4 GEOLOGY AND SOILS

4.1 INTRODUCTION

The Gas Field Component is located in the Surat Basin, in the Western Downs region of Queensland. *Chapter 4* identifies the geology and soil-related issues associated with the construction and operational development of the Gas Field.

The most significant potential soil issue associated with the Gas Field is erosion and management of topsoil to provide successful rehabilitation outcomes.

A discussion of the potential for subsidence as a result of Associated Water extraction is provided in *Volume 3, Chapter 10*.

4.2 METHODOLOGY

The assessment of geology and soils comprised a desktop review of available data and field inspection of selected sites within the Gas Field study area. Preliminary maps and associated data were reviewed to identify specific locations for field investigation. Areas prioritised for inspection included soils with the following constraints:

- high soil erodiblity
- very low soil fertility
- shallow soil depth
- severe stoniness and presence of rock outcrop
- saline subsoil
- severe gilgai microrelief
- potential to generate dust.

Field investigations were conducted in the field in late 2008 and early 2009. This comprised field observations at 66 key points within the Gas Field study area as well as detailed soil sampling at 45 sites (refer to *Figure 3.4.3*). During field investigations, soils were excavated to a maximum depth of 1m, or to bedrock in soil profiles of less than 1m thickness.

Reference should also be made to the full Geology and Soils Report which is provided in *Appendix 3.1.*

4.3 PROJECT ENVIRONMENTAL OBJECTIVE AND VALUES

The Project environmental objective for geology and soils is to protect soils from contamination and erosion arising from Project Activities.

The sections that follow outline the existing environmental values related to geology and soils.

4.3.1 Geology

The Gas Field Component is located in the Surat Basin, a large intracratonic basin of Mesozoic age covering approximately 300,000 km^2 of southeastern Queensland and northern New South Wales. The basin forms part of the larger Great Australian Basin, and interfingers westward across the Nebine Ridge with the Eromanga Basin, and eastward across the Kumbarilla Ridge with the Clarence-Moreton Basin. Basement blocks consisting of the Central West Fold Belt and the New England Fold Belt limit the basin to the south, while in the north the basin has been eroded and unconformably overlies Triassic and Permian sediments of the Bowen Basin.

The Surat Basin contains up to 2,500m of sedimentary rocks deposited during the latest Triassic to Early Cretaceous periods. The latest Triassic to earliest Cretaceous succession in the basin consists of five fining-upwards sedimentary cycles dominated by fluvio-lacustrine deposits. The lower part of each cycle typically comprises coarse-grained mature sandstone, grading up into more labile sandstone and siltstone, with mostly siltstone, mudstone and coal in the upper part. In the Cretaceous, inundation of the land through an increase in sea level led to deposition of predominantly coastal plain and shallow marine sediments in two cycles. Structurally the Surat Basin is relatively simple with the area of maximum deposition, the Mimosa Syncline, overlying the thickest Permian-Triassic rocks in the Taroom Trough of the underlying Bowen Basin. Major faulting within the basin predominantly mirrors basinal boundary faults of the underlying Bowen Basin. There is substantial folding across the basin, which is due to compaction and draping, as well as some rejuvenation of older pre-Jurassic structures and faults. Formations outcrop along the northern erosional boundary and dip gently to the south and southwest at less than 5 degrees.

The current landscape and soil profiles are the result of post Cretaceous uplift and deformation over several phases, the most significant of which resulted from the effects of the Tertiary break up and formation of the nearby Coral Sea. Approximately 52 per cent of the surface area of the Gas Field Component is directly underlain by subcrop of Surat Basin sedimentary rocks. The remaining area can be categorised as directly underlain by post Cretaceous consolidated to poorly consolidated sedimentary rocks of Tertiary to Quaternary age, and more recent unconsolidated alluvium, often associated with present waterways. An estimate of the surface area directly underlain by these sediments is; 5 per cent Tertiary age sedimentary rocks; 31 per cent Tertiary to Quaternary sedimentary rocks and unconsolidated alluvium and 12 per cent recent unconsolidated alluvium.

The geological formations found within the Gas Field Component are summarised in Table 3.4.1 and their distribution shown in *Figure 3.4.1*.

The depth to bedrock over the Gas Field varies greatly, ranging from less than 0.3m to greater than 1.2 m. Approximately 51 per cent of the area has a depth to bedrock greater than 1.2 m. Areas with shallow bedrock generally occur to the north of the town of Miles, in association with shallow soils (shallow sands and sandy loams, shallow loams and clay loams) on low hills, hills and rises (refer to *Figure 3.4.2*).

Depth to top bedrock occurs at depths between 0.3 and 0.9 m in a further 13 per cent of the study area, mainly to the south of the Moonie Highway and in the northern section of the Gas Field south and west of Wandoan, where the major soil management groups occur on little-weathered sedimentary rocks. Areas with a tendency for shallow depth to bedrock also have a tendency for the presence of cobbles in the soil profile. Tenements with the potential for large areas of shallow bedrock include PLA 276, PLA 227, ATP 574, ATP 768, PL 171 and the northern section of ATP 647.

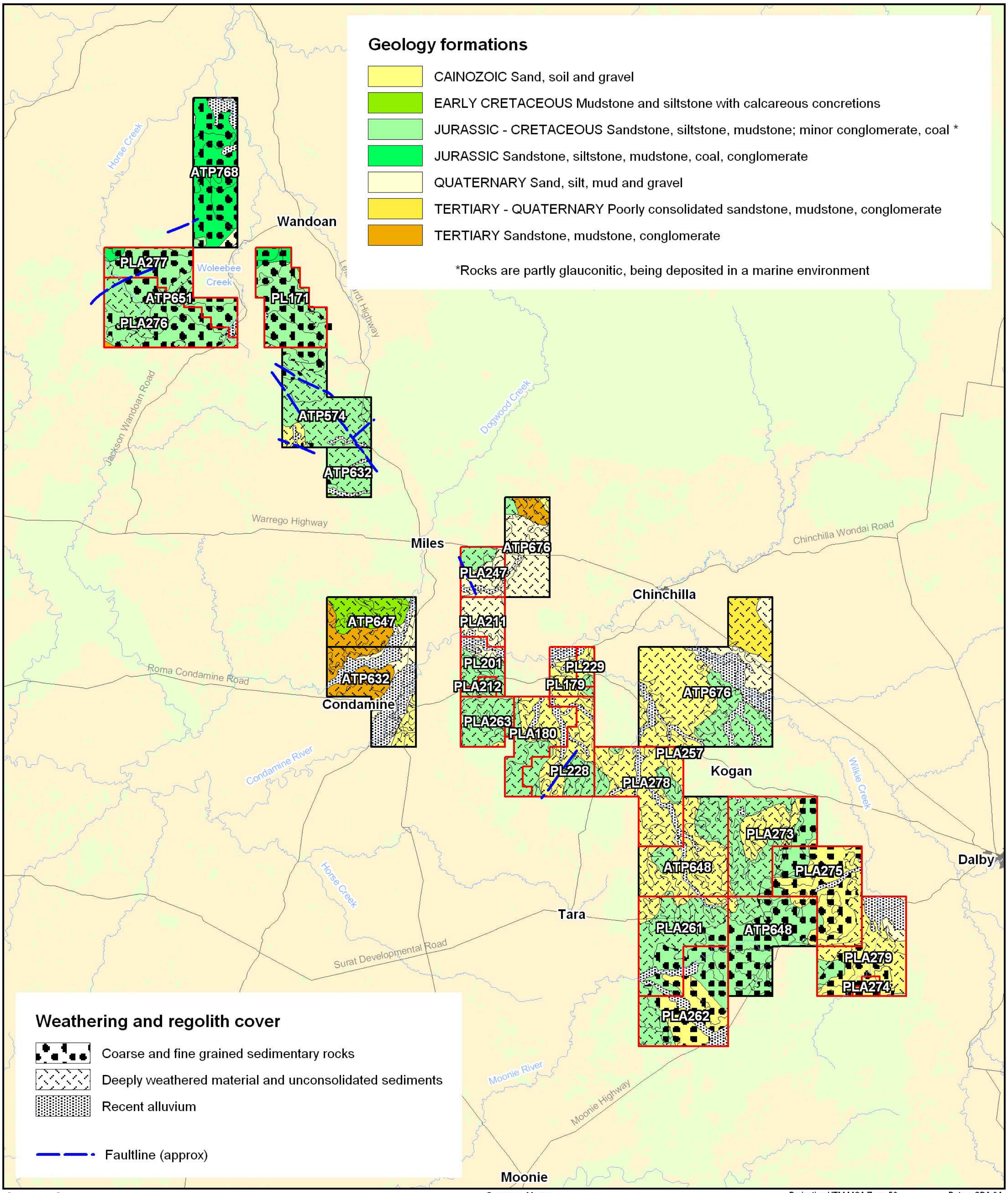
The Gas Field is considered very stable in geological terms. Although there is known faulting in the near subsurface, and significant deeper basement structure, the region is tectonically stable. Approximate locations of minor fault lines are presented in *Figure 3.4.1*. No significant seismic activity is reported in Queensland's Department of Employment, Economic Development and Innovation (formerly Department of Mines and Energy) geological reports covering the Gas Field area.

During the technical study, no information was available on the potential for the release of heavy metals which may be retained within geological materials associated with the Gas Field study area.

Table 3.4.1 Gas Field Geological Formations

Age[1]	Brief description [2]	Area (ha)	Area (%)
Quaternary (up to 1.8 mya)	Alluvium: Sand, silt, mud, gravel	57,830	12.3
Tertiary-Quaternary	Poorly consolidated sandstone, mudstone, conglomerate	7,175	1.7
Tertiary (≈ 1.8-65 mya)	Sandstone, mudstone, conglomerate	17,270	3.7
Cainozoic (up to 65 mya)	Very poorly sorted sand, soil and gravel	146,175	31.1
Cretaceous (≈ 65-141 mya)	Wallumbilla Formation: Mudstone and siltstone with calcareous concretions	7,715	1.7
Jurassic-Cretaceous [3] (≈ 65-205 mya)	Bungil Formation, Gubberamunda Sandstone, Kumbarilla Beds, Mooga Sandstone, Orallo Formation: Siltstone, mudstone; sandstone, minor conglomerate, siltstone, coal	208,715	44.4
Jurassic (≈ 141-205 mya)	Injune Creek Group: Sandstone, siltstone, mudstone, coal, conglomerate	23,800	5.1
Total		468,680	100.0

1. Age is given as millions of years ago (mya).
2. The brief description is summarised for all map sheets.
3. Several formations are described as glauconitic, meaning they have been deposited in a marine environment.



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0 10 20 30 40
Kilometres

N

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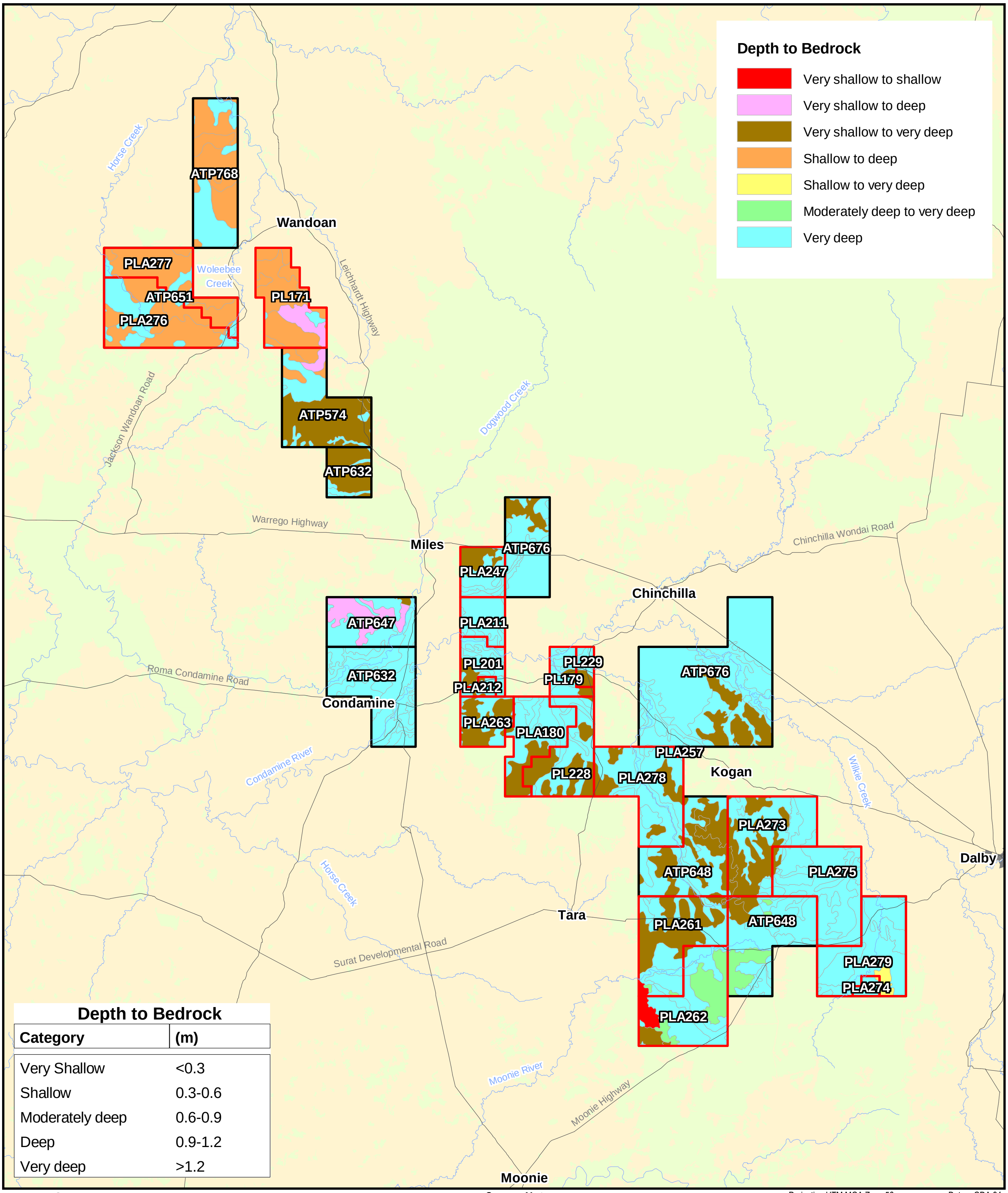

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0 10 20 30 40
Kilometres

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4.3.2 Soils

4.3.2.1 Soil Types

Soils identified in the Gas Field vary from shallow sandy soils associated with outcropping sedimentary rocks to deep clay soils on level-to-gently-undulating plains. For the purpose of this report, the wide range of soils within the Gas Field has been amalgamated into a series of soil management groups. Each soil management group consists of soil types that have similar profile features as well as similar chemical and physical properties and thus require similar management inputs to ensure sustainable use and to minimise environmental impact.

All descriptions of soil management groups in this report use standard terminology of the *Australian Soil and Land Survey Field Handbook* (McDonald *et al* 1990). Twelve soil management groups have been identified within the Gas Field area and these are summarised in *Table 3.4.2* and illustrated in *Figure 3.4.3*.

Where one soil management group represents at least 70 per cent of the mapping unit, only one group has been illustrated. The two main soil management groups are shown, separated with "/", where no one group accounts for 70 per cent of the mapping unit. A correlation of each soil management group with the equivalent taxonomic unit from the Australian Soil Classification (Isbell 1996) is also included.

4.3.2.2 Topsoil Thickness

In this section, topsoil refers to the soil material within the landscape that is suitable for use as "topsoil" during rehabilitation. Information on the topsoil depth for the various soil management groups is presented in *Table 3.4.2*.

4.3.2.3 Existing Erosion

During the field inspection, it was found that while many of the soils of the Gas Field are highly erodible, the grazing and forestry practices and mainly gentle slopes have created only minor erosion at the locations inspected.

On grazing and forestry land, minor sheet erosion was evident on the sloping *sandy texture contrast soils (dispersive)* and *loamy texture contrast soils (dispersive)*. More severe sheet erosion was evident on the steeper grazing land with *shallow sands and sandy loams* or *shallow loams and clay loams.*

On the cropping land, run-off control structures and appropriate land management practices have generally been adopted and effectively minimised ongoing erosion. As a result, only minor soil movement due to sheet and rill erosion between run-off control structures was evident.

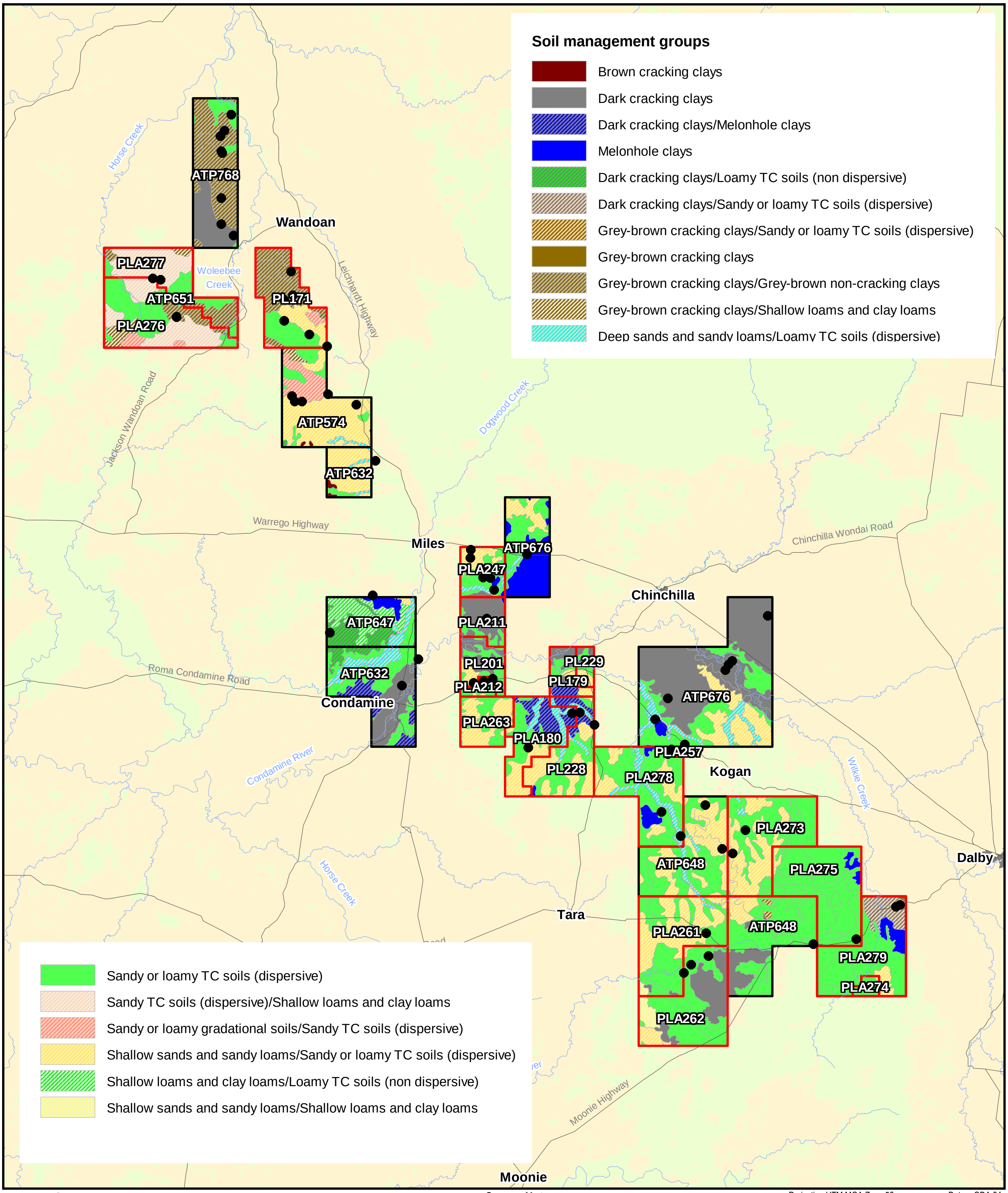
Table 3.4.2 Gas Field Soil Management Groups

Soil management group [1]	Major terrain unit [2]	Brief description	ASC Suborder [3]	Area [4] (ha)	Area [4] (%)
Shallow sands and sandy loams	Little-weathered sedimentary rocks	Shallow and gravelly soils with thin, brown, grey or black, loamy sand to sandy loam that either directly overlies weathered rock or grades into a paler subsurface layer of similar texture which then overlies rock. Mainly found on deeply weathered material where they occupy hills, low hills, rises and plateau scarps, but may occur throughout the study area, occasionally on little-weathered sedimentary rocks. Topsoil depth: <100 to 300mm. Weathered rock at <100 to 300 mm depth.	Clastic Rudosols, Leptic Tenosols and Bleached-Leptic Tenosols	5,205	1.1
	Deeply weathered material			87,035	18.6
Shallow loams and clay loams	Deeply weathered material	Shallow and gravelly soils with thin, brown, grey or black, sandy clay loam, loam or clay loam that either directly overlies weathered rock or grades into a paler subsurface layer of similar texture which then overlies rock. Occupies the same landform components as the *Shallow sands and sandy loams* but is much less extensive. Topsoil depth: <100 to 300mm. Weathered rock at <100 to 300 mm depth	Clastic Rudosols, Leptic Tenosols and Bleached-Leptic Tenosols	5,845	1.3
Deep sands and sandy loams	Recent alluvium	Deep soils with very thick, dark brown to grey, sand to sandy loam that overlies subsoil of similar texture but with a brighter, red or yellowish brown, colour. Occupy levees and channel benches in the level-to-gently-undulating floodplains that flank major streams. Their most widespread occurrence is along the Condamine River between Condamine and Miles. Buried layers may occur below 400 mm depth, total soil profile depth, including the buried layers is more than 1 m.	Stratic Rudosols, Red-Orthic Tenosols and Brown-Orthic Tenosols	17,040	3.6
Sandy or loamy gradational soils	Deeply weathered material	Moderately deep to deep soils with very thick, brown, sandy loam to clay loam, sandy grading into red or yellow subsoil of sandy light clay to medium clay that may be strongly mottled at depth. Major soil management group on the plateau remnants and mainly occur south and south-west of Wandoan, covering approximately 1% of the study area. Topsoil depth: 100 to 300 mm. Weathered rock below 600 mm depth.	Red Kandosols and Yellow Kandosols	6,000	1.3

				Area [4]	
Loamy texture contrast soils [5] (non- dispersive)	Little-weathered sedimentary rocks	Deep soils with thin, grey or brown, clay loam abruptly overlying brown medium clay subsoil. There may be a very thin, sporadically bleached subsurface layer. Topsoil depth: <100 to 300 mm. Weathered rock below 1 m depth.	Brown Chromosols	0	0.0
Loamy texture contrast soils (dispersive)	Little-weathered sedimentary rocks	Moderately deep to deep soils with thin, brown or dark grey, loam, sandy clay loam or clay loam often overlying bleached subsurface of similar texture which abruptly overlies brown, grey or mottled, brown and grey, sandy light clay to medium clay subsoil. Widespread throughout the study area, mainly on rises and plains but may also occur on low hills. Topsoil depth: <100 to 300 mm. Weathered rock below 600 mm depth.	Brown and Grey Sodosols, Brown and Grey Kurosols	34,830	7.4
	Deeply weathered material and unconsolidated sediments			32,615	7.0
	Recent alluvium			3,810	0.8
Sandy texture contrast soils (dispersive)	Little-weathered sedimentary rocks	Moderately deep to deep soils with thick, brown or dark grey, sand, loamy sand or sandy loam usually overlying a bleached subsurface of similar texture which abruptly overlies mottled brown, grey or yellow, sandy light clay to sandy medium clay subsoil. Most widespread soil management group throughout the study area, occurring on all types of terrain except dissected plateaus. Topsoil depth: 100 to 300 mm to >300 mm. Weathered rock below 600 mm depth.	Brown, Grey and Yellow Sodosols, Brown, Grey and Yellow Kurosols	52,705	11.2
	Deeply weathered material and unconsolidated sediments			84,880	18.1
	Recent alluvium			4,830	1.0
Brown cracking clays	Little-weathered sedimentary rocks	Deep soils with thin, dark brown, light clay to light medium clay overlying brown or reddish brown, medium clay to medium heavy clay subsoil. Occupy level-to-gently-undulating plains developed on little-weathered sedimentary rocks between Miles and Wandoan. Topsoil depth: <100 to 300 mm. Weathered rock below 1 m depth	Brown Vertosols	460	0.1
Grey-brown cracking clays	Little-weathered sedimentary rocks	Deep soils with thin, brown or dark grey, light clay to medium clay texture overlying brown, dark grey or reddish brown, medium clay to heavy clay subsoil becoming brown to yellowish brown with depth. Occupies rises and undulating plains developed on little-weathered sedimentary rocks, mainly south-west of Wandoan. Topsoil depth: <=100 mm. Weathered rock below 1 m depth.	Brown Vertosols and Grey Vertosols	32,905	7.0
	Unconsolidated sediments			80	<0.1
Grey-brown non-cracking clays [6]	Little-weathered sedimentary rocks	Moderately deep to deep soils with thick, brown or black, light clay to medium clay overlying greyish brown to reddish brown subsoil of similar texture. Occur on rises and undulating plains developed on	Grey Dermosols and Brown	0	0.0

				Area [4]	
		little-weathered sedimentary rocks west of Wandoan. Topsoil depth: <100 to 300 mm. Weathered rock below 600 mm depth.	Dermosols		
Dark cracking clays	Little-weathered sedimentary rocks	Moderately deep to deep soils with thin, black or dark grey, sandy light clay to medium heavy clay overlying light medium clay to heavy clay subsoil of similar colour, often becoming paler grey or brown with depth. Occupy rises and plains developed on little-weathered sedimentary rocks, unconsolidated sediments and recent alluvium, being widespread between Miles, Condamine, Kogan and Brigalow. Substantial areas also occur in the south-east corner of the Gas Field. Weathered rock below 600 mm depth.	Black Vertosols and Grey Vertosols	16,650	3.6
	Deeply weathered material and unconsolidated sediments			50,000	10.7
	Recent alluvium			19,895	4.2
Melonhole clays	Unconsolidated sediments	Deep soils with melonhole gilgai and very thin, grey or brown, light medium clay to heavy clay overlying grey, medium clay to heavy clay subsoil. Occupy level-to-gently-undulating plains developed on unconsolidated sediments, mainly south of the Warrego Highway. Weathered rock below 1 m depth.	Grey Vertosols	13,895	3.0
Total				468,680	100.0

1. A soil management group represents several soils that have similar profile features, chemical properties and physical properties and thus require similar management inputs to ensure sustainable use and to minimise environmental impact.
2. A terrain unit is based on weathering history of the underlying rocks and resultant regolith cover. A major terrain unit is one in which the soil management group is the most widespread and is therefore listed first.
3. ASC Suborder represents the soil taxonomic classification (to its second or suborder level) using the Australian Soil Classification (Isbell 1996).
4. The *sandy texture contrast soils (dispersive)* and *loamy texture contrast soils (dispersive)* could not be separated in many mapping units and the individual area of each has been estimated in these units as being one-half of the total area of the mapping unit.
5. *Loamy texture contrast soils (non dispersive)* are not the major soil management group in any terrain unit but are co-dominant with other soil management groups on 12,680 ha south-west of Miles.
6. *Grey-brown non-cracking clays* are not the major soil management group in any terrain unit but are co-dominant with *grey-brown cracking clays* on 29.9 ha north-west of Miles.



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Gas Fields - Authority to Prospect

● Inspection Site

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0 10 20 30 40
Kilometres

N

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However, in all areas, evidence of rill, gully and tunnel erosion was observed occasionally and in all instances was due to nearby construction works (e.g. roads, pipelines). This was most commonly associated with *sandy texture contrast soils (dispersive)* and *loamy texture contrast soils (dispersive)* and with *grey-brown non-cracking clays* in the northern sections of the Gas Field.

4.3.2.4 Soil and Subsoil Salinity

Desktop research and selected soil analysis has indicated that salinity at the soil surface is not a significant issue within the study area. However, land that is either entirely or partly severely constrained due to subsoil salinity occurs extensively throughout the study area.

Salinity remains low to very low through the soil profile of *shallow sands and sandy loams*, *shallow loams and clay loams*, *deep sands and sandy loams* and *sandy or loamy gradational soils.* However, salinity generally increases in all other soil management groups and reaches the following levels deep in the subsoil:

- high in some profiles of the *loamy texture contrast soils (non-dispersive)*
- low to high in the *loamy texture contrast soils (dispersive)*
- medium to extreme in the *sandy texture contrast soils (dispersive)*
- medium in the *brown cracking clays*
- low to medium in the *grey-brown non-cracking clays*
- very high to extreme in the *grey-brown cracking clays*
- low to medium in the *dark cracking clays*
- medium to very high in the *melonhole clays*.

4.3.2.5 Soil Fertility

An analysis of soil samples from the Gas Field area and existing desktop information revealed that all soil management groups within the Gas Field study area have a low to very low level of at least one major nutrient and have a soil fertility constraint of some degree. A summary of the soil fertility levels for each soil management group is presented in *Table 3.4.3*.

Total nitrogen reserves in each soil management group are generally quite variable and are strongly influenced by vegetation cover and land use history. This variability reflects the diverse range of sites that have been sampled to collate these ratings. Available phosphorus is less variable than nitrogen and exchangeable potassium levels are the least variable. Levels of these nutrients have been shown to be closely related to source geology and history of weathering throughout Queensland, though land use history still has some effect.

Table 3.4.3 Summary of Soil Fertility

Soil group	Tot N [1]	Avail P [2]	Exch K [3]
Shallow sands and sandy loams	Low-very high	Very low	Low
Shallow loams and clay loams	Low-very high	Very low	Low
Deep sands and sandy loams	Low-very high	Low-medium	Medium-very high
Sandy or loamy gradational soils	Low-high	Very low	Low-high
Loamy texture contrast (TC) soils (non- dispersive)	High-very high	Very low-low	Low-very high
Loamy TC soils (dispersive) - on recent alluvium	Low-very high	High	High
Loamy TC soils (dispersive) - on other material	High-very high	Very low-low	Medium-very high
Sandy TC soils (dispersive) - on recent alluvium	Low	Very low-low	Medium-high
Sandy TC soils (dispersive) - on other material	Very low-very high	Very low-low	Low-medium
Brown cracking clays	Low	Low	Very high
Grey-brown cracking clays	Low-very high	Medium	High-very high
Grey-brown non-cracking clays	Low-very high	Medium	High-very high
Dark cracking clays	Low-very high	Low-very high	High-very high
Melonhole clays	Low-very high	Low-very high	High-very high

1. Tot N represents total nitrogen and is a measure of the total nitrogen reserves in the soil.
2. Avail P represents available phosphorus and is a measure of the amount of phosphorus that is readily available for plant use.
3. Exch K represents exchangeable potassium and is a measure of the amount of potassium that is readily available for plant use.

4.3.2.6 Acid Sulfate Soils

Acid sulfate soils (ASS) refers to soil profiles, soil layers and sediments that contain iron sulfides with the most common of these being pyrite.

ASS characteristically occur in estuaries, tidal mangroves, wetlands, floodplains, lakes and other areas at elevations less than 5 m above sea level. ASS can also be found at higher elevations inland, where pyrite forming conditions are present.

Pyrite can form where there is an abundance of iron in the sediment, organic matter, saline water and anaerobic conditions. These conditions are only met inland where there are organically enriched deposits at the edges of saline lakes and waterways.

Such conditions are not known within the Gas Field and as it is considered extremely unlikely that ASS are present no further assessment was completed.

4.3.3 Good Quality Agricultural Land

The Queensland Government introduced a State Planning Policy in 1992 (SPP 1/92) to protect Good Quality Agricultural Land (GQAL). In support of this policy, four classes of agricultural land were defined for Queensland:

Class A Crop land

Class B Limited crop land

Class C Pasture land

Class D Non-agricultural land.

An assessment has been carried out to determine the areas within the Gas Field study area that would be considered to be GQAL as defined in State Planning Policy 1/92 and a summary of this assessment is presented in *Table 3.4.4* and *Figure 3.4.4.*

Table 3.4.4 Good Quality Agricultural Land

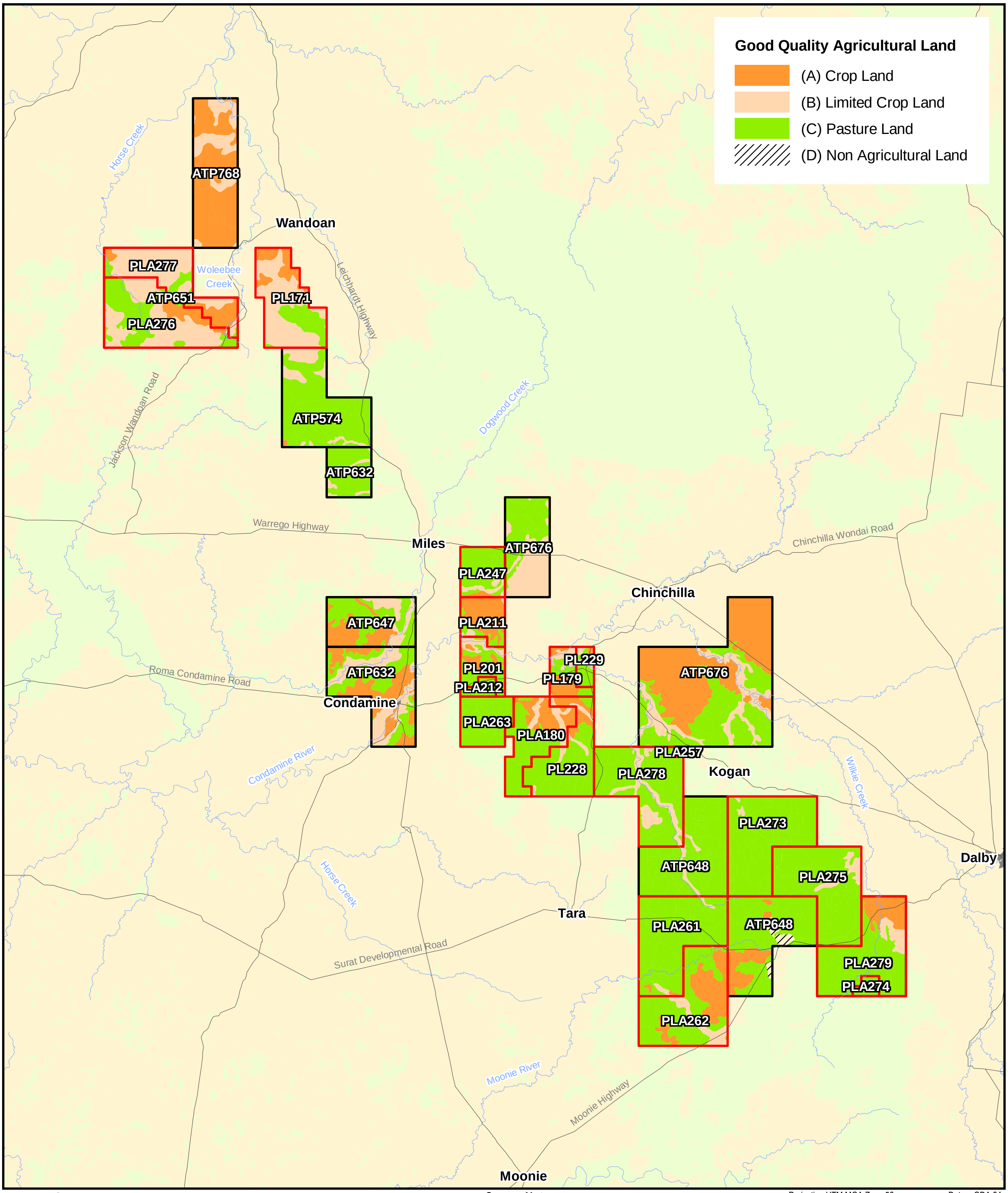
Agricultural Land Class	Status	Area (ha)	Area (%)
Class A	GQAL	96,965	20.7
Class B	GQAL	86,945	18.5
Class C	Pasture land	283,485	60.5
Class D	Non-agricultural land	1,285	0.3
Total		**468,680**	**100.0**

Approximately 39 per cent of the study area is considered GQAL (crop or limited crop land), 60.5 per cent is pasture land and less than 0.5 per cent is non-agricultural land. Most of the GQAL is in the centre of the study area roughly bounded by Miles, Brigalow, Kogan and Condamine though substantial areas also occur along the Moonie Highway in the south-east and in the north-west, surrounding Wandoan.

The highest value cropping land in the study area is allocated to Agricultural Land Class A which comprises almost 21 per cent of the study area, including significant sections of ATP 676, ATP 632, ATP 768 and PLA 211. This land consists of most of the *brown cracking clays*, *grey-brown cracking clays*, *grey-brown non-cracking clays*, *dark cracking clays* and land containing *loamy texture contrast soils (non-dispersive)*.

Approximately 18.5 per cent of the Gas Field has been allocated to Agricultural Land Class B which has limited crop potential, including significant portions of PL 171, PLA 276, PLA 277 and the northern section of ATP 676. Limited cropping land comprises the *melonhole clays*, small areas of the other clay soils, the *deep sands and sandy loams* and small areas of *sandy texture contrast soils (dispersive)* and *loamy texture contrast soils (dispersive)*.

Approximately 80 to 90 per cent of the GQAL east and south of Miles is currently cropped, while much of the adjacent land is also being cropped though not deemed GQAL by the Department of Environment and Resource Management (DERM) (formerly the Department of Natural Resources and Water). The majority of the GQAL west and south of Wandoan is not currently cropped (refer to *Figure 3.4.5*).



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0 10 20 30 40
Kilometres

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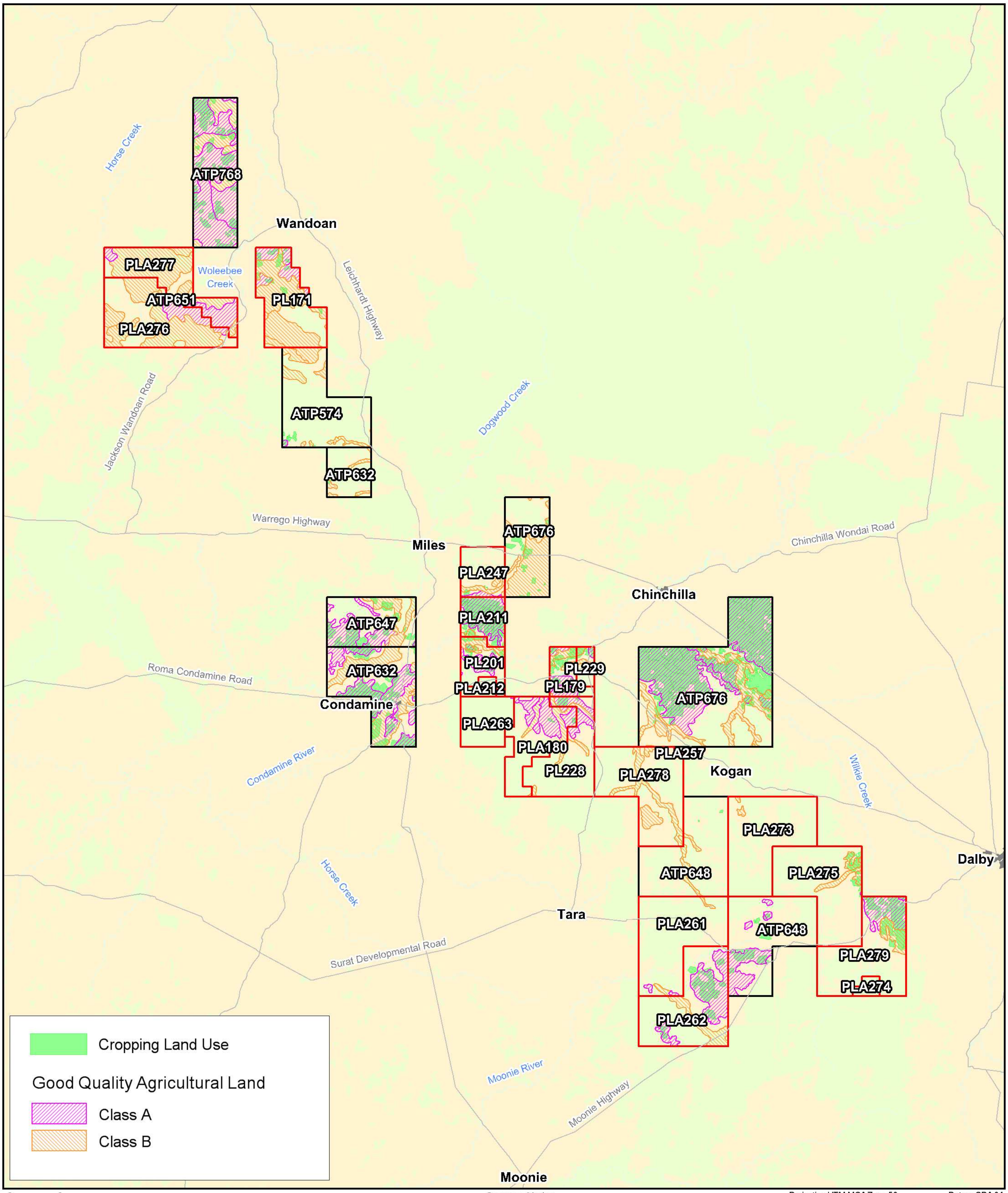

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Project	Queensland Curtis LNG Project	Title	**Extent of Current Cropping**
Client	QGC - A BG Group business		
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4.4 ASSESSMENT OF POTENTIAL IMPACTS

Project activities which have the potential to impact on the soils and terrain of the Project area include:

- removal of vegetation and excavation activities for the establishment of well sites, gathering systems/pipelines and associated infrastructure
- installation of above-ground infrastructure sites e.g. wells, field compressor stations, central processing plants, water management infrastructure, camps
- development of additional access tracks
- establishment and operation of any construction work areas
- establishment of borrow pits.

Potential impacts may include:

- soil erosion and sedimentation
- loss of/degradation of topsoil leading to reduced rehabilitation success
- exposure of saline subsoil
- bulldust generation
- degradation of GQAL.

The following section provides a summary of the key constraints associated with the Gas Field study area and a summary of the potential impacts arising from the construction and operation of the Gas Field.

4.4.1 Soils

4.4.1.1 Summary of Key Constraints

The range of constraints identified in association with each soil management group identified within the Gas Field is summarised in *Table 3.4.5*. As described in *Section 4.3*, the constraints associated with the field vary between and within soil management groups. Variation within a particular soil management group can be due to:

- variation of a soil feature (e.g. profile depth) sufficiently within one group to affect the severity of the constraint
- the constraint being largely influenced by factors other than soil type (e.g. topography) and the soil management group occupying differing landscape elements

the constraint being a combination of soil features and landscape elements, such as erosion hazard and soil fertility, and the soil management group having several combinations.

Table 3.4.5 Soil Management Group Constraints

Soil group	Topography [1]	Depth to bedrock	Stoniness and rock outcrop	Erosion hazard [2]	Soil fertility [3]	Topsoil depth [4]	Salinity
Shallow sands and sandy loams	Nil-severe	Severe-extreme	Severe-extreme	Moderate-extreme	Severe	Thin	Nil
Shallow loams and clay loams	Nil-severe	Severe-extreme	Severe-extreme	Minor-extreme	Severe	Thin	Nil
Deep sands and sandy loams	Nil	Nil	Nil	Nil	Minor	Very thick	Nil
Sandy or loamy gradational soils	Nil	Nil-moderate	Nil	Moderate	Severe	Thick	Nil
Loamy TC soils (non-dispersive)	Nil	Nil	Nil	Moderate	Moderate	Thin	Moderate
Loamy TC soils (dispersive)	Nil-minor	Nil-moderate	Nil	Minor-extreme	Minor-moderate	Thin	Moderate
Sandy TC soils (dispersive)	Nil-moderate	Nil-moderate	Nil	Minor-extreme	Moderate-severe	Thick-very thick	Severe
Brown cracking clays	Nil	Nil	Nil	Nil	Minor	Thin	Moderate
Grey-brown cracking clays	Nil	Nil-moderate	Nil	Nil-minor	Minor	Very thin	Severe
Grey-brown non-cracking clays [6]	Nil	Nil-moderate	Severe	Minor-severe	Minor	Thin	Minor
Dark cracking clays	Nil	Nil-moderate	Nil	Nil-minor	Minor	Not usable	Minor
Melonhole clays	Nil	Nil	Nil	Nil-minor	Minor	Not usable	Moderate

1. The topography constraint is based on landform and slope categories and will vary for individual soil management groups that occur across a wide range of landforms.
2. Erosion hazard rating is a product of soil erodibility and topography factors and thus varies within each soil management group according to landform characteristics.
3. Soil fertility varies for the dispersive texture contrast soils depending on geology; profiles overlying recent alluvium have higher fertility status and a lower constraint than all other profiles.
4. The *grey-brown cracking clays*, *grey-brown non-cracking clays* and *brown cracking clays* have light to medium clay textures in their surface layers and may have partly usable “topsoil”.
5. *Grey-brown non-cracking clays* are not the major soil management group in any terrain unit and hence their constraints are discounted to some extent by those assigned to the major soil management group.

Refer to the *Appendix 3.1* for additional information regarding the decision matrix to determine the scale of the constraint and/or impact.

In summary, the *shallow sands and sandy loams* and *shallow loams and clay loams,* which comprise approximately 21 per cent of the Gas Field (refer to *Figure 3.4.3*), have the largest number of moderate, severe or extreme constraints and requires the highest level of control measure to achieve suitable mitigation. In contrast, the *sandy or loamy gradational soils* and various clay soils (brown and dark cracking clays and melonhole clays) which comprise 22.9 per cent of the Gas Field, have the fewest, or least severe, constraints and impacts. However, these soil management groups are associated with substantial areas of highly productive cropping land, which is an extremely important land use for the region.

Erosion hazard, soil fertility and dust generation are the only major constraints and impacts associated with the dispersive texture contrast soils. If the erosion hazard is not appropriately managed, resultant erosion and sedimentation can have a pronounced impact on the environment. The major soil fertility constraint associated with these soils means that the appropriate management procedures must involve correct revegetation measures (refer to *Section 4.5* for additional information).

4.4.1.2 Soil Stability and Erosion

Environmental impact due to soil erosion can result from the following activities that are associated with the proposed development and will disturb the ground surface and ground cover, including:

- clearing vegetation for infrastructure
- building access tracks
- excavation for wells, gathering systems, pipelines and associated infrastructure
- concentrating run-off water flow from disturbed areas.

Soil erosion is governed by the inherent erodibility of the soil profile, topography, volume and intensity of the incident rainfall and land use practices which determine the amount of vegetative cover and condition of the ground surface.

Though the rainfall regime for the Gas Field study area is characterised by low average rainfall (compared with the coast), intensity can be very high due to occurrence of summer storms that move through the district with weather fronts and due to the occasional incidence of low-pressure systems which are remnants of tropical cyclones.

An erosion hazard rating for the soil groups within the Gas Field was determined to account for the high level of disturbance associated with most construction activities proposed for the study area. The erosion hazard rating has been determined within the existing rainfall regime and takes into account the soil erodibilty rating for the soil management groups as well as the landform slope category.

The erosion hazard rating for the Gas Field is illustrated on *Figure 3.4.6* and the decision matrix is presented in *Table 3.4.6*.

Table 3.4.6 Erosion Hazard Rating Decision Matrix

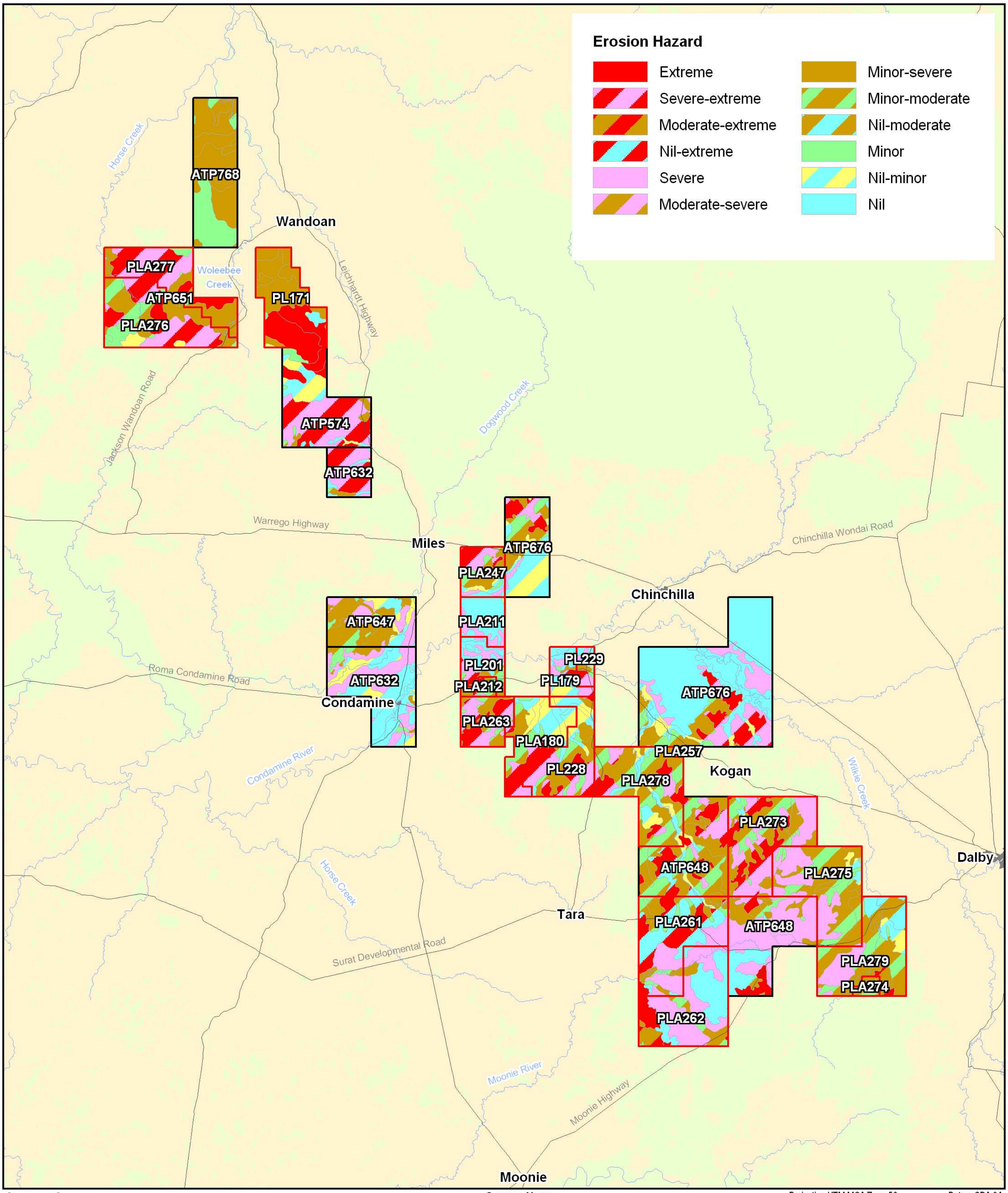
Soil erodibility	Landform-slope categories [1]	Constraint rating
Very low to low	Steep to precipitous mountains, hills, dissected plateaus and plateau scarps	Extreme
Moderate	Rolling hills and low hills	
High to very high	Undulating low hills and rises	
Very low to low	Rolling mountains, hills and low hills	Severe
Moderate	Undulating low hills and rises	
High to very high	Undulating rises and plains	
Very low to low	Undulating low hills and rises	Moderate
Moderate	Undulating rises and plains	
High to very high	Level to gently undulating plains	
Very low to low	Undulating rises and plains	Minor
Moderate	Level to gently undulating plains and plateau surfaces	
High to very high	Level plains	
Very low to low	Level to gently undulating plains and plateau surfaces	Nil
Moderate	Level plains	

Slope categories are from the second edition of the *Australian Soil and Land Survey Field Handbook* (McDonald *et al* 1990):

Steep to precipitous	≥ 32%	Rolling	10-32%
Undulating	3-10%	Gently undulating	1-3%
Level	<1%		

Approximately 13 per cent of the Gas Field is rated as having no erosion hazard. This land is generally associated with various cracking clays on level to gently undulating plains surrounding the Condamine River and along the Moonie Highway in the south east. An erosion hazard rating applies to the remainder of the Gas Field, despite the generally gently undulating landscape. This hazard rating is mainly due to the predominance of dispersive texture contrast soils, which have a high to very high inherent erodability. Approximately 32 per cent of the Gas Field has a moderate to severe or extreme erosion hazard rating.

Erosion by overland flow will be a particular issue in the highest value cropping land where the farming system often involves cropping patterns, sequences and physical structures specifically designed to reduce run-off velocity and amount and to spread rather than concentrate flow.



Legend:

Gas Fields - Petroleum Lease/Petroleum Lease Application

Gas Fields - Authority to Prospect

Source Note:
1:250,000 Topographic Vector copyright Geoscience Australia
Erosion Hazard information from LRAM PTY LTD

Projection UTM MGA Zone 56 Datum GDA 94

0 10 20 30 40
Kilometres

N

QUEENSLAND CURTIS LNG A BG Group business	Project Queensland Curtis LNG Project Client QGC - A BG Group business	Title **Erosion Hazard Rating**
ERM Environmental Resources Management Australia Pty Ltd	Drawn Mipela — Volume 3 — Figure 3.4.6 Approved CDP — File No: QC02-T-MA-00049 Date 10.06.09 — Revision A	Disclaimer: Maps and Figures contained in this Report may be based on Third Party Data, may not be to scale and are intended as Guides only. ERM does not warrant the accuracy of any such Maps and Figures.

Loss of soil through erosion processes will limit the effectiveness of rehabilitation and potentially lead to long-term erosion issues due to the exposure of subsoils. Erosion potential within the Gas Field may be reduced by limiting the extent of clearing, minimising the length of any slope exposed to overland water flow, controlled stormwater run-off around exposed areas and prompt restoration of disturbed areas including disturbance to existing erosion control features. Refer to *Section 4.5* for a summary of the mitigation measures proposed.

4.4.1.3 Loss/Degradation of Topsoil

Potential impacts to topsoil may occur as a result of:

- inadequate removal of topsoil prior to development activities
- mixing of topsoil with subsoil during excavation, stockpiling or restoration
- prolonged stockpiling of topsoil.

Adverse impacts on topsoil can limit the effectiveness of restoration and reduce the availability of nutrients and biomass, thus limiting the future productivity of the soil and adversely impacting revegetation and rehabilitation success.

Approximately 7 per cent of the Gas Field study area is severely constrained by thin topsoil where *loamy texture contrast soils (dispersive)*, *shallow sands and sandy loams* and *shallow loams and clay loams* are the dominant soil management groups. Removal of the thin topsoil in these units for use as planting media without exposing or including any unsuitable subsoil material below is likely to be difficult.

A further 47 per cent of the study area consists of differing soil combinations that result in quite variable topsoil thickness and a detailed site inspection will be required in these areas to determine the depth of usable topsoil.

Where there is insufficient material from stripping on site, suitable topsoil may be imported from elsewhere. Measures proposed to ensure that topsoil is successfully removed and managed to enable successful restoration and rehabilitation are outlined in *Section 4.5.*

4.4.1.4 Soil Fertility

Soil fertility is a prime determinant of the ability to successfully revegetate disturbed areas. Low soil fertility can result in:

- inadequate establishment of plant species used for revegetation
- ongoing exposure of bare land in poorly rehabilitated areas
- increased soil erosion due to greater exposure of bare land
- damage to infrastructure through soil erosion.

Approximately 60 per cent of the Gas Field study area is considered to have a severe or moderate to severe fertility constraint. The dominant soils on this land are either *shallow sands and sandy loams*, *shallow loams and clay loams* or those profiles of *sandy texture contrast soils (dispersive)* that are not developed on recent alluvium. Profiles of *sandy texture contrast soils (dispersive)* that overlie recent alluvium have a higher fertility status and thus lesser constraint rating.

Stripped topsoil that has a fertility constraint will require the addition of soil ameliorants to ensure successful growth of plants. Refer to *Section 4.5* for proposed management measures.

4.4.1.5 Salinity

Elevated soil salinity within the root zone can retard plant growth. Very high to extreme levels of salt can also corrode concrete and steel foundations and steel pipe. With regard to the proposed development, soil salinity can:

- reduce revegetation efforts on disturbed areas
- affect plant growth surrounding disturbed areas if saline water is released from excavations and thus increase erosion hazard
- corrode inappropriately designed foundations for infrastructure.

Approximately 35 per cent of the Gas Field has a moderate to severe salinity constraint due to subsoil salinity. This occurs on land associated with *grey-brown cracking clays*, *sandy texture contrast soils (dispersive)* or *loamy texture contrast soils (dispersive)* as the major soil management groups.

A further 26 per cent of the study area has a combination of severe constraint on *sandy texture contrast soils (dispersive)* and nil constraint on associated *shallow sands and sandy loams* or with *shallow loams and clay loams*.

The objective of the mitigation measures will be to minimise the exposure of saline subsoils and where this cannot be avoided, ensure that the subsoils are reburied with a suitable cover (refer to *Section 4.5*).

4.4.1.6 Dust

All soils have a capacity to create dust when the vegetative cover is removed and when they are subjected to vehicular traffic or disturbance by machinery. Dust can impact upon:

- occupational health and safety of workers
- health and working conditions of agricultural workers within the surrounding areas
- efficiency and working life of nearby machinery
- crop and pasture production where dust conditions are extreme.

Sands and soils with a clayey texture in the surface layer create the least dust whereas surface layers dominated by fine sand and silt can generate overwhelming clouds of “bulldust”. Once a soil turns to bulldust it is very difficult to manage and final rehabilitation and revegetation can be difficult because the soil structure has been destroyed.

Dust generation has the potential to impact on approximately 75 per cent of the study area. Land dominated by *sandy texture contrast soils (dispersive)* and *loamy texture contrast soils (dispersive)* represents 40 per cent of the area and has a capacity to generate severe bulldust. *Sandy texture contrast soils (dispersive)* and *loamy texture contrast soils (dispersive)* are associated with other soils of lesser capacity to generate dust on a further 35 per cent on the Gas Field.

4.4.1.7 Borrow Pits

While the location and scale of borrow pits for the establishment and operation of the Gas Field has not been determined, it is likely that additional borrow pits and/or quarries will be required. Borrow pits may impact on the environment both during and after their active use through:

- accelerated soil erosion on disturbed cut faces and in the floor of the pit
- leaching of soluble salts from exposed saline soil material onto surrounding land and into local waterways
- loss of productive rural land and interruptions to its efficient use, especially in high-value cropping land.

Environmental controls aim to minimise impacts through:

- adopting appropriate erosion control measures
- careful location of pits in dissected terrain and outside cultivation areas within the high-value cropping land
- bunding any pits that expose saline subsoil.

Refer to *Section 4.5* for further information.

4.4.2 Good Quality Agricultural Land

There are approximately 183,910 ha of GQAL within the Gas Field study area. Most of the GQAL is in the centre of the study area roughly bounded by Miles, Brigalow, Kogan and Condamine though substantial areas also occur along the Moonie Highway in the south-east and in the north-west, surrounding Wandoan.

Construction and ongoing production activities listed in association with the development of the Gas Field have the potential to have a major impact on cropping by:

- reducing the actual area that can be cropped
- impeding optimal farm layout for efficient crop production
- interrupting essential physical run-off control measures that are designed to minimise erosion

- modifying overland flow patterns, particularly via concentration of run-off, changes in run-off times of concentration and increased velocity along access tracks and around wellheads
- introducing weed species into the cultivation during both construction and ongoing maintenance activities.

Associated with the actual loss in production area will be impacts on farming and grazing practises on contiguous areas. Without adequate mitigation, this has the potential to:

- reduce the productive area and increase the costs of crop production
- lower the value of the land itself
- increase erosion and thus increase sedimentation of the nearby waterways
- be a potential source of weed species for the production areas.

Based on a wellhead density of one every 750 m and wellhead clearing of 100 m x 100 m, it is calculated that during drilling wellheads within cropping land will create an obstruction of between 1 ha in size every 18 ha and 1 ha in size every 196 ha. This variability is dependent on the location of wells relative to property boundaries and the size and shape of individual properties. These reference case well densities do not consider mitigation measures to reduce well densities on cropping land, such as appropriate siting of wells and multiple wells drilled from a single drill pad. If partial restoration reduces the hardstand area to 80 m x 60 m for wellhead operation, an obstruction will be created during production of between 1ha in size for every 72 ha and 1 ha in size for every 784 ha of cropping land. In addition, gravelled access tracks of around 4 m width will be formed between existing property access tracks and wells. Table drains of approximately 1 m width, on either side of the access tracks, will also be unusable for cropping. If wells are installed on a fixed 750 m grid, access tracks plus 1 m-wide table drains could occupy 1 ha of land for every five wells.

The size of individual cultivation paddocks varies within the study area but many are 70 ha to 100 ha. Under the proposal, each of these paddocks will, on average contain two to three wellheads plus around 0.5 ha of gravel tracks. The total area potentially taken out of crop production will be around 2.5 to 3.5 ha during drilling, representing 2 to 5 per cent of the paddock. During the gas production phase, the total area removed from crop production in an individual paddock would reduce to approximately 1 per cent or less, as partial restoration is performed.

Loss of GQAL and other cropping land under this proposal is potentially significant. Careful planning of the location of wells and associated infrastructure will be undertaken in consultation with landholders to minimise the disruption and impact on cropping activities (refer to *Section 4.5*).

There will be less effect on grazing land. Construction and production activities will reduce the area available for grazing and may temporarily impede stock management practices such as mustering. Some possible interruption to overland flow may also occur, especially due to construction of access tracks. However, overall constraints and impact on grazing practices should be minor.

4.5 PROPOSED MITIGATION AND MANAGEMENT MEASURES

The following section provides a summary of the mitigation measures proposed for the development of the Gas Field. Reference should also be made to the Gas Field's draft Environmental Management Plan (Draft EMP) which is provided in *Volume 9.*

These mitigation measures have been developed to take into consideration the nature of the proposed development activities and the wide range of constraints associated with the Gas Field. The primary objectives are to:

- preserve topsoil quantity and quality
- limit the area of disturbance
- control overland water flows around disturbed areas
- maintain the low erosion condition of the area
- maintain the cropping productivity of the area
- maintain the salinity levels in soil surface layers
- keep subsoil salinity at depth below the surface of disturbed areas.

Prior to disturbance, the soil management group of the area to be disturbed will be confirmed and control measures applied, based upon the specific issue identified and the control measures outlined in the following section.

4.5.1 Standard Measures across the Gas Field

4.5.1.1 Timing of Disturbance

The Queensland Department of Transport and Main Roads has analysed long-term rainfall records to determine the monthly and annual erosive potential, or "erosivity", throughout the state (Main Roads 2002). Rainfall erosivity at Dalby between November and February represents almost two-thirds of the average total erosivity for an entire 12-month period.

Major earth works programmes will, where practical, be minimised during wet weather. During periods of expected high rainfall, all standard control measures will be adopted and additional measures will be implemented on sloping areas with dispersive texture contrast soils.

4.5.1.2 Erosion Control Measures

Standard erosion control measures will be required on all works that disturb the land surface where slopes exceed 1 per cent. Measures to minimise the risk or erosion will include:

- minimising access and disturbance to only essential areas
- diverting upslope stormwater run-off from around disturbed areas
- incorporating run-off control devices to reduce slope length on access

tracks and on other disturbed areas of bare ground

- stripping and stockpiling of topsoil to occur immediately before starting bulk earthworks
- ensuring stockpiles are constructed on the contour, protected from run-on water with diversion banks or similar device upslope, and formed with run-off control devices immediately downslope
- revegetating or rehabilitating disturbed areas as soon as works are completed
- designing channels/drains and inlet and outlet works to convey water at least up to the design peak flow
- incorporating check dams and/or sediment retention basins within major development sites to slow peak discharge and reduce sediment load in water entering the local waterways
- placing all water quality and quantity control structures above the riparian zone
- designing sediment retention basins to adequately handle dispersive soil material in the dispersive texture contrast soils and to handle clayey subsoil material in all other areas
- installing energy dissipaters at drainage outlets.

4.5.1.3 Preservation and Management of Topsoil

It has been identified that not all surface layers within the study area are suitable for reuse as topsoil. Surface layers with medium clay texture or heavier are unsuitable for reuse and any dispersive soil material is also unsuitable. Where insufficient topsoil material exists, additional material may be sourced from other areas. In this case, less material will be stripped to ensure that a minimum 100 mm of suitable topsoil material is left on site to encourage revegetation and to minimise erosion.

Prior to disturbance, the soil management group of the area to be disturbed will be confirmed and specific control measures applied. The stripping depths will be based upon the values provided in *Table 3.4.7.* The following measures will be applied as required by the location, soil properties and duration of the activities:

- Stripped material with a low to very low fertility will be ameliorated with a suitable nitrogen-phosphorus-potassium (NPK) fertiliser (controlled or slow release)
- Where fertility is low, composted organics can be added to the stripped surface layers to increase the water holding properties of the soils, soil drainage (leaching) and nutrient retention and help stabilise the topsoil to resist erosion and promote healthy plant growth
- Dispersive and/or heavy clay subsoil will be stockpiled separately from the topsoil. Inclusion of these materials can result in a hard setting, or crusting, planting media that impedes seed germination, restricts water entry and

enhances erosion of the revegetated area

- The duration of stockpiling will be minimised to reduce nutrient rundown and colonisation by weeds
- Where stockpiles are to remain throughout the production period for use during decommissioning, soil removed for later use during rehabilitation will be landscaped into low mounds, sown with an appropriate plant mix and managed to ensure adequate groundcover is maintained. This will minimise erosion and leaching of nutrients from the soil material and will provide a seed source when the material is eventually used.

Table 3.4.7 Soil Stripping Depths

Soil group	Stripping depth [1] (mm)	
	Earthworks footprint	**Outside footprint (where additional topsoil is required)**
Shallow sands and sandy loams	50-300	0-200
Shallow loams and clay loams	50-300	0-200
Deep sands and sandy loams	150-400	50-300
Sandy or loamy gradational soils	300-500	200-400
Loamy texture contrast (TC) soils (non-dispersive)	100-300	0-200
Loamy TC soils (dispersive) - on recent alluvium	50-150	0
Loamy TC soils (dispersive) - on other material	100-300	0-200
Sandy TC soils (dispersive) - on recent alluvium	300-500	200-400
Sandy TC soils (dispersive) - on other material	100-500	0-400
Brown cracking clays [2]	50-150	0
Grey-brown cracking clays [2]	50-100	0
Grey-brown non-cracking clays [2]	50-100	0
Dark cracking clays	0	0
Melonhole clays	0	0

1. The recommended stripping depth includes suitable soil material from the surface layer and from the underlying subsurface layer (if present).
2. The *grey-brown cracking clays*, *grey-brown non-cracking clays* and *brown cracking clays* have light to medium clay textures in their surface layers and may be only partly usable.

4.5.1.4 Watercourses

Minor watercourses that drain to major streams and creeks in the area generally have soils and soil conditions similar to the adjoining land and on occasions with a thin veneer of unconsolidated alluvium. Crossings for access tracks and pipelines on minor watercourses require special attention because many of the streams will have dispersive texture contrast soils or clay soils on their banks with very steep bank slopes. This can create a severe to extreme erosion hazard.

Control measures will include:

- locating crossing points:
    - where turbulence of stream flow is least and there is no active undercutting of either bank and no dumping of sediments within the stream bed
    - away from bends in streams or close to where two streams meet
- minimising extent of vegetation removal and disturbance
- rehabilitating disturbance as soon as possible by refilling and slightly compacting, capping with at least 200 mm of suitable topsoil and revegetating the site.

4.5.2 Issue-specific Mitigation Measures

4.5.2.1 Dissected Terrain

There is a significant topography constraint on approximately 1.6 per cent of the Gas Field study area or 7,385 ha. This land also has very shallow depth to bedrock and a severe to extreme stoniness and rock outcrop constraint.

The presence of dispersive texture contrast soils on steep slopes also creates an extreme erosion hazard. The soils have severe soil fertility constraints and disturbed areas will not revegetate readily without boosting the soil fertility.

It will be extremely difficult to control erosion during construction and to revegetate and rehabilitate any disturbed areas. There is a medium risk of gathering systems/pipelines being exposed and undermined after a few intense rainfall events.

These areas will be avoided as far as possible. Where this is not possible, measures will include:

- minimising the infrastructure and access tracks located in these areas
- locating any essential tracks on gentle grades diagonally across the slope rather than perpendicular to it
- minimising drainage line crossings or, where necessary, locating entry and access points at an angle to the drainage line and leaving sufficient capacity for uninterrupted stream flow
- incorporating all special erosion control measures described in *Section 4.5.2.2*
- incorporating general all-purpose fertilisers into local topsoil used as planting media during revegetation or importing special planting media.

4.5.2.2 Sloping Areas with Dispersive Texture Contrast Soils

Any land with slopes greater than 1 per cent and containing dispersive texture contrast soils has a moderate to extreme soil erosion hazard. In addition to the measures previously outlined, the following controls will apply, subject to landholder preferences:

- clearing and grubbing operations should avoid inverting the soil, leaving clay subsoil on top
- any clay subsoil that is exposed on cut batters or areas of hard fill should be treated as soon as possible through amelioration, capping (with planting media or impermeable material) or both
- grubbing operations outside any earthworks footprint must leave at least 100 mm of undisturbed soil material (surface and/or subsurface layers) on top of the clay subsoil
- the land surface outside an earthworks footprint should be levelled immediately after any clearing and grubbing operations are finished. The levelling should create a slight convex shape that spreads run-off water away from the disturbed area rather than allowing it to concentrate
- any holes should be filled with soil material from the surface and/or subsurface layers. If necessary, suitable topsoil should be brought in from elsewhere to ensure no clay subsoil remains exposed. The levelled surface may have to be lightly compacted to ensure it is not easily moved by raindrop splash and running water
- the land surface on top of laid gathering systems or pipelines and adjacent service tracks should be left in a slight convex shape that spreads run-off water away from the pipeline or track rather than allowing it to concentrate
- the pipeline mound should have a cap of at least the original topsoil depth of suitable, ameliorated topsoil and this planting media should be seeded with appropriate plant species
- if a pipeline or access track is not mounded, slope length along the disturbed area should be reduced by placing run-off control devices (such as “whoa boys”, sediment fences or geotextile socks) at regular intervals to intercept and slowly spread water off the area; such devices should be used even on very gentle slopes of 1 to 2 per cent.

4.5.2.3 High-value Cropping Land

The following mitigation measures are proposed to avoid significantly diminishing productivity of high-value cropping land associated with the Gas Field:

- as far as possible, drill sites and associated infrastructure will be located along paddock boundaries, access areas etc. and not be located within areas of cultivation
- where the only option is placement within a cultivation area, the wellheads will be positioned, in consultation with the landholder, to cause the least obstruction to the normal working pattern and to overland flow of stormwater within the paddock
- where possible, and with landholder consultation, access tracks will be

located along internal headlands or along contour banks

- disturbance to existing erosion control measures will be avoided as far as possible. Where disturbance is necessary, the duration of disturbance will be minimised and restoration promptly completed
- upon restoration, hardstand and gravel material will be removed along with any associated operational materials and the initial topography and drainage will be re-established. Any soil fertility or structural impacts within the hardstand areas will also be remediated

4.5.2.4 Areas with Severe Subsoil Salinity

Moderate to severe salinity can retard plant growth and care should be taken when excavating or dealing with subsoil from the *loamy texture contrast soils (dispersive)*, *loamy texture contrast soils (non-dispersive)* and *brown cracking clays* as well as from the *sandy texture contrast soils (dispersive)* and *grey-brown cracking clays*. Control measures will include:

- sampling of excavated subsoil in high-risk areas to confirm extent of salinity
- deep burial or capping of excavated subsoil at a suitable depth, nominally at least 300 mm of suitable topsoil following construction activities. This will allow plants that are being established to achieve a reasonable root layer before encountering the saline material
- if saline subsoil is to be stockpiled for a short period, the stockpile will be bunded to prevent water running onto the pile from further upslope and to detain run-off water within the stockpiled area.

4.6 CONCLUSION

Soils in the region of the Gas Field Component of the Queensland Curtis LNG Project are susceptible to erosion. However, the short-term nature of construction work and mitigation strategies detailed above will ensure the impact on soil from development works will be minor, if not negligible. A summary of the impacts outlined in this chapter is provided in *Table 3.4.8* below.

Table 3.4.8 Summary of Impacts for Soils and Geology

Impact assessment criteria	Assessment outcome
Impact assessment	Negative
Impact type	Direct
Impact duration	Short-term
Impact extent	Local
Impact likelihood	High

Overall assessment of impact significance: minor.