# 12

# SOILS AND LAND SUITABILITY

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# 12 Soils and Land Suitability

## 12.1 Introduction

This section of the EIS identifies the environmental values of soils and land suitability within the Project area, provides an assessment of potential impacts, and outlines mitigation measures, where required.

In addition, the section provides a description of the distribution of topsoil resources and an assessment of their suitability for rehabilitation. The study area, which extends beyond the Project area, has a total area of 780,417 ha, covered by three Authorities to Prospect (ATPs) and three Authority to Prospect Applications (ATPA) consisting of the following: ATP 1025 (63,012 ha), ATP 759 west (95,425 ha), ATP 1103 (414,756 ha), ATPA 742 (72,029 ha) ATPA 749 (47,947 ha) and ATP 1031 (87,248 ha). For the purposes of this study, these are categorised into the Northern, Central and Southern sectors (Figure 12–1).

A cross reference to the locations where each of the requirements of the ToR has been addressed is given in Appendix B which references both the study chapters (Sections 1 through 34) and/or the Appendices (A through EE).

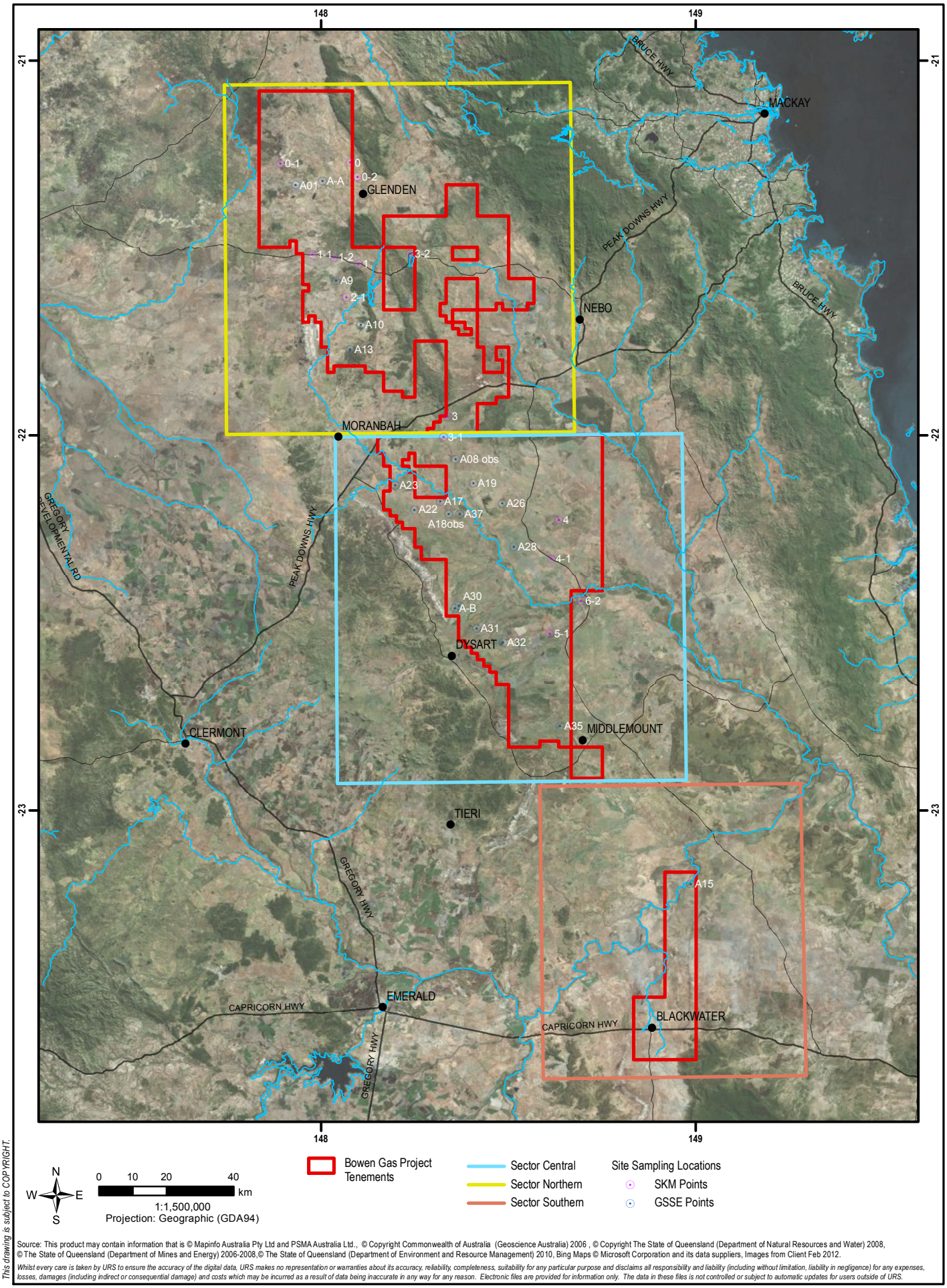
## 12.2 Objectives

The major objectives of this assessment are to:

- Classify and determine the soil profile types within the study area;
- Assess the pre and post-disturbance land suitability classes within the study area;
- Assess the pre and post-disturbance agricultural land classes within the study area;
- Assess the pre and post-disturbance Good Quality Agricultural Land (GQAL) classes within the study area;
- Provide preliminary assessment of the likely presence of Strategic Cropping Land (SCL);
- Assess the occurrence of acid sulphate soils (ASS) within the study area;
- Assess the suitability of the current topsoil for rehabilitation including the identification of unfavourable materials within the study area; and
- Provide soil management recommendations for topsoil management.

## 12.3 Physical Environment Overview

A detailed description of the geology of the Project area is provided in the Geology chapter (Section 13) and Groundwater and Geology Technical Report (Appendix L) of this EIS. The Carborough Range and Kerlong Range are the prominent ranges within the study area, located in the northern area (ATP 1103), approximately 5 km south of Glenden and 40 km west of Nebo. These ranges run parallel and extend 45 to 50 km from the north to the south east. Carborough Range in the east has an altitude of approximately 280 m ASL and Kerlong Range in the west has an altitude of approximately 340 m ASL. Approximately 7 km west of Kerlong range lies Burton Range, which surrounds Burton and is approximately 16 km away and 450 m above sea level. To the south lies Iffley Mountain, approximately 30 km south east of Moranbah, partially lying within the central sector (ATP 1103).



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BOWEN GAS PROJECT EIS

# SOIL AND LAND SUITABILITY ASSESSMENT AREA

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## SOILS

Figure: 12-1

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## 12.4 Soils Assessment

This study has adopted a significance based impact assessment approach (refer to Impact Assessment Method chapter (Section 6) of this EIS).

The Soils and Land Suitability Technical Report (Appendix K of this EIS) presents the detailed methodology and results of the soils and land suitability assessment for the Project.

### 12.4.1 Desktop Analysis Methodology

The desktop analysis involved the undertaking of background research and evaluation of existing information about the study area from a number of references such as maps, publications, regional government policies and technical reports associated with the Project. All information was cross-referenced and a gap analysis was undertaken to nominate key representative locations within the study area for the implementation of the field survey.

An initial reconnaissance soil map was developed for the study area to identify overall values and target field investigation sites. The map was developed using the following background information, resources and techniques:

- Aerial photos, satellite image and topographic map interpretation was used as a remote sensing technique to provide detailed analysis of the landscape and map features expected to be related to the distribution of soils. Previous land resource mapping, geology and soil surveys of the area were utilised to assist in defining boundaries of units and classes at a more intensive scale where applicable.
- Source materials were used to obtain correlations between the landscape features (identified from aerial images and map analysis) and soil properties that may be observed in the field. These materials included cadastral data, prior and current physiographic, geological, vegetation and water resources studies. Relevant reports cross-referenced include the *Lands of the Isaac – Comet Area, Queensland* (R. Story *et al.,* 1967), *Lands of the Nogoa – Belyando Area, Queensland* (R.H. Gunn *et al.,* 1967), the *Arrow Bowen Gas Pipeline EIS Soils Technical Report* (SKM, 2011), the *Bow Energy Soils and Terrain – CSG Fields Draft Technical Report* (URS, 2011), and the *1:250,000 Digital Geological Map Sheets of the Bowen Basin, Queensland* (DME, 2008).
- Stratified observations: landform features, surface soil exposures, topography and vegetation were assessed visually throughout the potential disturbance areas based on a broad soil map to verify potential soil types and geological association. Approximate unit boundaries and preferred locations for subsurface investigations were determined from this information.

### 12.4.2 Field Survey Methodology

The field survey undertaken was an integrated qualitative free survey conducted in May 2012. This survey method assumes that many land characteristics are interdependent and tend to occur in correlated sets (McKenzie *et al.*, 2008). Background reference information derived from sources were used to predict the distribution of soil attributes in the field. The field assessment also determined the following additional parameters required for assessment: soil erosion stability, structure, erodibility, dispersivity, rockiness, sodicity, and plant available water capacity.

Using a ground-truthing approach, a 1:1,000,000 scale was selected for the study area based on the land systems identified to provide a dataset of soil and land suitability information for the assessment of potential environmental impacts. To satisfy the 1:1,000,000 scale in accordance with the *Guidelines for Surveying Soil and Land Resources* (NCST, 2008); four observations per 100 ha were required. For the study area this equates to a total of 40 observations. The actual field survey made 34 observations; however, this was complemented by relevant data referenced from the *Arrow Bowen Gas Pipeline EIS Soils Technical Report* (SKM, 2011) which provided 15 observations, totalling 49 assessed observation sites to fulfil the broad-scale survey minimum requirements.

Soil samples from 16 representative soil profile description sites were included in the laboratory testing programme. Samples were analysed to:

- Assist in the classification of soil taxonomic classes;
- Assist in the determination of land suitability classes; and
- Determine suitability of soils as topdressing media.

Samples were collected in 10 cm increments within the soil profile in accordance with Agricultural Land Class (ALC) guidelines. These samples were sent to the Australian Laboratory Services (ALS) Brisbane (Queensland, Australia). Additionally, soil samples of one to two kilograms were collected from within each soil horizon and sent separately to the Scone Research Centre (New South Wales, Australia) for analysis. These laboratories are National Association of Testing Authorities (NATA) accredited. Full results for these analyses are provided in the Soils and Land Suitability Technical Report (Appendix K) of this EIS. A total of 271 soil samples were collected.

### 12.4.3 Soil and Land System Survey Results

Land systems are defined as being an area or group of areas with a recurring pattern of topography, soils and vegetation that can be recognised. Such land systems identified are further sub-divided into land units based on increased detailed of recurring features such as topography and soils. Within the Project area there are 26 established land systems comprising 140 major land units and 28 dominant soil types (Table 12–1). Whilst detailed information for each of the Land Unit Codes (LUC) are not available from updated spatial land unit references, selective ground truthing was undertaken for the land systems and associated soils based on information provided by the *Land Research Series* mapping by the Commonwealth Scientific and Industrial Research Organisation (CSIRO, 1967 and CSIRO, 1968), *Arrow Bowen Gas Pipeline EIS* data (SKM, 2011), *Bow Energy Draft EIS* data (2011) and field data collected from the Project field survey. Descriptions of the land systems, land units and soil types have been outlined in the Soils Technical Report (Appendix K) of this EIS and are presented in the Land Systems Map (Figure 12–2) excluding the LUC, which form part of the data gaps in this study. A full description of the characteristics of each of the land systems listed in Table 12–1 is provided in the Soils Technical Report (Appendix K) of this EIS.

**Table 12-1 Land Systems and Land Units**

| Land System[1] | Area (ha) | Percent of Study Area | Land Unit Number | LUC | Representative Soil Types (ASC)[2] |
|---|---|---|---|---|---|
| Barwon | 407.71 | 0.05 | 1 | BW1 | Vertosol |
| | | | 2 | BW2 | Chromosol |
| | | | 3 | BW3 | Chromosol |
| | | | 4 | BW4 | Unknown |
| Bedourie | 607.10 | 0.08 | 1 | BE1 | Dermosol |
| | | | 2 | BE2 | Vertosol |
| | | | 3 | BE3 | Rudosol |
| Black Alley | 176.10 | 0.02 | 1 | BA1 | Rudosol |
| | | | 2 | BA2 | Rudosol |
| Blackwater | 49,896.61 | 6.39 | 1 | BL1 | Vertosol |
| | | | 2 | BL2 | Vertosol |
| | | | 3 | BL3 | Sodosol |
| | | | 4 | BL4 | Vertosol |
| | | | 5 | BL5 | Sodosol |
| | | | 6 | BL6 | Sodosol |
| Carborough | 19,220.95 | 2.46 | 1 | CA1 | Rudosol |
| | | | 2 | CA2 | Rudosol |
| | | | 3 | CA3 | Sodosol |
| | | | 4 | CA4 | Sodosol |
| Comet | 16,998.43 | 2.18 | 1 | CT1 | Vertosol |
| | | | 2 | CT2 | Sodosol |
| | | | 3 | CT3 | Sodosol |
| | | | 4 | CT4 | Tenosol |
| | | | 5 | CT5 | Vertosol |
| | | | 6 | CT6 | Unknown |
| Connors | 40,550.50 | 5.19 | 1 | CO1 | Chromosol |
| | | | 2 | CO2 | Sodosol |
| | | | 3 | CO3 | Tenosol |
| | | | 4 | CO4 | Chromosol |
| | | | 5 | CO5 | Vertosol |
| | | | 6 | CO6 | Vertosol |
| | | | 7 | CO7 | Sodosol |
| Cotherstone | 29,754.35 | 3.81 | 1 | CS1 | Rudosol |
| | | | 2 | CS2 | Kurosol |
| | | | 3 | CS3 | Kurosol |
| | | | 4 | CS4 | Kandosol |

## Section 12 Soils and Land Suitability

| Land System[1] | Area (ha) | Percent of Study Area | Land Unit Number | LUC | Representative Soil Types (ASC)[2] |
|---|---|---|---|---|---|
| | | | 5 | CS5 | Chromosol / Tenosol |
| | | | 6 | CS6 | Dermosol / Chromosol |
| Daunia | 37,681.76 | 4.82 | 1 | DA1 | Vertosol |
| | | | 2 | DA2 | Vertosol |
| | | | 3 | DA3 | Vertosol |
| | | | 4 | DA4 | Sodosol |
| | | | 5 | DA5 | Sodosol |
| | | | 6 | DA6 | Vertosol |
| Durrandella | 16,238.11 | 2.08 | 1 | DU1 | Rudosol |
| | | | 2 | DU2 | Rudosol |
| | | | 3 | DU3 | Kandosol |
| | | | 4 | DU4 | Sodosol |
| | | | 5 | DU5 | Sodosol |
| | | | 6 | DU6 | Unknown |
| Funnel | 8,541.87 | 1.09 | 1 | FU1 | Vertosol |
| | | | 2 | FU2 | Vertosol |
| | | | 3 | FU3 | Sodosol |
| | | | 4 | FU4 | Sodosol |
| | | | 5 | FU5 | Alluvial |
| Girrah | 34,696.23 | 4.45 | 1 | GI1 | Vertosol |
| | | | 2 | GI2 | Vertosol |
| | | | 3 | GI3 | Sodosol |
| | | | 4 | GI4 | Sodosol |
| | | | 5 | GI5 | Unknown |
| Highworth | 3,790.15 | 0.49 | 1 | H1 | Vertosol |
| | | | 2 | H2 | Sodosol |
| | | | 3 | H3 | Vertosol |
| | | | 4 | H4 | Vertosol |
| | | | 5 | H5 | Vertosol |
| | | | 6 | H6 | Sodosol |
| | | | 7 | H7 | Sodosol |
| | | | 8 | H8 | Sodosol |
| | | | 9 | H9 | Sodosol |
| | | | 10 | H10 | Unknown |
| Hillalong | 34,401.95 | 4.41 | 1 | HI1 | Sodosol |
| | | | 2 | HI2 | Vertosol |
| | | | 3 | HI3 | Vertosol |
| | | | 4 | HI4 | Unknown |

## Section 12 Soils and Land Suitability

| Land System[1] | Area (ha) | Percent of Study Area | Land Unit Number | LUC | Representative Soil Types (ASC)[2] |
|---|---|---|---|---|---|
| Hope | 810.52 | 0.10 | 1 | HO1 | Chromosol / Kurosol / Sodosol |
| | | | 2 | HO2 | Chromosol / Kurosol / Sodosol |
| | | | 3 | HO3 | Chromosol / Kurosol / Sodosol |
| | | | 4 | HO4 | Unknown |
| Humbolt | 145,963.20 | 18.70 | 1 | HU1 | Sodosol |
| | | | 2 | HU2 | Vertosol |
| | | | 3 | HU3 | Vertosol |
| | | | 4 | HU4 | Sodosol |
| | | | 5 | HU5 | Sodosol |
| | | | 6 | HU6 | Kandosol |
| Junee | 30,304.78 | 3.88 | 1 | JU1 | Sodosol |
| | | | 2 | JU2 | Kandosol |
| | | | 3 | JU3 | Sodosol |
| | | | 4 | JU4 | Rudosol / Tenosol |
| | | | 5 | JU5 | Sodosol |
| Kinsale | 27,424.46 | 3.51 | 1 | KI1 | Dermosol / Vertosol |
| | | | 2 | KI2 | Dermosol / Vertosol |
| | | | 3 | KI3 | Dermosol / Vertosol |
| | | | 4 | KI4 | Vertosol |
| | | | 5 | KI5 | Dermosol / Vertosol |
| | | | 6 | KI6 | Unknown |
| Lennox | 14,718.55 | 1.89 | 1 | LE1 | Kandosol |
| | | | 2 | LE2 | Kandosol |
| | | | 3 | LE3 | Chromosol / Kurosol / Sodosol |
| | | | 4 | LE4 | Kandosol |
| | | | 5 | LE5 | Chromosol / Kurosol / Sodosol |
| Monteagle | 127,337.15 | 16.32 | 1 | MO1 | Sodosol |
| | | | 2 | MO2 | Kurosol |
| | | | 3 | MO3 | Sodosol |
| | | | 4 | MO4 | Vertosol |
| | | | 5 | MO5 | Kandosol |
| | | | 6 | MO6 | Sodosol |
| Nebo | 4,157.00 | 0.53 | 1 | NE1 | Vertosol |
| | | | 2 | NE2 | Vertosol |
| | | | 3 | NE3 | Sodosol |
| Oxford | 25,072.60 | 3.21 | 1 | OX1 | Vertosol |
| | | | 2 | OX2 | Vertosol |
| | | | 3 | OX3 | Vertosol |

## Section 12 Soils and Land Suitability

| Land System[1] | Area (ha) | Percent of Study Area | Land Unit Number | LUC | Representative Soil Types (ASC)[2] |
|---|---|---|---|---|---|
| | | | 4 | OX4 | Vertosol |
| Percy | 4,998.84 | 0.64 | 1 | PE1 | Rudosol / Tenosol |
| | | | 2 | PE2 | Rudosol / Tenosol |
| | | | 3 | PE3 | Rudosol / Tenosol |
| Planet | 4,760.51 | 0.61 | 1 | PL1 | Rudosol |
| | | | 2 | PL2 | Kandosol |
| | | | 3 | PL3 | Kandosol |
| | | | 4 | PL4 | Sodosol |
| Somerby | 28,087.02 | 3.59 | 1 | SO1 | Vertosol |
| | | | 2 | SO2 | Sodosol |
| | | | 3 | SO3 | Sodosol |
| | | | 4 | SO4 | Sodosol |
| | | | 5 | SO5 | Sodosol |
| | | | 6 | SO6 | Vertosol |
| Thomby | 2,147.22 | 0.27 | 1 | T1 | Vertosol |
| | | | 2 | T2 | Sodosol |
| | | | 3 | T3 | Vertosol |
| | | | 4 | T4 | Sodosol |
| | | | 5 | T5 | Sodosol |
| | | | 6 | T6 | Sodosol |
| | | | 7 | T7 | Kandosol |
| | | | 8 | T8 | Vertosol |
| | | | 9 | T9 | Sodosol |
| | | | 10 | T10 | Sodosol |
| | | | 11 | T11 | Sodosol / Chromosol |
| Unknown | 71,673.33 | 9.18 | Unknown | Unknown | Unknown |
| **Total** | **780,417.00** | **100** | | | |

Source: DAFF 2012a

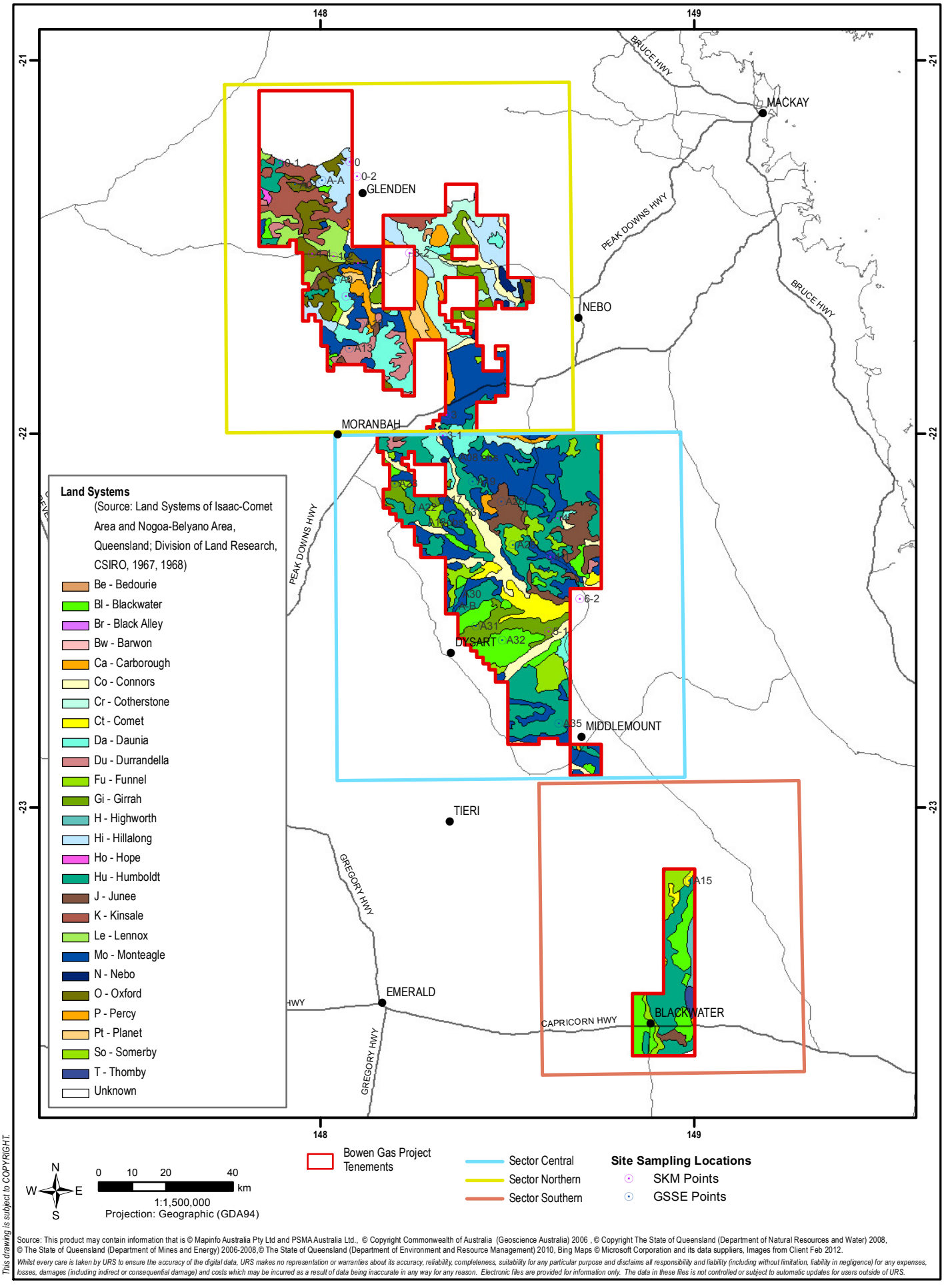
1. Table 12–1 is based on summarized information from Story (1967) and Gunn (1967)

2. These are soil types based on the Australian Soil Classification (ASC) that are normally encountered in each LUC. It should be noted however, ASCs discussed in each LUC serve as a guide and may differ from actual field observations as well as from previous mapping information depending on scale. “Unknown” soil type indicates that a representative soil type has not yet been nominated for that particular LUC in either reference studies.

### 12.4.4 Acid Sulphate Soils (ASS)

ASS are naturally occurring soils, sediments or organic substrates (e.g. peat) formed under waterlogged conditions containing iron sulfide minerals (mainly pyrite and relatives) or their oxidation products. Upon exposure to air due to the lowering of the water table (e.g., dewatering, groundwater abstraction or drainage) or by excavation, the sulphides in these soils readily oxidise, releasing sulphuric acid and iron into the soil and groundwater, often in harmful quantities. This acid can, in turn, release aluminium, nutrients and heavy metals / metaloids (particularly arsenic) held within the soil matrix (Ahern *et al.*, 2004). This does not include acid generation potential within the overburden material (consolidated bedrock below two to three metres in depth).

ASS, which are the main cause of acid generation within the soil mantle, are commonly found less than five metres above sea level, particularly in low-lying coastal areas. The study area is located within the Isaac and Central Highlands region (approximately 400 km from the coast at >300 m AHD and there has been little history of ASS material within this region. An assessment of ASS for the Project area is not considered necessary for this soils investigation, as supported by the investigation triggers as outlined in State Planning Policy 2/02 *Planning and Managing Development Involving Acid Sulfate Soils*.



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# LAND SYSTEMS WITHIN THE STUDY AREA

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SOILS

Figure: 12-2

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Ten of the 27 land systems were targeted and assessed for their representative soil types evaluated in this study and these are summarised in Table 12–2. The assessed sites include studies from the *Arrow Bowen Gas Pipeline EIS Soils Technical Report* (SKM, 2011) and this study.

**Table 12-2 Land Systems and Assessed Representative Soil Types**

| Land System | Site | Soil Type |
|---|---|---|
| | **Number** | **ASC** |
| Blackwater | A31 | Dark Grey Vertosol |
| Daunia | A09 | Grey Vertosol |
| | A10 | Brown Kandosol |
| | SKM 2-1 | Brown Sodosol |
| Girrah | A22 | Brown Dermosol |
| | A23 | Brown Chromosol |
| | A32 | Brown Vertosol |
| | SKM 5-1 | Dark Grey Vertosol |
| Hillalong | SKM 0 | Brown Sodosol |
| | SKM 0-2 | Brown Sodosol |
| | SKM 3-2 | Brown Sodosol |
| Humbolt | SKM 0-1 | Red Vertosol |
| | A19 | Brown Vertosol |
| Junee | A13 | Red Dermosol |
| | A26 | Brown Tenosol |
| Lennox | SKM 1-2 | Brown Vertosol |
| Monteagle | A15 | Brown Dermosol |
| | A35 | Brown Dermosol |
| | A37 | Brown Sodosol |
| | SKM 3 | Brown Vertosol |
| | SKM 3-1 | Brown Vertosol |
| | SKM 4 | Red Sodosol |
| | SKM 4-1 | Red Sodosol |
| Oxford | A01 | Brown Vertosol |
| | SKM 1-1 | Grey Sodosol |
| Somerby | A17 | Grey Vertosol |
| | A28 | Brown Vertosol |
| | A30 | Brown Sodosol |

## 12.5 Land Assessment

A land assessment has been undertaken for the Project area to determine land suitability for agricultural activities and relative agricultural significance for the region. The land suitability assessment evaluates ALC and GQAL. The study area's overall land suitability ranking for each soil unit is determined in accordance with the *Guideline for Land Suitability Assessment Techniques* (DME, 1995a). Following this, suitability rankings for the encountered soils units are interpreted using the Planning Guidelines - *The Identification of Good Quality Agricultural Land* (DPI, 1993) - and translated into ALC. Lastly, the ALCs are compared against the local shire(s) planning document to determine which of the ALCs are considered to be GQAL for the specific region.

### 12.5.1 Land Suitability and Agricultural Land Class Agreement

Soil units encountered in the study area cover a range of land suitability classes. Some soil units are suited to rain-fed broad-acre cropping activities (Table 12–3). Four of these are Vertosols whereas one is a Chromosol and the other a Dermosol. These sites indicate soil moisture presence that can sustain broad-acre cropping. Other soil units that are not suited to rainfed broad-acre cropping have been assessed for pastoral suitability. Some soil units encountered in the study area are considered suitable for beef cattle grazing activities. Moderate to severe limitations for these soil units are present with moisture being the dominant limitation.

**Table 12-3 Good Quality Agricultural Land Assessment**

| Site | Soil Unit | ALC |
|---|---|---|
| **Number** | | **Class** |
| A01 | Brown Vertosol | A |
| A09 | Grey Vertosol | A |
| A10 | Brown Kandosol | C1 |
| A13 | Red Dermosol | C3 |
| A15 | Brown Kandosol | B |
| A17 | Grey Vertosol | C2 |
| A19 | Brown Vertosol | C3 |
| A22 | Brown Vertosol | A |
| A23 | Brown Chromosol | A |
| A26 | Brown Tenosol | C3 |
| A28 | Brown Vertosol | C3 |
| A30 | Brown Sodosol | C1 |
| A31 | Grey Vertosol | A |
| A32 | Brown Vertosol | A |
| A35 | Brown Dermosol | C2 |
| A37 | Brown Sodosol | B |

Given the broad range of land classes within the study area at pre-development stage, the post-Project land suitability for the entire study area continues to fall within their defined land classes. Where key infrastructures are to be developed (i.e. gas processing facilities) or where major ground disturbance is to be undertaken (i.e. pipe-laying), a minimum broad category Class 4 for grazing land is required to be met during rehabilitation. Where Land Classes 1-3 are determined, post-development requires that these be achieved if not exceeded. As the scale of this study was broad and site locations for specific facilities (i.e. surface infrastructure, wellhead facilities, gathering systems, reinjection wells, water monitoring bores, and water gathering, transfer and treatment facilities) are yet to be determined, it is recommended that detailed site evaluation in each facility location be undertaken post detailed design to provide a deterministic land suitability.

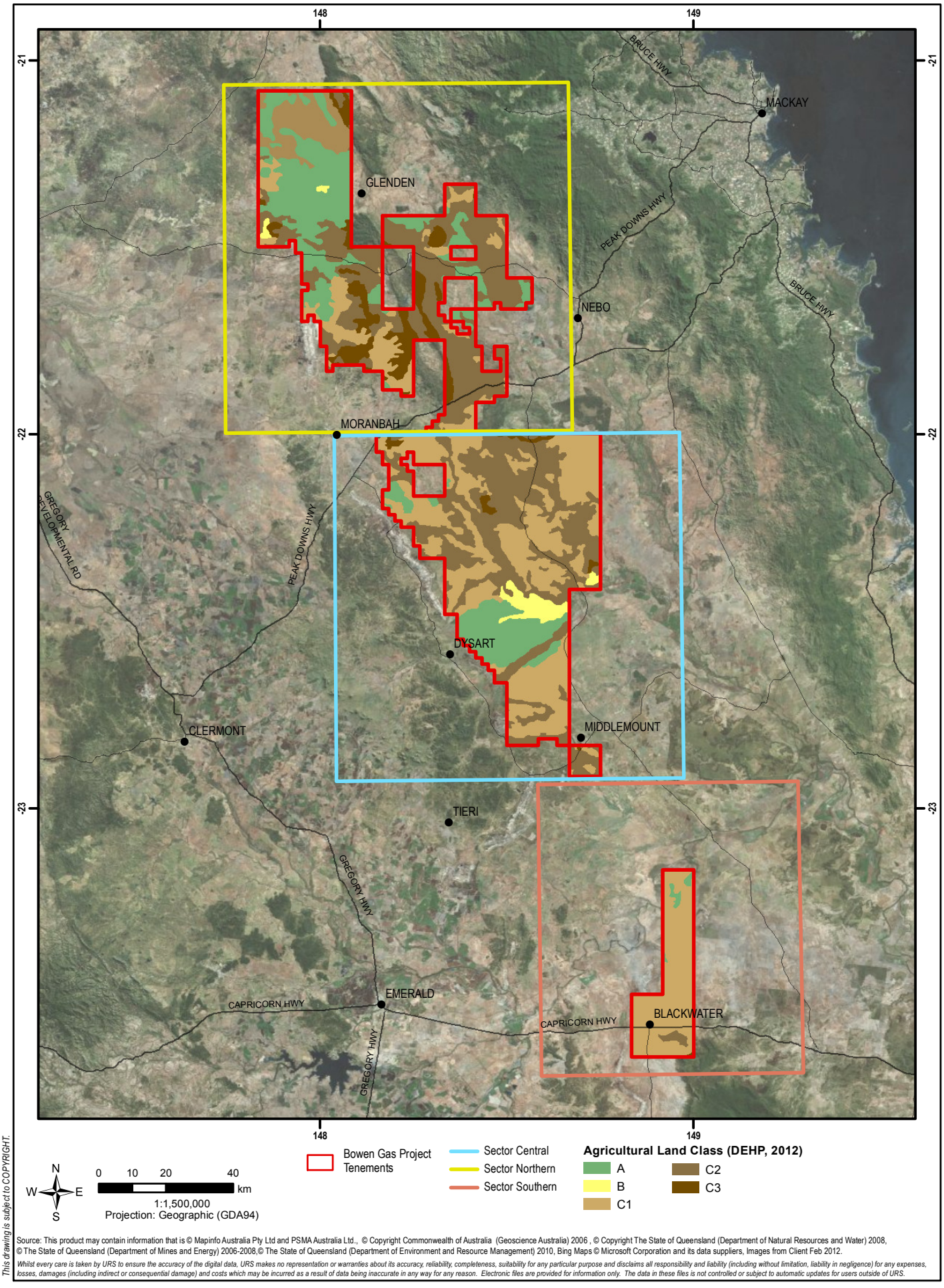
The soil units encountered in the sampling sites within the study area are considered suitable for a range of agricultural enterprises. Agricultural Land Classes range from Class A through to Class C3. Class A and B indicates that crop activities may be able to be undertaken and Class C that grazing activities are suitable (Figure 12–3). The Project area has been assessed by EHP (2012) and is largely covered by Class C1 and Class C2 land.

### 12.5.2 Good Quality Agricultural Land Assessment

Approximately 51.74% of the study area is currently considered GQAL based on existing maps (Table 12–4). Around 41.75% of the study area is currently considered to be non-GQAL and this includes ALCs C2 and C3. Approximately 6.51% of the study area has been classified as ‘unknown’ as information was insufficient for ACL assessment or classification, this is included in Table 12–4 below.

**Table 12-4 Good Quality Agricultural Land Assessment**

| Agricultural Land Class | GQAL | Area | |
|---|---|---|---|
| **Class** | **Assessment** | **ha** | **%** |
| A | Yes | 122,548.82 | 15.96 |
| B | Yes | 13,910.34 | 1.81 |
| C1 | Yes | 260,902.54 | 33.97 |
| C2 | No | 276,511.17 | 36.00 |
| C3 | No | 44,145.57 | 5.75 |
| D | No | 0.00 | 0.00 |
| Unknown | Unknown | 50,000.00 | 6.51 |
| **Total** | | **768,018.44** | **100** |



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# AGRICULTURAL LAND CLASSES OF THE STUDY AREA

URS

SOILS

Figure: 12-3

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## 12.6 Strategic Cropping Land Assessment

SCL is a scarce natural resource defined by soil, climate and landscape characteristics which result in an area highly suitable for crop production. A preliminary assessment of the potential for the Project to impact upon SCL was undertaken using the *Protecting Queensland's strategic cropping land: A policy framework* (2011), as guidance. Consultation with EHP published *SCL Draft Trigger Maps* indicates that potential SCL areas occur within the study area.

Whilst the guidelines were adhered to in undertaking this study, the scope renders it a 'preliminary assessment' in terms of intensity of scale and some specific criteria under the survey methodology. The results, nonetheless, have allowed for provision of a preliminary assessment to identify where SCL is likely to exist.

### 12.6.1 Methodology

Sites from the soils field assessment were selected to represent the dominant features and characteristics of the area and were assessed to determine soil type and matched against the SCL criteria. To fulfil these criteria the *Protecting Queensland's Strategic Cropping Land: Proposed criteria for identifying strategic cropping land* (2011), outlines eight assessment criterion for the Western Cropping Zone used to determine the SCL (see the Soils Technical Report (Appendix K) of this EIS).

There are four types of SCL assessment sites, the use of which is dependent on the particular soil and landscape attributes of the assessment area, and the degree of evidence necessary to support the application. For the Western Cropping Zone, one site per 50 ha is the required observation density and can consist of any of the following types of assessment:

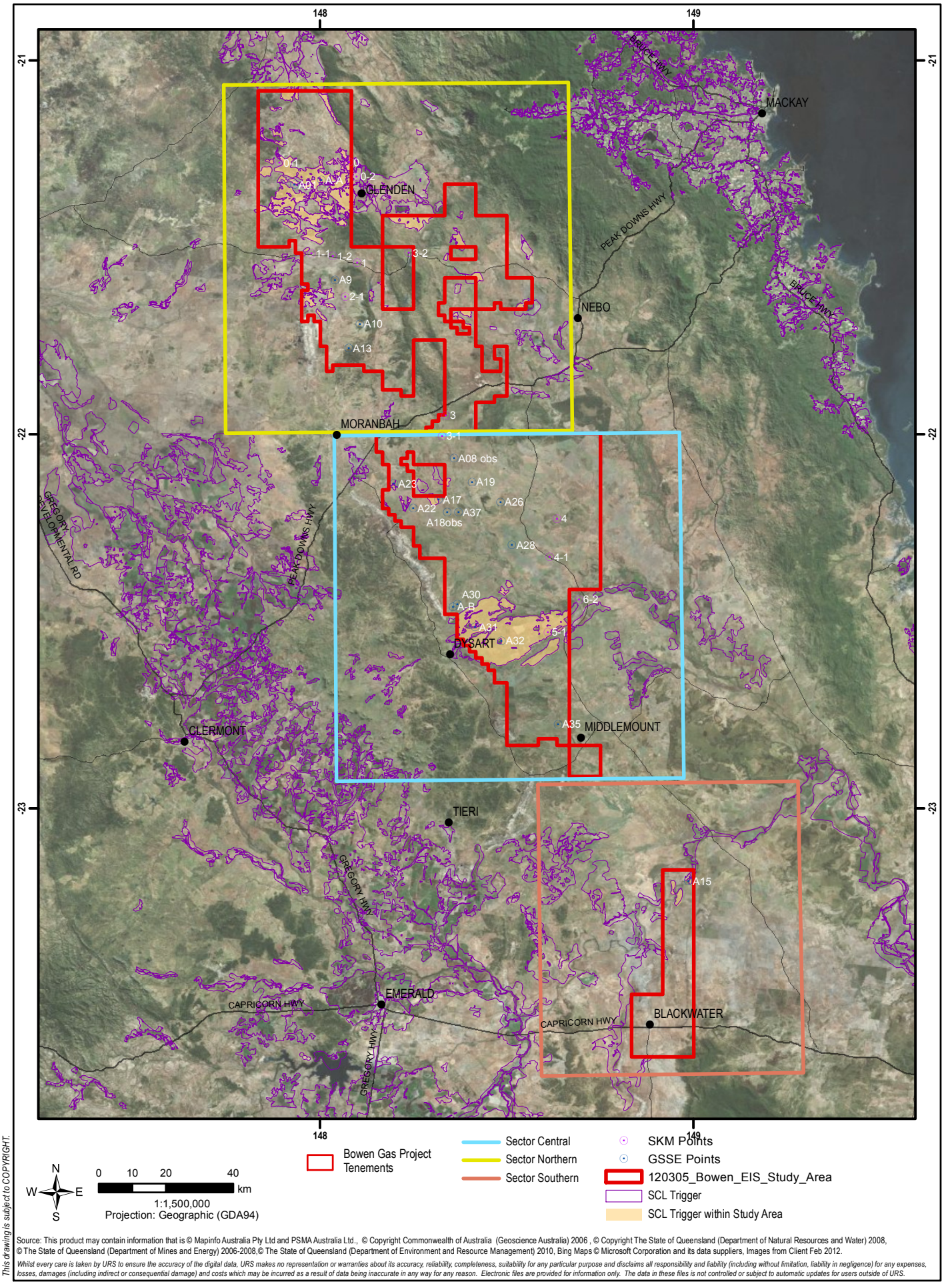
- Exclusion Sites – Locations where desktop or rapid ground truthing can detect slope, rockiness and gilgai characteristics; two sites required per mapping unit.
- Check Sites – Simple observations confirming consistent soil types; two sites required per mapping unit.
- Detailed Sites – Sites that are subject to a full field assessment and photographed; two sites required per soil type.
- Analysed Sites – Sites subject to full field assessment and laboratory analysis; one site required per soil type.

### 12.6.2 Assessment Results

Analysed, Detailed and Check sites were recorded throughout the established EHP-trigger mapped sections of the study area where access was possible at the time of the survey (Figure 12–4). A total of eight assessed sites were deemed to be an indication of potential SCL (all of these were lab analysed), while there were 17 sites that indicated the SCL criteria could not be met (eight of which were lab analysed). This study includes previous SCL assessment information from the *Arrow Bowen Gas Pipeline EIS Soils Technical Report* (SKM, 2011) and cross-referenced for inclusion with this SCL assessment.

The assessment was undertaken to determine the potential of SCL to be present throughout the study area. It has limitations due to the scale and methodology, both of which have been stipulated in the

EHP policy guidelines. The classification provided in this preliminary assessment is only indicative of the potential of the land to be SCL. Patches trigger mapped as SCL were not assessed due to access restrictions at the time of the survey. The study, however, provides an overview to the likelihood of SCL prohibiting or limiting potential disturbance activities throughout the study area. Areas where SCL criteria have been met occur in association with Vertosol and Dermosol soil types of the study area, and can be perceived to be sustaining cropping. Where sites were identified as potential SCL, additional remote sensing techniques were utilised to further confirm or deny such sites and where applicable, field data was used to eliminate unsuitable areas.



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# PROBABLE STRATEGIC CROPPING LAND WITHIN THE STUDY AREA

URS

SOILS

Figure: 12-4

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## 12.7 Land Disturbance Impacts, Mitigation and Management

The disturbance level for the Project is assumed to be covered by two general domains:

1. Infrastructure Disturbance (gas and water collection, processing and treatment facilities, storage, wells, transfer stations, pipelines, warehouses, and accommodations); and
2. Storage Dams Disturbance (brine ponds, CSG water storage dams).

The environmental protection objectives for soils and land suitability are to:

- Maintain or restore soil profiles to support the intended land use;
- Maintain or restore the land to its pre disturbance land suitability class;
- Minimise alteration of drainage systems; and
- Minimise erosion and sedimentation impacts on the surrounding environment.

Land, soil and drainage systems within the Project area have the potential to be disturbed by the footprint of the construction and operation of infrastructure for the Project. Parts of the disturbance footprint will be progressively rehabilitated immediately after construction with the remainder to be rehabilitated at the end of operations.

The assessment of the key Project impacts on the proposed footprint includes:

- Post-development land suitability assessment;
- Soil resource assessment, which assesses soil suitability for salvage and re-use for rehabilitation;
- Topsoil management recommendations of stripped and salvaged soil resources;
- Soil erosion hazard assessment, which assesses potential soil erosion during land disturbance; and
- Erosion and sediment control recommendations to be implemented on the site.

### 12.7.1 Post-Development Land Suitability

It is assumed that all infrastructure, apart from pipelines, will be removed post-development, and as such post-development land suitability classes of the study area are considered to be the same as the pre-development classes. Pipelines will be capped and where necessary filled with an inert material and remain in-situ to avoid disturbing the re-established vegetation within the pipeline corridor by excavation and removal. The activities likely to have potential impacts on achieving this target, which may require mitigation measures, are listed below:

- Increased erosion resulting from ground disturbance, vegetation clearance, alteration of natural drainage and flow concentration due to construction activities that disturbs the ground;
- Deposition of eroded material downslope or downstream;
- Soil compaction from spoil placement or access tracks and laydown areas, potentially affecting long-term cropping and grazing productivity;
- Alterations to topography from soil and rock borrow pits; and
- Increased soil waterlogging as a result of differential settlement of pipeline backfill and padding.

The following general mitigation measures are proposed to minimise the impacts listed above:

- Minimise the disturbance footprint and vegetation clearing [B114];

- Clear areas progressively and implement rehabilitation as soon as practicable following construction and decommissioning activities [B033];
- Use existing roads and tracks, where practicable [B115]; and
- Erosion and Sediment Control Plans will be developed and maintained in accordance with the International Erosion Control Association (IECA) (2008) *Best Practice Erosion and Sediment Control* guidelines. All proposed erosion and sediment control measures will be implemented in advance of, or in conjunction with clearing activities [B066].

The implementation of the above mitigation measures, combined with appropriate rehabilitation techniques, will ensure the post disturbance land suitability goals are achieved. For further details on rehabilitation refer to the Decommissioning and Rehabilitation chapter (Section 29) of this EIS.

### 12.7.2 Soil Resource Assessment

The determination of suitable soil to conserve for later use in rehabilitation works has been conducted in accordance with Elliot and Reynolds (2000). The procedure involves assessing soils based on a range of physical and chemical parameters.

The assessment has shown that the suitability of the soil subject to disturbance has a recommended stripping depth between 0.3 to 1.5 m, depending on location. The recommended depths are soil depths that could be salvaged from the stripping process and re-used in progressive and post construction rehabilitation works. It should be noted that these depths are indicative and initially apply only within the sampling sites and immediate area, and requires further assessment for detailed disturbance evaluation and future site rehabilitation. The results are presented in detail in Table 12–5.

**Table 12-5 Recommended Topsoil Stripping Depths**

| Site | GSSE Representative Soil Type | Recommended Stripping Depth | Main Limitation(s) | Suitability |
|---|---|---|---|---|
| **Number** | **ASC** | **m** | **Description** | |
| A01 | Brown Vertosol | 0.90 | None | High |
| A09 | Grey Vertosol | 0.35 | Strongly sodic sub-horizon | Moderate |
| A10 | Brown Kandosol | 1.10 | None | High |
| A13 | Red Dermosol | 0.10 | Strongly sodic | Low |
| A15 | Brown Dermosol | 0.10 | pH exceeds 8.4 | Low |
| A17 | Grey Vertosol | 0.20 | Soil pH exceeds 8.4, sodic | Low |
| A19 | Brown Vertosol | 0.30 | Sodic and saline sub-horizon | Moderate |
| A22 | Brown Vertosol | 0.60 | Strongly sodic sub-horizon | Moderate |
| A23 | Brown Chromosol | 1.50 | None | High |
| A26 | Brown Tenosol | 0.00 | Absence of soil structure | Marginal |
| A28 | Brown Vertosol | 0.00 | Sodic to strongly sodic | Marginal |
| A30 | Brown Sodosol | 0.20 | Sodic, saline sub-horizon | Low |
| A31 | Grey Vertosol | 0.40 | Sub-horizon pH exceeds 8.4 | Moderate |

| Site | GSSE Representative Soil Type | Recommended Stripping Depth | Main Limitation(s) | Suitability |
|---|---|---|---|---|
| **Number** | **ASC** | **m** | **Description** | |
| A32 | Brown Vertosol | 0.45 | Sodic sub-horizon | Moderate |
| A35 | Brown Dermosol | 0.00 | Marginally to strongly sodic | Low |
| A37 | Brown Sodosol | 0.20 | Marginally sodic | Low |

### 12.7.3 Topdressing Management

The Project's disturbance activities include the need for immediate rehabilitation of infrastructure components. As such, stripped and salvaged soil will be re-used within a short period of time in areas where rehabilitation immediately follows the installation of low key infrastructures [B040].

The following management and mitigation strategies are proposed for implementation during disturbance and rehabilitation activities in order to reduce the potential for degradation within the Project area and adjoining lands. These recommendations are based on the assessment of the existing site conditions and experience with the management of disturbance impacts at sites throughout Central Queensland and apply to both topsoil and subsoil stripping:

- Strip soil to the depths stated in Table 12–5, subject to further field investigations during stripping [B051].
- Where practicable, place stripped material directly onto area to be rehabilitated and spread immediately (if rehabilitation sequences and weather conditions permit) to avoid the requirement for stockpiling [B052].
- Separate soils into windrows for later collection or respreading to minimise compression effects of heavy equipment [B053].
- Soil transported by dump trucks may be placed directly into storage. Soil transported by scrapers is best pushed to form stockpiles by other equipment (e.g. dozer) to avoid tracking over previously laid soil to minimise compaction [B054].
- The surface of soil stockpiles should be left in as coarsely structured a condition as possible to promote infiltration and minimise erosion until vegetation is established or suitable erosion controls have been applied, and to prevent anaerobic zones forming [B055].
- A maximum stockpile height for topsoil of 2 m is maintained as a general rule. Clay soils should be stored in lower stockpiles for shorter periods of time compared to coarser textured sandy soils [B056].
- For long term stockpiling, seed and fertilise stockpiles as soon as possible [B057].
- Subsoil and topdressing will be spread to depths dependent on target land suitability [B058].
- Suitable topsoil should be re-spread directly onto rehabilitation areas, where practicable. Topsoil should be spread, ameliorated (if required), treated with fertiliser and seeded in one consecutive operation, to reduce topsoil loss potential to wind and water erosion. Where possible, soil ameliorants will be applied prior to topsoil stripping to ensure adequate mixing [B059].

### 12.7.4 Soil Erosion Hazard

Soil erosion can be a significant hazard on and downstream of construction sites where ground cover is disturbed and the soil is subject to the erosive agents of water and wind. Soil erosion occurs when soil particles detach and are transported offsite. This process is affected by a range of site specific factors. The main factors for the study area are soil erodibility and steepness of terrain.

A hillslope erosion map of Australia showing erosion values in tonnes per hectare per year (t/ha/yr) has been provided in the *Arrow Bowen Gas Pipeline EIS Soils Technical Report* (SKM, 2011). The hillslope erosion map has been produced as a product of the "Water-borne erosion and sediment transport" project conducted by the National Land and Water Resources Audit (NLWRA, 2001). The map shows estimated erosion ratings along the Project based on the hillslope erosion map of Australia. Erosion ratings (as used in Australian Agriculture assessment 2001 reporting) are categorised as High (>10 t/ha/yr), Medium (between 0.5 and 10 t/ha/yr) and Low (<0.5 t/ha/yr) (Figure 12–5).

The hillslope erosion map was derived using an amended version of the universal soil loss equation (USLE): Soil Loss = K×R×C×S×L t/ha/year[1].

Soil erodibility is quantified using the soil erodibility factor (hereafter referred to as the K factor derived from the Universal Soil Loss Equation). Soil texture is the principle component affecting K; however, other factors such as soil structure, soil organic matter content as well as soil profile permeability also contribute to the soil's inherent erodibility. Soils that have the highest erodibility are those which have weak bonds between soil particles and contain an abundance of easily transportable soil particles.

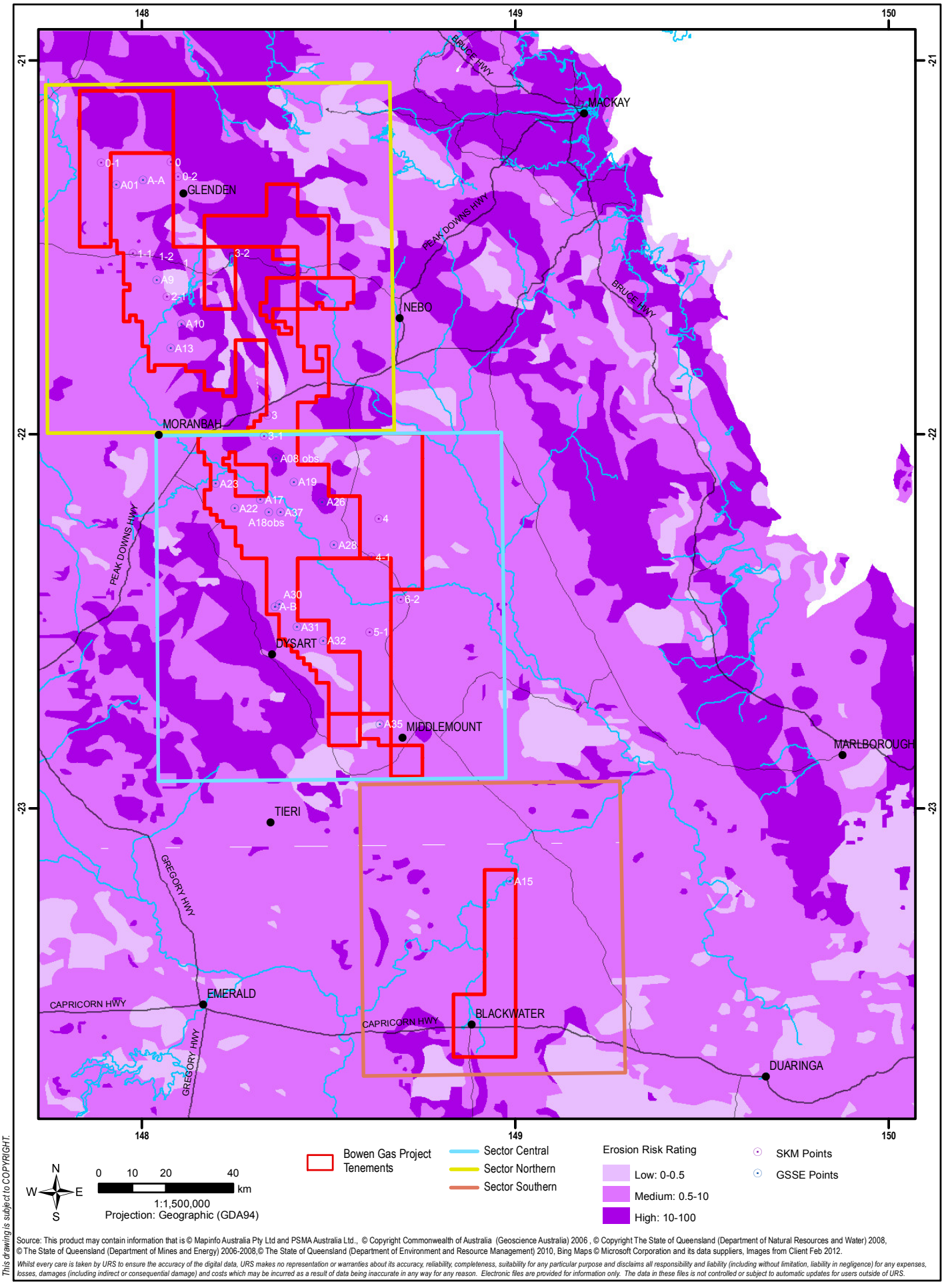
Soil erodibility has been considered to a depth of 0.3 m for each soil type encompassed by the disturbance footprint. This depth is appropriate for disturbance activities of less than 0.3 m in depth. Slope gradient is also a major factor for the study area as steeper slopes increase erosive activities and facilitate the transport of particulate matter. Where ground disturbance may require depths greater than 0.3 m, appropriate erosion control and stabilisation may be required. Work at slopes may additionally require slope stabilisation to minimise, if not prevent erosion from taking place.

The assessment of soil erosion hazard in each of the sampled sites is presented in Table 12–6. Erosion hazard ratings are presented according to the sampling site K-Factor ratings and correlated with the mapping previously undertaken by SKM (2011). Except for Site A30, all K-factor based hazard ratings are considered to be moderate. Sites A10 and A26 fall within high erosion risk while site A35 is within the Low Erosion risk based on the SKM Ratings. Detailed erosion risk investigations are recommended to be undertaken particularly for site development purposes, as this evaluation only presents an overall background analysis of the study area.

[1] Where K is soil erodability factor; R is rainfall and runoff factor; C is crop vegetation and management factor; and S and L are slope / length gradient factor.

**Table 12-6 Assessed Site Soil Erosion Hazard**

| Site | GSSE Representative Soil Type | K Factor | Erosion Hazard (K Factor) | Erosion Hazard (SKM Erosion Risk Rating) |
|---|---|---|---|---|
| | | **Rating** | **Rating** | **Rating** |
| A01 | Brown Vertosol | 0.021 | Moderate | Medium |
| A09 | Grey Vertosol | 0.029 | Moderate | Medium |
| A10 | Brown Kandosol | 0.034 | Moderate | High |
| A13 | Red Dermosol | 0.032 | Moderate | Medium |
| A15 | Brown Dermosol | 0.024 | Moderate | Medium |
| A17 | Grey Vertosol | 0.026 | Moderate | Medium |
| A19 | Brown Vertosol | 0.032 | Moderate | Medium |
| A22 | Brown Vertosol | 0.028 | Moderate | Medium |
| A23 | Brown Chromosol | 0.037 | Moderate | Medium |
| A26 | Brown Tenosol | 0.04 | Moderate | High |
| A28 | Brown Vertosol | 0.035 | Moderate | Medium |
| A30 | Brown Sodosol | 0.042 | High | Medium |
| A31 | Grey Vertosol | 0.027 | Moderate | Medium |
| A32 | Brown Vertosol | 0.032 | Moderate | Medium |
| A35 | Brown Dermosol | 0.037 | Moderate | Low |
| A37 | Brown Sodosol | 0.029 | Moderate | Medium |



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# EROSION RATING WITHIN THE STUDY AREA

URS

SOILS

Figure: 12-5

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## 12.7.5 Erosion and Sediment Control Operations

### *12.7.5.1 Minimising Disturbance*

Land disturbance will be minimised by clearing the smallest practical area of land ahead of construction, as well as ensuring the land is disturbed for the shortest possible and practical time [B047]. This will be achieved by:

- Limiting the cleared width to that required to accommodate the proposed operations [B060];
- Staging the clearing activities where possible and limit activity in cleared areas which reduces the time the areas are exposed [B061];
- Erosion and Sediment Control Plans will be developed and maintained in accordance with the IECA (2008) *Best Practice Erosion and Sediment Control* guidelines. All proposed erosion and sediment control measures will be implemented in advance of, or in conjunction with clearing activities [B066];
- Stabilise topsoil stockpiles as soon as practical. Develop and implement management strategies through an EM Plan and Erosion and Sediment Control Plan in line with all statutory legislation and regulations, Arrow energy policies, procedures / management plans, and industry standards [B062];
- Conducting pipeline construction in a manner that limits the duration of exposure of soils. Stripped and salvaged soil will be re-used within a short period of time (i.e. 28 days) in areas where rehabilitation immediately follows the installation of pipelines [B063]; and
- Develop rehabilitation plans addressing ground preparation requirements, natural and constructed drainage patterns, soil erodibility, contamination, slope steepness and length, vegetation cover, land use and landowner requirements [B064].

Drainage and sediment control measures will be installed prior to any clearing activities. Clearing may occur for the purpose of installing these measures, in which case, only the minimum clearing required to install such measures shall occur [B048].

Prior to the commencement of clearing and soil stripping, clear delineation of disturbance boundary limits of works will be established [B049]. All operations will be planned to ensure that there is no damage on any vegetation, cropping or pasture areas outside the limits to be cleared [B050].

### *12.7.5.2 Surface Water Diversion*

To minimise the volume of potential sediment laden water for treatment, all run-off water needs diversion into clean water drainage lines and off site into the natural drainage systems. Suitably designed and constructed diversion drains will be implemented where required [B077]. Further key mitigation measures for minimising erosion and sedimentation are outlined below:

- Reduce flow concentration and gully creation by minimising disruption to natural overland flow paths through the re-establishment of natural surface drainage lines [B043];
- Where possible, flood banks and artificial levees will be avoided [B071];
- Where possible, the disturbance of contour banks and irrigation bays will be avoided [B070];

- Where possible, minimise impact on irrigation flow or current farming practices from underground structures and where such must cross actively farmed arable land, ensure soil cover it is deep enough to allow normal cultivation practices to resume safely [B072];
- To allow settlement of backfill, avoid soil mounding along pipelines in irrigated paddocks, to the greatest extent practicable [B073];
- Prevent subsurface water flows and erosion along the backfilled trench by appropriate means, such as trench blocks and compaction of backfilled soils [B074]; and
- Discharge water from Project activities at a rate and location that will not result in erosion and install additional erosion protection measures [B075].

#### *12.7.5.3 Stockpiles*

Prior to any excavation or earthworks, topsoil and vegetation will be appropriately stockpiled separately for rehabilitation [B042]. Erosion and Sediment Control Plans will be developed and maintained in accordance with the IECA (2008) *Best Practice Erosion and Sediment Control* guidelines. All proposed erosion and sediment control measures will be implemented in advance of, or in conjunction with clearing activities [B066]. Long term stockpiling will require suitable stabilisation (i.e. polymer, cover crop or hydro mulch or similar) to protect the soil from raindrop impact and rill erosion [B067]. Strip, salvage and stockpile topsoil separately to subsoils [B068].

#### *12.7.5.4 Landform*

Development of landform management strategy used to identify key areas to re-establish pre-development landform at decommissioning. The landform management strategy shall incorporate provision for disturbed areas where infrastructure may be required for retention. Where pre-development landform is not practical, provide alternative landform design [B041]. Areas of differential settlement associated with buried infrastructure that interrupt the pre-existing surface water flow within intensively cultivated areas will be remedied as near as possible to pre-development landform [B065].

### 12.7.6 Impacts, Mitigation and Management

Table 12–7 below presents a summary of the potential impacts on soils and land suitability within the Project area along with proposed mitigation and management measures as discussed above and outlined in further detail in the Soils and Land Suitability Technical Report (Appendix K) of this EIS.

**Table 12-7 Summary of Soils and Land Suitability Impact Assessment**

| Potential Impacts | GSSE Site | Soil Type | Values Sensitivity | Pre-mitigated Impact | | Summary of Avoidance, Mitigation and Management Measures | Residual Impact | |
|---|---|---|---|---|---|---|---|---|
| | | | | Magnitude | Signifi-cance | | Magnitude | Signifi-cance |
| Land Degradation – Erosion and Associated Sedimentation, and Reduction in Soil Quality (Physical and Chemical) | | | | | | | | |
| **Construction**<br>• Increased erosion resulting from ground disturbance, vegetation clearance, alteration of natural drainage and flow concentration due to construction activities that disturbs the ground.<br>• Deposition of eroded material downslope or downstream.<br>• Soil compaction from spoil placement or access tracks and laydown areas, potentially affecting long-term cropping and grazing productivity.<br>• Alterations to topography from soil and rock borrow | A01 | Brown Vertosol | High | High | High | **General Measures**<br>• Stripped and salvaged soil will be re-used within a short period of time in areas where rehabilitation immediately follows installation of low key infrastructures [B040].<br>• Development of landform management strategy used to identify key areas to re-establish pre-development landform at decommissioning. The landform management strategy shall incorporate provision for disturbed areas where infrastructure may be required for retention. Where pre-development landform is not practical, provide alternative landform design [B041].<br>• Areas of differential settlement associated with buried infrastructure that interrupt the | Low | Low |
| | A09 | Grey Vertosol | High | High | High | | Low | Low |

| Potential Impacts | GSSE Site | Soil Type | Values Sensitivity | Pre-mitigated Impact | | Summary of Avoidance, Mitigation and Management Measures | Residual Impact | |
|---|---|---|---|---|---|---|---|---|
| | | | | Magnitude | Signifi-cance | | Magnitude | Signifi-cance |
| Land Degradation – Erosion and Associated Sedimentation, and Reduction in Soil Quality (Physical and Chemical) | | | | | | | | |
| pits.<br>• Increased soil waterlogging as a result of differential settlement of pipeline backfill and padding.<br><br>**Operation**<br>• Increased erosion and deposition of eroded material downslope / downstream resulting from alteration of natural drainage.<br>• Soil compaction along access tracks.<br>• Increased soil waterlogging resulting from differential settlement of pipeline backfill and padding. | A10 | Brown Kandosol | High | High | High | pre-existing surface water flow within intensively cultivated areas will be remedied as near as possible to pre-development landform [B065].<br>• Appropriately stockpile topsoil and associated vegetation separately for rehabilitation prior to excavation or earthworks [B042].<br>• Minimise disruption to natural overland flow paths through re-establishment of natural surface drainage lines [B069].<br>• Ensure that subsurface infrastructure does not impact on surface features or processes [B044].<br>• Prevent subsurface water flows and erosion [B045].<br>• All run-off water needs diversion | Low | Low |
| | A13 | Red Dermosol | Moderate | High | High | | Low | Low |

| Potential Impacts | GSSE Site | Soil Type | Values Sensitivity | Pre-mitigated Impact | | Summary of Avoidance, Mitigation and Management Measures | Residual Impact | |
|---|---|---|---|---|---|---|---|---|
| | | | | Magnitude | Signifi-cance | | Magnitude | Signifi-cance |
| Land Degradation – Erosion and Associated Sedimentation, and Reduction in Soil Quality (Physical and Chemical) | | | | | | | | |
| **Closure and Rehabilitation**<br>• Increased erosion resulting from ground disturbance and vegetation clearance.<br>• Alterations to topography from soil / rock borrow pits and brine ponds / dams.<br>• Re-profiling of micro-relief leading to patchy exposure of sodic and saline subsoils from soil profile inversion during material backfill. | A15 | Brown Dermosol | Moderate | High | High | into clean water drainage lines and off site into natural drainage systems [B076].<br>• Suitably designed and constructed diversion drains will be implemented where required [B077].<br>• Minimise land disturbance with the smallest practical area of land being disturbed in the shortest practicable time [B047].<br>• Drainage and sediment control measures will be installed prior to any clearing activities. Clearing may occur for the purpose of installing these measures, in which case, only the minimum clearing required to install such measures shall occur [B048].<br>• Establish clear delineation of disturbance boundary limits of | Low | Low |
| | A17 | Grey Vertosol | Moderate | High | High | | Low | Low |

| Potential Impacts | GSSE Site | Soil Type | Values Sensitivity | Pre-mitigated Impact | | Summary of Avoidance, Mitigation and Management Measures | Residual Impact | |
|---|---|---|---|---|---|---|---|---|
| | | | | Magnitude | Signifi-cance | | Magnitude | Signifi-cance |
| Land Degradation – Erosion and Associated Sedimentation, and Reduction in Soil Quality (Physical and Chemical) | | | | | | | | |
| | A19 | Brown Vertosol | Moderate | High | Major | works prior to commencement of clearing and soil stripping [B049].<br>• Planning of all operations to ensure minimal damage on any vegetation, cropping or pasture areas outside the limits to be cleared [B050].<br><br>**Specific Measures**<br>• Strip soil according to designated profile depths, subject to further field investigations during stripping [B051].<br>• Where practicable, place stripped material directly onto area to be rehabilitated and spread immediately (if rehabilitation sequences and weather conditions permit) to avoid the requirement for stockpiling [B052]. | Low | Low |
| | | | | | | | | |

| Potential Impacts | GSSE Site | Soil Type | Values Sensitivity | Pre-mitigated Impact | | Summary of Avoidance, Mitigation and Management Measures | Residual Impact | |
|---|---|---|---|---|---|---|---|---|
| | | | | Magnitude | Signifi-cance | | Magnitude | Signifi-cance |
| Land Degradation – Erosion and Associated Sedimentation, and Reduction in Soil Quality (Physical and Chemical) | | | | | | | | |
| | A22 | Brown Dermosol | High | High | High | • Separation of soils into windrows for later collection or respreading to minimise compression effects of heavy equipment [B053].<br>• Soil transported by dump trucks may be placed directly into storage. Soil transported by scrapers is best pushed to form stockpiles by other equipment (e.g. dozer) to avoid tracking over previously laid soil to minimise compaction [B054].<br>• Surface of soil stockpiles to be left in as coarsely structured a condition as possible to promote infiltration and minimise erosion until vegetation is established or suitable erosion controls have been applied and to prevent anaerobic zones from forming [B055]. | Low | Low |
| | A23 | Brown Chromosol | High | High | High | | Low | Low |

| Potential Impacts | GSSE Site | Soil Type | Values Sensitivity | Pre-mitigated Impact | | Summary of Avoidance, Mitigation and Management Measures | Residual Impact | |
|---|---|---|---|---|---|---|---|---|
| | | | | Magnitude | Signifi-cance | | Magnitude | Signifi-cance |
| Land Degradation – Erosion and Associated Sedimentation, and Reduction in Soil Quality (Physical and Chemical) | | | | | | | | |
| | A26 | Brown Tenosol | Moderate | High | High | • A maximum stockpile height for topsoil of 2m is maintained as a general rule. Clay soils should be stored in lower stockpiles for shorter periods of time compared to coarser textured sandy soils [B056].<br>• For long term stockpiling, seed and fertilise stockpiles as soon as possible [B057].<br>• Subsoil and topdressing will be spread to depths dependent on target land suitability [B058].<br>• Suitable topsoil should be re-spread directly onto rehabilitation areas, where practicable. Topsoil should be spread, ameliorated (if required), treated with fertiliser and seeded in one consecutive operation, to reduce topsoil loss potential to wind and water | Low | Low |
| | A28 | Brown Vertosol | Moderate | High | High | | Low | Low |

| Potential Impacts | GSSE Site | Soil Type | Values Sensitivity | Pre-mitigated Impact | | Summary of Avoidance, Mitigation and Management Measures | Residual Impact | |
|---|---|---|---|---|---|---|---|---|
| | | | | Magnitude | Signifi-cance | | Magnitude | Signifi-cance |
| Land Degradation – Erosion and Associated Sedimentation, and Reduction in Soil Quality (Physical and Chemical) | | | | | | | | |
| | A30 | Brown Sodosol | Moderate | High | High | erosion. Where possible, soil ameliorants will be applied prior to topsoil stripping to ensure adequate mixing [B059].<br>• Stage clearing activities where possible and limit activity in cleared areas which reduces the time the areas are exposed [B061].<br>• Stabilise topsoil stockpiles as soon as practical. Develop and implement management strategies through an EM Plan and Erosion and Sediment Control Plan in line with all statutory legislation and regulations, Arrow Energy policies, procedures / management plans, and industry standards [B062].<br>• Pipeline construction to be conducted in a manner that limits | Low | Low |
| | A31 | Dark Grey Vertosol | High | High | High | | Low | Low |

| Potential Impacts | GSSE Site | Soil Type | Values Sensitivity | Pre-mitigated Impact | | Summary of Avoidance, Mitigation and Management Measures | Residual Impact | |
|---|---|---|---|---|---|---|---|---|
| | | | | Magnitude | Signifi-cance | | Magnitude | Signifi-cance |
| Land Degradation – Erosion and Associated Sedimentation, and Reduction in Soil Quality (Physical and Chemical) | | | | | | | | |
| | A32 | Brown Vertosol | High | High | High | the duration of exposure of soils. Stripped and salvaged soil will be re-used within a short period of time (i.e. 28 days) in areas where rehabilitation immediately follows the installation of pipelines [B063].<br>• Develop rehabilitation plans addressing ground preparation requirements, natural and constructed drainage patterns, soil erodibility, contamination, slope steepness and length, vegetation cover, land use and landowner requirements [B064].<br>• Develop a landform management strategy used to identify key areas to re-establish pre-development landform at decommissioning. The landform management strategy shall incorporate provision for disturbed areas where infrastructure may be required for retention. Where pre-development landform is not practical, provide | Low | Low |
| | A35 | Brown Dermosol | High | High | High | | Low | Low |

| Potential Impacts | GSSE Site | Soil Type | Values Sensitivity | Pre-mitigated Impact | | Summary of Avoidance, Mitigation and Management Measures | Residual Impact | |
|---|---|---|---|---|---|---|---|---|
| | | | | Magnitude | Signifi-cance | | Magnitude | Signifi-cance |
| Land Degradation – Erosion and Associated Sedimentation, and Reduction in Soil Quality (Physical and Chemical) | | | | | | | | |
| | A37 | Brown Sodosol | Moderate | High | High | alternative landform design [B041].<br>• Areas of differential settlement associated with buried infrastructure interrupting the pre-existing surface water flow within intensively cultivated areas will be remedied as near as possible to pre-development landform [B065].<br>• Appropriately stockpile topsoil and associated vegetation separately for rehabilitation prior to excavation or earthworks [B042].<br>• Erosion and Sediment Control Plans will be developed and maintained in accordance with the IECA (2008) *Best Practice Erosion and Sediment Control* guidelines. All proposed erosion and sediment control measures will be implemented in advance of, or in conjunction with clearing activities [B066].<br>• Long term stockpiling will require suitable stabilisation (i.e. polymer cover crop or hydro mulch) to | Low | Low |

| Potential Impacts | GSSE Site | Soil Type | Values Sensitivity | Pre-mitigated Impact | | Summary of Avoidance, Mitigation and Management Measures | Residual Impact | |
|---|---|---|---|---|---|---|---|---|
| | | | | Magnitude | Signifi-cance | | Magnitude | Signifi-cance |
| Land Degradation – Erosion and Associated Sedimentation, and Reduction in Soil Quality (Physical and Chemical) | | | | | | | | |
| | | | | | | protect the soil from raindrop impact and rill erosion [B067].<br>• Strip, salvage and stockpile topsoil separately from subsoils [B068].<br>• Minimise disruption to natural overland flow paths through re-establishment of natural surface drainage lines [B069].<br>• Where possible, the disturbance of contour banks and irrigation bays will be avoided [B070].<br>• Where possible, flood banks and artificial levees will be avoided [B071].<br>• Where possible, minimise impact on irrigation flow or current farming practices from underground structures and where such must cross actively farmed arable land, ensure soil cover above it is deep enough to allow normal cultivation practices to resume safely [B072].<br>• To allow settlement of backfill, | | |

| Potential Impacts | GSSE Site | Soil Type | Values Sensitivity | Pre-mitigated Impact | | Summary of Avoidance, Mitigation and Management Measures | Residual Impact | |
|---|---|---|---|---|---|---|---|---|
| | | | | Magnitude | Signifi-cance | | Magnitude | Signifi-cance |
| Land Degradation – Erosion and Associated Sedimentation, and Reduction in Soil Quality (Physical and Chemical) | | | | | | | | |
| | | | | | | avoid soil mounding along pipelines in irrigated paddocks to the greatest extent practicable [B073].<br>• Prevent subsurface water flows and erosion along the backfilled trench by appropriate means, such as trench blocks and compaction of backfilled soils [B074].<br>• Discharge water from Project activities at a rate and location that will not result in erosion and install additional erosion protection measures [B075].<br>• Suitably designed and constructed diversion drains will be implemented where required [B077]. | | |