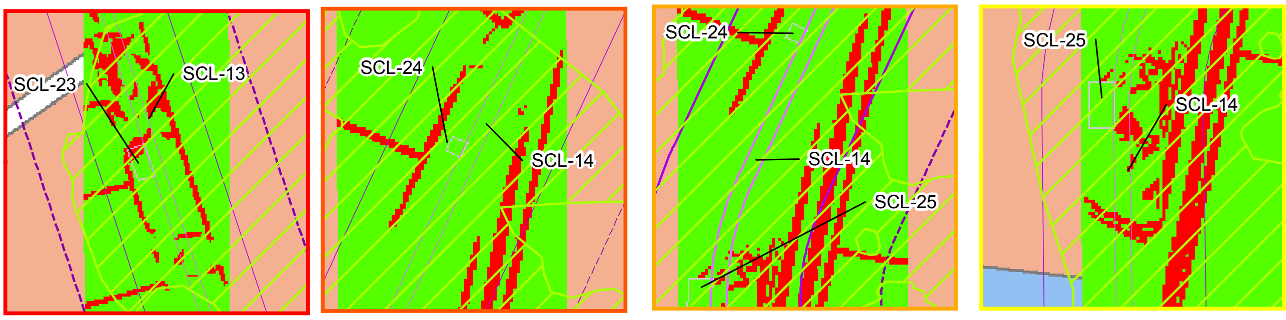
Data source: GA: Populated Places/2007; Adani: NGBR Corridor 06/06/2013, NGBR Corridor 13/05/2013, Ancilliary Infrastructure/2013; DNRM: Strategic Cropping Land Zones/2012, Stategic Cropping Land/2012, Cadastre/2013. Created by:MS





Property: Havilah | Property: Havilah | Property: Havilah | Property: Havilah

LEGEND

- Population Centres
- Strategic Cropping Land within Project Footprint
- Strategic Cropping Land

Slope
- <3%
- >3%
- Strategic Cropping Land Zones

Intersected Properties
- Fig Tree
- Havilah

- No Impact
- North Galilee Basin Rail Baseline study area (1km buffer)
- North Galilee Basin Rail 1000m Corridor
- North Galilee Basin Rail 100m Corridor
- Ancillary Infrastructure

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Kilometres
Horizontal Datum: GDA 1994
Grid: GCS GDA 1994

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North Galilee Basin Rail Project

Slope analysis on Strategic Cropping Land

Job Number	41-26457
Revision	D
Date	30 Aug 2013

Figure 5-5
Sheet 3 of 4

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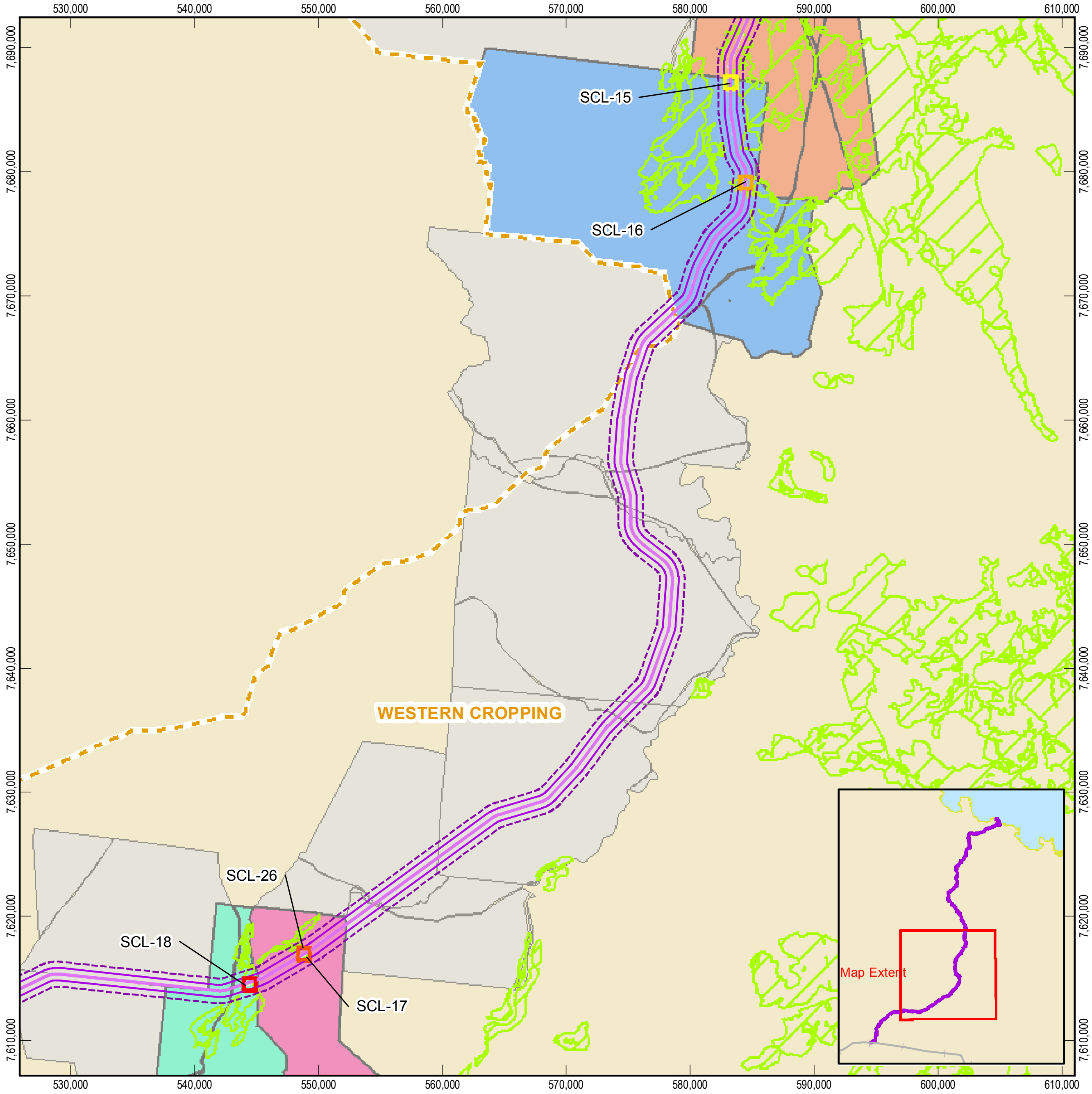
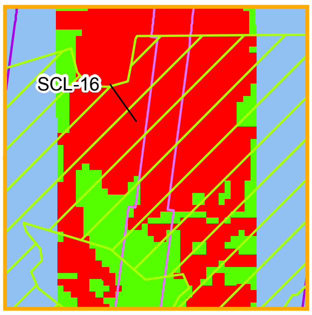
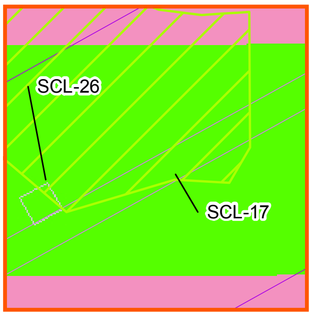
Data source: GA: Populated Places/2007; Adani: NGBR Corridor 06/06/2013, NGBR Corridor 13/05/2013, Ancilliary Infrastructure/2013;
DNRM: Strategic Cropping Land Zones/2012, Stategic Cropping Land/2012, Cadastre/2013. Created by:MS



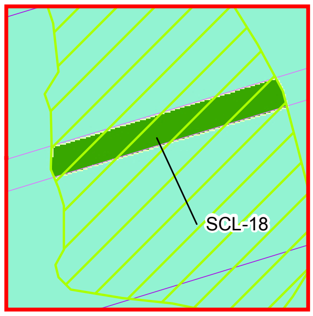
Property: Fig Tree



Property: Fig Tree



Homestead: Cantaur Park



Homestead: Glenavon

LEGEND

- Population Centres
- Strategic Cropping Land within Project Footprint
- Strategic Cropping Land

Slope
- <3%
- >3%
- Strategic Cropping Land Zones

Intersected Properties
- Cantaur Park
- Fig Tree
- Glen Avon
- Havilah

- No Impact
- North Galilee Basin Rail Baseline study area (1km buffer)
- North Galilee Basin Rail 1000m Corridor
- North Galilee Basin Rail 100m Corridor
- Ancillary Infrastructure

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1:25,000 Paper Size A4
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Kilometres
Horizontal Datum: GDA 1994
Grid: GCS GDA 1994

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North Galilee Basin Rail Project

Slope analysis on Strategic Cropping Land

Job Number	41-26457
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Figure 5-5
Sheet 4 of 4

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Data source: GA: Populated Places/2007; Adani: NGBR Corridor 06/06/2013, NGBR Corridor 13/05/2013, Ancilliary Infrastructure/2013;
DNRM: Strategic Cropping Land Zones/2012, Stategic Cropping Land/2012, Cadastre/2013. Created by:MS

5.3.6 Acid sulfate soils

State Planning Policy 2/02 Planning and Managing Development Involving Acid Sulfate Soils (SPP 2/02) designates a number of conditions where assessment of acid sulfate soil is required, in relation to elevation on the Australian Height Datum (mAHD):

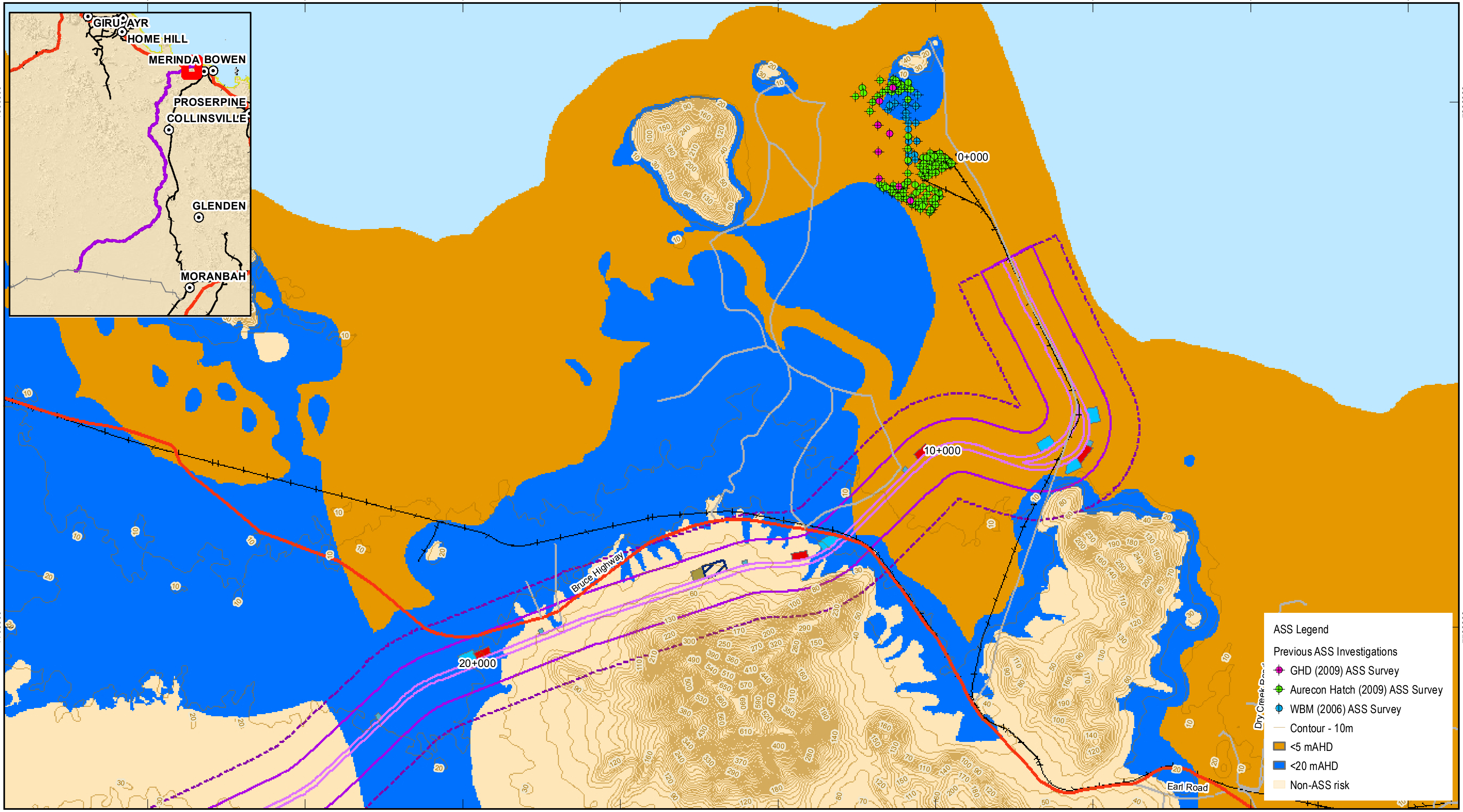
- If surface elevation is over 20 mAHD, no further assessment is required
- If surface elevation is between five mAHD and 20 mAHD and no excavation is proposed, no further assessment is required
- If surface elevation is between five mAHD and 20 mAHD, and excavation is proposed below five mAHD but is less than 100 m^3, no further assessment is required
- If surface elevation is between five mAHD and 20 mAHD, and excavation of more than 100 m^3 is proposed below five mAHD, further assessment is required
- If surface elevation is at or below five metres AHD, further assessment is required.

Areas with a risk of acid sulfate soils were identified through a review of topographic and geological mapping. This assessment was supplemented by a review of previous studies conducted within the study area.

The State Planning Policy 2/02 requires acid sulfate soils to be considered when surface elevations of 20 mAHD or less are encountered. There are two portions of the study area that are at or below 20 mAHD:

- 9.3 km, between chainages 3.4 km to 12.7 km, associated with multiple minor ephemeral creeks, including Saltwater Creek
- 3.6 km, between chainage 19.1 km and chainage 22.7 km, associated with Splitters Creek.

The initial 8.6 km of the 9.3 km portion is at or below five mAHD (refer Figure 5-6).



1:100,000 (at A4)

0 1,000 2,000 3,000

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

LEGEND

- Highway
- Local Road
- Railway
- North Galilee Basin Rail 1000m Corridor
- North Galilee Basin Rail 100m Corridor
- North Galilee Basin Rail Baseline Study Area (1km buffer)

Ancillary Infrastructure Areas

- Bridge Laydown Area
- Concrete Batch Plant
- Construction Camp
- Track Laydown Area
- Turning Circle

Adani Mining Pty Ltd
North Galilee Basin Rail Project

Job Number 41-26457
Revision A
Date 30-08-2013

Acid sulfate soils

Figure 5-6

G:\41\26457\06 GIS\Maps\MXD\0400_Geology_Soils\41_26457_0430_rev_b.mxd Level 9, 145 Ann St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data source: DNRM: DEM (2008), © Commonwealth of Australia (Geoscience Australia): Localities, Railways, Roads, Watercourse (2007); Adani: Project Rail Alignment, Camp Sites, Alignment Functional Areas (2013). Created by: MS

5.3.7 Contaminated land

The legislative requirements covering contaminated land in Queensland are primarily contained in the *Environmental Protection Act 1994* (EP Act) and subordinate regulations and policies. Schedule 3 of the EP Act lists a number of notifiable activities related to land contamination.

A review of the Department of Environment and Heritage Protection (DEHP) Environmental Management Register (EMR) and Contaminated Land Register (CLR) was conducted for all allotments intersected by the final rail corridor. A total of 60 lots were searched, which does not include the eight parcels of land identified as easements. Of the 60 lots within the final rail corridor, six lots were identified as listed on the EMR, four of which were lots split from a single parent lot which was listed on the EMR. No allotments were listed on the CLR. The DEHP was contacted for further information pertaining to those properties that are listed on the EMR. The search conducted by DEHP on its database did not yield any substantial information regarding the site condition or environmental incidences associated with the EMR listings. Table 5-11 provides the chainage and property details of properties listed on the EMR that are intersected by the preliminary investigation corridor.

Table 5-11 Contaminated properties listed on the EMR

Lot on plan	Location of property (chainage)	Petroleum product or oil storage	Livestock dip or spray race
Lot 3 SP194889 (subdivided from Lot 1 RP738758)	4.3 km to 5.7 km	✓	
Lot 2 RP748627 (subdivided from Lot 1 RP738758)	5.3 km to 5.5 km	✓	
Lot 1 RP748627 (subdivided from Lot 1 RP738758)	5.3 km to 5.6 km	✓	
Lot 4 SP194889 (subdivided from Lot 1 RP738758)	5.3 km to 5.6 km	✓	
Lot 1 SB279	42.6 km to 47 km		✓
Lot 618 PH2106	117 km to 132 km	✓	✓

5.4 Potential impacts and mitigation measures

This section assesses the potential construction and operation impacts of the NGBR Project on topography, geology, soils and land contamination. This includes:

- Topography, landform and geology
- Soil resources
- Good Quality Agricultural Land
- Strategic Cropping Land
- Acid sulfate soils
- Contaminated land.

5.4.1 Construction

Topography, landform and geology

Construction of the NGBR Project will require cut and fill activities as well as the formation of batter slopes and embankments. These activities will result in localised changes to landform contours and topography in several locations along the preliminary investigation corridor. The need for deep cuts (>15 m) is required at nine locations, with approximately 3.4 km of cut greater than 15 m in depth. The need for deep fills (>15 m) is required at 11 locations, with approximately 4.5 km of fill greater than 15 m in depth. The rail embankment would reach a maximum height of approximately 25 m in some locations. The majority of these significant cut and fill locations are concentrated around the Leichhardt Range and Clarke Range (refer Volume 1 Chapter 2 Project description). Design of the NGBR Project final rail corridor aimed to minimise large cut or fill activities by avoiding steep terrain.

To inform detailed design of the NGBR Project, an extensive geotechnical investigation will be undertaken along the length of the final rail corridor and in locations of ancillary infrastructure. The geotechnical investigation will provide site specific geological data, including the suitability and stability of existing geological conditions for the construction of NGBR Project. This detailed information will inform the detailed design to ensure that structures are appropriately engineered. This data does not alter the conceptual design which has been utilised for this impact assessment.

Activities associated with construction of the NGBR Project have the potential to alter or impede overland surface flow and drainage patterns which may result in erosion and localised changes to topography over time.

Soil resources

Topsoil will be stripped during construction and stockpiled onsite for reuse during rehabilitation and landscaping. Topsoil known to contain noxious/declared weed seed will be stripped and stockpiled separately and respread in the general area from which it was obtained during rehabilitation.

A soil survey will be undertaken prior to construction commencing to identify soil types and develop a Soils Management Plan. The methodology for the soil survey is provided in Volume 2 Appendix E Topography, geology, soils and land contamination. An Erosion and Sediment Control Plan (ESCP) for construction will also be prepared and will outline measures to minimise erosion from exposed soils during vegetation clearing and stockpiling of topsoil.

The Soils Management Plan outlined in Table 5-12 will be included in the Environmental Management Plan (refer Volume 2 Appendix P Environmental management plan framework) and detail staging of vegetation clearing, grubbing, topsoil stripping and stockpiling.

A number of activities associated with construction of the NGBR Project have the potential to increase the risk of erosion including:

- Clearing of vegetation
- Topsoil stripping and stockpiling
- Major earthworks
- Construction of access tracks
- Activities in areas with steep or long slopes

- Activities in areas where soils exhibit high erodibility
- Construction during high rainfall events

The potential for erosion and sedimentation will increase for construction works on steep slopes or works during periods of high rainfall. Site-specific, adaptive erosion and sediment control measures will be established and maintained in accordance with the ESCP to minimise erosion from high risk locations and high rain-fall events.

Construction activities associated with bridge and culvert structures will also implement site-specific erosion and sedimentation measures to minimise the potential for sedimentation of waterways and drainage lines.

Erodibility of soils is a measure of the susceptibility of soil particles to detach from soil aggregates during rainfall and become mobile during runoff (Sunshine Coast Regional Council 2008). Factors affecting soil erodibility include texture, organic matter content, structure and permeability (Sunshine Coast Regional Council 2008).

Soils with a high erodibility potential within construction areas will be identified from physical and chemical analysis during a soil survey prior to construction commencing. Site-specific controls for areas of high erodibility potential will be included within the ESCP. Soil types intersected by the study area, as outlined in Section 5.3.3, have been classified as high or low based on the potential for erosion relating to impact on stormwater quality and receiving environments. This classification considers the expected soil physical and chemical properties. Soils allocated a higher risk are those with poor structure, those susceptible to structural decline following disturbance, and those with naturally high sodium levels. These soil characteristics would mean that they have potential to be dispersive and or result in high suspended loads in stormwater. The results of the initial soil risk classifications found that 18 high risk soils, five moderate risk soils and two low risk soils were identified and are further discussed in Volume 2 Appendix E Topography, geology, soils and land contamination. Further refinement of erosion risk will be established following a soil survey that will confirm soil types and distribution.

Sodic soils are susceptible to dispersion when wet (Hazelton & Murphy 2007) and will become problematic if exposed during construction activities. Dispersion of sodic soils may lead to surface crusting, low infiltration, low hydraulic conductivity, compaction of subsoils and increased susceptibility to erosion (Hazelton & Murphy 2007). Soils with potential sodic properties have been identified in Section 5.3.3 and Figure 5-3 and will be further identified during soil surveys prior to construction commencing. The Soils Management Plan outlined in Table 5-12 will include mitigation and management measures for sodic soils.

Certain chemical and physical properties of soils will restrict plant growth and may impact success of progressive rehabilitation. Such limiting properties include elevated sodicity, salinity, acidity and high alkalinity. The preconstruction soil surveys will also identify any limiting properties of soil units that may affect rehabilitation and landscaping.

Compaction of soils during construction works may affect physical and chemical, properties of the soil resource. Compaction increases soil density, reduces hydraulic conductivity surface water infiltration (Hazelton & Murphy 2007). Areas where ancillary and rail infrastructure will be located will be compacted as part of construction activities to improve soil stability for engineering purposes. Incidental compaction and settlement of soils within the final rail corridor will also occur due to the movement of vehicles and machinery.

Extensive clearing of vegetation from areas with a high water table has the potential to impact localised groundwater levels. As a result, soluble salts within the soil profile may mobilise and accumulate at the soil surface, causing secondary salinisation of topsoil. Areas with existing high water tables within the NGBR final rail corridor are located adjacent to watercourses however, given the extent of vegetation clearing required in these locations, occurrence of secondary salinisation is considered unlikely.

Land systems and soil units characterised by gilgai that have the potential to occur with the final rail corridor have been identified in Section 5.3.3. Further soil survey prior to construction commencing will determine extent, variability and problematic soils within gilgai areas and specific mitigation and management measures will be included with the Soils Management Plan.

Irrigation of treated effluent can cause changes in soil chemical and physical characteristics that may positively or negatively impact on the soil resource. Irrigation feasibility studies, including soil characterisation, will occur in areas where proposed irrigation is to be undertaken. Such studies will determine the suitability of soil for irrigation and model the potential of the soil and associated biomass to store and/or remove treated effluent and residual nutrients.

Progressive rehabilitation will be undertaken to stabilise temporarily disturbed areas as soon as is practical and in accordance with the following guidelines:

- Best Practice Erosion and Sediment Control. International Erosion Control Association (Australasia) (IECA 2008)
- Department of Environment and Heritage Protection, 2010, Urban Stormwater Quality Planning Guidelines, viewed 27 August 2013, http://www.ehp.qld.gov.au/water/policy/pdf/urban-water-web.pdf
- Manual for Erosion and Sediment Control Version 1.2. Sunshine Coast Regional Council, November 2008 (SRSC, 2008)
- Managing Urban Stormwater: Soils and Construction. Landcom, New South Wales Government (Landcom, 2004).Good Quality Agricultural Land

Construction of the final rail corridor will affect approximately 1,669.5 ha of land classified at GQAL (Class A, B and C1). The area on which rail infrastructure is to be placed, approximately 1,112.1 ha, will result in permanent sterilisation of this land as an agricultural resource. Topsoil will be stripped, prior to commencement of construction, and re-used during progressive rehabilitation activities. A further 557.4 ha of GQAL underlying ancillary infrastructure will result in a temporary loss of this area as an agricultural resource.

Approximately 1,264 ha of GQAL will become sterilised due to the final rail corridor and a further 405 ha will be temporarily sterilised due to ancillary infrastructure.

Potential impacts on GQAL have been avoided and minimised through route selection whereby GQAL constraints (amongst others) were considered. The final rail corridor largely avoids land mapped as being Class A GQAL and attempts to traverse the outer extremes of Class B mapped areas to avoid and minimise fragmentation. Consultation with affected landowners in relation to limiting the effects of fragmentation is ongoing. In the course of consultation, mitigation measures such as provision of stock crossings, limiting vehicle movement to designated access tracks and compensation arrangements are being discussed. Temporarily disturbed areas will be reinstated progressively after construction to pre-development equivalent conditions.

Impacts and mitigation strategies pertaining to erosion, secondary salinisation, compaction and irrigation of the soil resource are also applicable to GQAL.

Fossil presence

As the study area traverses areas that may contain fossils, including fossil material of flora in sedimentary material, a stop work procedure will be included in the Construction Environment Management Plan. The stop work procedure will include notification of appropriately qualified archaeologist advisor for fossil finds. Items will not be destroyed, damaged, moved, excavated or disturbed unless documented approval has been granted by the construction environmental manager.

The potential for fossils finds will be outlined in inductions to create awareness and train employees in the identification of archaeological material and actions to take in the case of a find.

Strategic cropping land

Only one property containing SCL polygon was identified as passing the HOC assessment (Birralee property, of which 17.1 ha is triggered SCL). An application forms for a protection or compliance decision will be submitted for this property to the Department of Natural Resource Management (DNRM). For properties containing SCL polygons that did not pass the HOC, application forms for validation of HOC are required for submission to DNRM. Mitigation or financial assurances will be paid by Adani following the outcome of consultation with DNRM.

The associated mitigation costs for the SCL that is to be permanently impacted will be paid in a staged manner, prior to the disturbance to each new area of SCL. This will cater for any changes to the final rail corridor and positioning of ancillary infrastructure, and ensure mitigation costs are paid only for those areas of SCL that will be impacted.

In submitting these forms, the justification for identifying the areas of permanent and / or temporary impacts will also be provided. A pre-lodgement meeting with DNRM will be held prior to submission of these applications. A detailed description of requirements for the validation, protection and compliance process is provided in Table 5-12.

Potential impacts on SCL have been avoided and minimised through numerous strategies. Where mapped SCL was unable to be avoided, the route selection process considered (amongst other environmental, social, cultural, economic and technical constraints) the placement of the final rail corridor such that it traverses around or as close as possible to, the edges of polygons to minimise fragmentation. Disturbances have been clustered together to reduce the overall footprint and reduce the extent of SCL fragmentation. Furthermore, impacts have been positioned at the extremities of cropping units or paddocks, or adjacent to areas where cropping is likely to be permanently impeded due to existing physical or logistical constraints on cropping e.g. roadways, shallow rocky soils and other existing landscape impediments to cropping.

Further measures to minimise the impact on SCL will be undertaken, including:

- Reducing the extent (area) of disturbance to the minimum that is practicable
- Limiting the duration of an activity, particularly relevant for ancillary infrastructure
- Minimising or preventing the severity and depth of soil excavation, soil mixing, compaction or contamination with foreign material
- Immediately reinstating and remediating temporary disturbances.

Impacts and mitigation strategies pertaining to erosion, secondary salinisation, compaction and irrigation of the soil resource are also applicable to SCL.

Acid sulfate soils

Construction works may impact on acid sulfate soils once confirmed during soils investigations conducted in the pre-construction phase.

Under the SPP 2/02, acid sulfate soils must be considered where surface elevation is at or below 20 m AHD. Two portions of the study area were identified as at or below 20 m AHD, and the chainages and expected activities are summarised below:

- The initial 9.3 km portion (chainages 3.4 km to 12.7 km), which has multiple minor ephemeral creeks, including Saltwater Creek. Construction activities are assumed to be predominately filling, with any potential excavation or piling associated with bridge structures.
- A 400 m portion between chainage 19.6 km and chainage 22.0 km, which is associated with Splitters Creek. The construction method will consist of filling, with excavation associated with bridge structures.

Construction in these areas will involve the use of suitable fill material, as well as potential excavation of piers for bridge structures over:

- Splitters Creek
- Bruce Highway
- North Coast rail line between and over Saltwater Creek
- Minor excavation to bed culverts at various locations will also be undertaken.

Chainage 19.6 km to 22 km is at approximately 20 m AHD, and limited excavation is expected at this point, the SPP 2/02 indicates that an acid sulfate soils assessment is not required in this area. However, between chainages 3.4 km and 12.7 km, surface elevation decreases to at or below five mAHD. The area at or below five mAHD is confined to the area between chainages 3.4 km and 9.9 km. As such, the initial acid sulfate soils investigation will only be undertaken between these chainages for an approximate length of 6.5 km. This assessment area will need to be refined following detailed design and confirmation of cut and fill areas.

Heaves and mud waves can occur where soft muds are compacted and covered by fill material, such as road base. Heaves and mud waves occur where compaction of one area produces associated rising of material in another area due to fluidity of the underlying soil structure. These disturbances can bring potential or actual acid sulfate soils to the surface and/or above the water table where they can be exposed to oxygen and become acid generating. Risk of heaves and mud waves will be determined following a detailed geotechnical investigation and, if applicable, management measures will be included in an Acid Sulfate Soil Management Plan.

Dewatering should be avoided where possible to ensure that Potential Acid Sulfate Soils (PASS) within the site and on adjacent properties is not exposed to oxygen during the construction phase of the NGBR Project. Subsequently, surrounding land and nearby waterways may become contaminated with acids and metals released from the sediments. Under acidic conditions, metals such as aluminium and iron, as well as trace heavy metals (including arsenic) become more mobile and are taken up by infiltrating waters. This may result in significant degradation or destruction of the ecosystem. This reaction may continue even with the re-saturation of sediment and in the absence of oxygen.

Under natural conditions, PASS are usually located below the water table. Groundwater levels of existing wells within the coastal plains range from 1.2 m to metres below ground level (Volume 2, Appendix H1 Water resources). Impact of dewatering will depend on depth of PASS in the soil profile; however, a shallow water table will require a larger quantity of water to be extracted, potentially exposing a greater amount of PASS. A risk assessment of dewatering activities will be developed in the Acid Sulfate Soils Management Plan.

Mitigation measures for addressing the impacts of acid sulfate soils include:

- Undertaking a detailed acid sulfate soils investigation in accordance with SPP 2/02 (refer Section 5.3.6)
- Developing an Acid Sulfate Soils Management Plan specifically tailored to the construction activities based on the results of the investigation.

Refer to Section 5.4.3 for requirements and considerations of development of an Acid Sulfate Soils Management Plan.

Contaminated land

Construction and operation activities have the potential to disturb land containing contaminants deposited through previous land use activities and release these contaminants into the environment. Construction and operation activities may also release new contaminants into the environment as a result of unintended spillages or accidents.

Three land parcels (six land parcels inclusive of subdivided properties) are listed on the EMR. The allotment at chainage 117 km to 132 km is listed for ‘livestock dip or spray race’ and ‘petroleum product or oil storage’. The allotment at chainage 42 km to 47 km is listed for ‘livestock dip or spray race’, and the allotments at chainage 4.3 km to 5.7 km are listed for ‘petroleum product or oil storage’. No properties intersected by the NGBR Project are registered on the CLR.

Additional investigations on all land within the final rail corridor will be undertaken in order to assess the contamination status and develop appropriate procedures to manage identified potential or actual contamination. Additional assessments will include a site inspection by a ‘suitably qualified person’ (in accordance with the EP Act) as a minimum. Consultation with affected land holders will also be required to ascertain the presence of additional notifiable activities or potentially contaminating activities in areas to be disturbed by the final rail corridor.

Further intrusive investigations may be required to assess the actual contamination status of areas within the final rail corridor that are identified by the site inspection and land holder consultation as having *potential* contamination issues. These investigations will be undertaken in accordance with a site specific Sampling and Analysis Plan (SAP) tailored to each property / potentially contaminated area. The SAP will be developed to identify sources of pollution and contamination through visual inspections and relevant analysis of soil samples.

Potentially contaminated land should be assessed in accordance with relevant guidelines and legislation. The required extent of contaminated land investigations will vary depending on the findings of previous stages of assessment. Where the results of a contaminated site investigation and risk assessment indicate that remediation is required before the site would be suitable for the NGBR Project land use, a Remediation Action Plan (RAP) will be required; the RAP will outline the volume of material requiring remediation, measurable targets for remediation and the relevant procedures to be undertaken to achieve and subsequently validate these targets.

A Site Management Plan (SMP) will be developed for each site where investigations have determined that construction activities have the potential to result in contamination; SMPs will incorporate any RAPs relevant to the site. The SMP will aim to manage any potential environmental harm that may be caused by contamination of the land associated with the use or activities carried out on the land associated with the construction of the NGBR Project. The SMP will include:

- Specific conditions under which contaminants will be managed on-site
- A statement of the objectives to be achieved and maintained under the SMP
- A statement of how the objectives are to be achieved and maintained
- Provision for the monitoring and reporting of compliance with the SMP.

SMPs will be developed prior to the commencement of construction activities. The objectives of the SMP will comprise measurable levels of contamination over which additional treatment or disposal may be required. The monitoring and compliance reporting will be made available to the relevant authorities and will be provided in the appropriate format as outlined in the guidelines and legislation.

Current established mitigation measures to be implemented during the construction and operational phases of the final rail corridor are detailed in Section 5.4.3.

5.4.2 Operation

Operation of the NGBR Project has the potential to impact localised soil quality through accidental spills or leaks of fuel or oil from trains or maintenance vehicles. Any notifiable activities during operation relating to land contamination under Schedule 3 of the EP Act will be reported to DEHP. Further information pertaining to land contamination and mitigation measures are provided in Volume 1 Chapter 18 Hazard and risk, health and safety

A Decommissioning and Rehabilitation Management Plan will be developed for implementation during staged decommissioning of temporary construction infrastructure. This plan will outline measures for stabilising areas containing high risk dispersive soils and changed hydrological or hydraulic conditions.

Periodic maintenance of drainage structures along the final rail corridor will be undertaken to ensure they are free from sediment and debris that may cause impediment to intended drainage flows resulting in erosion.

5.4.3 Summary of mitigation and management measures

The mitigation and management measures provided in Section 5.4.3 will be implemented to minimise and avoid the potential impacts of the NGBR Project on topography, geology, soils and land contamination. These mitigation and management measures will be implemented in combination with the measures outlined in other chapters of this EIS, specifically:

- Volume 1 Chapter 3 Land use and tenure
- Volume 1 Chapter 6 Nature Conservation
- Chapter 7 Matters of national environmental significance
- Volume 1 Chapter 9 Water resources
- Volume 1 Chapter 9 Water resources
- Volume 1 Chapter 18 Hazard, risk, health and safety
- Volume 2 Chapter P Environmental management plan.

Table 5-12 Summary of mitigation and management measures

Timing	Mitigation and management measures
Pre-construction	Detailed design of the final rail corridor will aim to avoid construction on steep slopes and significant landform change.
Pre-construction	A detailed soil survey will be conducted prior to construction works commencing to validate proposed management practices for specific soil types and related issues. The investigation will be undertaken in accordance with a specific soil survey methodology and will include: • SCL assessment • GQAL assessment • Acid sulfate soils assessment • Contaminated land assessment • General soil characterisation and suitability assessment The survey for acid sulfate soils will be consistent with: • State Planning Policy 2/02 Guideline: Acid Sulfate Soils • Guidelines for Sampling and Analysis of Lowland Acid Sulfate Soils in Queensland 1998 (CR Ahern, MR Ahern, and B Powell 1998) • Acid Sulfate Soils Laboratory Methods Guidelines (CR Ahern, AE McElnea and LA Sullivan 2004).
Pre-construction	An Erosion and Sediment Control Plan (ESCP) will be developed in accordance with the following guidelines: • Best Practice Erosion and Sediment Control. International Erosion Control Association (Australasia) (IECA 20013) • Urban Stormwater Quality Planning Guidelines 2010 (DEHP 2010) • Manual for Erosion and Sediment Control Version 1.2. Sunshine Coast Regional Council, November 2008 (SRSC, 2008) The key objectives of the ESCP will be to: • Control surface water movement through construction sites • Minimise the extent and duration of soil disturbance • Minimise soil erosion • Minimise sediment laden water leaving construction sites • Promptly stabilising disturbed areas • Maximising sediment retention on site

Timing	Mitigation and management measures
	• Maintaining ESC measures in proper working order The ESCP will also include the following: • Site analysis, site characteristics and constraints (locality, topography, geology, groundwater, soils, vegetation, sensitive receptors), rainfall distribution and amounts relevant to the study area, staging of construction, details of proposed land disturbance activities and timeframe for construction implementation • As appropriate, management and monitoring strategies to minimise erosion and sedimentation with respect to specific soil types • Design and construction details of drainage, sediment control measures and sediment basins (if any) Plans and figures for erosion and sediment control including: • Explanatory notes and installation sequences • Contingency plans – in the case of rainfall events or unforseen situations • Soil management – location of stockpiles, management of dispersive soils, potential acid sulfate soils, high erosion risk areas, soils with extreme pH, required amelioration • Site access – and associated temporary sediment controls • Vegetation management plan – vegetation clearing, site stabilisation, rehabilitation • Monitoring program –for drainage, erosion and sediment controls, water quality • Maintenance and water discharge program.
Pre-construction	Problematic soils identified during the detailed soil survey will be managed through a Soils Management Plan. The Soils Management Plan will include management measures including: • Identification of cracking clays with potential trafficability hindrances • Identification of unstable soils that would require additional provisions in the ESCP • Identification of saline soils, which will typically be unsuitable for use in rehabilitation • Identification of acidic or sodic soils that may require amelioration and management prior to rehabilitation.
Pre-construction	Prior to construction commencing, a detailed acid sulfate soils investigation will be undertaken in areas < 5 mAHD.
Pre-construction	Based on the acid sulfate soil investigation, an Acid Sulfate Soils Management Plan (ASS Management Plan) will be developed for any activities below 5 mAHD that will:

Timing	Mitigation and management measures
	• Disturb >100 m^3 (bulked volume) of acid sulfate soils material • Place hard fill material of >500 m^3, with an average thickness >0.5 m and/or • Disturb existing groundwater or surface water regimes. Where avoidance of acid sulfate soils disturbance is not possible, soils will be managed in accordance with the State Planning Policy 2/02 (SPP 2/02). Applicable management techniques include: • Chemical neutralisation (use of pure fine agricultural lime, Aglime) through mechanical mixing by plough or excavator, to provide adequate homogeneity of the sediment-lime mix • The less preferred, risky method of anoxic storage or placement below the water table and beneath clean non-ASS fill • Disposal of neutralised material upon acceptance of relevant permits. The ASS Management Plan will include a risk assessment procedure for dewatering activities to ensure that potential acid sulfate soils within the site and on adjacent properties are not exposed to oxygen during construction.
Pre-construction	Adani will consult with landholders on how the NGBR Project may impact on the landholders' obligations under an Environmental Risk Management Plan (ERMP) and develop further mitigation measures relating to these obligations in cooperation with the landholders.
Pre-construction	Relevant forms will be prepared and submitted to DNRM for any property on which triggered SCL is intersected by the final rail corridor and/or ancillary infrastructure (if any). For those properties passing the HOC assessment, Adani will submit an application for a strategic cropping land protection decision or compliance certificate.
Pre-construction	In the case of temporary impacts on SCL, the following information will be provided to DNRM: • Description of the area of temporary impact on SCL associated with each activity in addition to a detailed description of the actual physical land disturbance, operational work and construction activities involved in each temporary impact activity with attention paid to the location, extent (area), method of disturbance and duration of each activity • A detailed restoration plan, including a description of the benchmarked predevelopment site condition, the methods to be applied to ensure site restoration to an equivalent condition including restoration milestones / targets and monitoring regime • The timeframe for complete restoration to pre-development equivalent conditions.
Pre-construction	In the case of permanent impacts on SCL, the following will be undertaken: • Description of the area of the permanent impact on SCL associated with each activity will be provided and a detailed description of the actual physical land disturbance, operational work and construction activities involved in each permanent impact activity with attention

Timing	Mitigation and management measures
	paid to the location, extent (area), method of disturbance and duration of each activity • Calculation of the mitigation costs for all SCL impacted by the activity where a permanent impediment to cropping will be unable to be avoided. Fractions of one hectare will be rounded up to the nearest hectare for the purposes of calculating the mitigation liability within different SCL subzones.
Pre-construction	For the properties containing SCL that failed the preliminary HOC assessment, Adani will submit applications to DNRM for HOC validation. Consultation with DNRM will occur prior to the submission of these forms to ensure the application process is streamlined. This process requires submission of two application forms: • Part A—Strategic cropping land validation—all applications application form • Part B—Strategic cropping land validation—cropping history application form.
Pre-construction	A ground-truthing exercise will be undertaken if the preliminary site investigation of the properties identifies the likelihood of any contamination within the final rail corridor or ancillary infrastructure areas. This ground-truthing will involve a visual inspection of the following: • Recording of site features and layout of structures • Inspection for visual signs of potential contamination – disturbed, distressed vegetation; soil staining etc. • Presence/location of the following – fill; stockpiled soils/material; chemicals; fuel storage; waste material; equipment/machinery relevant to potential site contamination • Inspection for evidence of former infrastructure; previous fuel/chemical storage, evidence of spills/leaks; condition of roads and infrastructure • Ground-truthing will determine the need for any intrusive investigations and sampling needs.
Pre-construction	Where ground truthing determines that further investigation and sampling is required, a Sampling and Analysis Plan (SAP) will be developed and tailored to each property / potentially contaminated area. The SAP is to cover the following information: • Description of proposed activity / disturbance • Pollution sources • Sampling and analysis methodology • Quality assurance and quality control procedures • Data assessment and reporting

Timing	Mitigation and management measures
Pre-construction	Continued consultation will be conducted with landholders, whose GQAL property is intersected by the final rail corridor to limit the effects of fragmentation. Mitigation measures such as provision of stock crossings, amelioration of soils, limiting vehicle movement to designated access tracks and compensation would be considered if necessary.
Pre-construction	An extensive geotechnical investigation will be undertaken along the length of the final rail corridor and in locations of auxiliary infrastructure. The aim of the geotechnical investigation will be to provide site specific geological data, including the suitability and stability of existing geological conditions for construction of the NGBR Project.
Construction	Minimising severity and depth of soil excavation, mixing of soils, compaction and contamination with foreign material.
Construction	Where construction on steep slopes and significant landform change cannot be avoided, appropriate control measures will be tailored and implemented to minimise disturbance of topography and landform. This will be addressed through the implementation of the ESCP.
Construction	Topographical features that pose a risk to the environment from erosion due to slope length and gradient are to be carefully managed during wet weather periods and erosive rainfall events. This will be addressed through the implementation of the ESCP.
Construction	Earthworks will not be conducted during high rainfall events. The Bureau of Meteorology website will be reviewed daily to determine any significant rainfall in the upcoming three days that may impact on construction activities.
Construction	Each construction site will be inspected regularly for potential sources of land contamination (e.g. inappropriately stored hazardous substances) or actual signs of contamination. Corrective measures will be implemented as required and may include clean-up, remediation and/or disposal of affected material.
Construction	All permanent erosion and sediment control devices will be installed and are functional prior to commencement of operation.
Construction	Soils and landform underlying temporarily disturbed areas will be reinstated progressively and after construction to pre-development equivalent conditions.
Construction	In the event of a fossil find during construction, at the discretion of the Construction Environmental Manager, work will stop in the vicinity of the find and an appropriately qualified archaeologist engaged to assess its significance and authenticity. Suspected fossils will not be destroyed, damaged, moved, excavated or disturb unless documented approval has been granted by the construction environmental manager. The potential for fossils finds will be outlined in inductions to create awareness and train employees in the identification of archaeological material and actions to take in the case of a find.
Construction and	Chemicals, oil, fuel and wastes will be managed in accordance with a Hazardous Substances Management Plan and a Waste

Timing	Mitigation and management measures
operation	Management Plan.
Construction and operation	All vehicles, plant and machinery will be routinely inspected and maintained to minimise the risks of leaking or spilling contaminants.
Construction and operation	All surface drains and erosion and sediment controls will be inspected and maintained regularly. Deficiencies, including drain blockages, damage to sediment controls and signs of erosion will be recorded and rectified in a timely manner.
Operation	The final rail corridor and ancillary infrastructure will be inspected regularly for potential sources of land contamination or actual signs of contamination.
Decommissioning	A Decommissioning and Rehabilitation Management Plan will be developed for the NGBR Project with the overall aim of minimising the amount of land disturbed at any one time during the life of the final rail corridor. The Decommissioning and Rehabilitation Plan will be developed in accordance with the legislative requirements current at the time of developing the plan. The Decommissioning and Rehabilitation Plan will include the following: • Relevant permits and approvals that may be required for the removal of facilities • Timing and methodology for the decommissioning • The intended use of the sites after decommissioning • Details of any structures or facilities that remain in place after decommissioning • Erosion and sediment controls during and after decommissioning • Rehabilitation details • Reuse, recycling or disposal options for removed facilities, structures and materials, including community legacy opportunities.

5.5 Conclusion

Impacts on topography, geology, soils, GQAL, SCL, acid sulfate soils and land contamination are anticipated to occur as a result of developing the NGBR Project. Four residual impacts are projected to occur within the NGBR Project footprint. Residual impacts are expected to be locally significant with respect to topography, soil resources, GQAL and SCL environmental values however are unlikely to be regionally significant.

Residual impacts will affect the environmental value of topography. Design of the final rail corridor has incorporated the minimisation of disturbance to topography and landform through route selection to avoid key features. However, cut and fill activities will alter the existing topography, specifically where infrastructure is proposed to traverse steep low hills from chainage 71.3 km to 82.2 km.

Residual impacts will affect the environmental values of soil resources. ESCPs will be developed to provide underlying principles to limit erosion and prevent sedimentation. The majority of sedimentation will be contained from entering waterways.

Residual impacts will affect the environmental values of GQAL and SCL. Adani will minimise impacts to areas of GQAL and SCL traversed by the final rail corridor through design and management strategies. Topsoil will be stripped and stockpiled to maintain the quantity of fertile soil resources. Temporary disturbances will be returned to pre-development equivalent conditions. Areas impacted by the permanent disturbance created by the NGBR Project will not be returned to pre-development equivalent conditions. In this instance, mitigation fees will be paid by Adani according to outcomes of consultation with DNRM.

In summary, a series of sub-plans will be developed within the EMP to mitigate impacts resulting from construction and operation activities of the NGBR Project. A soil survey will be undertaken to provide detailed information for management plans. Minimal residual impacts, predominantly of local significance, are anticipated to affect the topographical, geological, soils, GQAL, SCL, acid sulfate soils and land contamination environmental values.