Alpha Coal Project Environmental Impact Statement

Soils, Topography and Land Disturbance





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Section 05 Soils, Topography and Land Disturbance

5.1 Introduction

This section provides a discussion on the types of soils and landform within the Alpha Coal Project (Rail) (herein referred to as the Project) study area. The environmental values that may be affected by the Project have been identified so as to identify mitigation measures.

This assessment is based on a desktop review of available information. A more detailed assessment of soils and landform will require a site investigation in accordance with the Australian Soil and Land Survey Field Handbook (McDonald et al, 1990). This will be done prior to the construction phase of the Project.

In addition to this section a technical report relating to soils is provided in Volume 6, Appendix E.

5.2 Description of Environmental Values

5.2.1 Soils

5.2.1.1 ATLAS of Australia Soils Dataset

Soil types have been mapped for the Project using the Atlas of Australian Soils Dataset (refer to Figure 5-1). The soil types along the Project vary considerably and consist of the following types:

- · cracking clays;
- dark brown and grey-brown soils;
- · texture contrast soils;
- duplex soils;
- · gilgaied deep cracking clays;
- · uniform course textured soils;
- · red and yellow eaths; and
- · shallow rock soils.

The soil types identified in the available mapping for the Project each have environmental considerations that need managing, and these are discussed in Section 5.3 below.

The mapping data used to show different soil types along the Project is the Atlas of Australian Soils Mapping (1:2,000,000 scale). The Project corridor has been described in regards to the dominant soil types identified within each mapped unit that is traversed by the Project. The map units provide a number of possible soil types, and as such further investigation (field assessments) will be required in accordance with relevant standards / guidelines, for a detailed assessment of soil types to be produced prior to construction.

Commencing at the Alpha Coal mine site, the Project is within an area mapped as gently undulating or level plains with the dominant soils mapped as being loamy yellow earths with a prominent ironstone nodule horizon at moderate to shallow depths. The alignment progresses into an area with the

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dominant soil type being sandy or loamy red earths. At chainage 20 km the Project enters an area with the dominant soils mapped as being grey or light grey deep clays with loamy duplex soils throughout.

At chainage 30 km to Native Companion Creek, the dominant soils are mapped as loamy red earths with some loamy yellow earths; the lower laying areas potentially have a range of loamy duplex soils with the possibility of some occurrences of gilgaied clays.

The area around the Belyando River from chainage 40 km to 45 km is described as alluvial plains with the dominant soils being deep grey clays. Soil types return to similar soils present prior to the Belyando River, the dominant soils are mapped as being loamy red earths from chainage 45 km to 58 km.

The alignment progresses into an area with the dominant soils being mapped as brown loamy duplex soils, within undulating terrain, often with a gravelly A horizon. The alignment then returns to the loamy red earths at chainage 62 km. At chainage 80 km, the alignment traverses undulating and low hilly areas with some flat topped benched hills. The soils are moderate to shallow in depth and alternate over short distances consisting of loamy duplex soils, rocky outcrops, deeper loamy duplex soils (confined mainly to the drainage lines) and shallower stony soils in the higher areas.

From chainage 80 km the dominant soil type is mapped as loamy yellow earths, with areas of hard loamy red earths and loamy duplex soils within the shallow drainage lines. At chainage 95 km the alignment returns to an area with the dominant soils being loamy red and yellow earths with loamy duplex soils in the lower landscape areas. From chainage 107 km to 110 km the dominant soil types are the grey or light grey clays with some loamy duplex soils in the non-gilgaied areas. The alignment then returns back to traversing areas of loamy red and yellow earths.

Mistake Creek is crossed at approximately chainage 118 km through alluvial flood plains with the dominant soils being the loamy red duplex soils. Following this crossing, the alignment re-enters the mapped units with dominant soil types of grey or light grey clays and the red and yellow loamy earths. An area at approximately chainage 135 km is mapped as consisting of hilly lands with the dominant soils being very shallow mostly stony loams.

At chainage 140 km, where the Project approaches the Miclere Creek crossing and associated alluvial plains, the dominant soils are mapped as being deep grey clays. These deep clays (varying in colour) are mapped up to chainage 147 km whereby the alignment returns to a more gently undulating area with loamy red earths being the dominant soils. Both the dominant soils and associated soils are described as being strongly nodular at depth.

At chainage 158 km the Project re-enters an area with dominant soils mapped as grey or light grey deep clays with loamy duplex soils within areas that are not affected by gilgais (alternating micro-relief depressions and mounds). At chainage 166 km the dominant soil type is loamy or sandy red earths in the gently undulating plains, the alignment then progresses into area of deep grey clays from chainage 169 km through to chainage 176 km which includes the alluvial plains around Logan Creek. Following this, the alignment enters the broadly undulating or level plains with deep brown clays with occasional loamy red duplex soils.

The dominant soil type of deep grey clays is traversed prior to Diamond Creek where the dominant soils then change to deep cracking clays within the level plains. These clays are expected to be slight to moderate gilgaied (1-2 ft). Loamy duplex soils are expected closer to the streamlines within this

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area. At chainage 204 km the alignment starts to traverse areas with the dominant soil types mapped as loamy or occasionally sandy red earths within undulating lands.

Where Eaglefield Creek is located, at approximately chainage 220 km, within the alluvial flood plains, the dominant soil is loamy duplex soils with some small areas of cracking clays. The alignment reenters the deep grey clays mapped from Diamond Creek (chainage 196 km) to Suttor Deviation Road (chainage 250 km). To the west of the alignment from chainage 230 km to chainage 250 km, along the Suttor River area, the dominant soil types are mapped as alkaline yellow and grey bleached duplex deep soils on undulating plains, the soils may have a slightly gravel-strewn surface. In the lower depressions there is potential for grey deep cracking clays to be dominant. Where there are occasional low rises, the soils can change to red or yellow massive loamy earths.

The same soil types are briefly traversed after the Suttor Deviation Road, before progressing into an area of red massive loamy earths between chainage 256 km and chainage 260 km, where the soils are generally deep and neutral, in lower depression areas the soils may change to loamy alkaline grey or mottled bleached duplex soils with potential for occasional gilgaied deep clays. The dominant soil types return to the alkaline yellow and grey duplex soils mentioned earlier.

At chainage 264 km the alignment progresses into an area of deep grey and brown clays, then into loamy and sandy duplex soils within undulating terrain. From chainage 271 km the dominant soil types are slightly acid loamy red earths, with the soils on the scarps and mesas being loamy red earths with shallow stony loams throughout and loamy duplex soils within depressions.

From chainage 276 km the alignment passes trough an area of deep, slightly acid loamy red earths. At chainage 287 km the dominant soils change to deep sands on low hilly or strongly undulating lands, the alignment then progresses into an area of shallow mostly stony dark clays.

At chainage 301 km, near Cerito Creek the dominant soil types are grey slopes on the middle and lower slopes of the undulating plains. Deep clay soils are likely to occur within the lower alluvial plain areas. As the terrain gets higher in elevation the soil becomes shallower and is more of a brown to red clay.

At chainage 315 km the alignment passes through a small area of sandy to loamy mottled duplex soils of shallow to moderate depth within the broad undulating valleys. Areas of brown clays with moderate depth and loamy duplex soils are traversed from chainage 317 km to chainage 345 km. Also within this zone there are sandy duplex soils around areas of gently undulating plains.

At the Rosella Creek and Bowen River crossings around chainage 345 km, the dominant soil types are mapped as duplex soils with a deep sandy to sandy loam A horizon with a clear horizon change to reddish brown clay or sandy clay. The alignment runs parallel with Bowen River until approximately chainage 390 km. The alignment crosses that same dominant soil type at chainage 375 km. The main soil types traversed from Roselle Creek to chainage 390 km include loamy duplex soils within the moderate to undulating lands to chainage 360 km, then dark clays within the plains and lower ridges with stony shallow soils within the higher ridges and hills. These dominant soil types are intersected by the alignment up to chainage 410 km. To the west of the alignment from chainage 390 km to chainage 410 km are fairly shallow often stony loamy duplex soils within the undulating lands and low hills. Similar dominant soils extend to chainage 422 km.

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Where the alignment crosses the Bogie River the soils are mapped as deep alkaline yellow and grey bleached duplex soils. Following this crossing, the soils are mapped as changing to sandy or loamy alkaline mottled yellow and grey bleached duplex soils.

From chainage 440 km where the alignment runs parallel to the west of the high hills / mountainous area, the soils are predicted to be shallow and stony neutral red duplex soils, with rock outcrops common, to the west of the alignment within the valley floor the soils are more of a mottled bleached duplex soils.

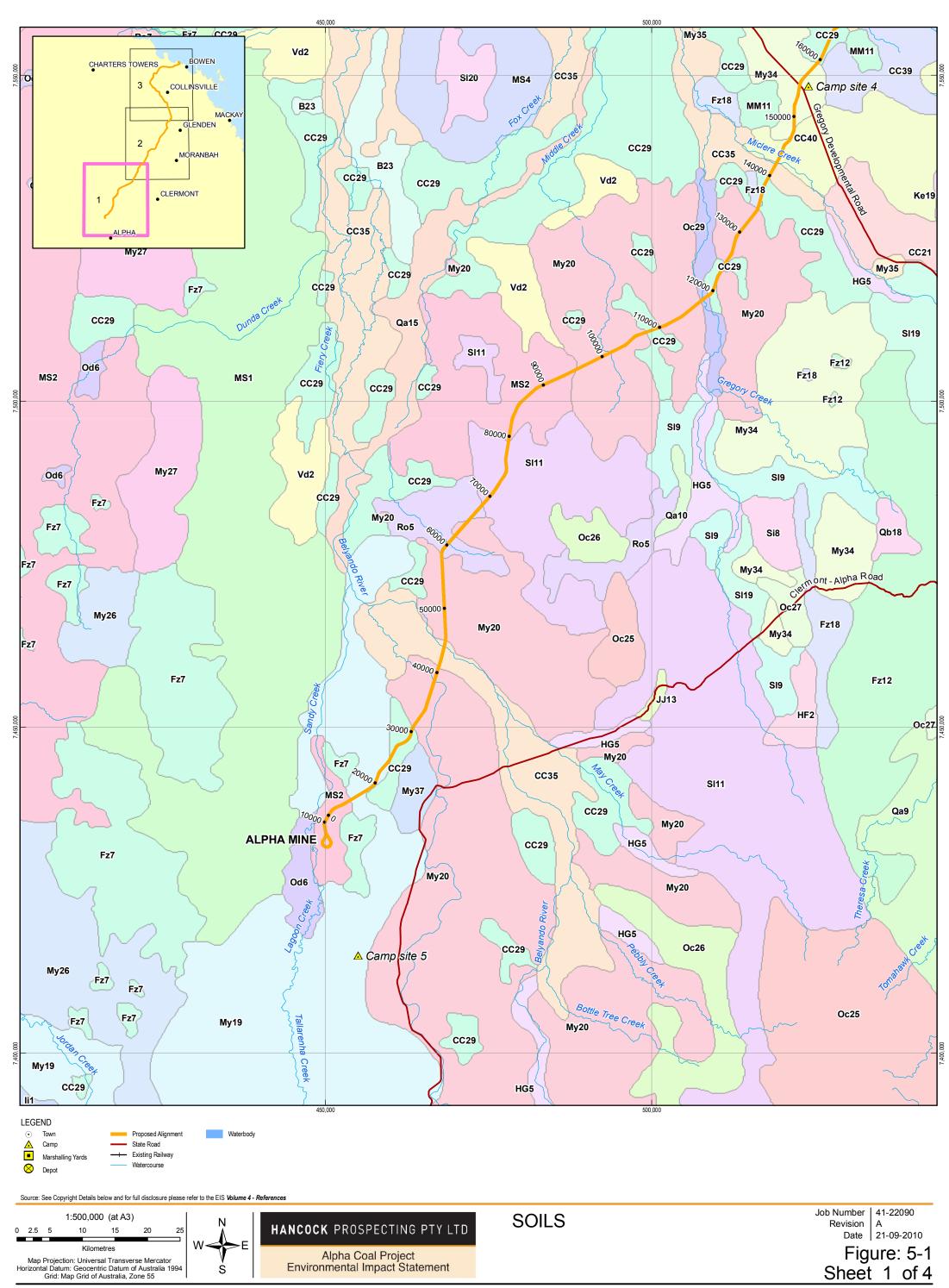
As the alignment heads east towards Abbot Point from chainage 450 km, the mapped dominant soil types alternate between the neutral red duplex soils and deep alkaline yellow and grey bleached duplex soils. After the Elliot River crossing the soils change to sandy to loamy and often gritty surface alkaline mottled yellow and grey bleached duplex soils.

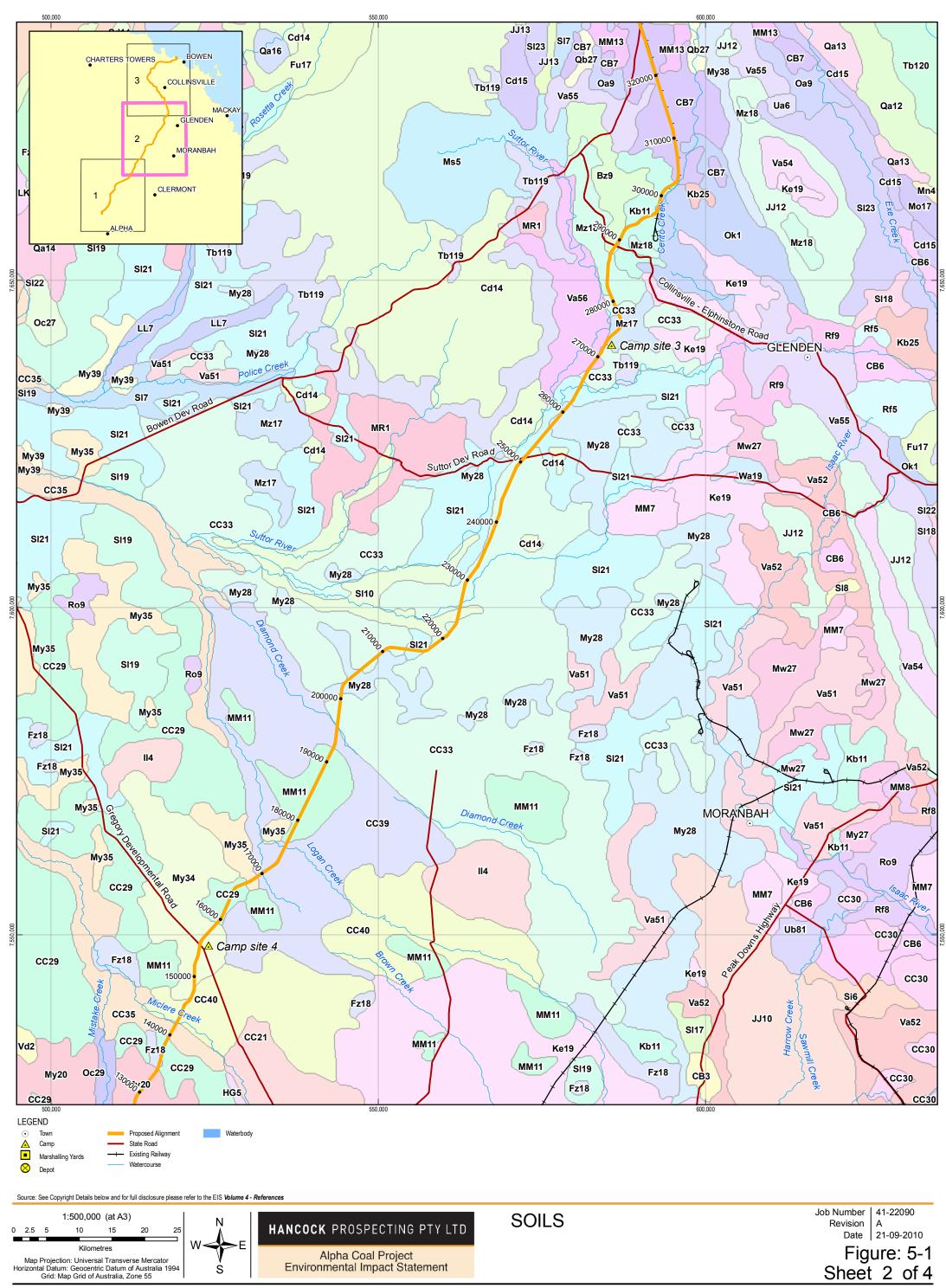
Where the alignment meets the Bruce Highway at chainage 485 km the soils change to dark deep cracking clays, followed by deep alkaline mottled yellow and grey bleached duplex soils with sandy or loamy and often gritty surface, this is then followed by shallow to moderately deep neutral red duplex soils. The rail loop at Abbot Point is mapped as salt pans and salt water couch meadow merging into mangrove swamps, subject to tidal inundation, with the soils being mostly deep yellow-brown mottled saline clays. Associated are a range of grey and dark alkaline bleached duplex soils, particularly within the vegetated areas.

5.2.1.2 Interpretations of the Mapped Soil Units

The dominant soil type identified within each mapped unit has been further expanded with reference to the Commonwealth Scientific and Industrial Research Organisation (CSIRO) Soils Division Technical Report 94 / 1992, whereby permeability, water holding capacity, soil texture profile, soil reaction trend, gross nutrient status, and soil depth has been allocated for the dominant soil type described within each mapped unit. It is recommended that this technical report (provided in Volume 6, Appendix E) is read in conjunction with this section as it highlights the limitations of the Atlas of Australian Soils Data and limitations of the estimated properties that have been established.

The allocated ratings are crude estimates only and, while adequate for identification of potential issues and mitigation measures, will need to be confirmed with site reconnaissance and analysis prior to the construction phase. Table 5-1 below details the estimated properties for the dominant soil types (refer to Figure 5-1 for the location of the map units and detailed descriptions).







Undulating basalt plains and plateaux with many low stony rises and occasional low conical hills. The soil surface ranges from stone-free (rarely) to a frequent occurrence of basalt boulders and stony outcrop (most common). The dominant soils are loamy red earths of shallow to moderate depth (18-40 in.) that commonly have some large basalt boulders in the profile. The chief forms are neutral (Gn2.12), but slightly acid forms (Gn2.11) are also common, particularly the shallower soils. In most soils small ironstone nodules occur throughout, and deeper soils may tend to have smooth-ped structure at depth. Small areas of friable earths (Gn3.12 and Gn3.11) occur locally. Low stony basalt rises commonly occurring throughout the unit have very shallow stony (Um5.51) soils. Also occurring in the unit are slightly lower areas of loamy yellow earths (Gn2.21), (Gn2.61), and (Gn2.24); these may be locally dominant in some areas. Also included in the unit are segmentally areas of a flat cracking class (unit). AA6 My37 dominant soils are gritty brown sands of variable depth (Uc5.11). Commonly associated are other gritty sands (Uc2.21), (Uc4.2), (Uc2.22), and (Uc1.21) and coarse sandy red earths (Gn2.12, Gn2.14, and Gn2.15). me lower hill slopes sandy duplex soils occur, chiefly (Dr2.11), (Dr2.12), (Dr2.22), and similar (Dy2) soils. Low hilly or strongly undulating lands with some lateritic or sandstone mesas; dominant soils are deep sands Bz9 (Uc1.21), but on the low mesas are leached sands (Uc2.12) and sandy red earths (Gn2.11). On the outwash slopes sandy duplex soils (Dy5.41 and Dy5.42) occur. Data are limited. Occurs on sheet(s): 14,15,16, areas. Also included in the unit are some small stony plains of dark cracking clays (unit Kb24) that are too small to map separately Moderate to gently undulating plains with very broad shallow valleys: on middle and lower slopes grey clays of moderate depth are dominant, usually with pronounced linear gilgai. The chief forms are (Ug5.22) and (Ug5.23), with lesser areas of (Ug5.13) and (Ug5.32). In lower sites and on associated small alluvial plains deep clay soils The more easterly extent of this unit has larger areas of gently undulating plains that have fewer low low stony rises and flow scarps. However, the soils nearly always have variable amounts of basalt boulders on the surface and throughout the profile. CB7 Yellow earths (Gn2.21), (Gn2.61), and occasionally (Gn3.21), thend to be more prominent in this area occur, chiefly (Ug5.25), (Ug5.16), (Ug5.15), and (Ug5.24). On the broad ridge crests shallower brown or red-brown clays (Ug5.32 and Ug5.37) are prominent, together with thin-surfaced loamy duplex soils (Dr2.13), (Dr2.13), (Dr2.13), (Dy2.13), and (Dy1.13). Also occurring in the unit are small alluvial plains of loamy duplex is (Ds1.33), (Dd1.33), and (Dy2.33), and occasional low basaltic hills with shallow stony soils (Uf6.32), (Uf6.31), (Ug5.12), and (Um6.31). Undulating lands with occasional lateritic scarps and low mesas: dominant soils are slightly acid loamy red earths (Gn2.11) which often Mz17 contain many ironstone nodules at depth. Associated are neutral loamy red earths (Gn2.12), and lesser loamy yellow earths (Gn2.22 and Gn2.25). The soils of the scarps and mesas are loamy red earths (Gn2.12) on the more extensive surfaces, elsewhere shallow stony loams (Um1.43) and (Um4.1) are common. On scarp slopes and in local depressions loamy duplex soils (Dy3.43) and (Dy2.43) occur. Marginally the unit may grade into or be closely associated with red and brown cracking clays (Ug5.38) and (Ug5.34), which have slight to moderate gligal microrelief. Occurs on sheet(s): 16,17 Level plains with moderate to strong gilgai microrelief (2 4 ft): dominant soils are grey or light grey deep clays (Ug5.24) with loamy duplex soils (Dy2.33) closely associated in non-gilgaled sites. Small flood-plains of (Dy2.43), (Dy3.43), and (Dd1.43) occur adjacent to associated drainage lines. Included in the unit, as mapped, are small areas of loamy and sandy red earths (Gn2.12 and Gn2.13) and yellow earths (Gn2.22). The cracking clays have the three reaction trends listed for unit CC20. CC29 Gently undulating plateau surface, often bounded by steep lateritic scarps where marginally dissected: dominant soils are deep slightly acid loamy red earths (Gn2.11), with some small marginal areas of loamy yellow earths (Gn2.21). The marginal lateritic scarps have Mz18 shallow red earths (Gn2.11) and stony loams (Um1.43) and (Um4.1), also less commonly (Uc2.12). Elsewhere the margins of the unit Level or very gently undulating clay plains with slight to moderate (1-2 ft) gilgai microrelief, occasionally stronger (2-4 ft). Where the unit is adjacent to major streams many small braided channels occur and C the area is subject to flooding. Dominant soils are deep grey clays (Ug5.24), occasionally (Ug5.28 and u Ug5.29), but areas of deep have the sands of unit Bz9. Small dissected mesa remnants are also included in the unit CC33 Undulating lands with broad rounded ridge crests and wide shallow valleys, some rock outcrop on higher ridges: dominant are loamy duplex soils of shallow to moderate depth (1424 in.). The chief form is (Dr2.13) but (Dr2.12) is closely associated. Other soils occurring include (Dr2.22 and Dr2.23), (Gn3.12), and (Db1,12 and Db1.13). In lower landscape sites cracking clays (Ug5.22), (Ug5.32), Oa9 brown clays are commonly associated (Ug5.34). In some areas brown clays occur on the gilgai banks and grey clays in the depressions. Closely associated throughout the unit are areas of loamy duplex soils (Dy2.33), (Dy2.43), (Db1.33), (Db1.43), and (Db1.13), particularly adjacent to stream channels. As mapped, the unit and (Ug5.14) usually occur together with some loamy (Dy2.43) soils associated with small stream flood-plains. includes small slightly higher islands of sandy or loamy red earths (Gn2.12 and Gn2.11), or less commonly Alluvial flood-plains often dissected by stream channels, many areas are wind-deflated: dominant are loamy red duplex soils (Dr2.33) yellow earths (Gn2.22). The cracking clays have the three reaction trends listed for unit CC20. Oc29 and (Dr2.13) with closely associated similar (Db1) and (Dy2) soils. Also occurring are small areas of grey or brown clays (Ug5.24 and (Ug5.34) which may be moderately gilgaied. Alluvial plains associated with major streams; numerous braided channels may occur and many areas are subject CC35 rative plants associated with implicate and in such as a fact of the plant flooding; dominant soils are deep grey clays (Ug5.24 and Ug5.25), with smaller areas of (Ug5.34) and (Ug5.5). Some clay soils possess a slight to moderate gliqai microrelief. Associated are lesser areas of thin-surfaced loamy duplex soils (Dd1.33), (Dy2.33), and (Dy2.43), and, less commonly, similar (Dr2) or (Db1) soils. The duplex soils may often be wind-deflated. Also occurring in the unit are occasional low sand dunes or sand-filled prior stream Small level plains: dominant are sandy or loamy-surfaced red duplex soils (Dr2.43) with lesser (Dr2.33) and (Dr2.13). Closely associated are similar (Dy2), (Dy3), and (Db1) soils together with small areas of grey cracking clays (Ug5.24). Also occurring are small areas of sandy or loamy red and yellow earths (Gn2.12, Gn2.13, and Gn2.22) and Od6 occasional low sand dunes (Uc1.23) and (Uc5.11). Small level plains: dominant are sandy or loamy-surfaced red duplex soils (Dr2.43) with lesser (Dr2.33) and (Dr2.13). Closely associated Extensive level old alluvial plains that have a very slight (few inches) gilgai microrelief: dominant soils are deep grey clays (Ug5.25) with lesser (Ug5.24) and (Ug5.29). Also occupying important areas are deep brown clays (Ug5.34 and Ug5.35), some of which may have a gravelly surface. are similar (Dy2), (Dy3), and (Db1) soils together with small areas of grey cracking clays (Ug5.24). Also occurring are small areas of sandy or loamy red and yellow earths (Gn2.12, Gn2.13, and Gn2.22) and occasional low sand dunes (Uc1.23) and (Uc5.11). Moderate to strongly undulating lands dissected by many small streams; rock outcrop is frequent: dominant are red loamy duplex soils (Dr3.33) with lesser (Dr3.13) and (Dr3.43). Associated are similar (Dr2) and (Dy2) soils with lesser (Db1.13) and (Db1.33). Very small Level plains: dominant soils are very deep clays with a slight (6-12 in.), or no, gilgai microrelief. The chief forms are grey (Ug5.25), occasionally (Ug5.28), (Ug5.29), and (Ug5.24), but brown clays (Ug5.34) are also common. These often have loose granular surface layer up to 3 in. thick. Small areas of red-brown (Ug5.38) and dark clays (Ug5.15) Ok1 CC40 clay plains occur locally with (Ug5.22), (Ug5.24), or (Ug5.13) soils. Low hilly to hilly lands with some strongly undulating marginal slopes; hill crests are often rounded and slopes are moderate; rock outcrop Qa11 is common throughout: dominant are mostly shallow and often stony loamy red duplex soils (Dr2.12) with lesser (Dr2.33) and (Dr2.62). Occasional areas of red friable earths (Gn3.12 and Gn3.15) also occur. On higher and more stony hills shallow loams (Um1.43) Low hilly to strongly undulating elevated lands with some steeper high hilly areas; rock outcrop is very common throughout Cd14 dominant soils are very shallow (6-18 in.) stony gritty leached sands or sandy loams (UC2.12). Less common are similar loams (Um2.12) and (Um4.1). On some slopes shallow stony duplex soils occur, chiefly (Dy3.41), (Dy3.42), and similar (Dy2) soils. Throughout this unit there may be small remnants of unit Tb119. and (Um4.1), with (Uc4.2) less often, are common. On some lower slopes and valley floors yellow or brown loamy duplex soils (Dy3.42), (Db1.12), and (Dy2.42) often occur. High hilly lands with some mountainous areas; nearly all hills have steep slopes but crests are often rounded. Marginal to the unit topography Hilly or high hilly lands with much massive volcanic rock outcrop: dominant soils are very shallow mostly stony loams (Um1.41), with lesser areas of (Um4.1) and (Um2.12). Lower flatter slopes have stony loamy duplex soils, chiefly (Dy2.42 and Dy2.43). Qa12 may be strongly undulating; rock outcrop is common throughout: dominant are shallow stony loamy red duplex soils (Dr2.12), with lesser (Dr2.22) and (Dr2.62). Other duplex soil also occur, chiefly (Db1.12), (Dy2.23), (Dy2.33), (Dy2.43), and similar (Dy3) soils. Small areas of red friable earths (Gn3.12, Gn3.14, and Gn3.15) are associated in some areas. Higher hicrests and more stony sites have shallow stony loams (Um1.43), (Um4.1), and (Um2.12) or sands (Uc2.12), (Uc4.1), and (Uc4.2). Occurs on sheet(s): 2,3,4,6,7 Fz18 As mapped, the unit may have marginal inclusions of deep cracking clays (Ug5.24), (Ug5.16), and (Ug5.34). Strongly undulating to low hilly lands: dominant soils are shallow stony loams (Um1.43) and (Um1.41). (Um4.1). and (Um5.5) Moderately or, less commonly, strongly undulating lands with occasional isolated hills surrounded by strongly dissected steep slopes; limited Fz7 Associated are shallow sandy soils (Uc2.12), (Uc3.12), and (Uc1.21). On some slopes shallow duplex soils (Uc2.12), (Uc3.12), and (Uc1.21). On some slopes shallow duplex soils (Uc2.12), (Uc3.12), and (Uc1.21). On some slopes shallow duplex soils (Dc3.13), and (Uc1.21) and Uc1.23) and (Uc5.21 and Uc5.22) occ Small areas of sandy red earths (Gn2.12 and Gn2.11) and yellow earths (Gn2.22 and Gn2.21) are also included in the Qa14 rock outcrop may occur throughout: dominant are loamy red duplex soils (Dr2.12) of shallow to moderate depth (18-30 in.). Commonly associated are (Dr2.11), (Dr2.21), (Dr2.22), (Gn3.12), and less often (Dr2.13). Some similar (Db1) soils occur and in some areas yellow loamy duplex soils (Dy2.21 and Dy2.22) are locally dominant. Also often closely associated, particularly on lower slopes, are mottled yellow duplex soils (Dy3.42), (Dy3.43), and (Dy3.32). The hilly areas have very shallow storny duplex soils (Dr2.12), (Dy2.12), and (Db 1.12); stony loams (Um 1.43) and (Um4.2); or gritty sands (Uc4.2) and (Uc2.12). Very occasional small areas of dark clays (Ug5.13) or red-brown clays (Ug5.37) may also be included in the unit. Level plains with slight to moderate qilqai microrelief (12-18 in.): dominant soils are very deep grey cracking clays (Ug5.28), II11 with lesser (Ug5.29, Ug5.24); the deep subsoils may be strongly acid. Associated are loamy duplex soils (Dy2.43) and (Dy3.43), Undulating or gently undulating lands: dominant are loamy red duplex soils (Dr2.12) of moderate depth. Also occurring are similar (Dr2.11) and occasionally (Dr2.22) soils. Closely associated, particularly on flatter sites and lower slopes, are loamy mottled duplex soils (Dy3.22), (Dy3.32), and (Dy3.42), together with similar alkaline forms. Limited areas of dark duplex soils (Dd1.12, Dd1.13) may also occur. Strongly undulating lands with some low cuesta-like hills that frequently have massive sandstone outcrops: dominant soils are shallow sands (Uc4.1 and Uc4.2), with some leached sands (Uc2.12). In some areas much quartz gravel may occur. On lower slopes sandy or loamy duplex soils (Dy3.42), (Dy3.43), and (Dy2.32) are common. Data are limited. Qa21 JJ13 On some higher ridge crests shallow stony (Dr2.12) soils occur adjacent to rock outcrop. Low fixed sand dunes paralleling the coastline: dominant soils are those of the older (more inland) dunes that have deep sands (Uc4.2), or less commonly (Uc4.3). The near coastal dunes have (Uc5.11), (Uc1.21), (Uc1.22), and (Uc1.23) sands. The most Gently undulating alluvial flood-plains, often with marked terraces, levees, and shallow drainage depressions. The dominant soils are those of the older terraces and levees; they have deep sandy or sandy loam A horizons (12-24 in.) with a clear change to reddish brown clay or sandy clay. The chief form is (Dr.2.21), with associated (Dr4.22), (Dy2.23), (Dy2.33), (Dp1.13), and (Dr2.23). In the shallow drainage depressions loamy duplex soils (Dy2.43) and (Dy3.43) occur, with uniform loams (Um6.11) on the most recent terraces which JK2 Qb27 recent dunes become calcareous (shelly) at variable depths (12 in. or more) and have (Uc1.11) or (Uc1.12) loose sands. As mapped, the unit may include small areas of mangroves and salt pans. Low hilly or strongly undulating lands with much massive granite or other acid rock outcrop; all soils are shallow and stony: dominant are gritty sands (Uc4.2) with associated (Uc4.1), (Uc2.21), (Uc2.21), and (Um4.2) soils. On lower slopes shallow stony duplex soils may be common, chiefly (Dy3.42), (Dr2.12), and (Dy2.22). may be subject to flooding. JK6 Undulating lands; dominant are brown loamy duplex soils (Db1, 33), (Db1, 23), and (Db1, 43), often with grayelly A horizons. Associated Ro5 are red duplex soils (Dr2.33) and (Dr2.23), and small areas of cracking clays (Ug5.32) and (Ug5.22). Other alkaline duplex soils with bleached A2 horizons also occur, chiefly (Dy2) and (Dd1). Occurs on sheet(s): 32,33 Salt pans and tidal flats or salt-water couch meadows merging into mangrove swamps; subject to frequent inundation by tidal waters: dominant soils on the salt pans are highly saline clays (Uf6.62), with some sandy duplex soils (Dy3.33), (Dy3.13), and (Dy2.43) on the margins. The duplex soils often have material added to or removed from the A horizons by wind or wave action. The small grassed areas in the unit have loamy duplex soils (Dy2.43), (Dy3.43), (Dd1.43), and (Dd1.33) or uniform clays (Uf6.41). Some areas of deep cracking clays (Ug5.14) and (Ug5.24) occur in minor depressions and various deep sands (Uc1.12), (Uc1.23), (Uc1.23), and (Uc4.2) occur on low included sand dunes or beach ridges. Jb1 Moderately undulating lands with some small level flood-plains associated with minor streams: dominant soils are fairly shallow (18-24 in.) thin-surfaced loams or clay loams overlying dense grey clay subsoils (Dy2.33), (Dy2.13), and (Dy2.43). Associated are similar (Dd1) and (Db1) soils with some small areas of clays (Ug5.22), (Ug5.12), and (Uf6.32). On some ridges a surface gravel layer may be present. The soils of the small flood-plains are chiefly (Dy2.43) and (Dy3.43). Si3 Level alluvial flood-plains that often have numerous braided stream channels; many areas are subject to flooding: dominant are SI10 loamy duplex soils (Dy2.43) and (Dy2.33) but closely associated are (Dd1.43), (Dd1.43), (Dd1.43), and (Db1.33); some areas are wind-deflated. Small areas of cracking clays (Ug5.24), (Ug5.25), and (Ug5.15) also occur together with other fine-textured soils (Uf6.32 and Uf6.33). Occasional old sand-filled channels or sandy levees near major streams have deep sand soils (Uc1.23), (Uc1.21), and (Uc5.21). Moderate or strongly undulating lands with stony low hills, benches, and bluffs; rock outcrops common: dominant soils are shallow mostly stony dark clays (Ug5.12, Ug5.13, and Ug5.14) and more friable shallow stony clays (Uf6.32 and Uf6.31), or clay loams (Um1.43 and Um1.41). Small areas of brown or red clays (Ug5.32 and Ug5.37) occur locally. Kb11 Small alluvial plains may occur in lower sites which have deep clay soils (Ug5.15 and Ug5.16). Strongly undulating or low hilly lands with some areas of flat-topped benched higher hills; the soils are mostly shallow and alter SI11 Hilly or low hilly lands with some moderately undulating plateau surfaces; the unit is often bounded by steep dissected st almost all soils are shallow and often stony: dominant are very dark brown clays (Ug5.12), but shallow red soils (Ug5.37) (Gn3.12) are also common. On stronger slopes and high hills very shallow stony clays (Uf6.32 and Uf6.31) occur. over short distances depending on parent material lithology; rock outcrops are frequent; dominant are loamy duplex soils (Dy2.43) and (Dy2.33) but closely associated are (Db1.33), (Dr2.13), (Dr2.33), and (Dr2.12). Smaller areas of (Dd1.33), (Dd1.43), and (Ug5.22) Kb25 occur on flatter sites. Associated drainage lines have small alluvial plains with deeper loamy duplex soils (Dy2.43) and (Dd1.43). The higher ridges and hills may have areas of shallow stony (Um1.41), (Um1.43), or (Um4.1) soils. Occurs on sheet(s): 31,32,33 Gently to broadly undulating plains interrupted by some stony ridges, basalt flow scarps, broad low hill crests, or occasional conical hills: dominant soils are shallow to moderately deep dark grey or dark brown cracking clays (Ug5.12), with lesser (Ug5.13 and Ug5.14). Linear gilgai often occurs on slopes. Also occurring are areas of dark red or red-brown clays (Ug5.37, Ug5.38, and Ug5.32) usually on higher landscape sites. In lower areas small level plains occur, often as narrow flood-plains Level or very gently undulating alluvial plains: dominant are thin-surfaced (2 4 in.) loamy duplex soils (Dy2.43) and (Dy2.33). Similar (Dy3) soils are closely associated but these normally have a deeper A horizon (6 10 in.). In some areas a very slight (4 6 in.) gligal microres is present and the puffs may have grey clays (Ug5.28, Ug5.29). Locally, slightly gligaled clay plains (Ug5.28), and less commonly (Ug5.16), may be more extensive. Also occurring in small areas are clays (Ug5.28) with a stronger gligal microrelief (12-18 in.). Ke19 SI16 adjacent to streams. The soils are deep dark clays (Ug5.15 and Ug5.16) with smaller areas of (Uf6.32 and Uf6.31). On higher stony ridges shallow clay soils (Uf6.31), (Uf6.32), and (Ug5.12) occur. Locally there may be small areas Undulating or moderately undulating lands with occasional low hills: dominant are fairly shallow (18-24 in.) often stony loamy duplex soils SI17 (Dy2.43) is most common but also occurring are (Dy2.42), (Dy2.43), (Dy3.43), (Dr3.43), (Dr2.42), (Dr2.43), (Dd1.43), (Db1.43), and (Db1.33). On higher ridges and low hills very shallow stony loams (Um4.1), (Um1.43), and (Um2.12) occur. As mapped, the unit may include of highly calcareous clays (Ug5.11). Level plains: dominant soils are deep dark cracking clays (Ug5.16), with lesser grey clays (Ug5.24, Ug5.29). A slight (6 12 in.) Kf13 very small areas of dark clays (Ug5.12). gilgai microrelief is often present; where it is more pronounced, the clays occur on the puffs, and in the depressions are loamly grey duplex soils (Dy3.43), (Dy2.43), (Dy3.33), and (Dy2.33), with lesser similar (Dd1) soils. Gently undulating plains: dominant are loamy duplex soils with a slightly gravel-strewn surface. The chief forms are (Dy2.43) and (Dy2.33) but (Db1.33), (Db1.43), and similar (Dy3) soils are often closely associated. Also occurring are smaller areas of slightly gligaled (1-2 ft) or non-gligaled grey clays (Ug5.24), or less commonly brown clays (Ug5.34). In addition there are occasional low rises of loamy or sandy red earths (Gn2.12) and yellow earths (Gn2.22). In some localities there may be occasional high stony ridges with shallow stony SI21 High stony hills, often with precipitous scarps; massive acid volcanic rock outcrop is commo LK17 loams (Um4.1) with lesser (Um2.12). On lower slopes shallow stony duplex soils occur, chiefly (Dy3.42), (Dy2.43), and (Dr2.12). soils (Uc1.21), (Uc2.12), (Um1.41), and (Um4.1). Moderate to strongly undulating lands with an occasional low hill; the area is usually strongly dissected by many small streams and nearly all soils have a gravel-strewn surface and are often eroded; rock outcrops are common. A complex array of loamy duplex soils is present, most are shallow (18-20 in.). The dominant soil is (Dy2.43) but commonly associated are (Dy2.33), (Dy3.43), (Dr2.37), (Dr2.47), (Dr2.17), (Dr2.17), (Dr2.17), (Dr3.31), and (Dr1.33). Limited areas of cracking clays (Ug5.22), (Ug5.32), and (Ug5.15) also occur. The occasional hills have extremely stony shallow (Dy2.43), (Um4.1), and (Um2.12) soils. Broadly undulating or level plains: dominant soils are deep brown clays (Ug5.34), with lesser red-brown (Ug5.38) and grey clays (Ug5.24). All are non-gilgaied or with only a very slight (6 in.) microrelief. Marginal to the unit are small areas of brown or red loamy duplex soils (Db1.13 and Db1.33) and (Dr2.13 and Dr2.33). Occurs on sheet(s): 23,24,25,26 MM11 SI23 Alluvial plains, sometimes with slight to moderate (1-2 ft) gilgai microrelief: dominant soils are brown deep clays (Ug5.34) with lesser grey clays (Ug5.25 and Ug5.24). Associated are many small areas with thin-surfaced loamy duplex soils (Db1.13 and Db1.33) and lesser similar (Dy2) soils. MM12 Very gently undulating or level alluvial plains: dominant are loamy duplex soils (A horizon 48 in.) with grey or grey-brown heavy clay subsoils (Dy2.43) and (Dy2.33). Associated are similar brown soils (Db1.13) and (Db1.33) and occasionally red or yellow duplex soils (Dr2.13), (Dr2.12), SI7 (Dy3.43), and (Dy3.33). Small areas of gilgaied clays (Ug5.24) may occupy lower landscape sites. As mapped, the unit may include low ridges of loamy red or yellow earths (Gn2.12, Gn2.11, Gn2.22, and Gn2.21). Undulating or level plains, occasionally with slight to moderate gilgai microrelief (1-2 ft): dominant soils are brown clays of moderate MM13 depth (Ug5.33 and Ug5.32) associated with similar grey clays (Ug5.22, Ug5.23, and Ug5.24). Included in the unit, as mapped are small areas of red-brown friable earths (Gn3.12); deeper clay soils (Ug5.25), (Ug5.15), Undulating to strongly undulating lands with many low sandstone mesas, lateritic scarps, and their dissected remnants: the dominant soils me small low basaltic hills with shallow stony (Um6) and (Uf6) soils; and small alluvial plains with loamy duplex Tb119 soils (Db1.33), (Dd1.33), and (Dy2.33). are probably those on higher sloping sites where very pale grey loamy duplex soils (Dy3.41) occur, associated with (Dy3.42) and similar (Dy2) soils. On the low dissected kaolinized sandstone mesas and pallid-zone scarps shallow stony sands (Uc2.12) are common associated Gently undulating or level plains: dominant soils are sandy or, less commonly, loamy yellow earths (Gn2.22), occasionally (Gn2.21 and Gn2.24). These soils are mostly underlain by nodular or concretionary laterite at shallow to moderate depths and occasionally outcropping. Closely associated are sandy to loamy red earths (Gn2.12) and (Gn2.42), which are much deeper. In broad shallow drainage lines loamy duplex soils (Dy2.43), (Dy2.42), (Dy3.33), (Dy3.43), and (Dy3.42) occur. Throughout the unit are small areas of earthy sands (Uc5.22). with very pale sandy or loamy duplex soils (Dy3.41), (Dy2.41), (Dg4.41), and (Dg2.81). Some more extensive level plains or plateau surfaces have loamy yellow earths (Gn2.21 and Gn2.25) with lesser areas of loamy red earths (Gn2.11 and Gn2.12). Throughout the unit adjacent to MS1 drainage lines are small plains of alkaline loamy duplex soils (Dy2.43) and (Dy3.43), and included in the unit as mapped are small inclusions of Gently undulating plains: dominant are sandy duplex soils with moderately deep (12-15 in.) A horizons. The chief forms are (Dy3.42) and (Dy3.32) but also commonly occurring are (Dy3.43), (Dy3.22), (Dy5.42), (Dy5.43), and (Dy5.32) together with similar (Dy2) soils. The alkaline forms are most common in lower landscape sites where there may also be small areas of (Dd1.33) and (Ug5.24) soils; the latter may have Gently undulating or level plains: dominant soils are loamy yellow earths (Gn. 2.2) with some (Gn. 2.21). (Gn. 2.62), and (Gn. 2.32). Most soils have a prominent ironstone nodule horizon at moderate to shallow depths (18-30 in.). Closely associated and locally dominant are areas of hard loamy red earths (Gn. 1.2), less commonly (Gn. 2.11); these may or may not have an ironstone horizon. Much smaller areas of sandy red earths and earths may control to locally. Broad shallow drainage lines have loamy duplex soils (Dy. 2.33), (Dy. 2.43), (Dy. 3.43), and (Dr. 2.13), or occasionally small areas of gilgaied Ub81 MS2 a moderate (1-2 ft) gilgai microrelief. Occurs on sheet(s): 11,12,13 Strongly undulating slopes rising to rounded low hilly areas; rock outcrop is common on higher landscape sites: dominant are shallow loamy duplex soils (Dy3.43) and (Dy3.33). Associated are shallow stony loams (Um1.43), (Um1.42), (Um1.41), and (Um2.12), and small areas of shallow stony red loamy duplex soils (Dr2.22), (Dr2.12), and (Dr2.43). Similar (Dy2) soils may also occur. Va45 cracking clays (Ug5.24). Outcrops of lateritic materials (billy and porcellanite) may occur with very shallow stony loams (Um1.43) and sands (Uc4.12). Moderate to strongly undulating lands with occasional low hilly areas, often dissected by shallow drainage lines; granite tor outcrop may be Va49 High hilly or mountainous lands, mostly with steep slopes; rock outcrop is often prominent: dominant soils are fairly shallow common: dominant are fairly coarse sandy duplex soils with strongly mottled sandy clay subsoils at moderate depths (10-15 in.). Most common Mj9 and nearly always stony friable earths with a dark loamy surface Fading to red clay subsoils (Gn3.14). A wide variety of other shallow stony soils occur, chiefly (Um1.43), (Um4.2), (Gn3.24), (Gn3.11), (Db1.11), (Dr2.11), (Dr2.12), and (Dy2.11). form is (Dy3.43) but (Dy3.42) and (Dy3.41) also occur. Associated are some areas of similar (Dy2) and (Dy5) soils and also occurrences of gritty gradational soils (Gn2.12) and (Gn2.45). On higher ridges and low hills gritty stony sands are common, cl (Uc4.2), and (Uc1.22). Also occurring in the unit as mapped are small areas of red loamy duplex soils (Dr2.12) and occasionally similar arradational soils (Gn3.12). non, chiefly (Uc5.11), (Uc2.12), (Uc4.11), Level or very gently undulating plains: dominant soils are sandy or loamy red earths (Gn2.12 and Gn2.11) with some yellow earths (Gn2.22 and Gn2.21). Associated are deep red sands (Uc1.23 and Uc1.22), often in the form of low dunes. Broad shallow drainage My19 Undulating or gently undulating lands: dominant are sandy or loamy often gritty duplex soils (Dy3.43) with lesser (Dy3.33) and (Dy3.42). Va50 lines often have loamy duplex soils associated, chiefly (Dv3.42), (Dv2.42), or (Dr2.32). In other depressed areas shallow red earths Some similar (Dy2) soils also occur. Closely associated, particularly on higher landscape sites, are loamy red duplex soils (Dr2.12), rarely (Dr2.13). Small areas of granite outcrop within the unit have shallow coarse sands (Uc4.2 and Uc4.1), less commonly (Uc2.12). are underlain by a clay D horizon. Small areas of clay soils (unit li1) may be included. Level or very gently undulating plains: dominant soils are loamy red earths (Gn2.12) with some loamy yellow earths (Gn2.22). Lower landscape sites have a range of loamy duplex soils, chiefly (Dr2.43), (Dr2.33), (Db1.33), (Dy2.43), (Dy2.33), and (Dd1.33), and limited occurrences of gilgaied clays (Ug5.24). Small flood-plains associated with drainage lines have (Dr2.33) and (Dd1.33) Undulating or moderately undulating lands with broad valleys; dominant are sandy to loamy mottled duplex soils of shallow to moderate depth Undurating or moderately undurating lands with broad valleys: dominant are sandy to loamy motited duplex soils of snallow to moderate depth (18-30 in.). The chief form is (Dy3.43) but a range of other loamy duplex soils also occurs, chiefly (Dy3.33), (Dy3.32), (Dr3.21), (Dr2.12), (Dr2.42), (Dr2.31), (Dp2.43), (Db1.13), (Db1.43), and (Db1.33). In some lower sites there may be small areas of slightly gilgaied brown clays (Ug5.32 and Ug5.34). Throughout the unit there are small areas where the soil surface is covered with a mantle of billy gravel to 4 in. diameter. Va55 My20 soils, and occasionally some low sand dunes (Uc1.21, Uc1.22, and Uc1.23). Undulating lands with some alluvial plains: dominant are very pale grey loamy or sandy duplex soils (Dy3.43) with similar neutral and acid forms occurring on higher landscape sites. Included in the unit as mapped are small areas of loamy or sandy yellow earths (Gn2.22) and small inclusions of unit Tb119. Data are limited. Gently undulating lands with broad ridge crests and low rises: dominant soils are loamy or occasionally sandy red earths (Gn2.12), less often (Gn2.21). Associated are lesser loamy or sandy yellow earths (Gn2.22). On lower slopes and in drainage depressions loamy Va56 My28 duplex soils (Dy3.43 and Dy3.42), and similar (Dy2) soils occur. Occasionally present are low lateritic scarps with shallow stony loams (Um1.43) and (Um4.1). Included in the unit, as mapped, are small areas of gilgaied cracking clays similar to units CC21 and CC33. Gently undulating outwash slopes and fans: dominant are deep loamy duplex soils (Dy3.43), with closely associated deep bleached sands Va86 (Uc2.22. Uc2.21). The sands are confined to the relic stream channel infills and fans. Minor associated soils include other loamy duplex soils ating plains, locally with stronger relief: dominant soils are loamy red earths (Gn2.12), with lesser (Gn2.11). Loamy (Dy2.43) and (Dy3.41) and occasionally (Dr2.21). Data are limited. My34 yellow earths (Gn2.22) are commonly associated. Both earths are commonly strongly nodular at depth and in some instances are underla by massive nodular laterite at shallow depths (15-20 in.). Broad shallow drainage-line valleys in the unit have loamy duplex soils (Dy2.43) Level or very gently undulating plains and broad shallow valleys associated with drainage lines: dominant soils have deep sandy A horizons and are chiefly (Dy3.33) and (Dy3.43), but (Dy3.23), (Dy3.32), and similar (Dy5) soils also occur. Smaller areas of loamy-surfaced (Dy2.33) soils are associated with some drainage lines. Included in the unit as mapped are small areas of sandy yellow earths (Gn2.22), (Gn2.62), Vd2 and (Dr2.43); and small local depressed areas may have gilgaied clays (Ug5.24). At the dissected margins of the unit gravelly duplex soils (Dr2.33) and (Dr2.13) are common. and occasionally swampy depressions with clay soils (Ug5.24). Undulating lands, often with high gravelly ridges: dominant soils are loamy or sandy red earths (Gn2.12 and Gn2.11) that are often gravelly Level or very gently undulating alluvial plains: dominant are duplex soils with fine sandy or loamy A horizons 6-10 in. deep. The chief forms are (Dy3.33) and (Dy3.43). Closely associated are slightly lower plains with a gilgai complex. The clay puffs are elevated (4 6 in.) and have grey or dark grey clays (Ug5.28) and (Ug5.16). Intervening areas have loamy duplex soils (Dy3.33), (Dy3.43), (Dy2.43), (Dy2.33), and (Dd1.33); A horizon depth ranges from 4 to 6 in. Also included in the association are smaller slightly gilgaied clay plains with clay-dominant soils (Ug5.16) and (Ug5.28), and some areas of thin-surfaced loamy duplex soils (unit Sl16). My35 Lesser areas of yellow earths (Gn2.22) occur on lower slope sites. The high gravelly ridges have either sandy red earths (Gn2.12), extremely gravelly sandy soils (Uc5.11), (Uc1.21), and (Uc1.23), or stony loams (Um1.43) and (Um4.1). Occurring throughout the unit, mostly in I Vd4 ower sites, are small areas of loamy duplex soils (Db1.13), (Db1.33), (Dy2.33), and (Dy2.43), or gilgaled clays (Ug5.24) and (Ug5.34). Source: See Copyright Details below and for full disclosure please refer to the EIS Volume 4 - References Job Number | 41-22090 1:500,000 (at A3) SOILS Revision HANCOCK PROSPECTING PTY LTD 10 15 Date 21-09-2010 W->E Figure: 5-1 Alpha Coal Project Man Projection: Universal Transverse Mercator

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Horizontal Datum: Geocentric Datum of Australia 1994 Grid: Map Grid of Australia, Zone 55

Map Unit Description at Proposed Rail Alignment Extend

Hilly or high hilly lands, often with very steep slopes and always with numerous large granite tor outcrops:

Environmental Impact Statement

Table 5-1: Dominant Soil Types and Estimated Properties

Map Unit	Dominant Principle Profile Form	ASC Soil Group ¹	Permeability	Profile Water Holding Capacity	Soil Texture Profile ²	Soil Reaction Class	Gross Nutrient Status	Soil Depth (m)
AA6	Uc5.11	Tenosol	fast	low	UC	Neutral	Low	Shallow<0.5
BZ9	Uc1.21	Rudosol	fast	very low	UC	Neutral	Low	Deep >1.5
CB7	Ug5.22	Vertosol	slow	low	UCr	Alkaline	Moderate	Mod. 0.5-1
CC29	Ug5.24	Vertosol	slow	low	UCr	Alkaline	Moderate	Deep >1.5
CC33	Ug5.24	Vertosol	slow	low	UCr	Alkaline	Moderate	Deep >1.5
CC35	Ug5.24	Vertosol	slow	low	UCr	Alkaline	Moderate	Deep >1.5
CC39	Ug5.25	Vertosol	slow	low	UCr	Alkaline	Moderate	Deep >1.5
CC40	Ug2.25	Vertosol	slow	low	UCr	Alkaline	Moderate	Deep >1.5
Cd14	Uc2.12	Tenosol	fast	very low	UC	Neutral	Low	Shallow<0.5
Fz18	Um1.41	Rudosol	fast	very low	UC	Strongly Acid	Low	Shallow<0.5
Fz7	Um1.43	Rudosol	fast	very low	UM	Neutral	Low	Shallow<0.5
II11	Ug5.28	Vertosol	slow	low	UCr	Alkaline	Moderate	Deep >1.5
JJ13	Uc4.1	Vertosol	fast	very low	UC	Acid	Low	Shallow<0.5
JK2	Uc4.2	Tenosol	fast	very low	UC	Acid	Low	Shallow<0.5
JK6	Uc4.2	Tenosol	fast	very low	UC	Acid	Low	Shallow<0.5
Jb1	Uf6.62	Hydrosol	slow	low	UF	Neutral	Low	Mod. 0.5-1
Kb11	Ug5.12	Vertosol	slow	low	UCr	Alkaline	Moderate	Mod. 0.5-1
Kb25	Ug5.12	Vertosol	slow	low	UCr	Alkaline	Moderate	Mod. 0.5-1

Map Unit	Dominant Principle Profile Form	ASC Soil Group ¹	Permeability	Profile Water Holding Capacity	Soil Texture Profile ²	Soil Reaction Class	Gross Nutrient Status	Soil Depth (m)
Ke19	Ug5.12	Vertosol	slow	low	UCr	Alkaline	Moderate	Mod. 0.5-1
Kf13	Ug5.16	Vertosol	slow	moderate	UCr	Neutral	Moderate	Deep >1.5
Lk17	Um4.1	Tenosol	moderate	very low	UM	Acid	Low	Shallow<0.5
MM11	Ug5.34	Vertosol	slow	low	UCr	Alkaline	Moderate	Deep >1.5
MM12	Ug5.34	Vertosol	slow	low	UCr	Alkaline	Moderate	Deep >1.5
MM13	Ug5.33	Vertosol	slow	low	UCr	Alkaline	Moderate	Mod. 0.5-1
MS1	Gn2.22	Kandosol	moderate	low	Gc	Alkaline	Moderate	Mod. 0.5-1
MS2	Gn2.22	Kandosol	moderate	low	Gc	Alkaline	Moderate	Mod. 0.5-1
Mj9	Gn3.14	Dermosol	fast	moderate	G	Acid	Moderate	Shallow<0.5
My19	Gn2.12	Kandosol	fast	moderate	G	Neutral	Low	Deep >1.5
My20	Gn2.12	Kandosol	fast	moderate	G	Neutral	Low	Deep >1.5
My28	Gn2.12	Kandosol	fast	moderate	G	Neutral	Low	Deep >1.5
My34	Gn2.12	Kandosol	fast	moderate	G	Neutral	Low	Deep >1.5
My35	Gn2.12	Kandosol	fast	moderate	G	Neutral	Low	Deep >1.5
My17	GN2.11	Kandosol	fast	moderate	G	Acid	Low	Deep >1.5
Mz18	Gn2.11	Kandosol	fast	moderate	G	Acid	Low	Deep >1.5
Oa9	Dr2.13	Chromosol	moderate	moderate	Du	Alkaline	Moderate	Mod. 0.5-1
Oc29	Dr2.33	Sodosol	slow	low	Du	Alkaline	Moderate	Mod. 0.5-1
Od6	Dr2.43	Sodosol	very slow	low	Du	Alkaline	Low	Mod. 0.5-1
Ok1	Dr3.33	Sodosol	slow	low	Du	Alkaline	Low	Mod. 0.5-1

Map Unit	Dominant Principle Profile Form	ASC Soil Group ¹	Permeability	Profile Water Holding Capacity	Soil Texture Profile ²	Soil Reaction Class	Gross Nutrient Status	Soil Depth (m)
Qa11	Dr2.12	Chromosol	fast	moderate	Du	Neutral	Moderate	Mod. 0.5-1
Qa12	Dr2.12	Chromosol	fast	moderate	Du	Neutral	Moderate	Mod. 0.5-1
Qa14	Dr2.12	Chromosol	fast	moderate	Du	Neutral	Moderate	Mod. 0.5-1
Qa21	Dr2.11	Chromosol	fast	moderate	Du	Acid	Moderate	Mod. 0.5-1
Qb27	Dr2.22	Chromosol	slow	moderate	Du	Neutral	Moderate	Mod. 0.5-1
Ro5	Db1.33	Sodosol	slow	low	Du	Alkaline	Low	Mod. 0.5-1
Si3	Dy2.33	Sodosol	very slow	very low	Du	Alkaline	Moderate	Mod. 0.5-1
SI10	Dy2.43	Sodosol	very slow	very low	Du	Alkaline	Low	Mod. 0.5-1
SI11	Dy2.43	Sodosol	very slow	very low	Du	Alkaline	Low	Mod. 0.5-1
SI16	Dy2.43	Sodosol	very slow	very low	Du	Alkaline	Low	Mod. 0.5-1
SI17	Dy2.43	Sodosol	very slow	very low	Du	Alkaline	Low	Mod. 0.5-1
SI21	Dy2.43	Sodosol	very slow	very low	Du	Alkaline	Low	Mod. 0.5-1
SI23	Dy2.43	Sodosol	very slow	very low	Du	Alkaline	Low	Mod. 0.5-1
SI7	Dy2.43	Sodosol	very slow	very low	Du	Alkaline	Low	Mod. 0.5-1
Tb119	Dy3.41	Sodosol	very slow	very low	Du	Acid	Low	Mod. 0.5-1
Ub81	Dy3.42	Sodosol	very slow	very low	Du	Neutral	Low	Mod. 0.5-1
Va45	Dy3.43	Sodosol	very slow	very low	Du	Alkaline	Low	Mod. 0.5-1
Va49	Dy3.43	Sodosol	very slow	very low	Du	Alkaline	Low	Mod. 0.5-1
Va50	Dy3.43	Sodosol	very slow	very low	Du	Alkaline	Low	Mod. 0.5-1
Va55	Dy3.43	Sodosol	very slow	very low	Du	Alkaline	Low	Mod. 0.5-1

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Map Unit	Dominant Principle Profile Form	ASC Soil Group ¹	Permeability	Profile Water Holding Capacity	Soil Texture Profile ²	Soil Reaction Class	Gross Nutrient Status	Soil Depth (m)
Va56	Dy3.43	Sodosol	very slow	very low	Du	Alkaline	Low	Mod. 0.5-1
Va86	Dy3.43	Sodosol	very slow	very low	Du	Alkaline	Low	Mod. 0.5-1
Vd2	Dy3.33	Sodosol	very slow	very low	Du	Alkaline	Low	Mod. 0.5-1
Vd4	Dy3.33	Sodosol	very slow	very low	Du	Alkaline	Low	Mod. 0.5-1
Vd5	Dy3.33	Sodosol	very slow	very low	Du	Alkaline	Low	Mod. 0.5-1

Notes:

- 1. ASC Soil Group Classification derived from conversion tables discussed in Volume 6, Appendix E.
- 2. UC uniform course; UM uniform medium; UF uniform fine; UCr uniform cracking; Gc gradational calcareous; Du Duplex; G gradational

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Reference was made to the federal Department of Agriculture, Fisheries and Forestry, Soil Health Knowledge Bank in relation to the attributes detailed in Table 5-1, and associated impacts and mitigation measures (Department of Agriculture, Fisheries and Forestry, 2010).

Soil permeability refers to the ability of a soil to absorb and transmit water. In this case, the soils with moderate to fast permeability ratings are considered to be well drained soils, which are mainly those soils with a gradational soil texture profile. The duplex soils with very slow permeability ratings are considered most likely to become waterlogged due to the presence of a compacted clay layer below the surface soils which impedes drainage. This water logging can lead to rising water tables which may result in encroaching salinity.

Profile water holding capacity (PWHC) refers to the ability of the soil to store water within the rooting depth. Mapped soil units with a PWHC of medium or above (>120 mm), are considered to be most reliable for cropping. The gradational textured soils have the best rating for this aspect, whilst the duplex soils, although having some rated as medium (possibly non-sodic duplex soils), are mostly very low (possibly due to being sodic duplex soils).

Soil texture profile refers to the change in soil texture throughout the profile. The most relevant observation from the above information is that duplex soils have severe limitations in regards to land uses due to the abrupt change in texture between the topsoil and subsoil, affecting drainage and the ability to hold sufficient water within the root zone.

Soil reaction class refers to the pH of the soil type. Acidic soils (<5.5) cause the most issues in regards to establishing vegetation, depending on vegetation type. The pH of the soils disturbed during the construction of this Project is particularly relevant when rehabilitation and reinstatement works are to be undertaken.

Gross nutrient status of the dominant soil types was low or medium, meaning there was major responses to N, P and K along with most micronutrients; and responses to N and P with occasional response to some micronutrients, respectively.

Soil depth of the mapped soil units ranged from shallow (<0.5 m), moderate (0.5-1.5 m) and deep (>1.5 m). This is particularly relevant in regards to topsoil resource. The dominant soil types that had gradational textured soils had the deepest soil depth.

5.2.1.3 Soil Erodibility

Soil erodibility is determined by the rate of infiltration at the surface, permeability of the soil profile, coherence of the soil particles, lack of vegetative cover, loss of soil organic matter and surface sealing (DMR, 2002). Soil types most susceptible to erosion, are the texture contrast soils (duplex soils), particularly soils that are highly sodic as the higher sodium content results in soil particles being easily separated and hence, more easily mobilised by wind and water.

Table 5-2 details the erodibility ratings of the various soil types likely to be encountered along the Project, included also are the relevant Australian Soil Classifications for the soil types (also found in Table 5-1), found along the Project. Refer to Figure 5-1 in particular the mapped unit descriptions, which detail the dominant soil type along with associated soil types that may exist within the mapped units.

Table 5-2: Erodibility of soil types encountered along the Project (DTMR, 2010)

Soil Types and ASC	Description of Erodibility Characteristics	Erodibility Rating			
sandy loams -	ly loams – sandy loam with single grained massive structure. Coarse textured osols and surface layers are generally either loose or incoherent or firm and				
Uniform loams and clay loams Massive - Kandasols Structured - Rudosols, Tenosols and Dermosols	Coherent loams, sandy clay loams and clay loams with massive to strong structure. The medium texture results in these soils being moderately permeable regardless of structure. Significant energy is required to detach such soils.	Very Low (1)			
Uniform non-cracking Clays - <i>Dermosols</i>	Light to heavy clays with strong structure: • fine aggregates – the high clay content is offset by the strong structure and moderate permeability due to the fine aggregates • coarse aggregates – similar erodible characteristics to the uniform cracking clays	Very Low (1) Low (2)			
Uniform cracking clays – Vertosols	Light medium to heavy clays that shrink and crack open when dry and swell when wet, Gilgai micro relief common. Moderate to strong structure but generally coarse aggregate below the surface resulting in slow to very slow permeability. Soils are erodible under considerable energy.	Low (1)			
Sandy Gradational Soils – Kandosols	Texture gradually increases from a sandy surface to sandy clay loam or sandy light clay with depth; single grain to massive structure. Similar erodible characteristics to the uniform sands and sandy loams.	Moderate (3)			
	Texture gradually increases from a loamy surface to sandy clay loam or clay with depth; massive to strong structure. These soils have a coherent medium textured surface that grades into clay subsoil. The soils are moderately permeable regardless of subsoil structure and require considerable energy to detach. The high proportion of clay sized particles makes them susceptible to erosion by running water.	Low (2)			
	Sandy or loamy surface abruptly overlaying non dispersive and generally friable clay subsoil. The erodibility of the surface and subsurface varies from moderate for the sandy layers to low for the loamy layers. The structure of the clay subsoil varies and profile permeability varies from slow to moderate. The clay particles in the subsoil are not prone to dispersion but their lightweight renders them very susceptible to erosion by running water.	Moderate (3)			
	Sandy or loamy surface abruptly overlying a hard, dispersive clay subsoil If soil is sodic (ESP 6-14) and/or Ca:Mg <0.5 If soil is strongly sodic (ESP >15) and/or Ca:MG <0.1	High (4) Very High (5)			

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Soil Types and ASC	Description of Erodibility Characteristics	Erodibility Rating
Waterlogged Soils - Hydrosols	Uniform sands, uniform clays, gradational soils and texture contrast soils that saturated with water for several months of the year. Within saline waterlogged soils, if the soils are drained and leached the removal of soluble salts generally results in sodic profiles and thus increases the erodibility rating to a moderate to high.	

5.2.1.4 Sodic Soils

A soil is considered sodic when sodium reaches a concentration where it starts to affect soil structure. In Australian soils this is commonly when the exchangeable sodium percentage (ESP) is greater than six per cent (Isbell, *et al* 1983). When sodic soils are wetted the sodium acts to weaken the bonds between soil particles, resulting in clay swelling and consequent slaking or dispersion (Rengasamy and Walters, 1994).

Slaking refers to the rapid disintegration of large aggregates (two to five mm diameter) of soil into finer aggregates (i.e. less than 0.25 mm) when wet and is caused primarily by a lack of strong organic particles and micro aggregates. This changes the macroscopic structure of the soil resulting in loss of macropores and alters the porosity and permeability.

Dispersion is a second process of structural breakdown and is caused by either high levels of exchangeable sodium or by excessive mechanical disturbance of a soil, particularly when wet. When dispersive soils are wet aggregates of clay, silt and sand breakdown with individual clay particles going into suspension. Such dispersion may occur in sodic soils without any disturbance at all. The dispersed clay particles can be easily moved by water or wind and can migrate through the soil clogging soil pores and reducing infiltration and drainage and causing higher run-off. This may lead to a range of problems including high erosion rates, water pollution, tunnel formation, reduced workability, difficulty with vegetation establishment, and reduced vegetation growth due to low water holding capacity and root penetration (Raine and Loch, 2003).

The three categories for sodicity corresponding to different ESPs are included in Table 5-3.

Table 5-3: Sodicity rating based on ESP

Sodicity Rating	Exchangeable Sodium Percentage	
Non-sodic	0-6%	
Marginally sodic to sodic	6-14%	
Strongly Sodic	>14%	

Sourced: Hazelton and Murphy, 2007

The Australian Soil Resource Information System (ASRIS) developed by CSIRO, provides best available soil and land resource information. This database was used to assess the presence of the above sodicity ratings of the soils likely to be disturbed on this Project. The Exchangeable Sodium Percentage Map provided in Table 5-3 shows the ESP levels of the subsoil material (B22 horizon) across the alignment.

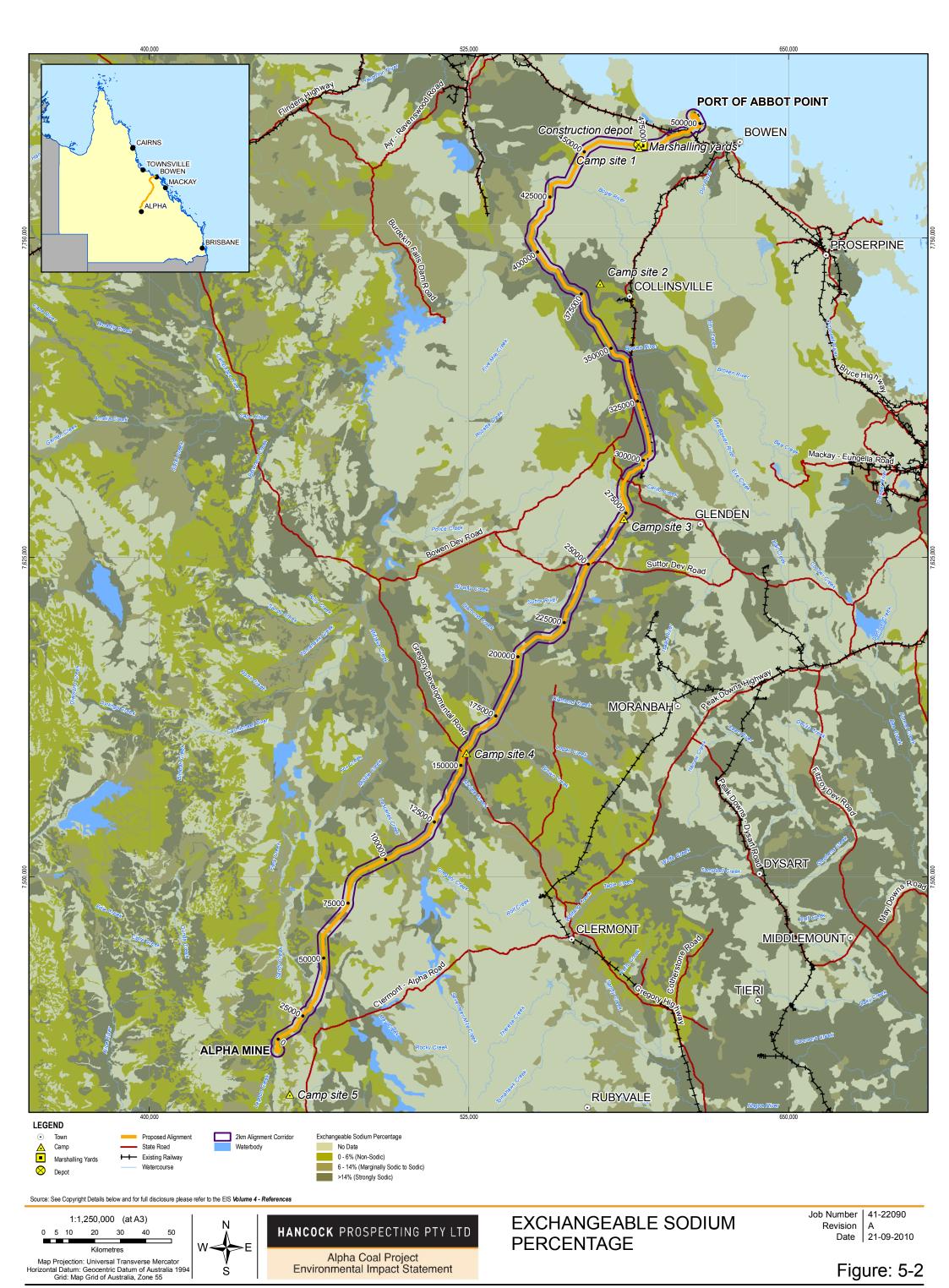
Table 5-4 details the area coverage of each sodicity ratings detailed in Table 5-4 within a 60 m buffer around the Project alignment.

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Table 5-4: Calculated area for the different sodicity ratings

Sodicity Rating	Hectares
Insufficient Data	866
Non-sodic	472
Marginally sodic to sodic	690
Strongly Sodic	1004

As detailed above, there is a significant portion of the alignment that could not be mapped due to insufficient data; however the ESP map and Figure 5-2 does show that extensive areas of marginal to strongly sodic levels of exchangeable sodium are present along the Project. This is particularly the case in the area from chainage 125 km to chainage 250 km and in the area around the Bowen River System. Soils identified as non-sodic are also interspersed throughout the Project alignment. The region itself appears to have increasing sodicity levels eastwards towards the coast with larger areas of strongly sodic soils mapped in the east compared to the west.



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5.2.1.5 Acid Sulfate Soils

5.2.1.5.1 Overview

Acid sulfate soils (ASS) are generally confined to low-lying coastal areas of Holocene to Quaternary-aged marine and estuarine sediments. With respect to local planning policies, developments that have the potential to disturb in-situ ASS fall under the assessment of the *State Planning Policy (SPP 2/02) Planning and Managing Development that Involves Acid Sulfate Soils*. The SPP 2/02 requires an ASS assessment if the Project falls in an area mapped as containing ASS or is below the five m Australian Height Datum (AHD) elevation.

The rail loop after chainage 493 km through to chainage 510 km traverses low-lying areas with a ground surface elevation ranging from less than one m to five mAHD. Under the SPP 2/02, the proposed development will require an ASS assessment and if required preparation of an ASS Management Plan. A desktop assessment has therefore been conducted for the rail loop area beyond chainage 493 km.

Note that while acid forming rock can be associated with geological formations crossed by the Project, the depths of excavation associated with construction is unlikely to expose such rock.

5.2.1.5.2 Desktop Assessment

The Geological Survey of Queensland 1:250,000 scale Digital Geological Mapping indicates that the low-lying coastal study area comprises of Quaternary-aged sediments and Carboniferous- to Permianaged intrusive volcanics. The geological units underlying the rail loop are summarised in Table 5-5 and a geology map illustrating the outcropping of individual units is shown in Volume 3, Section 4 of this EIS. The majority of the rail loop area consists of Quaternary-aged alluvium, coastal mud flats, minor evaporates, colluvium and soil. This particular geological unit (Qa) generally corresponds to areas that are below five m AHD, therefore these sediments have the greatest probability of containing ASS.

Table 5-5: Summary of Geological Units within the Low-lying Coastal Area

Geological Age	Map Symbol	Formation Name	Lithological Description	
Quaternary	Qa	Alluvium	Alluvium, coastal mud flats, minor evaporites, colluvium, soil	
Quaternary	Qr	Colluvium	Clay, silt, sand, gravel and soil; colluvial and residual deposits	
Carboniferous – Permian	CPg	Intrusive Granitoid	Adamellite, granodiorite, granite; minor microgranite, porphyry, quartz diorite, granophyre, microtrondhjemite	
Carboniferous	Cud	Intrusive Granitoid	Diorite, quartz diorite, tonalite, gabbro, granodiorite; rare adamellite, norite, monzonite, granite; abundant dykes	

5.2.1.5.3 Acid Sulfate Soil Risk Map

The Queensland Department of Environment and Resource Management (DERM) and the Queensland Acid Sulfate Soil Investigation Team (QASSIT) have published detailed mapping of ASS across the state, however no published mapping is available for Abbot Point. Broad scale information on soils obtained from CSIRO ASRIS identified that the study area contains a high probability of ASS occurrence.

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5.2.1.5.4 Previous Acid Sulfate Soil Investigations

A number of ASS investigations have previously been undertaken in the vicinity of the Project, associated with the following Projects:

- existing Abbot Point Coal Terminal (APCT) Stage 3 EIS (WBM, 2006);
- Abbot Point X110 Expansion Project Environmental Assessment (North Queensland Bulk Ports Corporation (NQBP), 2009); and
- Abbot Point Multi Cargo Facility Environmental Impact Statement (MCF EIS) (North Queensland Bulk Ports Corporation, 2010).

Existing Abbot Point Coal Terminal (APCT) Stage 3 EIS (WBM, 2006)

The ASS investigation area for the APCT EIS indicated that there was no potential acid sulfate soils (PASS) material within the Stage 3 Expansion area of the APCT. The underlying geology of the Stage 3 Expansion consists of low-lying Quaternary-aged coastal sand plains. The investigation concluded that there was no actual or potential ASS present within the soil to the proposed disturbance depth for the Project.

Abbot Point X110 Expansion Project EA (NQBP, 2009)

The ASS overview for the Abbot Point X110 Expansion Project identified PASS along the western boundary and the south-western boundary of the study area, which generally corresponds with the Quaternary-aged coastal mud flats (Qa) unit. A small area of ASS material was also identified within the existing rail loop. Data on oxidisable sulfur levels or acid neutralising capacity was not reported in the Environmental Assessment (EA). The EA indicated that levels of treatment to neutralise potential acid production of the soil were rated as very high (5 – 25 kg/tonne soil), with some areas rated as requiring extra-high levels of neutralising treatment (>25 kg/tonne soil). Treatment categories were taken from the QASSIT Soil Management Guidelines, 2004.

Abbot Point Multi Cargo Facility EIS (NQBP, 2010)

The ASS investigation for the Abbot Point MCF – Access Road, falls alongside the western side of the Project's rail loop. A total of 25 test pits to a depth of two m below ground level (BGL) were completed and 149 samples collected for ASS analysis. Both actual acid sulfate soils (AASS) and Potential acid sulfate soil (PASS) were confirmed within the sediments. According to the EIS, the reported average net acidity for samples that exceeded the guidelines is 0.45 %S and the maximum net acidity reported is 3.7 %S. The laboratory results also reported acid neutralising capacity at below the laboratory limit of reporting (LOR). The EIS report concluded that the sediments do not have any buffering capacity. The reported calculated liming rate required to neutralise all actual, potential and retained acidity was calculated as an average at 27 kg fine-grained neutralising agent per tonne of soil. The highest liming rate calculated was 170 kg fine-grained neutralising agent per tonne of soil.

5.2.1.5.5 Summary

Based on information identified, it is expected that some actual and potential ASS will be encountered during construction of the Project in the Abbot Point area. Potential impacts associated with ASS, together with mitigation measures are discussed in Section 5.3.4 below.

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5.2.1.6 Salinity

Soil salinity refers to the presence of water soluble salts in water or soils. The most common base for salts is sodium; however potassium, calcium, and magnesium can also contribute appreciably to soil salinity. These salts may be present as chlorides, sulfates, or carbonates. Elevated salt levels in soils can hinder vegetation growth, ultimately causing dieback and leaving exposed areas (surface scalds) where vegetation cannot re-establish. Salinity is a natural property of some soils but can be exacerbated by human activities, for example where tree clearing causes groundwater levels to rise, mobilising salt held in soils.

Evaluation of soil salinity on plant growth can be complex and requires consideration to the depth at which the saline zone occurs (e.g. shallow saline layers can have a greater impact on plant growth than saline soil at depth).

Measures of electrical conductivity (EC) from a soil / water suspension (EC_{1:5}) is a common measure of salinity in soil and water. The relationship between EC and the salinity effect to plant growth is dependant upon the salt tolerance of the plant, and is strongly influenced by soil texture, in particular clay content of the soil. The greater the clay content the higher EC will need to be before it has saline impacts on plant growth because clay soils are made of plates with strong electrical bonds i.e. the EC concentrations that severely inhibit vegetation growth in sandy soils may cause little adverse growth effects on in heavy clay soils.

The majority of the Project corridor has been assessed as part of the National Action Plan for Salinity and Water Quality, Burdekin Catchment, 2003. The area has been mapped for Salinity Hazard in regards to the Potential for Salt Mobilisation. The allocation of map ratings is based on the vulnerability of the landscape to salinity due to the inherent characteristics of the various landscapes.

The Project commencing from the Alpha Coal mine site is within an area mapped as moderate to high salinity hazard. The corridor remains within moderate to high risk areas until it crosses Mistake Creek where the risk levels reduce to a mostly moderate level. Low to moderate risk areas are mapped north of the Suttor River and North West of Collinsville. The risk level returns to moderate to high nearing the Bogie River crossing and remains elevated as the alignment nears Abbot Point.

5.2.2 Good Quality Agricultural Land

5.2.2.1 State Planning Policy

Good Quality Agricultural Land (GQAL) refers to land capable of sustainable use for crop or animal production, with a reasonable level of input, without causing degradation of land or other natural resources (QDPI, 1993). The State Planning Policy (SPP) 1/92, Development and the Conservation of Agricultural Land, sets out principles to guide the protection of GQAL and provides guidance to local authorities on how this issue should be addressed when carrying out their range of planning duties (DHLG and P, 1992). The relevant Planning Guidelines: the Identification of Good Quality Agricultural Land (DPI and DHLGP,1993) were referred to when conducting this assessment on GQAL.

GQAL is the land most suitable for farming. It is essential for:

- · food production, both domestic and international;
- local and regional economic prosperity;
- · valuable export earnings;

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- preserving the social fabric of rural communities; and
- · growth of secondary industries.

Australia has a limited supply of good quality agricultural land, with only 1-2% of land supporting highly productive agriculture. Environmental impacts from farming in these lands are easier to manage than in other areas, as the soil, topographic and climatic conditions are more favourable. Like any limited and non-renewable resource, it is important to conserve this land and the SPP 1/92 sets up the policy basis for protecting land that is suitable for agricultural production.

DERM publishes reports and mapping for areas within Queensland where GQAL or other Land Suitability assessments have been undertaken. The relevant reports and mapping data used to assess GQAL and Land Suitability for the area impacted on by this Project includes:

- land suitability study of the Collinsville-Nebo-Moranbah region. Queensland Department of Primary Industries (Shields, 1984);
- soils Burdekin-Townsville region. Queensland Resources Series. Department of National Development (Isbell et al, 1970);
- lands of the Nogoa Belyando Area, Queensland, Land Research Series No. 18, CSIRO, (Gunn et al 1967); and
- North Queensland Versatile Cropping Land, (Queensland Department of Environment and Resource Management 2009).

The above studies and the associated data sets allowed for an assessment of GQAL and Land Suitability to be conducted over the entire Project alignment. Analysis and allocation of GQAL / Land Suitability ratings was undertaken as per the *Planning Guidelines: the Identification of Good Quality Agricultural Land* (DPI and DHLGP,1993). Due to the variable dates in which these land studies were undertaken, field assessments of the findings will be required to establish their accuracy. The four classes of agricultural land defined in the planning guidelines are detailed in Table 5-6.

Table 5-6: GQAL classes

Class	Description
Α	Crop land - Land that is suitable for current and potential crops with limitations to production which range from none to moderate levels.
В	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.
С	Pasture land - Land that is suitable only for improved or native pastures due to limitations which preclude continuous cultivation for crop production; but some areas may tolerate a short period of ground disturbance for pasture establishment.
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.

The different data sets used to establish GQAL / Land Suitability along the Project do not all map units according to the GQAL Classes listed above; however correlative relationships between the mapped units of the various soil and land studies to the GQAL classes can be achieved by referring to the

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planning guidelines and by reviewing the information presented in the studies. Summaries of the findings of the different soil and land studies and their respective data sets are provided below:

5.2.2.2 Land suitability Study of the Collinsville-Nebo-Moranbah Region

The Land suitability study of the Collinsville-Nebo-Moranbah region (Shields, 1984) was undertaken to determine the cropping potential of the region. The major crops grown in Central Queensland include grain sorghum and sunflower during the summer and safflower and wheat during the winter.

Rainfed broad-acre raingrown cropping in the region is restricted to soils with a high plant available water capacity (PAWC). The majority of the rainfall (70%) occurs in the summer months when sorghum and sunflower are grown, however, rainfall variability is so high during this period that PAWC is a critical factor for successful cropping. In the winter months rainfall is negligible so any cropping of wheat and sunflower must rely almost entirely on stored soil moisture.

The only soils that were identified as having some potential for rain grown cropping were the cracking clay Vertosols soils. Cracking clays on sedimentary rocks must be deeper than 60 cm to be suitable for cropping in the Collinsville-Nebo area. The Vertosols with heavy clay subsoils below the self-mulching layer may be susceptible to hardpan development. Hardpans that develop immediately below the plough layer may severely restrict root and water penetration.

Gilgaied Vertosols clays with deep (40 to 100 mm) melonhole microrelief severely hinders cultivation and land levelling will bring the saline subsoils to the surface resulting in poor crop growth. They are unsuitable for rain grown cropping.

Vertsosols occur on gently undulating plains and rises. They are moderately to highly erodible and where present on slopes greater than one per cent, soil conservation measures would be required to minimise soil losses.

The Sodosols are unsuitable for rain grown cropping due to low PAWC and deep hard setting surface soils; however they are suitable for grazing. The sodic nature of the subsoils results in the soils having a high erodability potential, as discussed in Section 5.2.1.4 above. Relatively flat areas with slopes less than two per cent are suitable for pasture improvement, but slopes greater than this are unsuitable for cultivation and should be grazed for native pastures only.

The Dermosol rocks have a low PAWC, very low fertility and are unsuitable for rainfed cropping. They tend to support eucalypt woodlands that would be expensive to clear and prone to woody regrowth and are more suited to native pasture grazing.

The accompanying map to this study provided an overview of the land suitability allocating either a rating of Arable (suitable for rain grown agriculture or improved pastures) or Non-Arable (suitable for improved pasture, or suitable for grazing of native pastures and catchment protection), these ratings have been correlated to GQAL classes in accordance with the planning guidelines and is provided in Table 5-7.

5.2.2.3 Soils of the Burdekin-Townsville Region

The study of the soils in the Burdekin – Townsville region (Isbell et al, 1970) was undertaken to assess the soil resources within the study area and provide an assessment of the soils potential productivity. The assessment involved a review of; climatic conditions, management factors, soil moisture, nutrient status, soil parent material and available soil profile information and investigations.

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The following is a summary of the soil groups that are mapped within the rail corridor and their potential for agricultural uses.

Soils with texture contrast (duplex) profiles have the widest distribution and diversity within the study area. They are characterised by having a lighter texture surface soils overlying heavy clay subsoils. Generally the clayey subsoil causes sever impedance of internal drainage and the hard setting loamy surface soils leads to excessive runoff losses from high intensity rainfalls.

The neutral red duplex soils generally have a shallow sandy loam to sandy clay loam soil surface with an abrupt change to a strongly structured clay material at 10 - 20 cm. The soils are generally used for beef cattle grazing on fair suited to some cultivation. Their nutrient status is generally low but they do have a fairly high potential for pasture development.

The alkaline bleached duplex soils are fairly widespread, and occur on a range of parent materials, and range from shallow and stony to deep and stone free. Most of these soils are used for beef cattle grazing of generally poor quality native pastures.

Mottled soils have a coarsely structures, very dense and tough clay subsoils which severely impedes internal drainage and root penetration. The nutrient status is low with deficiencies in phosphorus, nitrogen, molybdenum and sulphur. There is some scope in areas for improved grass and legume pastures after clearing and fertilising.

Deep earthy sands have low to very low nutrient status and land use is restricted to sparse cattle grazing with some native hardwood production. Some of these soils are ideally suited to pastures but productivity will be variable as many of these soils have very low water holding capacity.

Dark cracking clays, occupy only a small area within the rail corridor. The soils have moderate to high nutrient status and high water holding capacity, but often have a stony nature which limits the potential. These soils between Home Hill and Bowen have areas of deep stone free dark clays with low phosphorus levels. The major use for the dark cracking clay soils is beef cattle grazing on native pastures.

5.2.2.4 Land of the Nogoa – Belyando Area

The Nogoa – Belyando Area survey covered an area of 35,000 square miles known as the Nogoa – Belyando Area (Gunn et al. 1967). Assessments were undertaken on landforms, soils and vegetation in order to map the varying land systems within the region. The area was mapped in terms of 43 different land systems. The land systems are described in relation to the three main characteristics, land form, soils and vegetation. An estimated land capability class is also provided for each of the land systems. A summary of the land systems that are within the Project include the following:

- Alpha (Al) Alluvial plains with box and texture contrast soils in non-basaltic alluvium;
- Avon (Av) Gently undulating grassland with cracking clay soils on alkaline clays deposited within the tertiary wetland;
- Blackwater (BI) Brigalow plains with cracking clays on acid clay exposed within the tertiary zone;
- Borilla (Bo) Rocky hills with ironbark and shallow, rocky soils cut below the Tertiary weathered zone on volcanics;
- Carborough (Ca) Mountains and hills with narrow leaved ironbark and lancewood, shallow rocky soils formed on quartz sandstone mainly below the tertiary weathered zone;

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- Comet (Ct) Flooded alluvial plains with brigalow and cracking clay soils;
- Disney (D) small lateritic mesas with ironbark and red and yellow earths on tertiary sandstone; surrounding lowlands with box and brigalow and texture-contrast soils on weathered Drummond Basin sediments;
- Funnel (Fu) Flooded alluvial plains with coolabah and cracking clay soils;
- Hope (Ho) Low stony hills and lowlands with narrow leaved ironbark and texture contrast soils on Drummond basin sediments below the tertiary weathered zone;
- Humboldt (Hu) Lowlands and plains with Blackbutt and brigalow with texture contrast soils formed on acid clay exposed within the tertiary weathered zone;
- Islay (I) Gidgee plains with gilgaied clay soils on acid clay exposed within the Tertiary weathered zone;
- Kinsale (K) Brigalow scrub on rolling basalt country with cracking clay soils within the Tertiary weathered zone;
- Lennox (Le) Plains and lowlands with silver leaved ironbark and yellow and red earths on intact tertiary land surface;
- Monteagle (Mo) Lowlands with box on texture-contrast soils on slightly stripped Tertiary land surface;
- Moray (My) Plains and lowlands with gidgee and cracking clay soils on Alkaline clay deposited within the tertiary weathered zone;
- Rutland (Ru) Lowlands and low hills with groved brigalow and ironbark and texture contrast soils
 on both weathered and fresh Drummond basin sediments;
- Somerby (So) Gilgaied plains with brigalow and cracking clay soils on acid clay exposed within tertiary weathered zone;
- Tichbourne (Ti) Undulating country with silver-leaved ironbark or melaleuca and red and yellow earths on partially stripped Tertiary land surface; and,
- Ulcanbah (U) Clay plains with gidgee and cracking clay soils on shales and acid clay exposed within the tertiary weathered zone.

The planning guideline provides correlative relationships between the different land systems and the GQAL classes.

5.2.2.5 North Queensland Versatile Cropping Land

The North Queensland Versatile Cropping Land (VCL) (DERM 2009) is a product of the DERM review of policy SPP 1/92 to protect the more 'versatile' agricultural land from inappropriate development and move away from the use of the established GQAL (Good Quality Agricultural Land) principle for the States Regional Planning process. VCL is represented by the values 'Y' or 'N'.

- Y being yes, meaning suitable land uses for a mapped unit being four or more; and
- N being no, is where the mapped unit has less than four suitable land uses.

This data is used to identify the VCL for planning purposes for both irrigated and non-irrigated land uses. Correlative relationships are not established within the planning guidelines, but estimated GQAL

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ratings have been provided, but will be required to be assessed in the field to determine appropriate ratings were allocated.

5.2.2.6 Allocation of GQAL Rating

As mentioned previously the Planning Guidelines for the Identification of GQAL provides correlations between varying studies, assessments and maps to the different GQAL classes. Table 5-7 details the correlative / relationships between the mapped units within the four different studies and their respective data sets to the GQAL ratings.

Table 5-7: Soil and land suitability mapped units correlation to Good Quality Agricultural Land

Report Title	Map Title	Map Units of Good Quality Agricultural Land
Land Suitability Study of the Collinsville – Nebo – Moranbah Region, 1984	,	A: Arable C: Non-arable (improved pastures)
Lands of the Nogoa-Belyando Area, Queensland (1967)	Land Systems Map	A: K, Ma, My, O, W B: Al, By, Bl, Ct, Cu, D, Fu, Hi, Hu, I, Mo, Pv, Ph, S, So, U, Wa, Wh C: Av, Cn, Fu, Ru, Wi
Soils. Burdekin-Townsville Region. (1970) –	Soils Map	B: Dark Deep Cracking Clays (Cf 17) C: Neutral Red Duplex (RC12, 13, 15), Alkaline Duplex (YD11, YE13, YE16, GG4, GH27), Deep Earthy Sands (Sg1).
Versatile Cropping Land, 2009	Versatile Cropping	A – Yes B - No

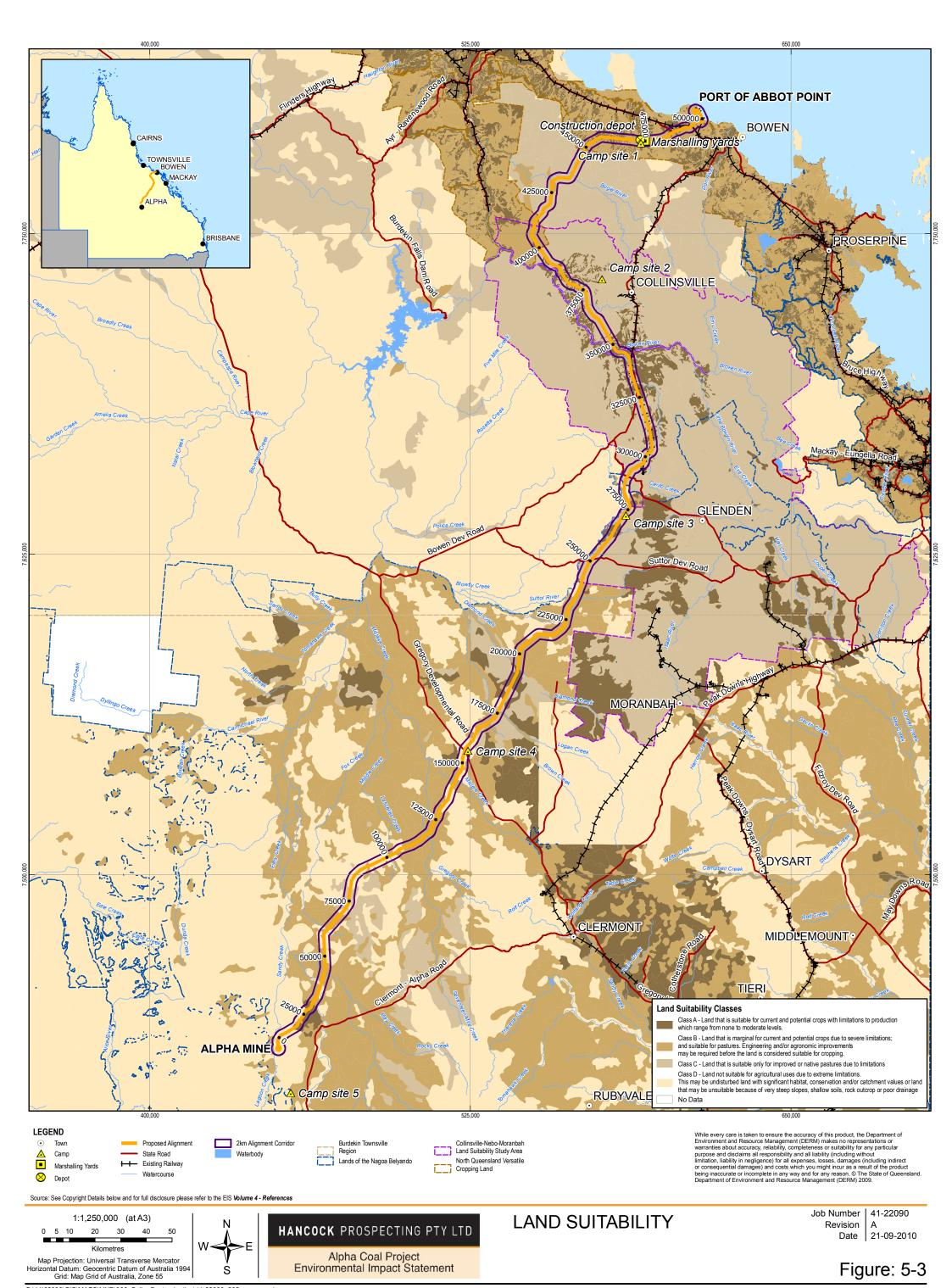
No correlative relationships are established for GQAL Class D soils. For the purpose of this assessment, mapped units without a GQAL correlation of A, B or C, are regarded as land unsuitable for agricultural use (Class D).

The Project transects each of the GQAL Classes at various areas along the alignment. Table 5-8 details the percentage and area of GQAL classes within the 60 m buffer of the Project corridor.

Table 5-8: Impact on GQAL within a 60 m buffer of the rail corridor

GQAL Class	Total Area (ha)	Percentage of Total Footprint
А	503	17
В	1077	35
С	644	21
Unallocated (Assumed to be Class D)	809	27
Total	3034	100

As shown in Table 5-8 above, there are significant portions of Class A and B land along the rail corridor; this is also represented in Figure 5-3.



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5.2.3 Topography

Information regarding the creeks, hydrology and catchment drainage is provided in Volume 3, Section 11 of this EIS. A broad overview of the varying topographical features encountered along the Project is provided in this section. Figure 5-4, shows the elevation and topographical features to be traversed along the rail corridor, also referred to in describing the topography were the available land studies (Gunn et al 1967 and Christian et al 1950) which provided additional details on the topographical features likely to be encountered.

From the Alpha Coal mine site, the Project commences within an area of plain and gently undulating slopes with alluvial flats closer to Lagoon Creek, before progressing into undulating country with level to low hilly reliefs, with some rugged country (knolls and breakaways) present to the west. From chainage 18 km to chainage 30 km the alignment traverses an area of low rises and ridges, with broad gently undulating country with gentle slopes. Available land systems reports suggest there is an area from chainage 21 km to chainage 23 km that may have some localised steep slopes up to 60% on the mesa edges.

From chainage 30 km the Project enters an area of occasional low hills within a lowland area of level to undulating plains before entering the alluvial plains closer to Native Companion Creek. The alignment progresses to an area of flooded alluvial plains before traversing the Belyando River, which is a braided river system; there are also some broad channels throughout the area around the Belyando River.

As the Project leaves the alluvial floodplains of the Belyando River area it returns to a lowland area with level to gentle undulations with possible rugged breakaways and depressions interspersed throughout. At chainage 50 km the Project passes through plain country with level to very gently undulating slopes with some more pronounced rises. At chainage 60 km the alignment crosses Lestree Hill Creek, and re-enters similar country of plains and lowlands, with interspersed depressions and crests of rises and low hills.

The Project crosses a small area on the upslope of the alluvial plains at approximately chainage 64 km, before re-entering an area of crests and rises with intermittent plains and shallow depressions. There may be some localised steeper slopes around the rises. From approximately chainage 72 km the Project is within undulating lowlands with some strike ridges and hills, narrow alluvial flats may be interspersed within the natural channels.

A small area after chainage 80 km is considered to be mostly level to low hilly undulations, with some knolls and breakaways in the more rugged terrain. The Project then enters a sustained area of level to very gently undulating slopes with sporadic hills and scarps with incised valleys from chainage 85 km to chainage 105 km. Within this country there is an area of small lateritic mesas with very low strike ridges at approximately chainage 90 km. Following Laselles Creek the Project enters an area of lowlands and plains with shallow depressions. This is consistent until around Gregory Creek at approximately chainage 118 km, whereby the Project enters an area of flooded alluvial plains around the creek line.

From chainage 120 km the alignment enters an area of plains and lowlands with some low local relief, breakaways, depressions and alluvial flats around the drainage areas. There is a possibility of a small area around chainage 135 km of rocky hills with the occasional strike ridges, before returning to the

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plains and undulating lowlands with occasional rugged outcrops. The area around Miclere Creek is within alluvial flat country before returning to similar country as previous.

From Gregory Development Road at chainage 155 km the Project enters an area of plains, lowlands and depressions with occasional rises and scarps. Flooded alluvial plains are traversed around Brown and Logan Creek at chainage 170 km. Following the alluvial plains, the alignment returns to gently undulating grassland areas, with some shallow valleys and narrow alluvial flats. There are some local relief areas, prior to entering an area of plains and lowlands at approximately chainage 186 km, the country grades into the alluvial floodplains around Diamond Creek (chainage 196 km) area.

Following Diamond Creek, the Project travels along the upper portion of undulating lowland country with some slight rises and shallow depressions. The Project then enters an area at chainage 205 km of small lateritic mesas with small rises, gently to moderately undulating with alluvial flats in some of the lower lying areas. The Project progresses through similar terrain until approaching Eaglefield Creek (chainage 224 km) where the land is predominantly plains with some local rises, with flooded alluvial plains confined mostly to around the creek area.

The Project remains in relatively plain lowland country with low to moderate undulations, with intermittent crests and rises, following the Eaglefield Creek crossing, until approximately chainage 255 km when the Project enters an area of lowlands with sporadic breakaways and knolls, with depressions and alluvial flats interspersed throughout. This remains until chainage 260 km whereby level to gently undulating country is traversed with alluvial flats around the Suttor Creek crossing. The terrain rises following this crossing back to undulating country.

From chainage 270 km onwards the terrain is rolling undulating country with some hills and rises. The elevation is decreasing as it heads towards Abbot Point, with the most noticeable change in elevation occurring after chainage 300 km where the alignment enters the Bowen River Catchment area. The alignment travels through several creek and drainage lines in undulating terrain with some sharper rises and depressions.

The alignment crosses the Bowen River at approximately chainage 345 km before running parallel with it to approximately chainage 388 km. The terrain around the river is gentle sloping levee country, with the river being the lowest point and the areas either side a mixture of small crests and gentle slopes. The Project travels west of the river within an area consisting of low gently undulating hills. The Project travels along the Bowen River traversing both kinds of terrain at various locations.

As the Project starts to move away from the Bowen River at chainage 388 km the Project travels through gently undulating terrain with some low hills and flatter lower parts. To the east of the alignment at chainage 390 km, 404 km, and 410 km there are some rugged hills / ranges with steep sloping parts. The Project generally follows a gently undulating line as it travels around these hills.

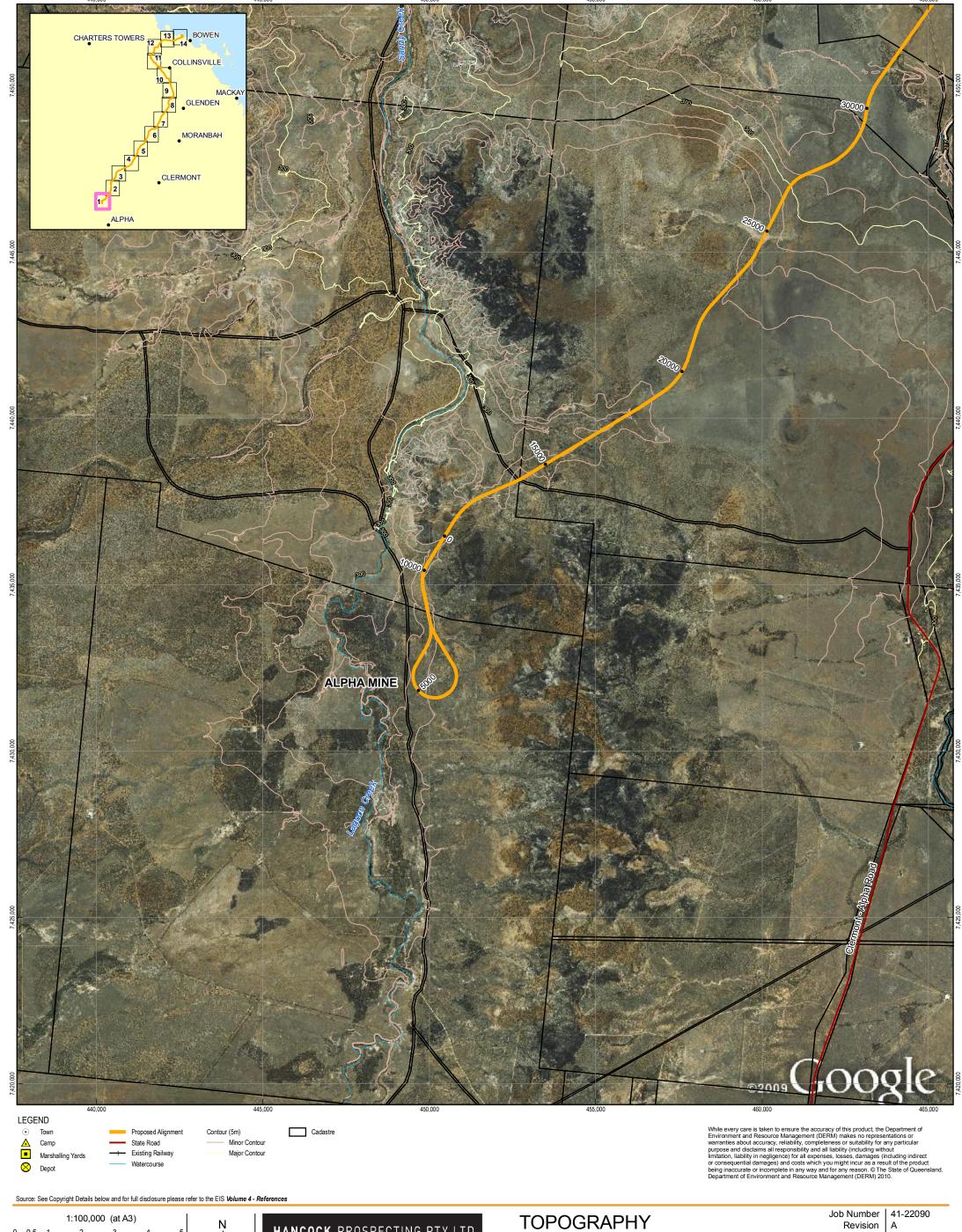
The Project enters an area of nearly flat terrain with some broad shallow depressions as it runs parallel to the Bogie River at chainage 427 km before crossing it at chainage 435 km. Following the river crossing it re-enters an area of undulating to gently undulating terrain. To the east of the alignment from chainage 442 km to chainage 448 km is an area of rugged ranges and hills.

As the Project turns to head east towards Abbot Point at chainage 45 km it remains within gentle undulating country with relatively flat country around the Sandy Creek and Elliot River areas. The terrain remains relatively flat with some moderate undulations as it enters into Abbot Point. The

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Project travels through a number of small streamlines as it progresses towards Abbot Point which would have localised variations in topography.

The Abbot Point rail loop is in a naturally low lying salt flat area. Two distinct increases in elevation are observed at chainage 490 km and chainage 500 km which are considered to be small hilly areas outside of the rail loop which is in an otherwise flat terrain.



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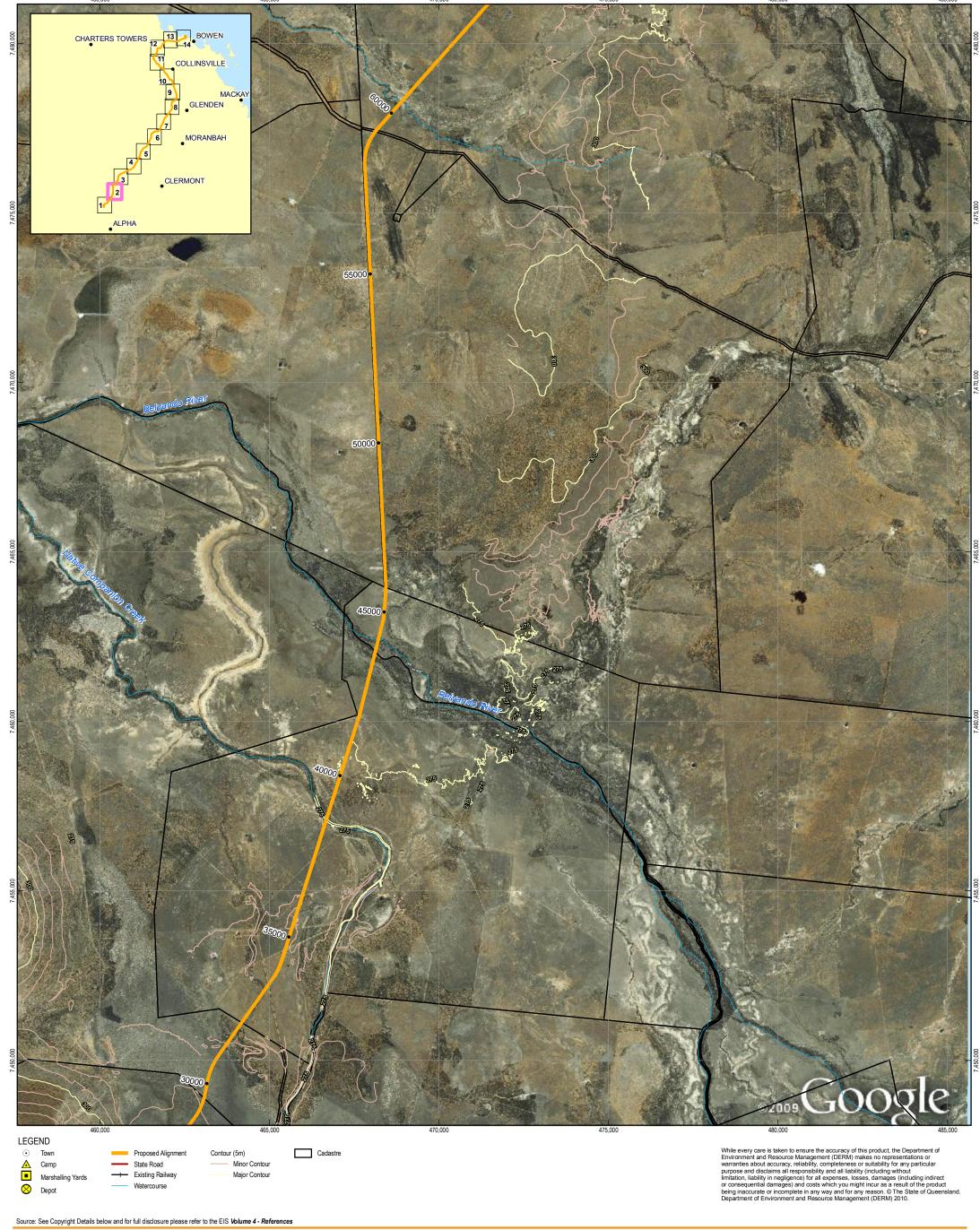
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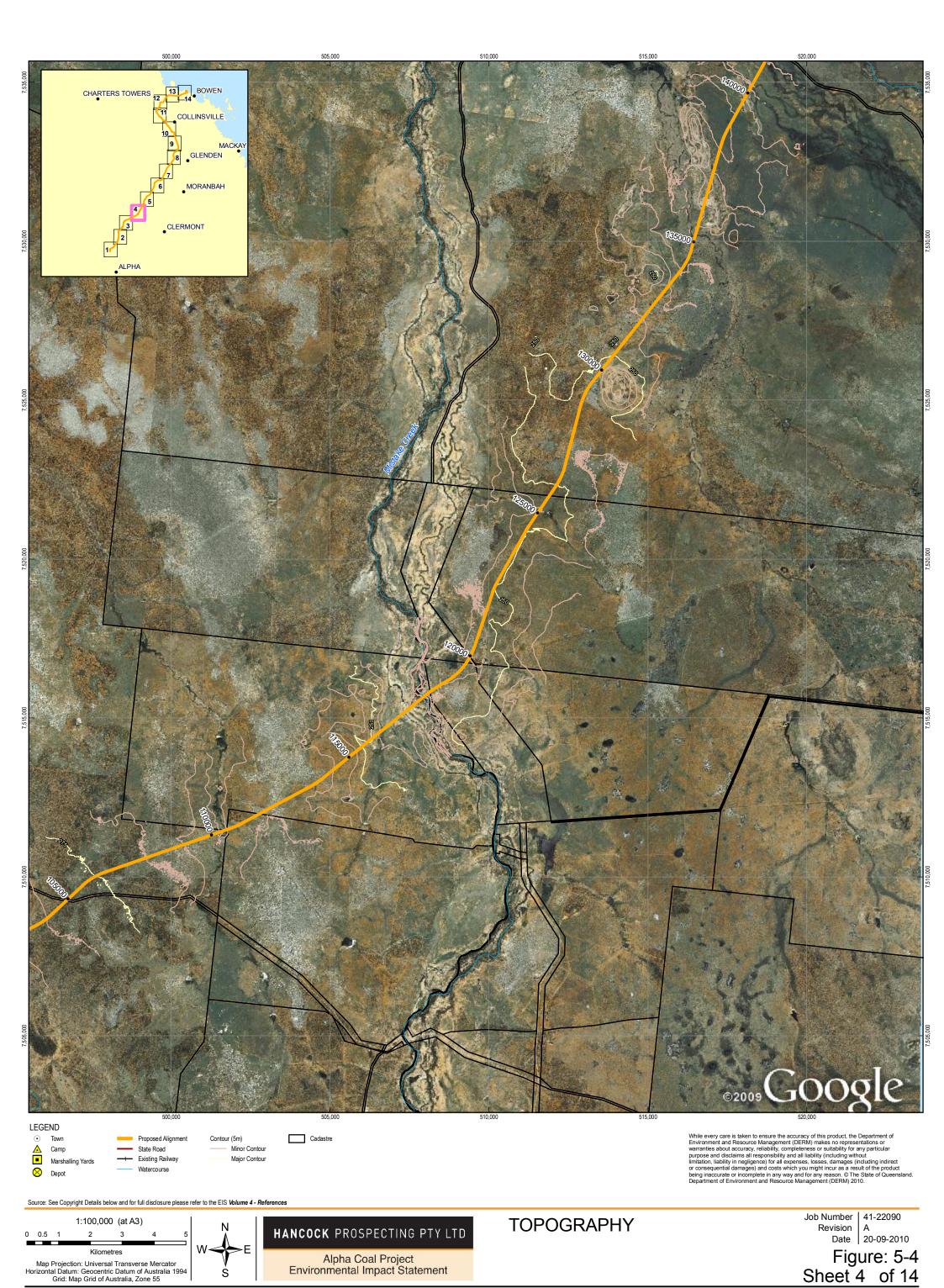
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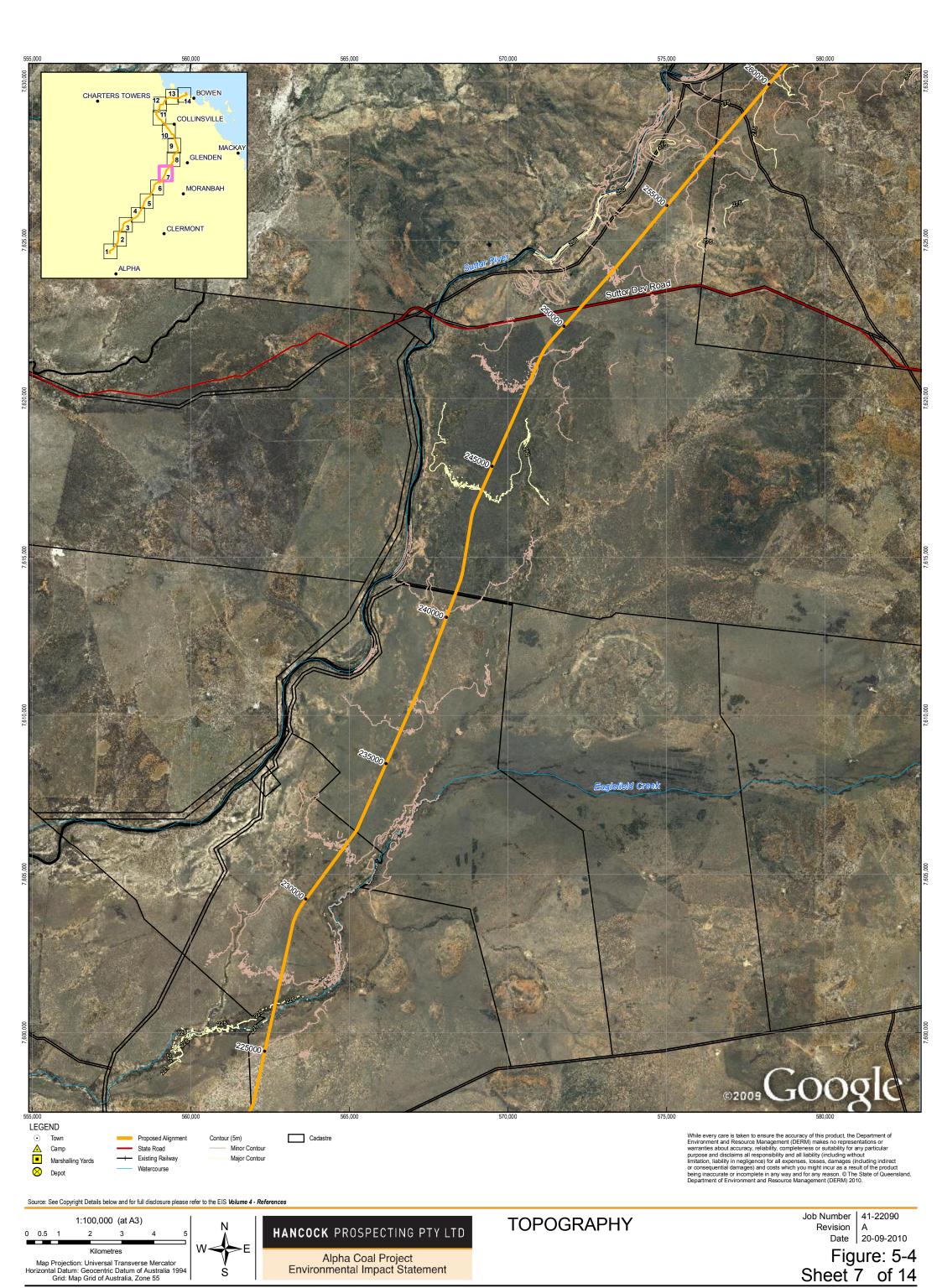
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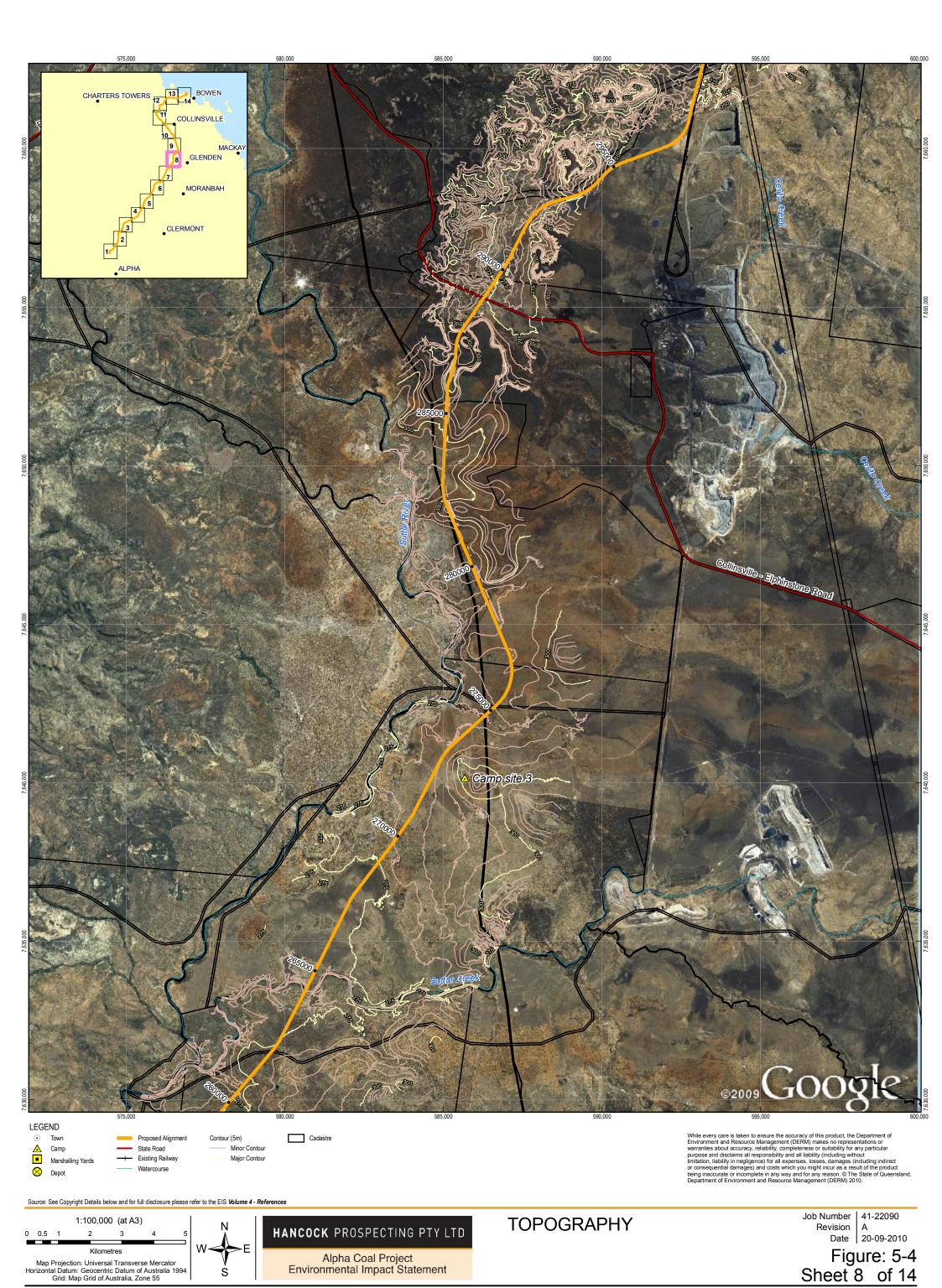
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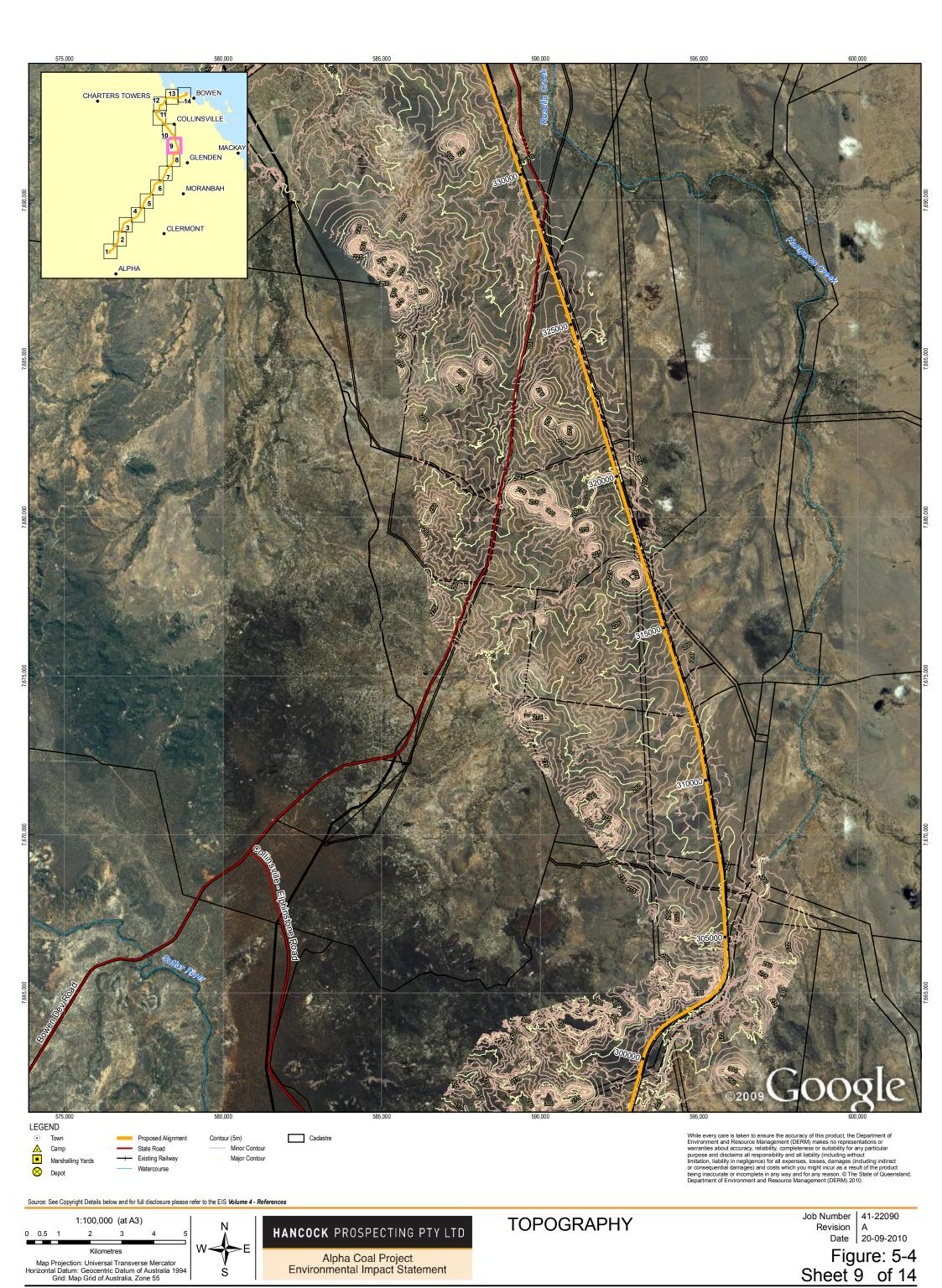
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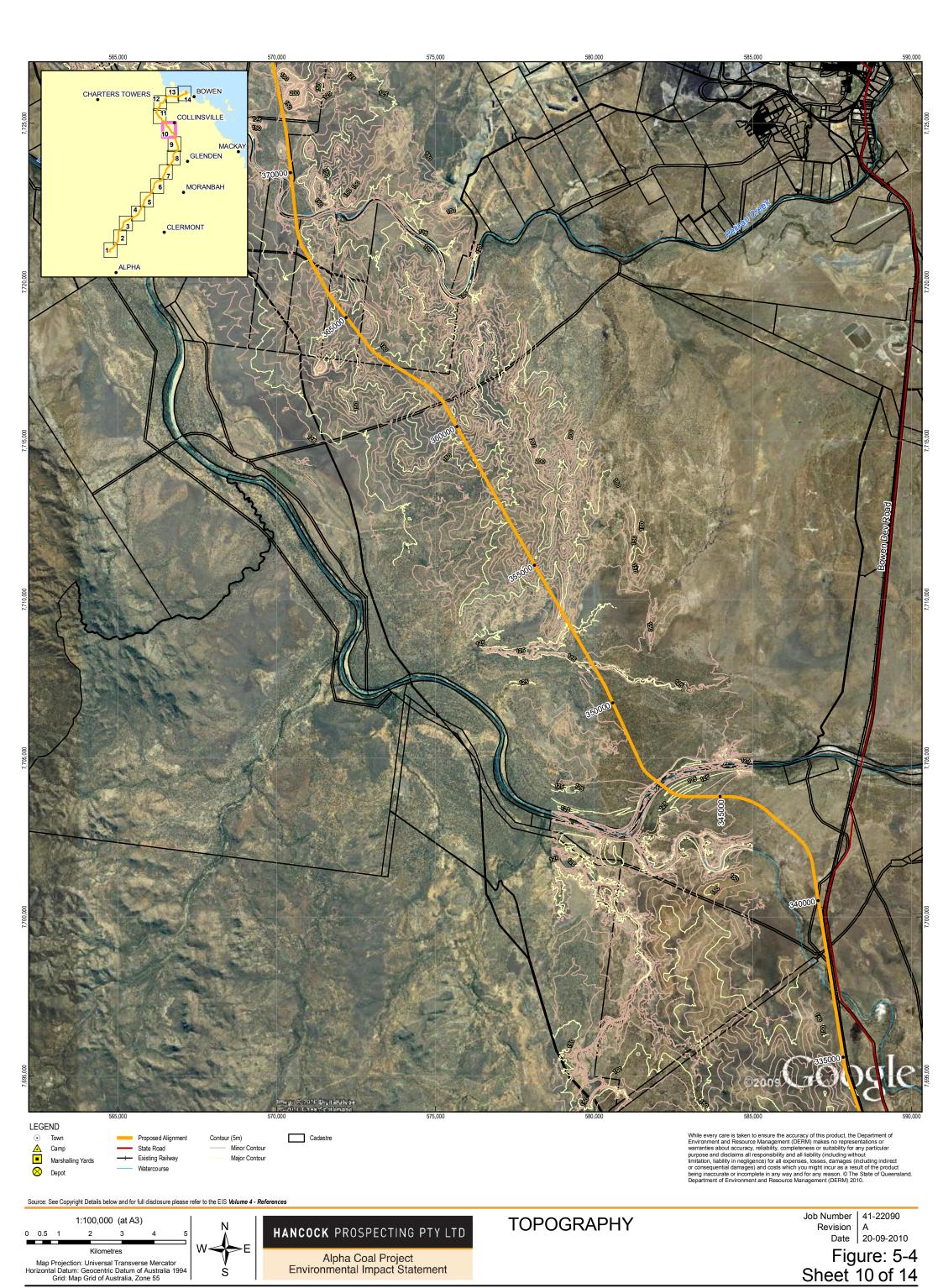
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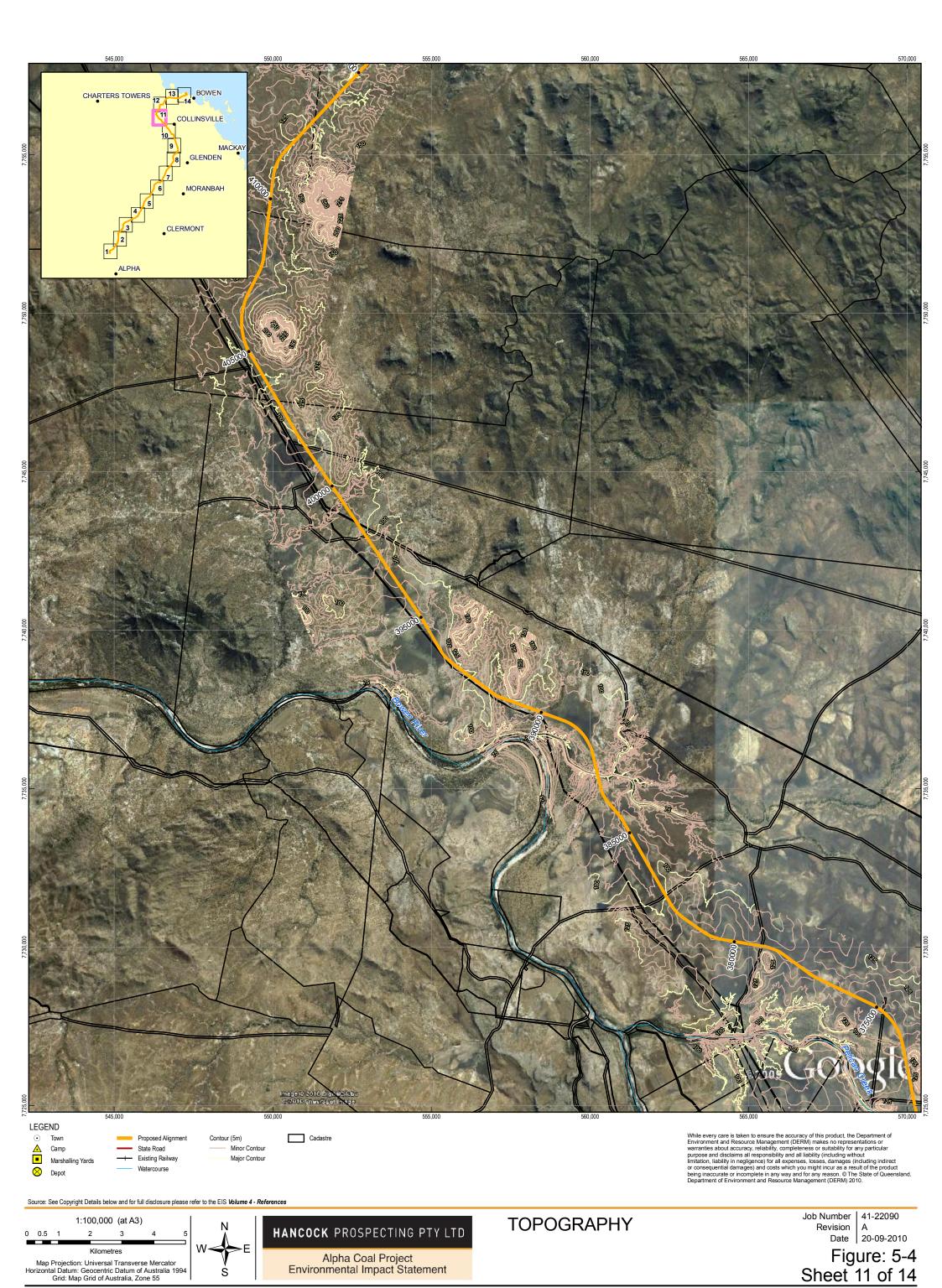
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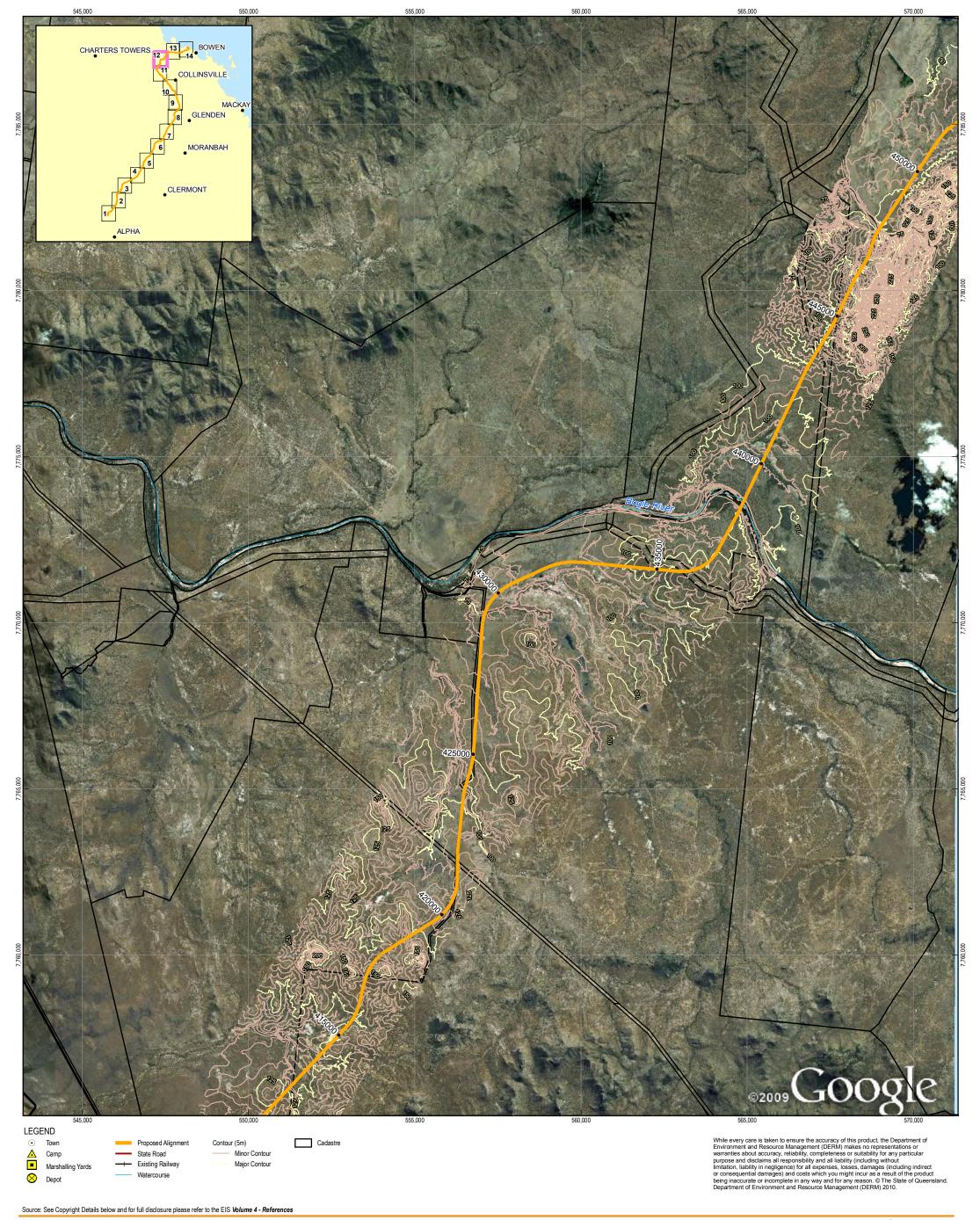












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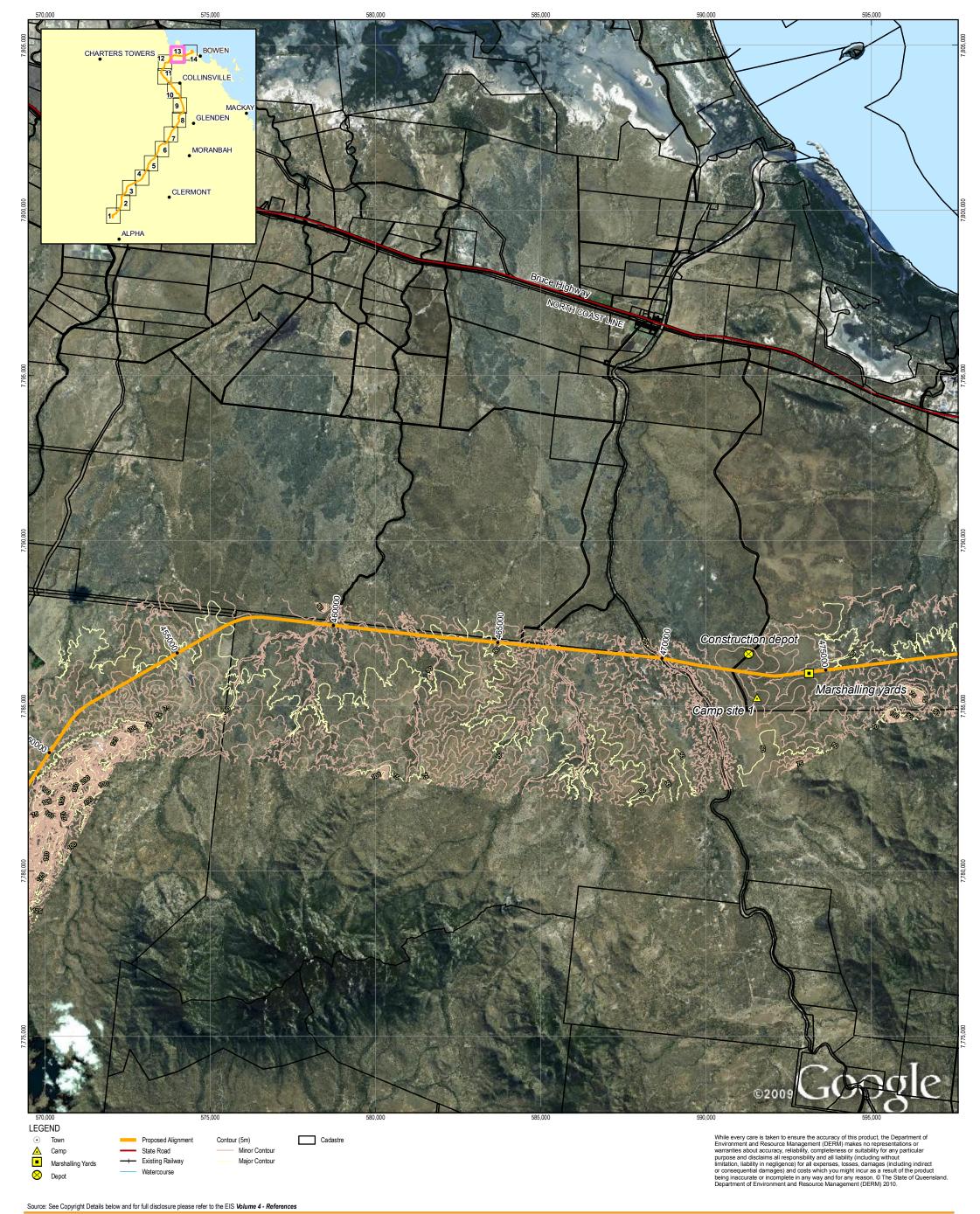
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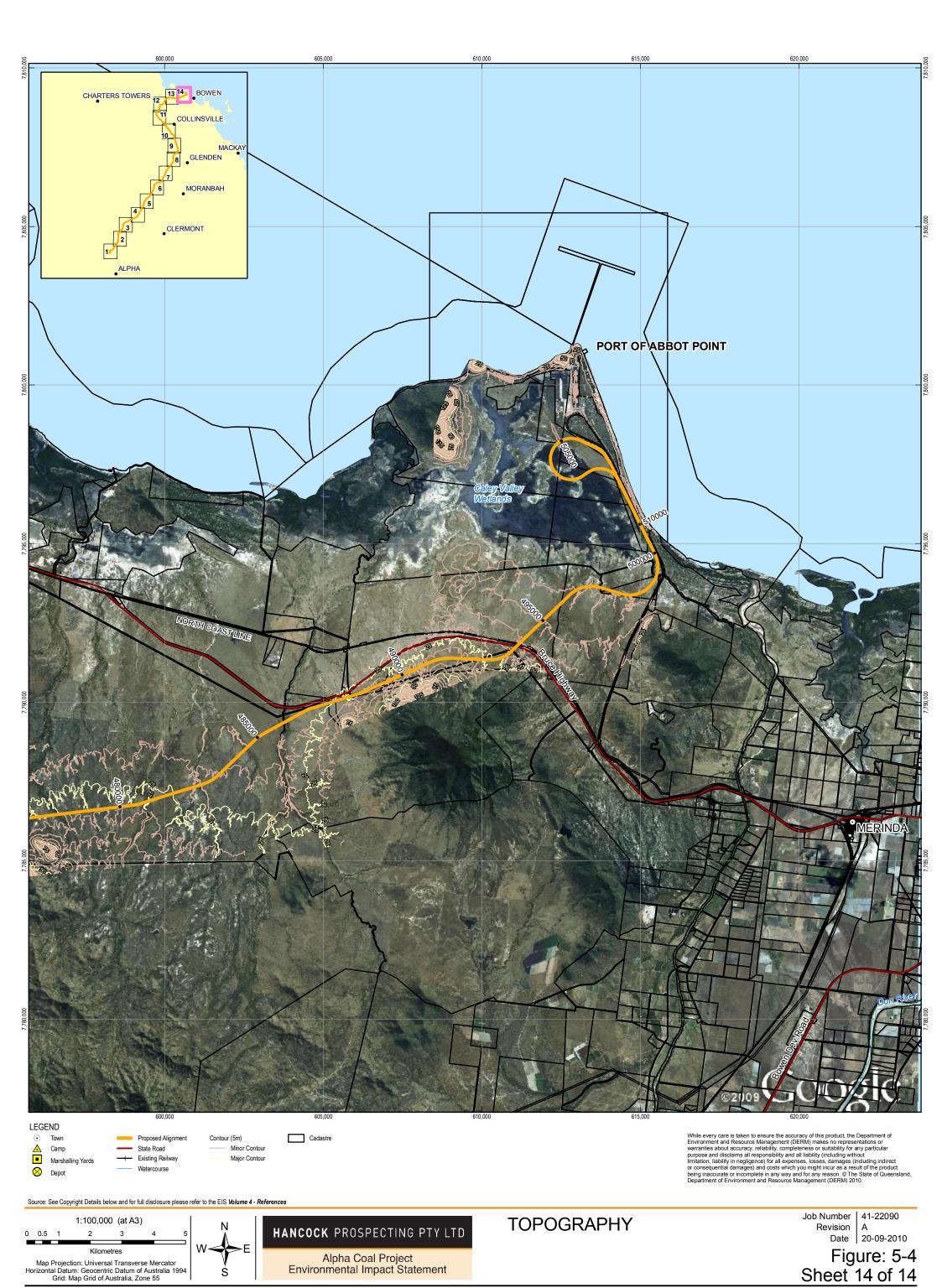
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5.3 Potential Impacts and Mitigation Measures

5.3.1 Topography

5.3.1.1 Potential Impacts

Areas of steep and long slopes are at risk of erosion and landslides under wet weather conditions. The impacts of erosion are discussed in Section 5.3.3 below. Erosion in regards to topography is a factor of both the slope gradient and slope length. The Queensland Department of Main Roads (DMR), Road Drainage Design Manual, 2002, details the erosion risk ratings for slope gradient and length. These are provided in Table 5-9.

Table 5-9: Erosion rating for modal slope classes¹

Class	Percent	Degree	Erosion Rating
Level	<1	0.35	Very Low (1)
Very Gently Inclined	1 to 3	0.35 to 1.45	Low (2)
Gently Inclined	3 to 10	1.45 to 5.45	Moderate (3)
Moderately Inclined	10 to 32	5.45 to 18	High (4)

^{1.} Table 2.11 of DMR, Road Drainage Design Manual, 2002.

The majority of the Project alignment is in areas ranging from level to gently incline. The Project does not travel through sustained areas regarded as steep to cliffed, and as such the highest risk rating of any topographical feature encountered along the Project is considered to be a maximum of high. The above assessment of risk in Table 5-9 is based on modal slope, being the most common slope gradient across a landform.

As mentioned, slope length is the other factor when discussing erosion risk from topographical characteristics. Slope length determines the capacity of the water runoff to concentrate and detach soil particles, with sustained slope length creating a higher risk of soil displacement. Erosion risk ratings based on Slope Length is provide in Table 5-10 below.

Table 5-10: Erosion rating for slope length¹

Slope Length	Торіс	
<5m	Very Low 1	
5 to 25m	Low 2	
25 to 50m	Moderate 3	
50m to 100m	High 4	
>100m	Very High 5	

Notes:

The Project alignment is likely to traverse areas of sustained slope length at varying gradients, which will require varying levels of erosion and sediment control management to reduce the risk of erosion and the associated impacts on the receiving environments. There will be slope lengths greater than 100 m, and as such the highest erosion rating based on slope length will be very high. However this

^{1.} Table 2.11 of DMR, Road Drainage Design Manual, 2002.

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risk rating, when discussing erosion risk based on topographical features, has to be looked at with the modal slope class risk, which is considered to range between very low to low for the majority of the alignment, with the occasional moderate risk area.

Erosion management practices will aid in reducing removal of valuable topsoil resource and mobilisation of potentially contaminated soils (Contaminated Land is discussed in Volume 3, Section 8 of this EIS) occurring due to erosion.

5.3.1.2 Mitigation and Management Measures

Erosion control techniques need to be implemented within those topographical regions that are considered to be at a higher risk of erosion. Slope length can be reduced by placing in drainage controls across the slope, which effectively reduces the length of the slope and catchment area.

The risk of erosion due to the slope gradient of the various topographical features is difficult to manage as that is a landscape constraint. Employing suitable erosion and sediment control management practices will reduce the likelihood of the erosion but will not reduce the risk rating of the gradient slope. Construction zones with a slope gradient risk rating of moderate are manageable in terms of reducing erosion, however working within areas of high to very high ratings will require some pre-planning in order to manage the impacts to a satisfactory standard, such planning will include when construction be undertaken, with provision for works to occur in the drier months which will have lower erosion risks.

In general, works within topographical features that pose a risk to the environment due to slope length and gradient, are to be avoided during wet weather periods and erosive rainfall events. As water is the main cause of detachment of exposed soils, the other being wind, works are required to be managed to avoid increasing the risk of erosion due to climatic conditions in areas where the topographical features are considered to be most susceptible to erosion.

5.3.2 Soils

5.3.2.1 Potential Impacts

The impacts to soils will be mostly contained within the rail corridor, which will not be used or returned to the previous land use. The following are the potential impacts which are mainly confined to soils within the rail corridor.

Soil permeability can be impacted on by this Project in the following way:

- compaction of clay soils due to repetitious traffic along access routes and pathways of mobilisation around the Project corridor, and storage areas including workers camps;
- deep drainage may occur when deep rooted perennial vegetation is removed, which may be required to occur in various locations along the Project; and
- diverting overland flow to areas that consist of soils not previously subject to water inundation. This
 may result in water logging of the lower-lying receiving areas.

PWHC is likely to be impacted on when disturbing the top soil and subsoil profiles. Soil texture and structure are two of the factors that will be disturbed during the construction of this Project that will cause a change in the PWHC. Replacing the disturbed topsoil in a manner that will promote regrowth

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and rehabilitation is an important consideration that if not managed can lead to on-going issues to reinstatement within the Project corridor.

Acidic and alkaline soils, if disturbed can lead to impacts on the environment (acidic impacts are discussed in Section 5.2.1.4 above), whereas alkaline soils may have calcium carbonates, high sodicity or presence of toxic compounds like sodium carbonate, which may be harmful to the receiving environment. Issues will also arise during rehabilitation and reinstatement on areas that are acidic or alkaline.

A change in the *gross nutrient status* as a result of soil disturbance, change in drainage, stockpiling and stripping may impact on the ability of the soils to be used for successful vegetation rehabilitation. Impacts will be mostly restricted to within the rail corridor, with changes to gross nutrient status of areas outside of the rail corridor unlikely to occur.

Soil depth will be impacted where cut and fill works will be undertaken. Removal of available topsoil resources will cause a reduction in the profile water holding capacity and permeability which will lead to issues when rehabilitating disturbed areas. This impact will most likely be contained to within the rail corridor.

Laboratory analysis can be performed to verify areas of sodic soils by testing for exchangeable cation concentrations, which allows for calculations of cation exchange capacity, exchangeable sodium percentage (ESP), and calcium / magnesium ratios. The results will allow for better management of works within sodic soils, from managing and mitigating erosion and also during rehabilitation.

5.3.2.2 Mitigation and Management Measures

Soils at risk of becoming waterlogged due to low permeability can be managed by reducing the compaction of such soils by avoiding trafficking during wet weather and selecting access tracks to avoid such areas susceptible to compaction and water logging. Sodic soils, which inhibit internal drainage, can be improved by applying gypsum, which will replace the sodium ions with calcium ions and thus improve the soil structure. Similar mitigation measures can be applied to improving and repairing the PWHC of the soils.

Alkaline and acidic soils can be treated by using ameliorants such as lime (to fix acidic soils) and elemental sulphur (to fix alkaline soils). Management of both acidic and alkaline soils will be required to allow for successful rehabilitation of disturbed areas following construction. Soil analysis will be required to ascertain the acidity or alkalinity of the soil in order to select the ameliorant type and quantity required.

Nutrient deficient soils can be improved by first establishing the nutrient status of the soil and then selecting the relevant fertiliser and ameliorants. These will be required to be added at a rate which is developed after laboratory analysis of soil nutrient status is conducted.

There may be a requirement to return disturbed areas that are situated outside of the 60 m Project corridor, to pre-construction conditions. These areas may include access tracks and construction camps; this may require any combination of the above mitigation measures.

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5.3.3 Erodible Soils

5.3.3.1 Potential Impacts

The construction and operation of the Project will result in a range of changes to the landscape that will increase the risk of erosion, these include:

- · clearing of vegetative cover;
- changes in topography, drainage patterns and localised concentration of storm water flows both due to construction of access tracks and rail corridor;
- · excavation and stockpiling of material;
- construction during high rainfall, particularly erosive rainfall events;
- · constructing through areas with high soil erodibility risks (refer to Table 5-2); and
- constructing in areas of high risk slope gradient and length.

Sediments that are entrained in water runoff have the potential to collect in the surface waters and estuary. The coarser soil particles such as sands and silts will deposit as the velocity of water slows down, whilst the suspended clays will remain in suspension until the water becomes still or mixes with saline waters.

Deposition of elevated levels of coarse and fine sediments can cause adverse effects on aquatic and estuarine ecosystems. Benthic communities can be smothered reducing light transmission through water, resulting in lowered ability for aquatic plants to function and generating negative impacts for organisms that rely on these plants for food and shelter.

Loss of topsoil and to a lesser extent subsoil from the construction area is also critical in terms of rehabilitation success. Topsoil is the most valuable resource in relation to rehabilitation and needs to be retained on site and in a good re-usable condition.

5.3.3.2 Mitigation and Management Measures

Construction activities for the installation of the Project will take place all year round. Erosion risk is highest in the wet season period due to the erosive nature of the rainfall. Poor design and/or lack of rehabilitation of disturbed areas may lead to considerable erosion over the life of the construction and operation of the Project. Areas of particular concern are steep slopes, sustained slopes, stream crossings, areas of dispersible and erodible soils, engineered drainage line flow paths, all of which have the potential to become severely eroded.

Design of infrastructure will assist in minimising ongoing erosion risk. Particular attention will need to be paid to:

- drainage along the Project alignment to minimise scouring along drainage lines, avoid concentration of flows, position of drainage and the receiving environment of the new drainage;
- · stabilisation of creek crossings to avoid scouring during wet season flows;
- avoidance of steep slopes. Where locally steep slopes exist at stream crossings they will be stabilized as much as possible and drainage controlled; and

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 design of drainage around hard stand and compacted areas to manage accelerated runoff from these areas.

All disturbed areas will be required to be stabilised and reinstated progressively during the Project construction.

A comprehensive Erosion and Sediment Management Control Plan (ESMCP) will be developed and implemented for the construction phase and rehabilitation phase of the Project. Core management principles for areas disturbed by the Project will include:

- drainage controls;
- · erosion controls; and
- · sediment controls.

The ESMCP will be prepared with details of catchment description, topography (site specific), soils, hydrology, vegetation, water quality (baseline and discharge quality), selection of control measures; design, installation, maintenance, and removal of control measures, monitoring reporting and auditing, relevant drawings, checklists, and sizings for sediment basins, diversion drains and catch drains. The following provides standard erosion and sediment control management practices which have been sourced from a number of guidelines and documents including the International Erosion Control Association 2008, Institution of Engineers Australia 1996, URS 2009, and Department of Transport and Main Roads 2010.

Drainage Controls are required to manage run off on site such that runoff does not cause accelerated erosion. Clean water is to be directed and discharged in a manner that does not cause erosion. Dirty water is to be directed and treated prior to being discharged off-site. The following considerations are required for drainage controls:

- drainage controls integrated into a total integrated water management plan for the Project;
- drainage controls for new areas to be installed during the dry season and in place well before predicted wet season onset;
- divert run-off water from lands upslope around active areas and stockpiles;
- install site drainage works to convey stormwater safely through and away from the site;
- direct water at non-erodible velocities. Reduce the erosive energy levels of concentrated water in constructed channels by:
 - constructing channels/drains with a parabolic or trapezoidal cross-section (rather than V-shaped);
 - widening the drain invert;
 - installing check dams;
 - installing appropriate channel linings;
 - installing energy dissipaters at outlets; and
 - outlets from all water conveyance structures will discharge water such that the erosion hazard to down slope lands and waterways is no greater than in the predevelopment condition. This can be achieved through use of water detention basins, waterways that increase the time of concentration, energy dissipaters, level spreaders, etc.

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Erosion Controls are required to reduce the velocity of water to prevent scouring and allow coarser sediments to settle. The following considerations are required for erosion controls:

- protecting the ground surface with a cover of suitable vegetation or gravel. Vegetation will be reinstated in rehabilitated areas as quickly as possible through inclusion of quick growing grass species in seed mixes;
- · reducing the volume of water flows;
- rock scour protection will be placed at the discharge of any un-piped stormwater flow to dissipate the flow energy of the discharge; thereby reducing the potential for erosion;
- placement of topsoil and planting of vegetation on stockpile areas as quickly as possible;
- · retention of buffer vegetation along creeks; and
- exposed surfaces can be stabilised using chemical stabilisers that are commercially available.
 These can provide instant protection and are suitable in areas while construction is in progress.

The use of sediment control devices are proposed to reduce the volume/concentration of suspended solids and other gross pollutants leaving the site. Where possible the intention is to entrap the sediment as close to the source as possible. The following considerations are required for sediment controls:

- sediment fences and filters downslope of stockpiles and other disturbed areas. Sediment fences should be placed close to areas of disturbance to maximise effectiveness;
- sediment basins to intercept sediment-laden runoff and retain most sediment and other materials, to protecting downstream waterways. Combined sedimentation and retardation basins are proposed to allow joint function of sediment settlement and collection of water for reuse and control of flows in creeks draining the site;
- use of flocculants if necessary to accelerate settlement of fine sediments; and
- sediment fencing is to be used to trap coarse sediments close to their source. The location of sediment fencing will be determined on a needs basis; but in general will be required down hydraulic gradient of stockpiles, battered slopes, disturbed areas, and at locations where sediment laden water has the potential to enter drains or waterways.

With these measures in place, mobilisation of soil and sediment into waterways will be minimised. Some sedimentation can be expected regardless of the effectiveness of drainage, erosion and sediment controls, particularly in large storm events.

Access Roads and Tracks will be required to construct and maintain the Project. Unmitigated substantial erosion can occur during the construction and operation of the Project due to exposure of bare soil to rainfall and the alteration of the land resulting in areas of concentrated flows. The location of access roads is largely governed by the rail alignment route so there will be little opportunity to avoid areas that would be typically problematic to unformed roads. However, from an erosion and sediment control perspective, the following principles will be considered in the construction of new unformed roads (DECC, 2008°):

 the catchment area above the road or track may be reduced by locating the road along a ridge or as high as possible on side slopes;

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- unformed roads and tracks will have at least a slight cross-sectional grade to allow free surface drainage and to avoid excessive ponding in wheel tracks;
- the longitudinal grade of an unformed road or track will ideally be less than 10 degrees (18 %).
 However, short lengths of steeper grade may be needed subject to topography and geotechnical survey;
- where grades of unformed roads are between 3% to 20% then easily trafficable diversion banks will be used to prevent scouring. Where higher grades occur then gravelling and more sophisticated road drainage will be required (e.g. turn outs);
- where table drains need to be established, they will be constructed to a broad dish shape, seeded
 and fertilised or lined appropriately, to prevent erosion. Table-drains will be slashed periodically to
 ensure vegetation growth is not restricting drainage flow;
- approaches on service tracks to gully and creek crossings will be as flat as practicable. The track
 will be sloped to direct runoff to a table-drain. In some vulnerable areas, it may be necessary to
 spread and compact coarse aggregate appropriately around / along the approaches to the crossing
 to provide stable access and to reduce erosion;
- cut and fill batters associated with service tracks will be formed to a safe slope and stabilised by groundcover vegetation, mulch, stone and rock armouring, or by the use of geo-fabric where appropriate;
- minimise the number of watercourse and drainage line crossings;
- avoid areas of riparian vegetation where possible and maintain buffer strips between the road and any watercourse;
- where provision of access in gullies or creeks causes disturbance of vegetation, re-vegetation and stabilisation work will be undertaken;
- all temporary construction tracks and associated disturbed areas will be stabilised / or revegetated when construction is completed; and
- minimise disturbance to soil and vegetation.

Stream or Water Crossings will be required as part of the Project construction where the alignment crosses watercourses there is significant potential for environmental degradation:

- where the Project crosses waterways measures may need to be undertaken to divert water, maintain flow and avoid upstream flooding while the crossings and culverts are being installed. (Note an approval may be required for altering the flow of a waterway);
- bridge crossings should be designed so that it does not become a channel constriction that may
 cause backup of flow or washouts during periods of high stream flow or cause any under cutting of
 structure, bed or bank of creek; and
- works in and around all streams and waterways will meet all statutory and other requirements of regulatory authorities for works in waterways. Procedures developed for works in waterways will describe methods to minimise erosion, water quality impacts and other impacts.

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Soil and Stockpile Management measures to minimise erosion and sediment release will be implemented before stripping or stockpiling of any material. Stockpiles should be:

- constructed at least five m from hazard areas, particularly likely areas of concentrated water flows,
 e.g. waterways, roads, slopes steeper than 10%, etc. Where rainfall events within the catchment are likely to cause the waterway to swell then this distance may need to be increased up to 50 m;
- no greater than two m high if the stockpile material is topsoil. This is to avoid excessive heat being generated and composting conditions that will degrade soil health;
- protected from run-on water by installing water diversion structures upslope;
- formed with sediment fences placed immediately downslope to protect other lands and waterways from pollution;
- stabilised if they are expected to be in-situ for extended periods and receive extended periods of
 potentially erosive rain they will be stabilised (e.g. sprayed with a chemical stabiliser; covered,
 grassed, etc); and
- soil/spoil materials with appreciable fines contents that are windrowed or stockpiled beside near sensitive receptors (e.g. waterways, water bodies, wetlands, etc) and pose a pollution risk following a rainfall event should be stabilised.

If excavated materials potentially contain acid sulfate or other contamination, prevent contamination of the underlying soil by stockpiling the excavated material in an adequately sized bunded area. The bund area will be constructed on a surface of low permeability, or by lining it with High Density Polyethylene (HDPE) sheeting. Where stockpiles are to be uncovered then bunds will be capable of containing runoff from the stockpile equivalent to a 10-year ARI, 24-hour duration rainfall event. Allow an additional 100 mm freeboard after the displacement of the stockpile has been taken into account.

5.3.4 Release of Acid from Acid Sulfate Soils

5.3.4.1 Potential Impact

The desktop study and previous investigations in the vicinity of the site indicated the potential for the presence of both AASS and PASS underlying the Project alignment. AASS and PASS sediments have the potential to generate significant quantities of sulfuric acid if disturbed and if not managed correctly have the potential to cause serious environmental harm.

The Project will require excavation and filling operations on natural ground likely to contain ASS. As a result, natural ASS will be disturbed and may potentially cause harm to the environment in the following ways:

- excavated soils containing ASS may become oxidised and release acid. Without any natural buffering capacity inherent in the natural material, the acid may leach out of the sediment and into surrounding waterways, groundwater and soils;
- excavation walls may oxidise and infiltrating groundwater may generate acid creating a pit containing acidic water, which may then enter the groundwater and surrounding sediments;
- oxidation of ASS and subsequent acid production can cause the following:
 - migration of acidic groundwater that potentially contains elevated concentrations of metals into the surrounding environment, waterways and into the bay;

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- precipitation of metals including iron, aluminium, arsenic and manganese out of solution due to acidic groundwater. The acidic water will become less acidic on mixing with seawater, which can result in precipitation of iron, potentially creating extensive red/orange iron staining (rust) in the water, which may deposit on the land surface, on infrastructure and on boats/vessels;
- fish kills and algal blooms as a result of increased levels of nutrients produced from oxidised ASS and discharge of the nutrient-rich water to adjacent waterways and the bay. The impacts of elevated nutrients are likely to be most significant in areas where flushing with 'fresh' seawater may be limited and hence potential for limited dilution of any nutrients discharged to waterways;
- discolouration and noxious odours emitted from open water bodies which are not regularly flushed (e.g. dredge decant ponds); and
- generation of acid within *in-situ* sediments (identified as PASS) if they are oxidised through lowering of the watertable (i.e. dewatering) or through excavation of material.
- filling activities may also disturb in-situ ASS by:
 - bringing AASS into contact with groundwater and thus mobilising acid present in the AASS into the groundwater;
 - displacing or extruding (i.e. creating a mud wave) previously saturated PASS material above the water table and allowing the sediments to oxidise; and
 - raising the natural groundwater level in the vicinity of the filling activities and mobilising acid in the AASS.

5.3.4.2 Mitigation and Management Measures

An ASS investigation shall be carried out in areas where:

- · disturbance of in-situ soils from excavation or filling activities on land that is below five m AHD; and
- dewatering or changes (permanent or temporary) in the groundwater regime are proposed.

The ASS assessment is required in order to locate and characterise the material underlying the proposed rail alignment. A detailed Acid sulfate soils management plan (ASSMP) will be prepared and approved by DERM prior to work commencing if the ASS investigation identifies ASS. ASS will need to be managed appropriately to ensure that environmental harm does not occur or is minimised.

5.3.5 Salinity

5.3.5.1 Potential Impacts

Removal of vegetation from some environments results in rising of the water table which in turn can lead to accumulation of soluble salts on the soil surface. This process is known as secondary salinisation. Salt accumulation in soils can have a profound and devastating effect on development and catchment health, leading to die back in non salt-tolerant vegetation and result in increased erosion hazard due to loss of groundcover and soil structural decline causing increased levels of runoff. Secondary salinisation can also affect infrastructure causing damage to building foundations, the breaking up of road pavements, and the corrosion of pipes and underground services.

Removal of trees and excavation of the soil is expected to alter the hydrology of the landscape and alter groundwater levels in areas lower in the landscape. Clearing of vegetation acts to increase groundwater levels due to the reduction in uptake; whilst it also may reduce the quantity of water

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entering the profile and aquifer recharge due to increased surface runoff. The consequence of changes to the hydrology can lead to alterations of stream flows and secondary salinisation. Effects of vegetation clearing and construction activities on groundwater are discussed in Volume 3, Section 12 of this EIS.

5.3.5.2 Mitigation and Management Measures

Avoid clearing of trees and other woody vegetation, or revegetate cleared areas as soon as practicable after construction is complete. This retention of vegetation assists in maintaining groundwater at a lower level reducing secondary salinisation that could result from a rise in groundwater levels. In areas where vegetation has been cleared for grazing or agricultural use, deep drainage may be required to lower the water table below the root zone in order to avoid secondary salinity impacts. Applying excess water on occasions to leach the build up of salts in the plant root zone is another means of combating salt build up throughout the soil profile.

5.3.6 Importing Construction Materials

5.3.6.1 Potential Impacts

The potential impacts associated with sourcing construction materials for the Project can be both onsite and off-site impacts. If the materials are to be sourced externally then quarrying will be required to retrieve the materials (ballast or fill material), which would result in further land degradation / disturbance plus considerable transport and handling costs. Whatever the case additional ground disturbance will be an impact in sourcing rail ballast and fill material (if required).

Alternatively materials can be sourced from within the rail corridor where cuttings and blastings will be undertaken in suitable ground. This would be beneficial in terms of costs, transport and ability to manage impacts within the site without having to manage an off-site area in addition, however if fill material is removed from areas of GQAL or soils suitable for other land uses then this would be regarded as a negative impact. If soil regarded as being good quality is in surplus following construction in particular areas then the soil will be used elsewhere for rehabilitation purposes where practicable and not as fill material.

If soil material from areas with soil types not conducive to agricultural use meets the geotechnical requirement as fill material, then this can be used in areas along the Project alignment.

5.3.6.2 Mitigation and Management Measures

Sourcing ballast material from an off-site source can be achieved through established licensed quarries or alternatively applying for the relevant permits to quarry an area identified as containing material suitable for rail ballast. If the ballast material is sourced from a quarry under the control of the proponent then an appropriate Environment Management Plan (EMP) specifically for the quarrying activities would need to be developed and implemented to cover the operation of the quarry and rehabilitation of the disturbed land to pre-disturbance condition.

Any surplus material that meets the geotechnical requirements can not be used as fill elsewhere along the alignment if it is of a condition suitable to be used for agricultural purposes or rehabilitation of disturbed areas.

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5.3.7 Good Quality Agricultural Land / Land Suitability

5.3.7.1 Potential Impacts

The Project will preclude any agricultural use within the immediate rail corridor for the life of the Project, thus sterilising approximately 3000 ha of agricultural land. The bulk of this (35%) is Class B, being marginally suitable for cropping but suitable for pastoral uses. A further 17% is Class A, being high quality crop land and the remainder is either Class C or D, being suitable or marginally suitable for pastoral uses.

The Project may directly affect GQAL through sterilisation within the Project footprint for the life of the Project. Indirect effects may also include fragmentation as well as reduced productivity due to construction disturbance and changes in drainage and groundwater characteristics. Potential impacts may include:

- Sterilisation: As stated in Table 5-8, approximately 503 ha of GQAL Class A land, 1,077 ha of Class B GQAL and 644ha of Class C GQAL will be unavailable for agricultural land use for the life of the Project. On decommissioning, it should be possible to restore some agricultural use of the corridor. This represents a small proportion of the overall GQAL available in the region, and so should not affect agricultural activity on a regional level. The loss of GQAL is an inevitable consequence of the Project as it is not possible to construct a rail line from the Galilee Basin to the coast without crossing GQAL. The economic assessment for the Alpha Coal Project indicates overall economic benefits, in spite of loss of a small area of GQAL.
- Soil Loss: Erosion of soils during construction may result in valuable topsoils being lost from the construction area. If disturbed areas are not stabilised after construction, this effect may be ongoing during the Project, particularly in those areas with highly dispersive soils that are prone to massive erosion. Additionally, if drainage patterns are altered during construction, changed surface runoff patterns may result in increased erosion in some areas. This may result in loss of GQAL outside the immediate Project footprint, if not managed. Erosion control measures and reinstatement will minimise this impact.
- Fragmentation of agricultural lands: Railway lines fragment land by limiting access between land areas on either side of the alignment. While this does not directly affect the agricultural productivity of land adjacent to the Project, it can make such land more difficult to farm, and may also reduce lot sizes to below viable thresholds for farming. Consultation with landowners has been carried out and is ongoing to identify optimum alignments through individual landholdings to minimise fragmentation effects. Landholdings along the alignment are typically large and less vulnerable to effects of fragmentation. In consultation with landholders, stock crossing locations will be included in the Project. With these measures in place, fragmentation impacts are not expected to be significant in terms of agricultural productivity.
- Nutrient Decline: Fertility of soil and nutrient levels are intrinsically linked. Disturbing a GQAL
 resource can result in a reduction in nutrient content due to increased leaching of nutrients and
 therefore reduces the ability to support plant growth and agricultural productivity. Nutrients are
 typically stored in the topsoil, which is most susceptible to erosion of the topsoil which will result in
 reduction in topsoil and hence a reduction in nutrient levels.
- Structural Decline: Disturbance to soils can cause a breakdown of the aggregates in which soil particles are held, resulting in a change in the soil particle composition. This is particularly an issue

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where movements of construction vehicles and equipment causes compaction, such that soil particles that were ordered and loosely packed with high pore space become more randomly and closely packed together with little pore space. A decrease in soil permeability, water holding capacity, aeration and microfauna may result from the breakdown of soil aggregates in which soil particles are held. This could cause the soil to be less favourable for plant growth and more prone to high water runoff, with the resulting increased potential for erosion and flooding problems (DLWC, 2000).

Salinisation: Salinity problems usually arise as a result of alteration to the hydrological regime of a catchment, with greater quantities of water infiltrating into the ground resulting in rising groundwater levels which bring salt to the ground surface. This causes an accumulation of salt in the soil and surface or groundwater, which at high levels is toxic to plants and thus prevents or retards the growth of crops, pasture and other vegetation. The resulting saline scald is highly prone to erosion and consequent sediment transport problems. Salt is also a highly corrosive agent and can cause serious and expensive damage to infrastructure such as building foundations, underground services and roads. Water quality is also adversely affected by high salt levels (Department of Land and Water Conservation 2000).

While direct impacts of sterilisation of GQAL cannot be avoided, other potential impacts on agricultural productivity of soils can be managed during construction. Reinstatement after construction can also prevent ongoing impacts.

5.3.7.2 Mitigation and Management Measures

Mitigation and management measures to avoid or minimize impacts on agricultural productivity of soils include:

- continue to consult with affected landowners in relation to limiting effects of fragmentation, for example through further realignments and by providing stock crossings and other crossings as necessary.
- Maintain surface drainage patterns through design of culverts and cut/fill areas. Where changes in flows cannot be avoided, consider stabilization of soils to prevent salinisation or other effects.
- limit overall areas of disturbance during construction
- limit vehicle movements to defined access tracks during construction
- strip topsoil from all disturbed areas and set aside for use in reinstatement. Manage topsoil stockpiles to maintain soil fertility and other soil properties
- develop and implement an erosion and sediment control plan. Erosion control structures will remain in place until reinstatement is complete
- reinstate all disturbed areas progressively during and after construction. Reinstatement will be as
 far as possible to pre-construction conditions. Where soils may have been damaged, reinstatement
 should include appropriate amelioration measures such as fertilizer to restore soils to preconstruction productivity.
- rip soils in areas where compaction may have occurred.

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5.3.8 Change to Landform

5.3.8.1 Potential Impacts

A localised change to landform (where the Project is situated) will be an unavoidable result of this Project. In order to construct the Project there will be requirements to fill and cut within the current landscape. While the Project will be confined to a 60 m wide corridor, the nature of the Project will result in the final contours after construction to differ from the original landform.

Landform, hydrology and hydrogeological conditions are closely connected which will be affected to varying degrees along the Project. There is a high likelihood that drainage, including groundwater infiltration, sheet flow and creeks / streams will be altered to varying degrees as a result of this Project. This may result in impacts on downstream ecosystems due to increases or decreases in runoff and redirection of drainage lines.

Hydrological impacts of the Project have been assessed and reported in detail in Volume 3, Section 11 of this EIS, whilst the hydrogeological (groundwater) impacts are detailed in Volume 3, Section 12 of this EIS. Avoiding impacts due to landform change will be done by maintaining natural drainage flow paths which will be achieved through the use of culverts.

5.3.8.2 Mitigation and Management Measures

Restoring the landforms in a way that will not alter the overall catchment behaviour is an important part in reducing the impacts on the change to landform. The following matters need to be addressed to ensure this aspect is managed appropriately:

- restore the drainage flows and pathways into the various catchments that will be affected by this Project;
- replacing the topsoil resources to nearest to pre-disturbance condition, which may require the addition of ameliorants;
- · restore the overall catchment gradients to that of pre-disturbance condition; and
- avoiding areas of steep slopes and areas that require significant landform change.

5.4 Conclusions

The types of soils vary from dispersive sodic soils to soils suitable for cropping. Each soil type will require varying levels of management to limit the impact on the environment and soil resource. Of particular concern in regards to impact to the environment are the erodible soils, potentially contaminated soils, sodic soils, acid sulfate soils, areas of high salinity risk and areas of GQAL.

A number of potential impacts on the soil resources and landforms may arise from this Project including:

- secondary salinisation;
- · loss of productive cropping land;
- · disturbance of ASS at Abbot Point;
- disturbance and possible migration of contaminants;
- contamination of soil from spills;

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- erosion of valuable topsoil resources during the construction and operation phase of the Project;
 and
- alteration to the topography and landforms resulting in a change in catchment characteristics.

Some environmental impact is unavoidable from a Project of this type. The mitigation measures and management practices that have been detailed in this section will however reduce the impact on the environment and soil resources. The impacts requiring management and mitigation are the disturbance and fragmentation of GQAL resources, erosion, sourcing of the construction materials and the rehabilitation materials post construction.

Specific management plans will need to be developed and implemented to ensure that all impacts have mitigation and management measures. Management plans may include a detailed EMP, ESCP, ASSMP and Rehabilitation Management Plan (RMP).