FINAL REPORT

GLNG Environmental Impact Statement - Gladstone LNG Facility Terrain Soils and Land Capability

Prepared for

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Description and Assessment of Environmental Values

Section 1

The proposed LNG Facility is to be located on Curtis Island to the north of Hamilton Point which is situated approximately 5 km north-east of the City of Gladstone. Access to the site will be via a bridge constructed between Friend Point on the mainland and Laird Point on Curtis Island. An access road together with an extension of the gas transmission pipeline will be located in a common corridor that runs in a south-easterly direction approximately 1.5 km inland from the coast, to link with the LNG facility in the vicinity of Hamilton Point (Refer to **Figure 1-1**).

1.1 Method of Assessment

The terrain of the project area has been assessed in terms of geological regimes, landform types and associated soil types. Terrain mapping has been carried out initially based on the interpretation of aerial photos with reference to existing geological, topographical and soils information. This information was compiled using the background data sources listed below which have provided the basis for identifying *Terrain Units* that occur within the proposed LNG development area.

As mapped, a terrain unit comprises a single or recurring area of land that is considered to have a predictable combination of physical attributes in terms of bedrock, surface slope and form, and soil/substrate conditions. Accordingly, engineering and environmental characteristics determined at one location may be extrapolated to other occurrences of the same terrain unit.

1.1.1 Data Sources

The following data were used for the description and assessment of the physical environment of the project area:

- Colour aerial photography – The State of Queensland (NRM&E) Series QAP 5719 flown 02/05/99 at a nominal scale of 1:40,000;
- Project area topographic base map prepared for Santos Ltd. with 1 m and 5 m contour intervals;
- Project area image base map;
- Geological Series Queensland, 1:100,000 Geological Mapping Data; included in the Geoscience Data Set compiled by the Geological Survey of Queensland (2005); and
- Land Resources and Evaluation of the Capricornia Coastal Lands (CCL) – Sheet 3 Calliope Area, NRW Data (1995).

1.1.2 Field Investigations

Following the preliminary aerial photograph interpretation and site mapping phase, sites representative of the range of landform types evident on the aerial photograph were pre-selected for field investigation to delineate the preliminary terrain mapping units and to identify the associated soil types.

A total of 26 sites were investigated within the general LNG facility site area and along the proposed corridor for the access road and gas transmission pipeline alignments. Due to restricted site access and inability to clear vegetation to provide ready access, a small tracked excavator supported by field personnel using quad bikes, was used to access the selected sampling sites. At each inspection location, terrain characteristics were noted and where possible, test pits were excavated to a maximum depth of 1.5 m or to weathered rock, whichever was the shallower. Soil types were identified in accordance with the guidelines of the 'Australian Soil and Land Survey Field Handbook' (McDonald *et al*., 1990). Representative soil profile samples were collected from each

of the test pits for subsequent in-house soil characterisation and indicative testing. Site details and soil descriptions are included in **Appendix A**.

1.2 Topography and Geomorphology

The topography of the LNG facility development area shown in **Figure 1-1** comprises low rounded hilly, intermediate steep hilly and steep high hilly lands developed on Upper Carboniferous to Lower Devonian Wandilla Formation sedimentary rock types and meta-sediments comprising mudstone, lithic sandstone, siltstone, chert, slate and local schist. The hilly crestal areas vary from reduced level (RL) 20-45 m Australian Height Datum (AHD) in the low hilly lands, to about RL 50-75 m AHD in the intermediate steep hilly areas and up to about RL 120-175+ m AHD in the high steep hilly lands. Hill and ridge slopes are mainly irregular planar to shallow concave on the lower slopes and vary from around 15% on the lower hilly areas increasing to 20-35% in the steep hilly areas and from about 25-45%+ in the higher hilly lands. The hilly areas are separated by gently to moderately inclined (5-15%) lower hill slopes and undulating lowlands with overall slopes mostly within a range of 3-7% which collectively form broad valley floors. Near flat to gently undulating alluvial plains with slopes mostly <2% occur in the valley bottoms. In most cases these alluvial valley flats extend towards the coast and merge with estuarine supra-tidal flats which are mostly fringed by tidal mangrove flats along the coast line.

1.3 Site Geology

The geology of the general area of interest has recently been mapped by the Geological Survey of Queensland (GSQ, 2005) as shown on the 1:100,000 Gladstone map sheet. The geological regimes that occur within the general vicinity of the proposed LNG Facility site area include:

- Quaternary (Holocene) estuarine delta and coastal marine deposits, comprising saline silty clays and clays, saline muds and sands;
- Quaternary alluvium, comprising clay, silt, sand and gravel deposits; and
- Carboniferous Wandilla Formation, comprising mudstone, lithic sandstone, quartz greywacke, siltstone, jasper, chert, slate and schist.

The main geological unit underlying the proposed LNG facility site is the late Devonian to early Carboniferous Wandilla Formation, which forms part of the Curtis Island Group. The Wandilla Formation comprises sediments and metamorphic rock types, including mudstone, lithic sandstone, quartz greywacke, siltstone, jasper, chert, slate, and schist. This Formation underwent metamorphism associated with the New England orogeny and north northwest trending faults associated with the Narrows Graben structure. Structural deformation in the Wandilla Formation has produced foliations dipping from 38° to 84° in a northeast and easterly direction. Vertical foliations are also present. These result in north northwest trending ridges of more competent quartz greywacke and flatter areas of altered mudstone.

Granite dykes have been mapped adjacent to the LNG facility site. These are thought to be of Permian to Triassic in age, and related to the intrusion of the Targinie Granite (approximately 10 km to the west).

Quaternary aged alluvial and colluvial deposits, comprising silt, sand, and gravel, overlie the Wandilla Formation units. The overburden is between 0.5 and 1.5 m thick on the higher ridges and 3 to 5 m thick on the lower-lying areas. Thicker alluvium has been deposited along the drainages lines draining the island. Quaternary aged mud, sand, and gravel estuarine deposits flank the shores in places in the vicinity of the LNG facility site.

Zones of secondary alteration are associated with the complex structural geology of the study area. Manganese deposits have been mapped within the Wandilla Formation on islands adjacent to Curtis Island, and were worked in the early 1900's and 1950's. Phosphate mineral deposits, including Turquoise deposits, were recorded on geological maps of the Gladstone area (Dept. of Mines, 1988, 2006), particularly one deposit noted on Ship Hill, adjacent to the north of the facility; however, this deposit not shown on the most recent sheet. The phosphate minerals are associated with the chert beds of the Wandilla Formation. Exploration of these deposits was carried out with a view to commercial exploitation in the late 1960's; however economic deposits were not discovered.

Groundwater results indicate elevated concentrations of dissolved metals (manganese) and metalloids (arsenic) (Section 4.1.6) within shallow and deeper aquifers. Based on the complex structural geology of the area, it is considered that the tectonic and intrusive history of the region have caused alteration of the host rocks and produced the above noted mineralisation. The natural elevated concentrations of these metals and metalloids reported to occur in the groundwater is interpreted to be as a result of metals of similar concentration existing within the strata of the Wandilla Formation.

The occurrence of the geological regimes within the LNG facility development area is shown in **Figure 1-2.**

Figure 1-2 also includes a series of photo-geological lineaments identified from aerial photograph interpretation. The trend of these lineaments is generally in an east-north-east, west-south-westerly direction. These lineaments are located in the central northern sector of the site and they may intersect the access road/gas transmission line corridor alignment which runs along the north-eastern margin the LNG facility area. These features may represent the surface expression of fault lines or geological structural trends.

1.4 Terrain Units

As discussed in **Section 1.1** above, the identification of terrain units provides a basis for the description of the physical environment and as mapped, the terrain units serve to show the occurrence and distribution of geological regimes, landform units and associated soil types which occur within the mapped area.

Ten (10) terrain units were identified within the LNG facility site area, the occurrence of which are shown in **Figure 1-2** where they are coloured on the basis of the geological regime in which they occur. A Key to the description of the terrain mapping units is provided in **Figure 1-2a**. More detailed descriptions of the terrain units together with an assessment of engineering/environmental attributes considered important for site development, are included in **Appendix B**.

Client	Project	Title
LNG / URS	GLADSTONE LNG PROJECT TERRAIN, SOILS AND LAND CAPABILITY REPORT LNG FACILITY	**TOPOGRAPHY AND SITE LAYOUT LNG FACILITY**

Drawn: VH	Approved: JB	Date: 29-01-2009	Figure: **1-1**	Rev:B
Job No: **4262 6220**	File No: 42626220-g-548.wor			**A4**

N
W E
S

0 500 1000m
Scale 1:40 000 (A4)
Datum : GDA 94, MGA94, Zone 56

Geological Regime Boundary
Geological Linaments
Site Soil Sampling Locations
Qe0/9 Terrain Unit Boundary
LNG Facility Study Area
LNG Facility Site Boundary
Gas Transmission Pipeline
Proposed LNG Facility Layout

NOTE: This Figure 1-2 must be viewed with Figure 1-2a.

Client	Project	Title
LNG / URS	GLADSTONE LNG PROJECT TERRAIN, SOILS AND LAND CAPABILITY REPORT LNG FACILITY	**GEOLOGY AND TERRAIN UNITS LNG FACILITY**

Drawn: VH	Approved: JB	Date: 29-01-2009	Figure: **1-2**	Rev:B
Job No: **4262 6220**	File No: 42626220-g-549.wor			**A4**

Client

Project

GLADSTONE LNG PROJECT
TERRAIN, SOILS AND
LAND CAPABILITY REPORT
LNG FACILITY

Drawn: VH | Approved: JB | Date: 29-01-2009

Job No: **4262 6220** | File No: 4262220-g-549.wor

Title

TERRAIN UNITS IDENTIFICATION KEY

Figure: **1-2a**

A4 | Rev:B

Generic Key to the Identification of Terrain Units

GEOLOGICAL REGIME		LANDFORM – TERRAIN TYPE		SOILS	
Symbol	Description	Type	Surface Form and Slope	Group	Soil Types [1]
Qe	Quaternary (Holocene) estuarine delta and coastal marine deposits; saline silty clays, clays, saline muds and sands	0	Channel floors, banks and active levees of major streams and waterways with irregular steep, and locally benched bank slopes and low flood terraces. Locally tidal mangrove and marine flats and tidal inlets with mangroves fringing.	0	Extensive areas of rock outcrop, locally with skeletal to shallow usually stony or gravelly soils.
				1	Skeletal, rocky or gravelly soils (>60% coarse fragments) with sandy, sily, loamy or clayey soil matrix (K- Uc1, Um1, Gn1, Uf1)
Qa	Quaternary Alluvium on water courses, terraces and floodplains; clay, silt sand and gravel deposits	1	Floodplains alluvial flats, lower stream terraces and flat to broadly depressional backplains, slopes typically <1%; periodically floodprone and locally poorly drained areas. Locally comprising estuarine/marine plains, extratidal and supratidal flats subject to periodic tidal inundation; slopes mostly <0.5%.	2	Sand soils; shallow to deep uniform or weakly gradational profiles; includes stratified alluvial soils, residual sand soils, earthy sands (Ucl-Uc6) [2]; Rudosols or Tenosol Soil Orders [3]
Cw	Carboniferous Wandilla Formation; mudstone, lithic sandstone, siltstone, jasper, chert, slate and schist	2	Flat to gently undulating or gently inclined intermediate to higher stream terraces, older alluvial plains or, floodplains and higher stream terraces, with slopes generally <2%;occasionally floodprone in lower-lying areas and along tributary drainage channels.	3	Coarse to medium-textured soils; uniform or gradational profiles; predominantly sandy earths silty or clayey sand profiles (Uc4-5, Uml-3); Tenosols or Podosol Soil Orders.
				4	Medium-textured sandy, sandy loam or silt to clay loamy surface uniform or gradational profiles, often (siliceous or ferruginous) gravelly or stony soils; (Um4-7, Gn1-2); Tenosols, Kandosols or Ferrosol Soil Orders.
		3	Undulating plain and gently rolling to broadly rounded rises with gently inclined planar to concave intervening lower-lying broadly depressional areas; slopes mostly in the range 1- 3%	5	Sandy to loamy surface duplex soils with neutral to acidic, in places strongly acidic sandy clay to medium to heavy clay subsoils (Dr1-5, Dy1-5); Chromosol or Kurosol Soil Orders.
		4	Undulating to strongly undulating plains and rolling rises, locally flat to undulating upland plateau crests and undulating uplands; with slopes mostly in the range 3-7%	6	Fine sandy, silty or clay loamy surface duplex soils with neutral to alkaline often calcareous, sodic and locally saline medium to heavy clay or heavy clay subsoils; (Db-Dd-Dy1-5); Chromosols, Sodosols or Calcarosols Soil Orders.
		5	Gently to moderately inclined planar to concave intermediate to lower hill and ridge slopes or convex planar dissection slope interfluves; slopes variable mostly within the range 5-12%	7	Uniform fine-textured (non-cracking) clay soils or gradational clay loam or light clay surface soils with acidic or alkaline often sodic and/or saline medium to heavy clay subsoils – locally incipient cracking clays; (Uf5-6); Dermosol or Hydrosol Soil Orders.
		6	Isolated low rounded hills and rises and low hilly lands mostly with broadly rounded crestal areas and hill slopes in the range 12-25%;	8	Uniform fine-textured (cracking) clay soils, locally with thin self-mulching surficial soils with dark grey, brown or black mostly alkaline or alkaline over acidic heavy clay subsoils; (Ug5-Ug6); Vertosols Soil Order.
		7	Steep hilly lands with mostly narrow rounded hill and ridge crests and steep irregular planar hill and ridge slopes mostly in the range 20 to 40%	9	Uniform, weakly gradational or weak duplex soils with highly organic silty to clay loamy surficial soils and seasonally or permanently saturated often gleyed and saline silty clay or medium to heavy clay subsoils; Um, Dd-Dy, Uf-Ug 5-6 profiles; Organosols, Hydrosols some Vertosol Soil Orders.
		8	Steep to very steep ridges and high hilly lands; mostly with narrow rounded ridge and spur crests, with slopes typically in the range 30-50%, with local subvertical rocky scarps and bluffs		
		9	Very steep high hilly to mountainous lands or very steep to locally sub-vertical or vertical escarpment slopes 35 ->100%		
			Example: **Terrain Unit Qa2/6-7** Qa (Geological Regime) 2 (Landform) 6-7 (Soils)		**Notes:-** (1) – Soil profile form and texture class (2) - Principal Profile Form (Northcote 1974) (3) - Australian Soil Classification (Isbell, 1996). Dual symbols eg (2-7) indicate both soil types may be present:

NOTE: This Figure 1-2a must be viewed with Figure 1-2.

1.5 Soils

1.5.1 Soil Groups

The Key to the Identification of Terrain Units, **Figure 1-2a** includes a generic suite of broad soil groups (nine in total) that may occur within a particular project area. The soil groups identified are generally characterised by increasingly finer (more clayey) texture and higher plasticity, with increasing soil group number. The scheme also allows for one or more soil profile variants (soil types) within a particular group where required. Soil characterisation and descriptions of soils identified at each of the sampling locations shown in **Figure 1-2** are included in **Appendix A**, together with site photographs and captions giving details of the soils and the associated terrain units in which they occur. Wherever possible, soil profiles have been identified or classified in terms of the following:

- Handbook of Australian Soils (Stace *et al.,* 1968);
- Principal Profile Form (PPF) of Northcote (1974);
- Australian Soil Classification (ASC) (Isbell, 1996); and
- Australian Engineering Soil Classification (AS 1726-1993).

The terrain units and associated soil groups that occur in the LNG facility site area are tabulated in **Appendix B.** The soil profile characteristics have been identified primarily from 26 test pits excavated as part of the field investigation program.

With reference to the generic soil groups described in **Figure 1-2a,** a general description of the main soils and soil associations and the terrain units in which they occur, within the LNG facility site area are as follows:

Soil Groups 1, 2, 3 – These soil groups were not identified within the LNG facility site area.

Soil Group 4 - Where encountered, these soils occur as shallow to medium deep mainly uniform or weakly gradational very stony and gravelly loams to clay loam soil profiles. They have brown to dark grey gravelly/stony loam to clay loam surface soil horizons with a paler yellowish-brown to grey subsurface (A2) horizon. The soil structure is massive, apedal, granular, loose with varying to high amounts of fine rounded ferruginous gravel and coarse sub-rounded to sub-angular siliceous stone (2-20 mm), underlain by highly weathered rock, predominantly siltstone.

No analytical data was acquired as Group 4 soils are generally not problematic; however cation exchange capacity and plant available water capacity are likely to be low. Soil salinity levels are low and testing of the fines content of the soils indicates non dispersive to very low dispersion characteristics.

As mapped, these soils occur locally on low rises in terrain unit Cw4/4-7 and on some upper marginal slopes and crests in terrain unit Cw7/4-7 in association with Group 7 soils.

Soil Group 5 – Within the LNG facility site area, the soils included in this group are mostly medium to deep (0.5-1.5 m) and have dark brown gravelly loam to gravelly clay loam surface soil horizons, in places with a pale or bleached (A2) gravelly loam or clay loam sub-surface horizon. There is usually a clear or sharp change to the subsoil (B) horizons which comprise yellowish-red or yellow-brown gravelly clays or acidic to neutral medium to heavy clays with moderate to strong fine blocky to prismatic structure and strong to very strong dry consistence. In places, mainly in the northern part of the site area, the gravelly loam (A) horizon and/or the gravelly clay subsoil (B1) horizon materials are directly underlain by variegated heavy clay substrate soils which are strongly

acidic with very dense massive structure and appear to form a transitional (B-C) horizon to the underlying fragmented weathered rock.

As mapped, these soils occur on the upper marginal slopes and on the mid to lower slopes in terrain unit Cw6/5. They also occur in association with soil Type 7.3 on the gently to moderately inclined foot-slopes in terrain unit Cw5/5-7 and on undulating lowlands in terrain unit Cw3/5-7. Locally on the lower parts of slopes in terrain unit Cw5/5-7 where the foot-slopes merge to form narrow flat to depressional valley floors, a thin surface veneer of pale brownish-grey silt loam may be present, which will tend to form bulldust if disturbed and reworked.

Analytical data (**Appendix C**) from two sites tested within terrain unit Cw5/5-7 indicate these soils are acidic tending to neutral in the deeper subsoils. Salinity levels are mostly low but tend to increase to medium levels in the underlying weathered rock (C horizon) materials. The less gravelly (more clayey) soil variants tend to be slightly sodic throughout the profile, becoming strongly sodic in the clay subsoils below a depth of about 0.5 m. Calcium/magnesium ratios are very low in all samples tested, indicating potential soil structural instability and potential for dispersion of the more clayey materials.

Soil Group 6 – As a group, these soils comprise mostly thin fine sandy loam, silt loam and clayey loam surface duplex soils, often with a pale or bleached subsurface (A2) horizon over brown, yellowish-brown or reddish-brown medium to heavy or heavy clay subsoils that are neutral to alkaline, locally strongly alkaline usually with carbonate present.

These soils are of limited extent in the LNG facility site area and occur locally in association with the soils of Group 7 – Soil Type 7.2 on alluvial plains in terrain unit Qa2/6-7. Where encountered in the LNG facility site, the soils have thin dark grey-brown weakly acidic clay loamy surface soils with friable granular to weak fine prismatic structure with some fine gravelly inclusions. There is a sharp transition to the subsoil (B) horizon which comprises diffusely mottled grey-brown and yellowish brown slightly acidic to neutral, medium to heavy clay soils, with weak to moderate fine blocky to prismatic soil structure to a depth of about 0.6 m. The deeper subsoils are massive apedal and strongly cohesive heavy clays which become increasingly more alkaline with depth.

Analytical data (**Appendix C**) on one profile of the Group 6 soils indicates medium to high levels of cation exchange capacity and plant available water capacity. The soils are non-sodic throughout the profile but salinity levels increase from slight to moderate levels with depth. The ratio of calcium to magnesium is low (<1.0) throughout the profile.

Soil Group 7 – As a group these soils comprise uniform fine-textured (non-cracking) clay soils or gradational clay loam or light clayey surface soils with either acidic or alkaline, often sodic and in places saline medium to heavy clay or heavy clay subsoils. Locally in some lower-lying areas these soils tend to exhibit characteristics of (incipient) cracking clay soils.

As mapped, three soil variants within this soil group have been identified in the LNG facility site area, details of which are as follows:

Soil Type 7.1 – These soil profiles comprise shallow to medium deep (<0.5-0.8 m) uniform and gradational dark brown or dark reddish brown clay loam, gravelly clay loam or gravelly clay surface soils which grade through brown or reddish-brown light to medium clay or gravelly clay sub-surface (A2) horizons with 30-50% fine gravel to coarse fragments over gravelly acidic clays or medium to heavy acidic clay subsoils underlain by weathered rock generally between about 0.6-1.2 m. As mapped these soils occur in terrain units Cw8/7.1, Cw7/4-7 and Cw4/4-7.

Analytical data (**Appendix C**) from two sites indicates the clayey subsoils contain slightly to moderately sodic and dispersive soil layers. Calcium to magnesium ratios in all samples tested were very low, indicating potential soil structural stability problems.

Soil Type 7.2 – These comprise medium to deep uniform clay soil profiles with greyish-brown hardset acidic silty clay surface soils becoming moderately to strongly alkaline in the deeper dark yellowish-brown or brown medium to heavy or heavy clay subsoils. As mapped these soils are of limited extent in the LNG facility site area and occur locally in terrain unit Qa2/6-7.

Analytical data from one site indicates these soils are sodic and dispersive in the upper soil layers and strongly sodic and dispersive in the deeper subsoils. Soil salinity levels are low near the surface and moderately high in the deeper subsoils. The ratio of calcium to magnesium is low (<0.75) throughout the profile.

Soil Type 7.3 – These soil profiles occur locally in association with soils of Group 5 on the lower footslopes in terrain unit Cw5/5-7 and on the estuarine flats in terrain unit Qe2/7.3. They comprise deep uniform or gradational brown to yellowish red silty clay or heavy clay surface soils with diffusely mottled reddish-brown, brown or yellow-brown acidic, locally strongly acidic medium to heavy or heavy clay subsoils.

Indicative testing (see **Appendix A**) together with analytical data (**Appendix C**) from one site tested in terrain unit Qe2/7.3 indicated that these soils are sodic and tend to become increasingly sodic to very high levels in the deeper heavy clay subsoils. However the samples tested from similar depths for dispersion class were non-dispersive (Class 6), possibly related to the strong levels of acidity throughout the profile. Calcium/magnesium ratios were all very low and soil salinity levels were moderate increasing to high in the deeper medium to heavy clay subsoil layer.

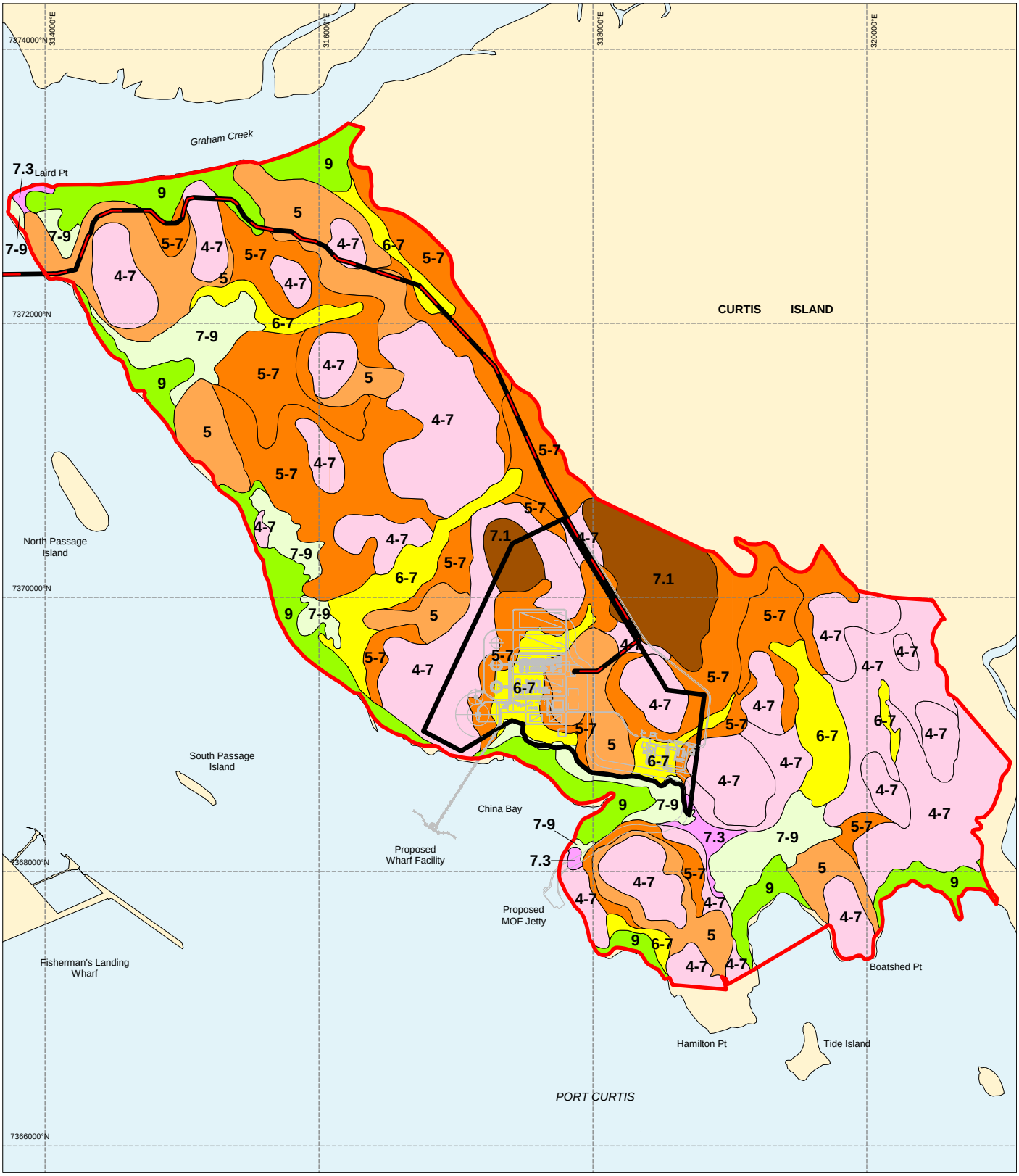
Soil Group 8 – Group 8 **soils were** not encountered within the LNG facility site area.

Soil Group 9 – The soils in this group vary considerably both in the vertical and horizontal directions and include deep to very deep, very soft, uniform, gradational and weak duplex soil profiles with highly organic silty clay, silty clay loam surface soils and seasonally or permanently saturated subsoils, typically gleyed and saline clays, clayey silt, silty sand or sandy mud.

As mapped, these soils occur on the estuarine supra-tidal flats in association with Group 7 soils which occur mainly along the landward margins of terrain unit Qe1/7-9. The Group 9 soils also occur on the tidal mangrove flats and tidal inlets in terrain unit Qe0/9.

No analytical data was acquired for the Group 9 soils. However soil chemistry data acquired as part of the Acid Sulfate Soils (ASS) investigations reported in **Appendix L** of the EIS**,** indicates that the surficial silty clay soils may comprise very strongly acidic Actual ASS and the deeper permanently saturated soil layers include very high levels of Potential ASS which will pre-dispose these soils to high levels of acid production if they are exposed to air and subject to the effects of oxidation.

The occurrence and distribution of soils within the LNG facility site area and the terrain units in which they occur are shown in **Figure 1-3**. A brief description and classification of soil types in the LNG facility area is provided in **Table 1-1.**



NOTE: This Figure 1-3 must be viewed with Figure 1-3a.

Client	Project	Title
LNG / URS	GLADSTONE LNG PROJECT TERRAIN, SOILS AND LAND CAPABILITY REPORT LNG FACILITY	**SOILS** **LNG FACILITY**

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Job No: **4262 6220**	File No: 42626220-g-550.wor			**A4**

Table 1-1 Description and Classification of Soil Types

Soil Group	Summary Soil Description	Soil Classification			
		Aust. Soil Group (1)	P.P.F. (2)	U.S.C. (3)	A.S.S. (4)
4	Shallow to deep (>0.5 m) mainly uniform or weakly gradational, very stony and gravelly loams to clay loam soil profiles.	Shallow Loams Gravelly Loams Lateritic Red – Yellow Earths	Um2.12 K-Um2.12 Um4.11	CL/GC-CL/GC GC-CL/GC	Brown Kandosol; Gravelly Lithic; Leptic Rudosols
5	Medium to deep (0.5-1.2 m) dark brown gravelly loam to gravelly clay loam surface soils, locally with a pale or bleached gravelly loam or clay loam sub-surface (A2) horizon over red-brown, brown or yellow-brown acidic medium to heavy clays or gravelly clays subsoils.	Red, Yellow & Brown Podzolic Soils ; Grey & Brown Soloths	Dr2.31 K-Dr3.21 Db3.51 K-Db3.51 Db1.41 K-Dy3.21 Dy3.32	GC-CL/GC/CH CL-ML/GC/CH or CL-CH ML/GM/CL-CH	Ferric Red-Brown Chromosols; Sodic Yellow & Brown Kurosols
6	Thin dark grey-brown acidic clay loamy surface duplex soils with diffusely mottled grey-brown and yellowish brown slightly acidic medium to heavy clay sub-soils over alkaline clay deep subsoils	Brown Solodic Soils	Db2.23	CL/CH/CL-CH	Subnatric Brown Sodosols
7	Three soil type variants identified include: *Type 7.1*: Shallow to medium deep (<0.5-0.8 m) uniform red-brown clay soils and gradational gravelly loam over yellow-brown to yellowish-red gravelly clay subsoils; *Type 7.2*: Medium deep (0.5-1.0 m) uniform silty clay over acidic structured heavy clay subsoils underlain by massive alkaline heavy clay deeper subsoils; *Type 7.3:* Medium to deep (0.5-1.5 m) uniform silty clay surface soils over brown or red-brown weakly structured acidic medium to heavy clay subsoils, and gradational clay loam to gravelly loam surface soils over gravelly light clay subsurface horizons transitioning to medium to heavy or heavy acidic to strongly acidic clay or gravelly clay subsoils	Uniform Gravelly Clays Alluvial Soils Grey, Brown or Red (Non-Cracking) Clay Soils	Uf6.61 Gn4.81 Gn4.14 Uf6.31 Uf6.61 Uf6.12 Gn4.12 Gn4.11 Gn2.11	CL-CH/CH GM-GC/GC/ CL-CH or GC-CL/GC/ CL-CH CL/CH/CH CL/CL-CH CL/GC-CL/CH CL/GC-CL/CH GC-CL/CL-CH CL/CL/GC-CL	Acidic Sodic Red Dermosols; Melanic Red & Brown Dermosol Sodic Brown Dermosol Acidic-Sodic Red Dermosol; Ferric Brown Dermosol; Ferric red Dermosol
9	Deep to very deep, very soft, uniform, gradational or weak duplex soil profiles, with organic silty clay to silty clay loam surface soils and seasonally or permanently saturated subsoils, typically gleyed saline clays, clayey silt, silty sand or sandy mud	Humic Gleys Solonchaks	Uf6.41 Dg2.11	CL-ML/OL-OH	Supratidal Hydrosols; Redoxic Hydrosols

Notes: - (1) - Common Soil Group Name (Stace et.al. 1968); (2) - Principal Profile Form (Northcote 1974);
(3) - Australian Engineering Soil Classification (AS 1726-1993); (4) - Australian Soil Classification (Isbell, 1996).

1.6 Topsoil Resources

1.6.1 Method of Assessment

The suitability of materials for use as topsoil resources for rehabilitation of lands that may be disturbed during the development and operating stages of the LNG facility site area has been assessed from the soil characterisation indicative testing and the results of the analytical data obtained. Indicative stripping depths of suitable topsoil material have been determined as shown in **Figure 1-3**. An assessment has also been made of materials that are considered to be marginal for use as topsoil material, but would have acceptable properties for the use as subsoil resources to supplement the topsoil resources if required.

1.6.2 Results of Assessment

Useable topsoil resources are mainly confined to the surficial (A) horizon materials and in places in the upper part of the subsurface (B1) horizons, which contain seed-stock, micro-organisms, organic matter and nutrients necessary for plant growth. Soil microbial activity, organic matter content and other parameters affecting soil productivity and fertility, tend to decrease with depth.

Comments with respect to topsoil suitability and availability and indicative stripping depths for the terrain units and associated soil types that occur within the LNG facility site area are as follows:

Group 4 Soils: - These soils are of limited extent and occur in association with the soils of Group 7 on the crests of some low rises in terrain unit Cw4/4-7 and on the upper slopes and crestal areas in terrain unit Cw7/4-7. The soils are shallow to medium deep, with mainly uniform or weakly gradational very stony and gravelly loams to clay loam soil profiles. They have brown to dark grey gravelly/stony loam to clay loam surface soil horizons with a paler yellowish-brown to grey gravelly silt loam to loamy gravel subsurface (A2) horizon underlain by weathered rock at a depth of about 0.5 m. Dependent upon the amount and size of the gravel/stone content present, potential topsoil resources in these soils are likely to be restricted to the upper 0.1-0.3 m (av.0.2 m) of the A horizon materials. The deeper subsoils are likely to be excessively gravelly and/or may contain silty fines which are prone to form bulldust when disturbed and reworked. Accordingly, these materials are considered to be unsuitable for use either for topsoil or as a supplementary resource.

Group 5 Soils: - These soils occur on the upper marginal slopes and on the mid to lower slopes in terrain unit Cw6/5. They also occur in association with Group 7 soils on the gently to moderately inclined foot-slopes in terrain unit Cw5/5-7 and on undulating lowlands in terrain unit Cw3/5-7. The soil profiles are medium to deep (0.5-1.2 m) and have dark brown gravelly loam to gravelly clay loam surface soil, locally with a pale or bleached gravelly loam or clay loam sub-surface (A2) horizon over red-brown, brown or yellow-brown acidic medium to heavy clays or gravelly clays subsoils. The surficial soil horizons contain variable, up to high amounts of gravel and coarse stone, some of which is of colluvial origin from the higher steeper parts of slopes. Although likely to vary locally, the topsoil stripping depth in these areas is likely to be limited to an average thickness of 0.15 m, primarily to make use of the organics and seedstock content of the soils. Useable supplementary soil resources may occur locally up to depths of about 0.5 m, but in general, unless the coarse-fraction material can be readily separated out, the subsurface materials are likely to be excessively stony for use either as topsoil or supplementary soil resources.

Group 6 Soils: - These soils are of limited extent in the LNG facility site area and occur locally in association with the soils of Group 7 on alluvial plains in terrain unit Qa2/6-7. Where encountered in the LNG facility site, the soils have thin dark grey-brown weakly acidic clay loamy surface soils with friable granular to weak fine prismatic structure with some fine (Fe) gravelly inclusions, abruptly underlain by neutral to alkaline frequently

sodic, dispersive and locally somewhat saline medium to heavy clay subsoils. Only the upper 0.15 m is worth recovering for the organic and seed-stock content. Where these soils occur in association with soil Type 7, blending of the Type 6 topsoil with the associated soil types would be beneficial.

Group 7 Soils: - These soils include uniform fine-textured (non-cracking) clay and gravelly clay soil profiles and gradational, mostly gravelly or stony clay loam or light clayey surface soils underlain by acidic or alkaline, medium to heavy clay or heavy clay subsoils, which are often sodic and in places moderately to highly saline in some lower-lying coastal areas.

As mapped the Group 7 soils occur in association with Group 4 soils in terrain units Cw4/4-7 and Cw7/4-7, where an average topsoil stripping depth for both the Group 4 soils and the Group 7 soils is 0.2 m. Depending on the gravel content of the subsurface materials, useable supplementary soil resources to a depth of 0.5 m may be available.

The (Group 7) soils also occur in association with Group 5 soils in terrain unit Cw3/5-7 and Cw5/5-7, where an average topsoil stripping depth for the Group 7 soils is 0.2 m. Depending on the gravel content of the subsurface materials, useable supplementary soil resources to a depth of approximately 0.5 m may be available.

The (Group 7) soils also occur in association with lesser occurrences of Group 6 soils in terrain unit Qa2/6-7. An average topsoil stripping depth for the Group 7 soils is 0.3 m. Depending on the gravel content and/or the plasticity, structure and consistence of the subsurface materials, useable supplementary soil resources to a depth of approximately 0.5 m may be available.

The (Group 7) soils comprise the dominant soil type in terrain unit Cw8/7.1 and local occurrences of terrain unit Qe2/7.3 fringing the estuarine/coastal flats. An average topsoil stripping depth in both of these soil/landscape situations is 0.2 m. Depending on the gravel content of the subsurface materials in the occurrences of terrain unit Cw8/7.1, useable supplementary soil resources to a depth of approximately 0.5 m may be available. In terrain unit Qe2/7.3, the subsurface horizons below the (0.2 m) topsoil stripping depth are strongly acidic and have increasing levels of soil salinity and are not likely to be suitable as a supplementary soil resource.

Group 9 Soils: - These soils occur in terrain units Qe0/9 and inQe1/7-9 on the estuarine coastal and mangrove flats. No topsoil resources are likely to be available from either of those locations.

1.7 Soil Erosion

The LNG facility site development activities will involve clearing and earthworks associated with the establishment of the plant and infrastructure requirements. This will involve the construction of an access road and an extension of the gas transmission pipeline to the facility. The potential environmental impact likely to result from these activities is primarily related to erosion potential of the land when areas are cleared for development.

1.7.1 Existing and Potential Soil Erosion

Based on interpretation of the aerial photography (May 1999 – 1:40,000 scale) and from field observations, the incidence of accelerated soil erosion, including sheet, rill or gully erosion, appears to be low within the LNG facility site area. This is primarily due to the well-established vegetative and grass cover that exists over most of the area and the minimal impact of any grazing or other land-use activities that have been undertaken in the area. The limited erosion that is occurring is largely confined to local, narrow, shallowly incised gullies in the mid to lower slopes of the low hilly and higher hilly lands. However, clearing of vegetation and stripping of topsoil

resources for site development will expose that land to erosion due to the combined effects of wind erosion and/or surface runoff in the short term. Accordingly, a general qualitative assessment of erosion potential has been made on a terrain unit basis (expressed as low (L), medium (M) or high (H).in **Appendix B.** The basis of the assessment of erosion potential is included in **Appendix D.** Some general comments on potential site impacts are as follows.

In the undulating to low hilly and hilly lands, the surficial soil horizons, to a depth of 0.5 m or more, mostly have a permeable massive, apedal tending to granular, loose soil structure and typically contain substantial amounts (40-60%) of fine rounded gravel to coarse sub-angular stone, the combination of which promotes surface water infiltration and reduces surface water runoff. In these undulating and hilly lands, terrain units Cw3/5-7 and Cw4/4-7 (with overall surface slopes mostly <7% but locally include sodic and moderately dispersive soil layers) have been rated as having low to moderate (L-M) erosion potential. Terrain units Cw6/5 which have slopes mostly in the range 12-25% and soils that may include some sodic and slightly dispersive soil layers have been rated as having moderate (M-H) erosion potential. Although the overall slopes are less steep, terrain unit Cw5/5-7 has been rated as having moderate to high (M-H) erosion potential, due to its topographic position in the landscape, the potential for downslope seepage and surface runoff and the likely occurrence of sodic and moderately dispersive soil layers. Terrain units Cw7/4-7 and Cw8/7.1 have also been rated as having moderate to high (M-H) erosion potential due mainly to the overall steepness of slopes, typically in the range 25-50% and locally steeper.

In the low-lying tidal marine/coastal flats and estuarine areas, terrain unit Qe0/9 has been rated as having low to moderate (L-M) erosion potential. The estuarine/marine coastal flats (terrain unit Qe1/7-9) and the slightly higher fringing land areas (terrain unit Qe2/7.3) have both been rated as having moderate (M) erosion potential, due in part to the lack of surface grass cover, relatively high silt content and sodic and dispersive properties of the surface soils, which may pre-dispose these areas in particular to the effects of wind erosion. The alluvial re-entrant valley floors (terrain units Qa2/6-7), have been rated as having moderate to high (M-H) erosion potential due to the locally high silt content and hard-setting properties of the surface soil horizons, the sodic and dispersive properties of the subsoil layers and the potential for periodic high velocity flood flows and local scouring effects.

1.8 Agricultural Land Capability

1.8.1 Agricultural Land Classes

An assessment of the agricultural land capability of the area has been carried out to provide a benchmark of existing/potential agricultural land use. As required in the project Terms of Reference, in accordance with State Planning Policy 1/92: *Development and the Conservation of Agricultural Land*, the assessment is based on the four class system for defining Good Quality Agricultural Land (GQAL) as detailed in the guidelines from the Department of Primary Industries (DPI) and the Department of Housing and Local Government (DPI/DHLGP - 1993) as summarised below:

***Class A*: -** Crop Land – land suitable for current and potential crops with limitations to production which range from nil to moderate levels.

Class B: - Limited Crop Land – land that is marginal for current and potential crops due to severe limitations, but is suitable for pastures. Engineering and/or agronomic improvements may be required before the land is considered suitable for sustainable cropping/cultivation.

Class C: - Pasture land – land suitable for improved or native pastures due to limitations which preclude continuous cultivation for crop production. Some areas may tolerate a short-term cultivation for improved pasture and forage crop establishment (Sub-class C1). Other areas are primarily suited to grazing of native pastures, with or without the addition of improved pasture species without ground disturbance (Sub-class C2). Elsewhere the land is suited to restricted light grazing of native pastures in accessible areas (Sub-class C3), otherwise very steep hilly lands more suited for forestry, conservation or catchment protection.

Class D: - Non-agricultural Land - land not suitable for agricultural uses due to extreme limitations. This may comprise undisturbed land with significant habitat, conservation and/or catchment values, or land that may be unsuitable because of very steep slopes, shallow soils, rock outcrop or poor drainage conditions.

In order to determine the appropriate agricultural land class, terrain units identified within the project area have been evaluated for land suitability for (rainfed) cropping and for cattle grazing enterprises. The system of classification is based on the identification of physical and chemical limiting factors or constraints with respect to the specific land use, by adopting the following format.

Class 1:- High quality agricultural land with few or very minor limitations for the intended land use.

Class 2:- Land with minor limitations for the intended land use.

Class 3:- Land with moderate limitations to sustaining the intended land use.

Class 4:- Marginal land with severe limitations that require major inputs to sustain the intended land use.

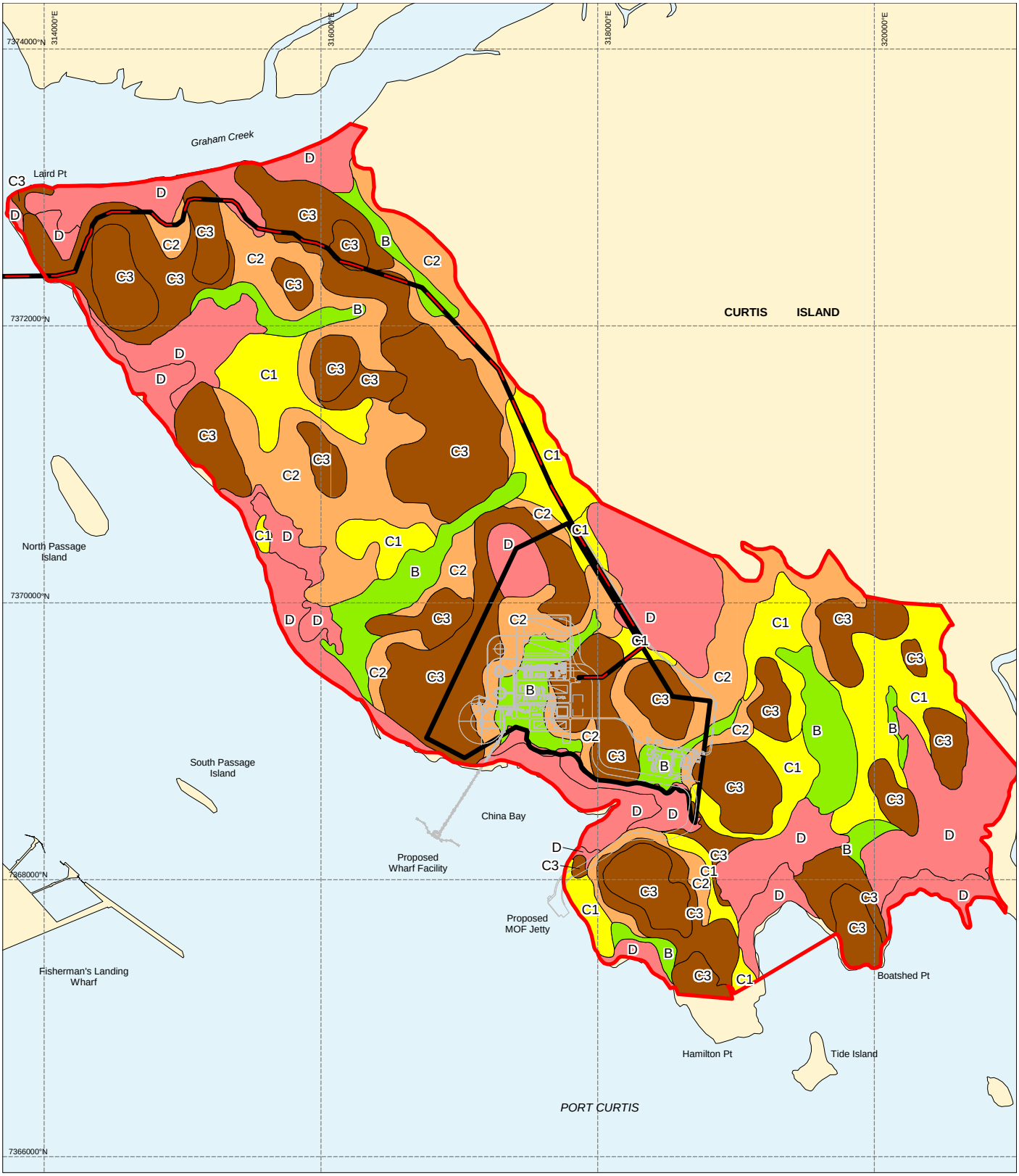
Class 5:- Unsuitable land due to extreme limitations for the intended land use.

The soil and landform limitations criteria on which the land suitability classifications are determined are included in **Appendix E.** These criteria are based on the guidelines for agricultural land evaluation published by the Queensland Department of Primary Industries (DPI - 1990), modified to some extent by inclusion of criteria proposed by Shields and Williams (1991).

The agricultural land capability classes, land suitability for dryland cropping and grazing land suitability classes and limitations of the terrain units identified within the LNG facility site area as shown in **Table 1-2**.

1.8.2 Results of the Assessment

Table 1-2 shows the agricultural land capability of the terrain within the LNG facility site area with the respective land classes assessed identified on the basis of terrain units as shown in **Figure 1-4**.



NOTE: This Figure 1-4 must be viewed with Figure 1-4a.

Client	Project	Title	
	GLADSTONE LNG PROJECT TERRAIN, SOILS AND LAND CAPABILITY REPORT LNG FACILITY	**AGRICULTURAL LAND SUITABILITY**	
	Drawn: VH	Approved: JB	Date: 29-01-2009
	Job No: **4262 6220**	File No: 42626220-g-551.wor	Figure: **1-4**
			Rev:B A4

Figure 1-4a Legend - Agricultural Land Classes

Description and Assessment of Environmental Values

As mapped the LNG facility study area includes a total land area of 1,865 ha. Based on the cumulative areas of the terrain units that occur within the site and the corresponding agricultural land classes determined as shown **Table 1-2**, a summary of the results of the (pre-development) land capability assessment is as follows:

- Class A land was not identified in the LNG study area;
- Class B land comprises 154.4 ha (8.3%) of the LNG study area;
- Class C1 land comprises 238.1 ha (12.8%) of the LNG study area;
- Class C2 land comprises 350.5 ha (18.8%) of the LNG study area;
- Class C3 land comprises 668.9 ha (35.9%) of the LNG study area; and
- Class D land encompasses 452.7 ha (24.3%) of the LNG study area.

As there was no Class A land identified, the occurrence of Good Quality Agricultural Land (GQAL) in the LNG facility study area is limited to the alluvial valley floors mapped as terrain unit Qa2/6-7 which have been rated as Agricultural Land Class B. Collectively these lands occupy an area of 154.4 ha (8.3%) of the LNG facility study area. If cleared of the native vegetation, due to the variable but locally high silt content in the surface soils, these areas have limited potential for sustained cultivation and dry-land crop production.

Land rated as Class C1 encompasses a land area of 238.1ha (12.8%) of the LNG facility study area. This land constitutes undulating lowlands in valley floors mapped as terrain unit Cw3/5-7 and undulating gently inclined footslope interfluves and low saddles in terrain unit Cw4/4-7. The land is suitable for occasional cultivation for the establishment of improved pastures and is well suited to grazing of native pastures.

Class C2 lands encompasses 350.5 ha (18.8%) of the LNG facility study area and includes moderately inclined planar to concave mid to lower hill slopes mapped as terrain unit and Cw5/5-7. These lands are mainly suited to grazing of native pastures.

Land rated as Class C3 collectively incorporates a total of 666.9 ha (35.9%) of the LNG facility study area and includes terrain units Qe2/7.3 near the coastline and low hilly to hilly lands of terrain units Cw6/5 and Cw7/4-7. This land is only suitable for limited controlled grazing of native pastures due to topographic constraints and erosion potential in the steeper hilly areas.

Land rated as Class D constitutes non-agricultural lands and collectively encompasses a total area of 452.7 ha (24.3%) of the LNG facility study area. This includes the coastal mangrove tidal flats and the estuarine mud flats - terrain units Qe0/9 and Qe1/7-9 and the steep high hilly lands of terrain unit Cw8/7.1. These areas are largely unsuitable for grazing except for very limited grazing of the lower slope of the higher hilly areas.

Table 1-2 Agricultural Land Capability in the LNG Facility study area

Terrain Unit (1)	Area (ha)	Ag. Land Class (2)	Cropping Suitability (3)		Grazing Suitability (4)		Remarks
			Class	Limitations (3)	Class	Limitations (4)	
Qe0/9	159.6	D	5	f5, w5, sa5	5	sa5, w5, f5	Mangrove mud flats
Qe1/7-9	188.6	D	5	f5, w5, sa5	5	sa5, w5, f5	Estuarine/coastal flats
Qe2/7.3	11.7	C3	5	m5, n5, sa3, w3, f4,	4	m4, n4, sa3, w2, f3, so4, a4	Slightly elevated estuarine plains
Qa2/6-7	154.4	B	3-4	m3, p3, sa3, w3, f3	2-3	m2, p2, sa3, w2, f2, so2	Alluvial valley floors
Cw3/5-7	98.2	C1	4	m4, n4, sa2-3,	2-3	m3, n3, so3 sa2-3, e2	Undulating lowlands and valley floors
Cw4/4-7	139.9	C1	4	m4, pt3, e4	3	m3, e3, n3, e3	Undulating foot-slope interfluves and saddles
Cw5/5-7	350.5	C2	4-5	m4, n4, sa2-3, e5	3-4	m3, n3-4, so3 sa2-3, e4	Mod. inclined planar to concave lower slopes
Cw6/5	240.5	C3	5	m5, e5, pg4	4	m4, e4, pg4	Low rounded hills and low hilly lands
Cw7/4-7	416.7	C3	5	m5, e5,	4-5	m4, e4, t4	Steep hilly lands
Cw8/7.1	86.6	D	5	m5, e5, t5	5	m4, e4, t5	Steep high hilly lands
Water	17.9	D	-	-	-	-	Marine embayment

(1) Refer to Appendix B for a Description of Terrain Units
(2) Agricultural Land Class in accordance with DPI/DHLGP (1993)
(3) Refer to Appendix E (Table E.1)
(4) Refer to Appendix E (Table E.2)

1.9 Acid Sulfate Soils

The EIS Terms of Reference (ToR) for the project require that an investigation and mapping of the occurrence and distribution of acid sulfate soils (ASS) is undertaken, together with an assessment of any potential environmental impacts associated with the proposed LNG facility site development. It is well known that ASS have previously been identified to occur along the coastal fringes on the mainland eastern coastline and along the western coastline of Curtis Island, in particular in the vicinity of and to the south of Graham Creek. To address the requirements of the ToR, a separate investigation of ASS has been carried out, the results of which, together with an assessment of potential impacts and mitigation measures are included in Section 9.3.3 of the EIS report.

1.10 Load Bearing Capacity of Marine Plains

The load bearing capacity of marine plain soils will be assessed as part of site geotechnical investigations and reported in Section 9.7.2 of the EIS report.

Potential Impacts and Mitigation Measures

Section 2

2.1 Summary of Findings

A terrain analysis of the general LNG facility study area has been carried out to assess the potential engineering or environmental constraints and opportunities, and any related potential environmental impacts. A series of terrain units were identified for each of the main geological regimes that occur within the general study area, based on landform characteristics (surface form and slope) and associated soil types. The occurrence and distribution of terrain units within the study area is shown in **Figure 1-2,** descriptions of which, together with an assessment of the key environmental constraints for site development are provided in **Appendix B**.

On a terrain unit basis, the potential environmental impacts related to site development within the construction disturbance footprints of each of the LNG facility site development components, relate to the following:

- Areas prone to tidal inundation and site flooding potential;
- Erosion potential;
- The presence of sodic and dispersive soils;
- Changes to agricultural land capability;
- Availability of topsoil resources;
- Soil reactivity; and
- Soil salinity.

A summary of findings and comments with respect to mitigation of potential impacts area are as follows.

2.1.1 Tidal Inundation and Site Flooding Potential

Within the LNG facility site, areas identified as terrain unit Qe0/9 – tidal mangrove flats are prone to regular tidal inundation, whereas the estuarine flats and extra-tidal mud flats (terrain unit Qe1/7-9) are subject to periodic tidal inundation due to extra high tide events. Terrain units Qe2/7.3 occurring around the fringes of the estuarine flats may be subject to tidal effects only on rare occasions. The alluvial valley floors (terrain unit Qa2/6-7) are rarely flood prone but may be subject to local flash flooding in the immediate vicinity of the tributary streams and area drainage ways.

Where necessary, existing drainage lines currently flowing through the development area will be re-directed and modified to link with the internal site drainage network to control potential flooding within the site. Where the site development platform encroaches onto the estuarine tidal flats, rock armouring of the flood prevention levee embankments may be incorporated where necessary to protect the integrity of the embankment from tidal ingress or possible storm surge.

2.1.2 Erosion Potential

The steep hilly and higher hilly lands (Terrain units Cw8/7.1 and Cw7/4-7) have been rated as having medium to high erosion potential if subject to disturbance and/or clearing of vegetation, primarily due to the overall steepness of the hill slopes. Although the overall slopes are less steep, terrain units Cw6/5 and Cw5/5-7 are also rated medium to high, mainly due to the sodic and dispersive nature of the sub-soils if they become exposed and remain unprotected. In addition, terrain unit Cw5/5-7 is rated medium to high due to the topographic position in the landscape, whereby these areas may be subject to considerable surface water run-

on from the adjacent higher hill slopes. Erosion potential in terrain units Cw3/5-7 and Cw4/4-7 has been rated low to moderate due to the overall, relatively gentle surface slopes and the gravelly nature of the surficial soils which permits rapid surface water infiltration.

In the lower-lying and generally flatter coastal lands and the alluvial valley floors, terrain unit Qe0/9 has low to moderate erosion potential due to the permanently saturated, fine-textured and cohesive nature of the surficial soils. Terrain units Qe1/7-9 and Qe2/7.3 are moderately susceptible to wind erosion due to the bare or sparse surface cover and the silty nature of the surface soils. Terrain unit Qa2/6-7 has been rated medium to high due to the hard-setting properties of the surface soil horizons, the sodic and dispersive properties of the subsoil layers and the potential for periodic flood flows and local scouring effects.

General erosion control measures are outlined below and may be implemented where necessary to minimise the potential effects of erosion during the site development process.

2.1.3 Erosion Control Measures

Erosion on sites should follow the erosion control measures outlined below to help minimise erosion and reduce sediment loss from the construction sites:

- Limit the area disturbed, and clear progressively, immediately prior to construction activities commencing;
- Safeguard the surface layer by stripping and stockpiling topsoil prior to construction;
- Control runoff and sediment loss from the site using appropriate short term erosion control measures such as silt fences, hay bales, diversion mounds, etc;
- Use temporary soil diversion mounds to control runoff within and to divert water away from the construction site where practicable;
- Minimise the period that the bare soil is left exposed to erosion; and
- Use sediment traps and sediment collection ponds to minimise off-site effects of erosion.

The control of erosion and sediment movement within and from the site will be employed both during the construction stage and subsequently during the operating life of the facility. Where access is required in the long term, tracks will be constructed with a gravel or sealed surface and maintained to permit all weather access. Where access is required for temporary (construction) use only, disturbed areas will be lightly ripped, restored to a stable condition and revegetated or returned to their pre-disturbance land use condition as soon as practicable following the completion of construction activities.

More specific erosion control measures outlined in **Appendix D** will be incorporated in a site-based environmental management plan and will be implemented to reduce erosion from disturbed areas. These erosion control measures are based on the Engineering Guidelines for Queensland for Soil Erosion and Sediment Control (Institute of Engineers Australia et al. 1996), as well as from the NSW Department of Conservation and Land Management (CALM - 1992).

2.1.4 Dispersive Soils and Sodicity

Sodicity is the level of exchangeable sodium in the soil and is determined using the exchangeable sodium percentage (ESP), which is the amount of exchangeable sodium expressed as a percentage of the Cation Exchange Capacity (CEC). General ratings for sodicity established by Northcote and Skene (1972) are provided in **Appendix B.** Sodic soils on exposure tend to exhibit the following general problems:

- Severe surface crusting;
- Likely dispersion on wetting;
- Very low infiltration and hydraulic conductivity;
- Very hard dense subsoils;
- High susceptibility to severe gully erosion if exposed and unprotected; and
- High susceptibility to tunnel erosion.

Sodic and locally strongly sodic soil profiles were found to occur in the estuarine and alluvial plains in terrain units Qe2/7.3, Qa2/6-7 and on the lower footslopes in terrain unit Cw5/5-7. In the more hilly areas, soils found in terrain units Cw7/4-7 and Cw8/7.1 and in the higher parts of terrain unit Cw5/5-7, exhibited slight to moderate levels of sodicity in the heavier clay (B and B-C) soil horizons.

Soils with medium to high levels of exchangeable sodium (ESP) generally tend to pre-dispose the material to dispersion. As a result the soil may become subject to rill or gully erosion if disturbed or exposed and left unprotected. However, in some situations where highly acidic soils occur (pH <5.5), this appears to counteract the dispersive effects of soil sodicity, with indicative dispersion testing indicating the majority of these sodic and strongly acidic materials being non-dispersive.

Where sodic and dispersive soils do occur, adopting the relevant erosion control measures outlined in **Appendix D** will assist in mitigating erosion impacts. In addition, where strongly or very strongly sodic and/or dispersive materials are identified; these materials will not be used for rehabilitation purposes. However, should suspected sodic or dispersive materials be exposed as a result of site earthworks (subject to confirmation by appropriate soil testing), then dolomite or gypsum-based soil conditioner could be spread and blended into the exposed surface soils to restore the ionic balance and thus reduce levels of sodicity and dispersion effects in the soils prior to the placement of topsoil material.

2.1.5 Agricultural Land Capability

A comprehensive assessment of the pre-development agricultural land capability is provided in **Section 1.8.** Changes to the agricultural land classes as a result of site specific development activities proposed are addressed in **Section 2.2.**

2.1.6 Topsoil Resources

The suitability of materials for use as topsoil resources for rehabilitation of lands that may be disturbed during the development and operating stages of the project has been discussed in **Section 1.6**. Indicative soil stripping depths of suitable topsoil material have been determined, as shown in **Figure 1-3**. An assessment has also been made of materials that are considered to be marginal for use as topsoil material, but would have acceptable properties for the use as subsoil resources to supplement the topsoil resources if required.

Topsoil management measures are described below.

2.1.6.1 Topsoil Management

Some variability will occur within the soil types and conditions that occur within each of the terrain units in the LNG facility site area. Consequently monitoring of soil type variability by the site environmental officer or other

qualified personnel is recommended during the pre-stripping of construction sites to ensure that the maximum quantity and quality of useable topsoil resources is recovered for later use in site rehabilitation.

2.1.6.2 Topsoil Stripping

Prior to the commencement of topsoil stripping, areas will be cleared of vegetation. Earthmoving plant operators will be trained and/or supervised to ensure that stripping operations are conducted in accordance with stripping plans and *in situ* soil conditions. This will ensure that excessive clearing does not occur, all suitable topsoil material resources are salvaged and the quality of the stripped topsoil is not reduced through contamination with unsuitable soils. Care will be taken during the stripping, stockpiling, and respreading operations to ensure that moisture content of the topsoil resources is such that structural degradation of the soil is avoided and excessive compaction does not occur during the stockpiling process.

2.1.6.3 Stockpiling

Where possible, topsoil material will be respread directly from stripped areas on to other areas being rehabilitated. Where this is not possible, topsoil shall be stored in stockpiles. Topsoil material stockpiles will be located in areas that are outside the construction project disturbance footprint area and away from drainage lines. Drainage from higher areas will be diverted around stockpiles to prevent erosion. Sediment controls will be installed immediately down-slope of the stockpiles to collect any washed sediment.

Stockpiles will be formed in low mounds of minimum height (approximately 3 m maximum) and maximum surface area, consistent with the storage area available. If the stockpile is to be retained for a period of more than 6 months, the stockpile will be deep ripped and sown with local grass seed-stock, legumes and where appropriate the use of any suitable potentially threatened (local) plant species will be considered in order to keep the soil healthy and maintain biological activity. Topsoil stockpiles will be clearly sign-posted for easy identification and to avoid any inadvertent losses. Establishment of weeds on the stockpiles will also be monitored and controlled.

2.1.7 Reactive Soils

These relate primarily to the occurrence of highly reactive (cracking) clay (Group 8) soils that exhibit substantial shrinkage and swelling characteristics due to wetting and drying cycles. This may result in damage to structures, foundations and buried services (including pipelines) due to differential ground movements. The degree of shrinkage and swelling of soils is dependent on the clay content and the clay mineral type present. The soil reactivity ratings and basis for the assessment of reactive soils is included in **Appendix B.** An explanation of the ratings used are as follows:

L – Non reactive or slightly reactive soils – predominantly sandy coarse-textured soils with low CEC (<10 meq/100g); predominantly kaolin clay minerals where present.

R1 – Moderately reactive soils – uniform (non-cracking), gradational or duplex soil profiles with medium to heavy clay subsoils with moderate levels of CEC (10-30 meq/100g); predominantly illite clay minerals; subject to non-critical soil shrinkage or swelling movements.

R2 – Shallow or medium deep, highly reactive (cracking) clay soils, with high levels of CEC (30-50 + meq/100g); predominantly smectite clay minerals, underlain by low or non-reactive substrate soils or weathered rock.

R3 – Deep, highly reactive (cracking) clay soils in places with melon-hole gilgai, subject to substantial swelling and shrinkage on wetting and drying, with high levels of CEC (30-50+ meq/100g); predominantly smectite clay minerals.

Reference to **Figure 1.2** shows that no highly reactive (Group 8) soils have been identified within the LNG facility study area. However in some locations in terrain units Qa2/6-7, Cw5/5-7 and Cw8/7.1 where heavy clay materials were encountered in the transition to the weathered rock substrate, high levels of CEC (>30 meq/100g) indicate the presence of potentially reactive materials.

2.1.8 Soil Salinity

Primary soil salinity (high levels of soluble salts) is salinity that occurs naturally within the soil profile. In addition to deleterious effects on plant growth, soils with high levels of soluble salts increase the potential for corrosion of buried steel and/or concrete products. The criteria used to assess low, medium and high levels of soil salinity are included in **Appendix B**.

Within the LNG facility study area, high levels of soil salinity are likely to occur throughout the soil profile in terrain units Qe0/9, Qe1/7-9 and mainly in the subsoil and deeper subsoil layers in terrain units Qe2/7.3 and Qa2/6-7.

The potential impact of soil salinity in the LNG plant site area relates primarily to the nature of the facilities to be constructed and in particular the possibility for corrosion of buried steel and/or concrete products. This in turn will depend on the anticipated depth of burial of the product pipeline network and associated services and facilities. Site specific geotechnical investigations will be undertaken to determine the appropriate type of corrosion protection required, if any.

2.1.9 Site Excavation Conditions

Whilst no site specific investigations were undertaken to determine the likely depth to hard or strong rock throughout the site, some general conclusions can be drawn from the soil test pit sites excavated using a small tracked excavator and from the results of the groundwater drilling investigations undertaken within the LNG facility area. Those investigations have indicated that the surficial materials including the upper levels of the highly weathered rock zone should be readily excavated to depths of at least 2.0 m, using conventional earth moving equipment with rock ripping capability. Excavation below 2.0 m to depths of up to approximately 6.0-8.0 m, may encounter more difficult ground conditions including stronger bands of moderately weathered to fresh rock that may locally require the use of rock breaking equipment for rock removal. The requirement to employ drilling and blasting techniques for rock removal is considered unlikely to be necessary for excavation depths of up to at least 6.0-8.0 m.

2.2 Site Specific Development Impacts

The overall development proposed for the LNG facility plant site and associated facilities will involve several site specific development components, including:

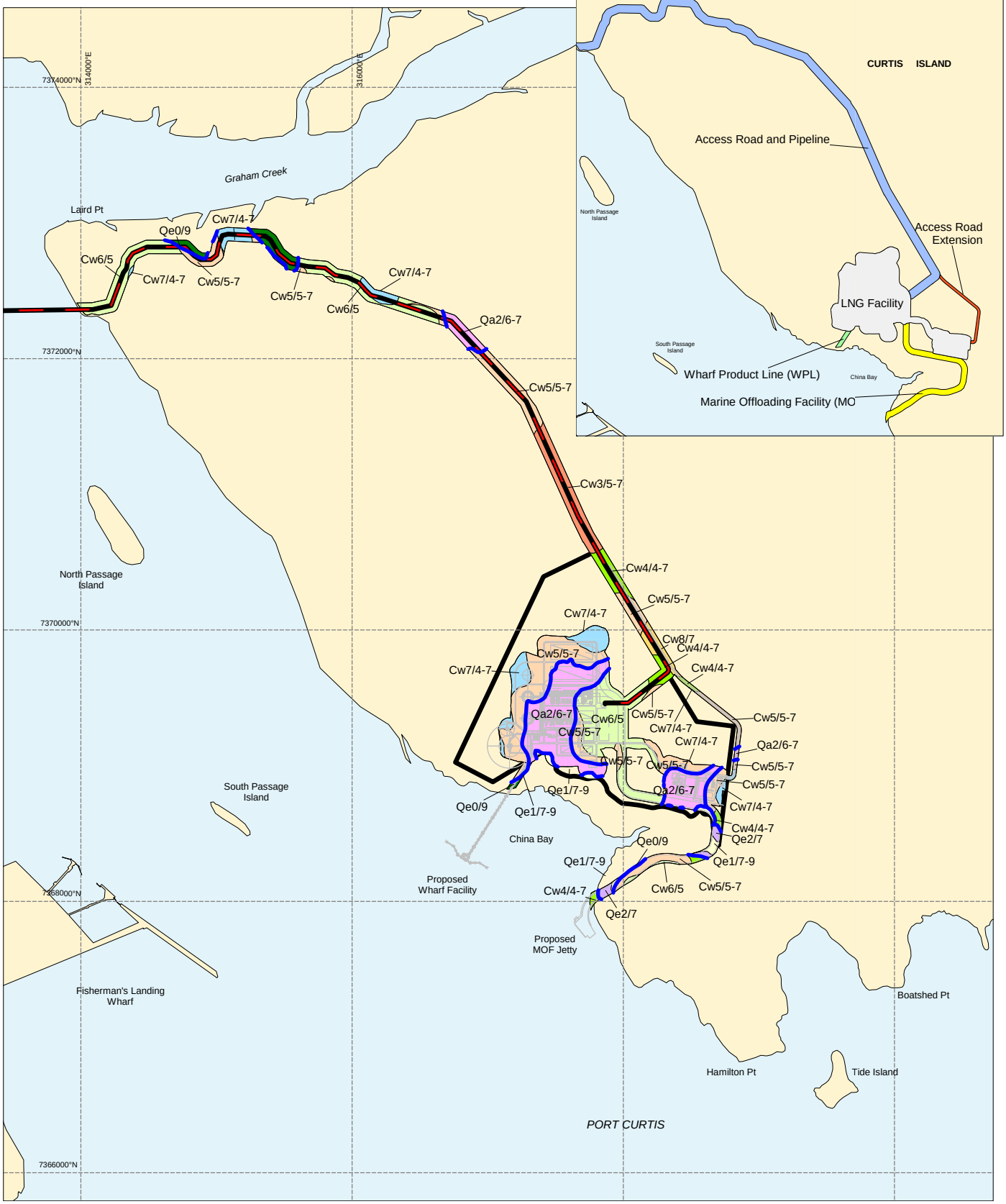
- The LNG facility site;
- The Access Road, Gas Transmission Pipeline and Power-line Route Corridor to the LNG plant site;
- The Marine Off-loading Facility (MOF); and
- The Wharf Product Line (WPL).

The layout of these proposed facilities (including designated buffer zones) is shown in **Figure 2-1** together with the terrain units encompassed within the disturbance footprint of each of the development components. The

cumulative areas (ha) of the terrain units included within each of the respective development components are summarised in **Table 2-1**.

Table 2-1 Areas of Terrain Units Associated with the LNG Facility Site Area Development Components

Terrain Units	Plant Site (ha)	MOF (ha)	WPL (ha)	Access Rd. & Pipeline (ha)	Access Rd. Extension (ha)
Qe0/9		0.7	0.4	5.2	
Qe1/7-9	1.0	1.8	0.1		
Qe2/7.3		0.8			
Qa2/6-7	33.7	1.7		3.4	0.3
Cw3/5-7				10.1	
Cw4/4-7		2.8		6.1	0.5
Cw5/5-7	29.9	4.4	0.7	15.3	1.9
Cw6/5	18.3	4.2		19.7	
Cw7/4-7	8.8			5.1	0.3
Cw8/7.1				2.9	0.1
Water					
Totals	(91.7)	(16.4)	(1.2)	(67.8)	(3.1)



Client

Project

GLADSTONE LNG PROJECT
TERRAIN, SOILS AND
LAND CAPABILITY REPORT
LNG FACILITY

Title

TERRAIN UNITS WITHIN LNG FACILITY AND ASSOCIATED INFRASTRUCTURE AREA DISTURBANCE FOOTPRINT

Drawn: VH	Approved: JB	Date: 29-01-2009
Job No: **4262 6220**	File No: 42626220-g-564.wor	

Figure: **2-1**

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2.2.1 Development Impacts – LNG Facility Site Development Area

The plant site development area in this context is taken to include the LNG facility site, the Marine Off-loading Facility (MOF), the Wharf Product Line (WPL) and the Access Road Extension to the plant site area. Collectively, these development components encompass a land area of approximately 112.4 ha. The main potential impacts relating to the development of the plant site and related facilities include:

- Changes to agricultural land capability;
- Erosion potential of the development area lands when subject to clearing and earthworks;
- The occurrence management of problem soil areas, including saline, sodic and dispersive soil areas; and
- Embankment construction or filling over soft ground potentially containing ASS.

Agricultural Land Capability. Plant site construction and development activities will result in changes to the pre-development land classes shown in **Table 1-2**, which will result in an overall increase of Non-agricultural lands during the project life-span. On a terrain unit basis, this will result in:

- Changes to 35.7 ha of Class B land, (23.1% of the Class B land shown in **Figure 1-4**);
- Changes to 3.3 ha of Class C1 land, (1.4% of the Class C1land shown in **Figure 1-4**);
- Changes to 36.9 ha of Class C2 land, (10.5% of the Class C2 land shown in **Figure 1-4**);
- Changes to 32.4 ha of Class C3 land, (4.8% of the Class C3 land shown in **Figure 1-4**); and
- Changes 4.1 ha of Class D land, which will remain classified as Class D land post development. However there will be an effective increase of 107.7 ha of Class D land (an increase of 23.8% of Class D land shown in **Figure 1-4**), due to the cumulative changes to land rated as Classes B, C1, C2 and C3 that will be down-graded to land Class D due to the construction and operations of the LNG Plant site facilities during the operating life of the facility. .

The loss of agricultural land capability will be for the operational life of the LNG facility. Unless otherwise by agreement with the site Regulatory Authority, upon decommissioning of the project, structures and hard-stand areas will be removed and the land rehabilitated in order to return the land to as near as practicable to its pre-development land use capability status, principally grazing lands.

Erosion potential. Approximately 104.3 ha (93%) of the land in the LNG Plant site area has been rated as having moderate to high erosion potential where the land is subject to clearing and earthworks for site development purposes.

General erosion control measures outlined in **Section 2.1.3** will be implemented where necessary to minimise the potential effects of erosion during the site development works. More specific erosion control measures outlined in **Appendix D** will be incorporated in a site-based environmental management plan (EMP) for specific aspects of the development.

As part of the EMP an erosion monitoring program will be developed to ensure stability of any exposed cut slopes or embankment fill areas, as well as any other areas disturbed during the infrastructure development LNG facility construction process. This may include regular site photographic monitoring by the site Environmental Officer, the establishment of permanent transects on sloping sites to monitor the rate of soil loss (if any) and regular monitoring of water quality of any water-bodies within or adjacent to the site to as a means

of determining the extend of any sediment loss from within the site. For the access road and gas transmission pipeline corridor right-of-way, periodic high resolution 3D digital imaging may be adopted to monitor ground conditions along the corridor and to identify any potential erosion hazard areas.

Problem Soil Areas. Terrain units with moderate to high levels of salinity, sodicity and dispersive properties, particularly in the deeper clay subsoil and substrate materials, occur over more than 80 ha (>70 %) of the plant site development area. It is understood that the finished level of the plant site construction platform is proposed to be RL 16.5 m ASL. To achieve this level, following stripping and salvage of topsoil resources, the topographically higher outer margins of the area and central lower-lying parts of the site will be subject to cut and fill earthworks operations respectively. These earthworks operations may expose areas of saline, sodic and/or dispersive soil layers within the finished surface level of the construction platform. Accordingly, prior to commencing construction works or replacing topsoil resources, site specific geotechnical soils investigations will be undertaken to identify and treat any problem soils areas, in particular where strongly acidic and/or saline soils may occur which could give rise to corrosion of buried steel or concrete products. Where sodic and/or dispersive soils are identified, then dolomite or gypsum-based soil conditioner should be spread and blended into the exposed surface soils to restore the ionic balance and thus reduce levels of sodicity and dispersion effects in the soils prior to commencing construction or the placement of topsoil material.

Embankment Construction or Filling on the Coastal/Estuarine Tidal Flats.

Construction of the Marine Off-loading Facility, the Wharf Product Line WPL and parts of the LNG Plant site facilities will involve embankment construction or filling in an area of approximately 0.5 ha of soft saturated soils potentially containing acid sulfate soils (ASS). Site specific ASS investigations of these areas will be undertaken to determine if Actual ASS materials are present. If found to occur, lime treatment to neutralise the acidity levels will be required, as filling over Actual ASS (very strongly acidic) materials is prohibited unless the materials are treated. The high salinity levels also create a potentially highly corrosive environment for buried steel or concrete products and the requirement for cathodic protection will be investigated and implemented where required.

2.2.2 Development Impacts – Infrastructure Access Corridor

The infrastructure access corridor as shown in **Figure 2-1,** includes the access road to the LNG Plant site area, the final sector of the gas transmission pipeline and a power-line facility. The corridor extends from the proposed Laird Point bridge crossing site and heads approximately 2 km to the east along the footslopes and coastal fringe of the Graham Creek inlet, then heads in a south-easterly direction in a narrow valley to the LNG Plant site development area. As shown, the infrastructure access corridor including a 50 m buffer zone encompasses a total land area of approximately 68 ha. As for the LNG Plant site development area, the potential impacts relating to construction and management of the access road corridor and associated infra-structure, relate to:

- Changes to agricultural land capability;
- Erosion potential of the development area lands when subject to clearing and earthworks;
- The occurrence management of problem soil areas, including saline, sodic and dispersive soil areas; and
- Construction including filling, on soft ground potentially containing ASS on the estuarine tidal flats.

Agricultural Land Capability. Development of the access road, powerline and gas transmission pipeline infrastructure corridor will result in changes to the pre-development Agricultural Land Classes shown in **Table 1-2**. This will result in an overall increase of Class D – Non-agricultural Land along the right-of-way, for the duration of and probably beyond the project life-span. In addition to the land class changes resulting from development of the LNG facility site, the access corridor ROW will result in:

- A loss of 3.4 ha of Class B land, (2.2% of the Class B land shown in **Figure 1-4**);
- A potential loss of 16.2 ha of Class C1 land, (6.8% of the Class C1 land shown in **Figure 1-4**);
- A potential loss of 15.3.ha of Class C2 land, (4.4% of the Class C2 land shown in **Figure 1-4**);
- A potential loss of 24.8 ha of Class C3 land, (3.7% of the Class C3 land shown in **Figure 1-4**); and
- Changes to 8.1 ha of Class D land intersected along the right-of-way which will remain classified as Class D land post construction. However there will be an effective overall increase of 44.4 ha of Class D land (an increase of 9.8% of Class D land shown in **Figure 1-4**), due to the cumulative changes to land rated as Classes B, C1, C2 and C3 that will be down-graded to land Class D due to the construction and operations of the infrastructure access corridor facilities, at least during the operating life of the LNG facility. .

The loss of agricultural land capability along the infrastructure access corridor is likely to be permanent as the beneficial future use of the facilities will likely compensate for the loss of agricultural land capability, predominantly for cattle grazing purposes.

Erosion potential: Approximately 46.4 ha (68.4%) of the infrastructure access corridor has been rated as having moderate to high erosion potential where the land may be subject to clearing for construction purposes.

General erosion control measures outlined in **Section 2.1.3** will be implemented where necessary to minimise the potential effects of erosion during the site development works. More specific erosion control measures outlined in **Appendix D** will be incorporated in a site-based environmental management plan (EMP) for erosion control along the infrastructure access corridor.

Problem Soil Areas: As shown in Appendix B, soils with moderate to high levels of soil salinity, sodicity and/or locally dispersive soil properties, particularly in the deeper clay subsoil and substrate materials, occur over more than 34 ha (50%) of the infrastructure access corridor. These soils occur mainly in terrain units Qe0/9, Qa2/6-7, Cw 3/5-7 and Cw5/5-7. Saline soils, in particular where they occur in association with strongly acidic subsoil conditions can give rise to corrosion of buried steel or concrete products.

Site specific geotechnical investigations including a soil resistivity survey along the pipeline alignment will be undertaken prior to the commencement of construction works, to identify and treat any potential problem soil areas. Where sodic or dispersive soils are identified, then a dolomite or gypsum-based soil conditioner will be incorporated to restore the ionic balance and help reduce levels of sodicity and soil dispersion effects.

Embankment Construction or Filling on the Coastal/Estuarine Tidal Flats: As currently proposed, the location of the infrastructure access corridor which includes the access road and gas transmission pipeline traverses an area of approximately 5 ha of estuarine tidal flats in the northern sector of the corridor. If practicable the alignment will be modified to avoid the area. Alternatively site specific acid sulphate soils (ASS) investigations will be undertaken to determine if ASS are present in the area. If actual ASS (very strongly acidic) materials are found to occur, lime treatment to neutralise the acidity levels will be required, as filling over

Actual ASS is prohibited unless the materials are fully lime-treated. The high soil and groundwater salinity in the area also creates a potentially highly corrosive environment for buried steel or concrete products.

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Section 3

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Soil Characterisation & Indicative Testing

Appendix A

Table A-1 Soil Characterisation and Indicative Testing

Horizon/ (Sample) Depth (m)	Soil Group/ Soil Type	Soil Horizon	Soil Description	Soil pH (1:5 H_2O)	EC (1:5 H_2O) (mS/cm)	Dispersion Class No.	Comments
Soil/ Landscape Notes:- #1- Slightly elevated estuarine plain-footslope transition in terrain unit Qe2/7.3, sparse grassland with uniform fine-textured alluvial soils (Type 7.3) – Uf6.61 – Acidic-Sodic Mottled Red Dermosol - Acidic-Sodic Dermosolic Hydrosol.							
0-0.3 (0.15)	7.3	A1-A2	Silty Clay (CL) medium plasticity, brown (7.5YR5/6) mottled grey, weak fine blocky tending to massive soil structure, firm moist consistence, some fine rounded ferruginous (Fe) gravel (<3 mm).	5.1 (5.6)	0.26 (0.25)	2(1)	Pale grey surface soil when dry; marginal topsoil resource, strongly sodic, low Ca/Mg ratio.
0.3-0.7 (0.45)		B1	Clay (CL-CH) medium to high plasticity, dark red (2.5R4/6) and pale grey mottled, weak fine polyhedral structure, (St .D. C), 5% (Fe) rounded ® gravel.	4.9 (5.4)	0.21 (0.253)	6	Strongly sodic, low Ca/Mg ratio.
0.7-1.1 (0.8)		B2	Clay (CL-CH) medium to high plasticity, reddish-brown (5YR5/6) distinctly mottled grey, weak fine blocky-prismatic structure (St. M. C.), some fine (Fe) gravel <5 mm.	4.9	0.537	6	Moderately saline.
1.1-1.3 (1.3)		B-C	Clay (CL) medium plasticity, reddish-brown (5YR6/1) with faint grey mottling, weak fine blocky-prismatic structure (V. St. D. C).	5.2 (5.4)	1.178 (1.36)	6	Highly saline, very strongly sodic, low Ca/Mg ratio.
1.3+		C	H W Sandstone.				
Soil/ Landscape Notes: - #2 – Mod. inclined footslope in terrain unit Cw5/5-7, with medium dense woodland and mid-high grass cover, with loamy surface brown duplex soils - (Db3.51); Brown Chromosol.							
0-0.1 (0.05)	5	A1	Clay Loam (CL) low to medium plasticity, dark brown (10YR3/3), friable tending to granular with a few cohesive lumps, massive structure, (F. M. C.), 25-30% r-s/r (Fe, Si) gravel (2-10 mm).	6.5	0.032	6	Suitable topsoil resource (300 mm), non-dispersive.

Soil Characterisation & Indicative Testing

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Horizon/ (Sample) Depth (m)	Soil Group/ Soil Type	Soil Horizon	Soil Description	Soil pH (1:5 H_2O)	EC (1:5 H_2O) (mS/cm)	Dispersion Class No.	Comments
0.1-0.3 (0.15)		B1	Gravelly Clay (CL-CH) medium to high plasticity, brown (7.5YR4/4), granular loose, 35-40% r -s/a W R gravel (5-20 mm).	5.5	0.108	6	Non-dispersive.
0.3-0.7 (0.4)		B21	Gravelly Clay (GC-CH) high plasticity fines, dark yellow brown (10YR4/4), massive tending to weak fine blocky-prismatic structure (Str. D. C.) with 40-45% r-s/a (Fe + W R) gravel (3-20 mm).	5.5	0.148	6	Acidic, non-dispersive.
0.7-1.0 (0.8)		B2-C	Gravelly Clay (GC-CL-CH) high plasticity fines, dark yellow brown (10YR5/6), massive, apedal, cohesive, (St. D. C.), 50% r-s/r (Fe + W R) gravel (3-20 mm).	5.4	0.197	6	Acidic, non-dispersive.
1.0-1.5 (1.3)		C	H W Rock – whitish-grey sandstone, siltstone with a silty clay matrix.	6.8	0.583	6	Moderately saline.
Soil/ Landscape Notes:- #3 – Lower slope in undulating lowland plains in terrain unit Cw4/4-7, with medium dense ironbark woodland with mid-high grasses, broken rock rubble and gravel covering 20-30% of the surface underlain by shallow gravelly loam soils (Um4.11); Ferric Brown Kandosol.							
0-0.3 (0.15)	4	A11	Clay Loam (CL) low to medium plasticity brown (7.5YR4/3) friable granular massive soil structure, 30% s/r-s/a gravel (10-20 mm).	5.7	0.136	6	Suitable topsoil resource.
0.3-0.45 (0.4)		A12	Gravelly Clay Loam (GC-CL) dark yellowish-brown (10YR4/2), massive granular loose with 50-60% s/r-s/a (Fe) gravel2-40 mm.	5.5	0.108	6	Non-dispersive fines.
0.45-0.8 (0.65)		A-C	Light Clayey Gravel (GC) - H W Rock – r-s/r-s/a (Fe) siltstone.	5.8	0.024	6	Non-dispersive fines.
0.8-1.0		C	H W Rock Gravel (GC) with 20-30% light clayey matrix.	5.1	0.059	6	Non-dispersive, strongly acidic.
1.0-1.5		C	H W Rock Gravel (GC) with 20-30% yellow-brown clayey matrix.	5.1	0.060	6	Non-dispersive, strongly acidic.

Soil Characterisation & Indicative Testing

Appendix A

Horizon/ (Sample) Depth (m)	Soil Group/ Soil Type	Soil Horizon	Soil Description	Soil pH (1:5 H_2O)	EC (1:5 H_2O) (mS/cm)	Dispersion Class No.	Comments
Soil/ Landscape Notes:- #4 – Slightly elevated extra-tidal low saddle between supra-tidal flats, in terrain unit Qe2/7.3, with sparse grass cover and scalded patches, with hardset gravelly surface medium deep uniform clay soil –(Uf6/61); Acidic-Sodic Mottled Red Dermosol – Acidic-Sodic Dermosolic Hydrosol.							
0-0.1 (0.05)	7.3	A	Clay (CH) high plasticity, yellowish-red (5YR5/6), mod. strong medium blocky-prismatic structure, friable (M. C.).	4.1	0.798	7	Marginal topsoil resource, very strongly acidic, mod. Saline.
0.1-0.5 (0.35)		B	Clay (CH) high plasticity, reddish brown (5YR6/3) and grey diffusely mottled, weak fine blocky-prismatic tending to massive soil structure (St.M.C.)	4.1	0.926	7	Strongly acidic, mod. Saline.
0.5-1.0 (0.6)		C	Gravelly Sandy Clay (GC) medium plasticity, variegated red, yellow and whitish grey EW claystone or older alluvial/ colluvial deposits.	4.1	1.107	2(1)	Strongly acidic, mod. to high salinity, mod. dispersive clayey fines.
1.0-1.5 (1.3)		C	Gravelly Sandy Clay (GC) – as above.	4.2	1.179	2(1)	Strongly acidic, mod. to high salinity, mod. dispersive fines.
Soil/ Landscape Notes:- #5 – Mid to lower hill slope in terrain unit Cw8/7.1, with dense mixed woodland and mid-high grasses with scattered broken rock cobbles at the surface, with shallow to medium deep gradational clay loam over gravelly structured clay soils (Type 7.1) – (Gn4.12); Sodic Red Dermosol.							
0-0.15 (0.1)	7.1	A	Clay Loam (CL) low to medium plasticity dark brown (10YR2/3), massive apedal granular loose soil structure, with 20% s/r-s/a gravel and HW rock fragments (2- 10 mm).	5.5 (5.7)	0.048 (0.120)	5	Highly organic topsoil resource to a depth of (0.3 m).
0.15-0.5 (0.3)		B1	Gravelly Clay (GC-CL) medium plasticity, dark reddish-brown (5YR3/3), massive apedal, granular loose soil structure, 50-60% r-s/r-s/a gravel and HW rock fragments (3- 15 mm).	5.5 (5.9)	0.028 (0.06)	5	Non-sodic, high Mg, low Ca.
0.5-0.8 (0.65)		B2-C	Clay (CH) high plasticity, red (2.5YR5/6), strong medium to fine blocky-prismatic structure, (VSt. D. C.), with 20-25% r-s/r-s/a gravel and HW rock fragments (2-10 mm).	6.0 (6.7)	0.059 (0.050)	6	Non-sodic, strongly magnesic.

Soil Characterisation & Indicative Testing

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Horizon/ (Sample) Depth (m)	Soil Group/ Soil Type	Soil Horizon	Soil Description	Soil pH (1:5 H_2O)	EC (1:5 H_2O) (mS/cm)	Dispersion Class No.	Comments
0.8-1.2 (1.0)		C	Clay (CL-CH) medium to high plasticity, red (2.5YR4/6), mod. strong medium to fine blocky-prismatic structure, friable (St. D. C.), with 20-25% r-s/r-s/a HW rock fragments (2-10 mm).	6.1 (6.8)	0.127 (0.14)	2(2)	Mod. dispersive, sodic, strongly magnesic, very low Ca/Mg ratio.
1.2+		C	HW Rock – sandstone.				
Soil/ Landscape Notes:- #6 – Mid to upper slope of steep-sided hill in terrain unit Cw7/4-7, with medium dense woodland, with shallow to medium deep gradational clay loam over structured clay soils (Type 7.1) – (Gn4.11); Acidic Red Dermosol.							
0-0.2 (0.1)	7.1	A	Gravelly Clay Loam (GC-CL) medium plasticity, dark reddish-brown (5YR3/2), massive apedal, granular loose soil structure, 50% s/r-s/a stone (15 - 20 mm).	5.5	0.046	5	Useable topsoil resource with high stone content.
0.2-0.35 (0.25)		B	Clay (CL) medium plasticity, dark red-brown (5YR3/3) massive apedal, granular loose, 30-40% s/a stone (5-15 mm).	5.1	0.021	6	Strongly acidic.
0.35-0.6 (0.4)		B-C	Clay (CL-CH) medium to high plasticity, dark red (2.5YR3/6), weak to mod. strong fine blocky-prismatic structure, crumbly. (F.-St. D. C.), with 30-40% s/a chert rock fragments (5-15 mm).	5.0	0.038	6	Strongly acidic, non-dispersive, rough ped fabric.
0.6-1.3 (0.7)		C	Gravelly Clay (GC-CL-CH) – medium to high plasticity, dark red (10R3/6) 50-60% cherty rock fragments (5-20 mm) – EW rock.	5.3	0.036	6	Strongly acidic, non-dispersive.
1.3+		-	HW Rock.				
Soil/ Landscape Notes:- #7 – Gently inclined footslope in terrain unit Cw5/5-7 with medium dense to open mixed woodland and mid-high grasses, with deep gradational red-brown clay soils (Gn2.11-Uf 6.53) – Ferric Red Dermosol.							
0-0.2 (0.1)	7.3	A11	Clay Loam (CL) medium plasticity, dark brown (10YR3/3) apedal massive with cohesive lumps, friable (F. M. C.) 10% fine s/r gravel (2-5 mm).	5.4	0.021	6	Good topsoil resource.

Soil Characterisation & Indicative Testing

Appendix A

Horizon/ (Sample) Depth (m)	Soil Group/ Soil Type	Soil Horizon	Soil Description	Soil pH (1:5 H_2O)	EC (1:5 H_2O) (mS/cm)	Dispersion Class No.	Comments
0.2-0.45		A12	Light Clay (CL) low to medium plasticity, dark brown (10YR3/3) massive apedal with cohesive lumps, friable (F. M. C.) 10-15% fine s/r gravel (2-5 mm)..	5.8	0.019	6	Useable topsoil resource to approx. 0.3m.
0.45-1.05 (0.8)		B1	Clay (CL) medium plasticity, red-brown (5YR4/4) massive apedal, granular loose, 30-40% r-s/r (Fe) gravel (2-10 mm).	5.8	0.023	6	Non-dispersive.
1.05-1.40 (1.3)		B-C	Gravelly Clay (CL) medium plasticity dark red (2.5YR4/6) apedal massive, granular loose with some cohesive lumps, friable (F. M. C.), 30-40% r-s/r-s/a (Fe) and chert gravel (5-15 mm).	5.6	0.043	6	Non-dispersive.
1.4+		C	HW Rock – clayey mudstone.				
Soil/ Landscape Notes:- #8 – Mid to lower hill slope in terrain unit Cw7/4-7, with low open woodland and mid-high grasses, with shallow to medium deep stony clay loam to light clayey soils (Type 7.1) over gravelly clay substrate soils (K-Uf6.12) – Ferric Red Dermosol.							
0-0.1 (0.05)	7.1	A11	Clay Loam to Light Clayey Gravel (GC) with 35% clayey fines of medium plasticity, dark red (2.5YR3/4) apedal granular loose with 60% s/r-s/a (Fe) gravel and (Si) stone (up to 25 mm).	5.9	0.023	6	Marginal for use as topsoil resource unless coarse fragments are removed.
0.1-0.4 (0.25)		A12	Clayey Gravel (GC) with 30% clayey fines of medium plasticity, apedal granular loose, 70% s/r-s/a (Fe & Si) gravel (5-15 mm).	6.0	0.34	6	Excessively gravelly for topsoil use.
0.4-1.0 (0.5)		A-C	Gravelly Clay-Clayey Gravel (GC) with 40% clayey fines of high plasticity, reddish-brown (5YR4/4), weak to mod. strong fine blocky-prismatic structure, crumbly (F. D. C.) with 50% s/r-s/a (Fe) and chert gravel (2-15 mm).	6.1	0.042	6	Non-dispersive clay fines.
1.0-1.5+		C	Gravelly Clay (GC) with 40% clayey fines of high plasticity yellow-brown (10YR5/6) with mod. strong fine blocky-prismatic structure, crumbly (F. D. C.) 50% s/r-s/a (Fe) and chert gravel (2-15 mm).	6.7	0.331	6	

Soil Characterisation & Indicative Testing

Appendix A

Horizon/ (Sample) Depth (m)	Soil Group/ Soil Type	Soil Horizon	Soil Description	Soil pH (1:5 H_2O)	EC (1:5 H_2O) (mS/cm)	Dispersion Class No.	Comments
Soil/ Landscape Notes:- #9 – Valley floor in terrain unit Qa2/6-7 with medium dense eucalypt woodland and mid-high grasses, with hardset uniform non-cracking clay soils (Type 7.2) - (Uf6.31) – Sodic Pedaric Brown Dermosol.							
0-0.1 (0.05)	7.2	A	Silty Clay (CL) medium plasticity, grayish-brown (7.5YR5/2) weak fine blocky-prismatic tending to massive (F. M. C.).	5.4 (5.9)	0.047 (0.08)	2(2)	Slightly sodic, mod. dispersive, marginal for use as topsoil.
0.1-0.3 (0.2)		B1	Clay (CH) high plasticity dark yellowish-brown (10YR4/4) diffusely mottled grey-brown, mod. strong fine blocky-prismatic structure, (St. D. C.).	5.6 (6.1)	0.049 (0.06)	2(1)	Slightly sodic, mod. dispersive, high Mg, low Ca.
0.3-0.8 (0.5)		B21	Clay (CH) high plasticity brown (10YR4/3), mod. strong fine to medium blocky-prismatic structure, (VSt. D. C.) some fine (Mn) gravel (3-5 mm).	6.4 (6.8)	0.301 (0.370)	2(1)	Strongly sodic, mod. Dispersive.
0.8-1.1 (0.85)		B22	Clay (CH) high plasticity light greyish-brown (10YR6/4), massive apedal cohesive (VSt. D. C.), some manganese inclusions.	8.1 (8.0)	0.657 (0.950)	2(1)	Very strongly sodic, moderately dispersive, mod. Saline.
1.1+		C	EW-HW Rock – sandstone.				
Soil/ Landscape Notes:- #10 – Gently to moderately inclined mid to lower slope in terrain unit Cw5/5-7, with medium dense low shrubby woodland with mid-high grass cover, with medium deep loamy surface duplex soils (Db3.51) – Ferric Brown Chromosol.							
0-0.2 (0.1)	5	A	Clay Loam (CL) low to medium plasticity, dark brown (10YR2/3) massive apedal granular loose with some cohesive lumps, friable (S.-F. M. C.) 20-25% fine s/r (Fe) gravel (2-5 mm).	5.8	0.011	6	Suitable topsoil resource.
0.2-0.55 (0.45)		B21	Sandy Clay (CL) medium plasticity brown (10YR4/3), massive apedal granular loose with 25-30% coarse sand - fine (Fe) gravel.	5.9	0.027	6	Suitable as supplementary topsoil resource.
0.55-0.9 (0.75)		B22	Sandy Clay (CL) low to medium plasticity brown (7.5YR4/6), massive apedal granular loose with 40-45% coarse sand - fine (Fe) gravel (2-8 mm).	6.0	0.024	6	Marginally suitable as supplementary topsoil resource due to gravel content

Soil Characterisation & Indicative Testing

Horizon/ (Sample) Depth (m)	Soil Group/ Soil Type	Soil Horizon	Soil Description	Soil pH (1:5 H_2O)	EC (1:5 H_2O) (mS/cm)	Dispersion Class No.	Comments
0.9-1.5 (1.4)		B-C	Clayey Gravel (GC) with 60% r- s/r (Fe) and chert gravel (2-20 mm) with 30-40% sandy clay fines of medium plasticity, massive apedal granular loose.	6.0	0.030	6	
Soil/ Landscape Notes:- #11 – Mid to upper hill slope in terrain unit Cw6/5, with medium dense low shrubby woodland with medium to deep gravelly loamy surface red duplex soils (Dr2.41) – Ferric Red Chromosol.							
0-0.35 (0.2)	5	A1	Gravelly Loam-Loamy Gravel (GC-GC) with 40% silty clay loam fines of low-medium plasticity massive apedal granular loose and 60% s/a (Si) stone (3-20 mm).	5.5	0.016	6	Excessively gravelly for topsoil use.
0.35-0.5 (0.4)		A2 (Pale)	Loamy Gravel (GC) with 25% silty and sandy clay fines of low to medium plasticity, apedal granular, loose, with 75% r-s/a fine (Fe) gravel and (Si) stone (2-20 mm).	5.9	0.010	6	Excessively gravelly for topsoil use.
0.5-1.5 (1.0)		B-C	Clay (CH) high plasticity, yellowish-red (5YR5/8) strong fine to medium prismatic structure (VSt. D. C.).	6.4	0.495	6	Slightly to moderately saline.
Soil/ Landscape Notes:- #12 – Mid to upper hill slope in terrain unit Cw6/5, with medium dense to open low scrubby woodland with sparse grass and broken rock scattered on the surface, with shallow to medium deep gravelly red duplex soils (KS-Dr2.51) Ferric Red Chromosol							
0-0.3 (0.2)	5	A	Gravelly Loam-Loamy Gravel (GC-CL) with clay loamy fines of low-medium plasticity dark brown (10YR3/3) massive apedal granular loose and 50% fine (Fe) s/r-s/a (Si) stone (3-20 mm).	5.2	0.020	6	Upper (0.15 m) may be suitable for topsoil use.
0.3-O.55 (0.45)		B-C	Clayey Gravel (GC) with 30% clay fines of medium to high plasticity, red-brown (2.5YR5/6) granular loose with 70% (Fe) and chert gravel s/r-s/a 2-15mm.	5.4	0.038	6	Marginal for topsoil due to stone content.

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Horizon/ (Sample) Depth (m)	Soil Group/ Soil Type	Soil Horizon	Soil Description	Soil pH (1:5 H_2O)	EC (1:5 H_2O) (mS/cm)	Dispersion Class No.	Comments
0.55-1.3 (0.9) 1.3+		C	Clayey Gravel (GC) – EW Rock, with 20% clayey fines of medium plasticity, yellowish-brown (10YR5/6) and 80% mainly angular broken rock fragments (2-25 mm). HW Rock – meta-sediments.	5.5	0.105	2(1)	Slightly to mod. Dispersive.
Soil/ Landscape Notes:- #13 – Valley floor/alluvial drainage flat, terrain unit Qa2/6-7, with medium dense eucalypt woodland and mid-high grasses with medium deep uniform fine-textured alluvial clay soils, (Uf6.12) – Ferric Brown Dermosol.							
0-0.15 (0.01)	7.3	A	Clay (CL) medium plasticity dark grey- brown (10YR4/2), weak fine prismatic tending to massive soil structure, apedal granular loose, with 25% fine r-s/r (Fe) gravel (2-8 mm).	5.7	0.009	6	Suitable topsoil resource.
0.15-0.3 (0.2)		A2 (Pale)	Clay (CL) low to medium plasticity dark brown (10YR3/3), weak fine blocky-prismatic structure partly granular loose, with 35-40% fine r-s/r (Fe) gravel (3-10 mm).	5.7	0.016	6	Suitable as topsoil supplement.
0.3-0.4 (0.35)		B1	Gravelly Clay (GC-CL) 50-60% clay fines of medium to high plasticity, yellowish-brown (10YR5/6), weak fine prismatic structure partly granular loose, with 40-45% r-s/r (Fe) gravel (3-10 mm).	6.1	0.016	6	Suitable as topsoil supplement.
0.4-0.6 (0.5)		B2	Clay (CH) high plasticity, yellowish-brown (10YR5/8), mod. strong fine to medium blocky structure, (VSt. D. C.) some fine r-s/r (Fe) gravel (2-8 mm).	6.2	0.026	6	Rough ped fabric, non-dispersive.
0.6+		C	HW Rock – mudstone.				
Soil/ Landscape Notes:- #14 – Alluvial plain-lower footslope transition between terrain units Qa2/6-7 and Cw5/5-7, with dense mixed eucalypt scrubby woodland and mid-high grass cover with gradational fine-textured structured alluvial clay soil (Gn4.14) – Sodic Red Dermosol.							
0-0.15 (0.01)	7.3	A	Clay Loam (CL) low to medium plasticity, dark grey-brown (10YR4/2) massive apedal granular loose with some cohesive lumps, friable (F. M. C.)	5.5 (6.1)	0.024 (0.060)	6	Suitable topsoil resource.

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Horizon/ (Sample) Depth (m)	Soil Group/ Soil Type	Soil Horizon	Soil Description	Soil pH (1:5 H_2O)	EC (1:5 H_2O) (mS/cm)	Dispersion Class No.	Comments
0.15-0.3 (0.2)		A2 (Pale)	Silty Clay Loam (CL-ML) low plasticity, dark brown (10YR4/3) massive apedal, partly granular loose with some cohesive lumps, friable (F. M. C.), 10% fine r-s/r fine (Fe) gravel (2-8 mm).	5.5 (6.0)	0.014 (0.030)	6	Suitable topsoil resource, slightly sodic.
0.3-0.4 (0.35)		B1	Clay (CL) medium plasticity, dark yellowish-brown (10YR4/6) diffusely mottled grey, massive apedal granular loose with some cohesive lumps, 30% fine r-s/r (Fe) gravel (3-8 mm).	5.6 (6.0)	0.018 (0.03)	2(1)	Moderately dispersive.
0.4-0.6 (0.5)		B2	Clay (CL-CH) medium to high plasticity weak to mod. strong fine blocky-prismatic structure(St. D. C.) with 25% r-s/a (Fe & Si) gravel (2-10 mm).	5.5	0.027	6	Non-dispersive.
0.6+		C	Clay (CL-CH) medium to high plasticity, yellowish-red (10YR4/6), weak fine prismatic tending to massive cohesive (St. D. C.) 40% fine (Fe) gravel and s/a-a HW rock fragments (2-10 mm).	5.6 (6.1)	0.027 (0.04)	6	Slightly sodic, strongly magnesic.
Soil/ Landscape Notes:- #15 – Gently to moderately inclined footslope in terrain unitCw5/5-7 with medium dense scrubby mixed woodland and sparse low to mid-high grasses, with shallow to medium deep silt loamy surface gravelly red duplex soils (Dr3.21) – Very Gravelly Sodic Red Chromosol.							
0-0.15 (0.1)	5	A1	Silt Loam (ML) low plasticity, dark grey (10YR3/1) massive granular loose, 35-40% s/r-s/a fine (Fe & Si) gravel (2-10 mm).	5.7	0.021	6	Prone to form bulldust when disturbed and reworked.
0.15-0.25 (0.15)		A2 (Pale)	Loamy Gravel (GM) with 30% silt loamy fines of low plasticity, grey (10YR5/1), massive apedal, granular loose, with 60 -70% s/r-s/a (Fe) fine gravel and (Si) stone 2-15 mm.	5.9	0.014	6	Non-dispersive.
0.25-0.6 (0.4)		B-C	Gravelly Clay (GC-CH) medium to high plasticity, variegated red (2.5YR5/8) and grey (2.5YR6/1), mod. strong fine to medium blocky-prismatic structure (VSt. D. C.) with 40-45% fine s/r-s/a (Fe) and HW rock gravelly inclusions (3-10 mm).	5.5	0.124	2(1)	Moderately dispersive.

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Horizon/ (Sample) Depth (m)	Soil Group/ Soil Type	Soil Horizon	Soil Description	Soil pH (1:5 H_2O)	EC (1:5 H_2O) (mS/cm)	Dispersion Class No.	Comments
0.6-0.9+ (0.7)		C	Clayey Gravel (GC) – EW. Rock.	5.5	0.201	2(1)	Moderately dispersive.
Soil/ Landscape Notes:- #16 – Slope to drainage in terrain unit Cw5/5-7 with open low eucalypt woodland and sparse grass cover and broken rock scattered on the surface with gravelly loamy surface duplex soils (K-Dy3.21) – Gravelly Natric Yellow-Brown Kurosol.							
0-0.05	5	A1	Gravelly Loam (GM-SM) low plasticity brown (10YR4/3), massive apedal, granular loose, with 45-50% s/r-s/a (Fe) fine gravel and (Si) stone (2-15 mm).	5.4	0.011	6	
0.05-0.2 (0.15)		A2	Loamy Gravel (GM) with 35-40% silt loamy fines of low plasticity, brown (10YR6/3) massive apedal, granular loose, with 50-60% s/r-s/a (Fe) fine gravel and coarse (Si) stone (2-25 mm).	6.1	0.011	2(1)	Marginal as topsoil resource due to gravel and silt content.
0.2-0.9 (0.4)		B-C	Gravelly Clay-Clayey Gravel (GC) with 40-50% clay fines of high plasticity, variegated yellow-brown (10YR5/8) grey and red strong fine to medium blocky-prismatic structure (VSt. D. C.) with 50-60% s/r-s/a HW rock gravel(2-25 mm).	4.9	0.279	2(1)	Mod. dispersive silty clay fines.
0.9-1.1 (1.0)		C	Clayey Gravel (GC) with 20-25% sandy clay fines of low to medium plasticity, brownish-yellow (10YR6/6) with 70% s/a-a HW rock gravel(up to 25 mm).	5.0	0.079	-	Mod. dispersive clay fines, strongly acidic.
1.1+			HW Rock – sandstone.				Strongly acidic.
Soil/ Landscape Notes:- #17 – Hillcrest in terrain unit Cw7/4-7, with low scrubby open eucalypt woodland, sparse low to mid-high grasses with stony and broken rock surface scatter, with gradational (Type 7.1) gravelly clay soils (Gn4.81) – Gravelly Melanic Brown Dermosol.							
0-0.2 (0.15)	7.1	A1	Gravelly Loam (GM-GC) low plasticity very dark grey (10YR3/1)), massive apedal, granular loose, with 45-50% s/r-s/a (Fe) fine gravel and coarse (Si) stone (2-30 mm).	4.9	0.036	6	Marginal for use as topsoil resource due to strong acidity and coarse stone content.

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Horizon/ (Sample) Depth (m)	Soil Group/ Soil Type	Soil Horizon	Soil Description	Soil pH (1:5 H_2O)	EC (1:5 H_2O) (mS/cm)	Dispersion Class No.	Comments
0.2-0.3 (0.25)		A2	Gravelly Clay (GC) medium plasticity yellowish-brown (10YR4/4) massive apedal, granular loose, with 45-50% s/r-s/a (Fe) fine gravel and (Si) stone (2-15 mm).	5.7	0.014	6	Non-dispersive.
0.3-0.45 (0.35)		B-C	Gravelly Clay (CL-CH) medium to high plasticity yellowish brown (10YR5/8) weak fine blocky-prismatic brittle crumbly structure (F-St. D. C.) with 30% s/r-s/a (Fe & SI) gravel (2-10 mm).	5.3	0.023	6	Non-dispersive ,strongly acidic, rough ped fabric.
0.45-0.9+		C	HW-MW Rock.				Refusal on sandstone at 0.9 m.
Soil/ Landscape Notes:- #18 – Upper hill slope in terrain unit Cw7/4-7 with medium dense scrubby woodland sparse grasses with a stone and rock cobbles surface scatter, with shallow uniform gravelly silty loam soils (K-Um2.12) - Very Gravelly Lithic Rudosol							
0-0.1 (0.05)	4	A1	Gravelly Loam-Loamy Gravel (GM) with 30-40% silt loamy fines of low plasticity dark grey (10YR4/1) massive apedal, granular loose, with 60-70% fine (Fe) gravel & coarse (Si) stone (2-30 mm).	5.7	0.020	6	Marginal for use as topsoil resource due to coarse stone content.
0.1-0.3 (0.2)		A2 (Bleach)	Gravelly Silt Loam-Loamy Gravel (GM) with 40% silt loamy fines of low plasticity, light grey when dry (10YR7/2), massive apedal, granular loose, 60% fine (Fe) gravel & (Si) stone (2-30 mm).	5.5	0.012	5	Not suitable for topsoil use due to high stone and silt content and potential to form bulldust.
0.3-1.0 (0.6)		C	EW-HW Rock – siliceous siltstone with white matrix (40%) silt loamy fines of low plasticity.	5.9	0.011	2(2)	Moderately dispersive,
1.0+			HW Rock – siltstone-fine sandstone.				
Soil/ Landscape Notes:- #19 – Upper slope in terrain unit Cw7/4-7 with medium dense mixed eucalypt woodland, sparse grass cover with stone and rock cobbles scattered over the surface with shallow to medium deep (Type 7.1) gradational loam over structured clay soils (Gn4.84) – Acidic Sodic Yellow Dermosol							
0-0.1 (0.05)	7.1	A1	Gravelly Loam-Loamy Gravel (GC-CL) with 30-40% loamy fines of low plasticity, dark brown (10YR3/3), with 50-60% fine rounded (Fe) gravel and medium coarse s/r-s/a (Si) stone (2-25 mm).	5.0	0.023	6	Requires pH correction and removal of coarse stone to be suitable as a topsoil resource.

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Horizon/ (Sample) Depth (m)	Soil Group/ Soil Type	Soil Horizon	Soil Description	Soil pH (1:5 H_2O)	EC (1:5 H_2O) (mS/cm)	Dispersion Class No.	Comments
0.1-0.4 (0.3)		A2-B1 (Pale)	Gravelly Clay- Clayey Gravel (GC-CL) medium plasticity dark brown (10YR4/3) massive apedal granular loose, with some cohesive lumps, crumbly (F. D. C.) with 40% fine (Fe) gravel & (Si) stone (2-30 mm).	5.4	0.008	2(2)	Mod. dispersive clay fines.
0.4-0.7 (0.55)		B2	Clay (CL-CH) medium to high plasticity, yellow-brown (10YR6/6) weak fine to medium blocky-prismatic (F. D. C.) with 30-40% fine (Fe) gravel and s/a-s/r (Si) stone (2-15 mm).	5.2	0.012	6	Non-dispersive, strongly acidic.
0.7-1.2 (0.95)		C	EW-HW Rock – clayey sandstone.				
Soil/ Landscape Notes:- #20 - Mid to upper slope in terrain unit Cw8/7.1, with medium dense tall mixed eucalypt woodland with mid-high grasses with medium deep gradational clay loam over structured clay soils (Gn4.21) – Acidic Red Dermosol.							
0-0.2 (0.1)	7.1	A1	Clay Loam (CL) low to medium plasticity, dark brown (10YR3/3), weak fine blocky-prismatic tending to massive granular loose soil structure with some cohesive lumps, friable (F. D. C.) with 20% fine (Fe) gravel and s/r-s/a WR fragments (2-8 mm).	5.7	0.032	6	Suitable as topsoil resource.
0.2-0.3 (0.25)		A2 (Pale)	Light Clayey Gravel (GC) with 30% sub-plastic clay fines of medium plasticity, dark yellowish-brown (10YR4/4) with 60-70% fine (Fe) gravel and s/a-s/r (Si) stone (2-20 mm), granular loose massive soil structure.	5.7	0.020	6	Excessively stony for topsoil use.
0.3-0.7 (0.55)		B2	Clay (CH) high plasticity dark red (2.5YR4/4), mod. strong fine to medium blocky-prismatic (St. D. C.) with <10% fine (Fe) gravel and s/a-s/r WR fragments (2-8 mm).	5.0	0.126	6	Non-dispersive, strongly acidic, rough ped fabric.
0.7+		C	EW-HW Rock – sandstone.				
Soil/ Landscape Notes:- #21 – Steep mid to upper hill slope in terrain unit Cw8/7.1, with medium dense tall mixed eucalypt woodland with mid-high grasses and rock-strewn surface, with shallow to medium deep gradational clay loam over structured clay soils (Gn4.14) – Melanic Red Dermosol.							

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Horizon/ (Sample) Depth (m)	Soil Group/ Soil Type	Soil Horizon	Soil Description	Soil pH (1:5 H_2O)	EC (1:5 H_2O) (mS/cm)	Dispersion Class No.	Comments
0-0.1 (0.05)	7.1	A1	Gravelly Loam (GC-CL) medium plasticity very dark grey-brown (10YR2/2) massive apedal granular loose soil structure with 30-35% fine (Fe) gravel and s/r-s/a WR fragments (2-20 mm).	5.7	0.057	6	Suitable topsoil resource.
0.1-0.25 (0.2)		A2-B1 (Pale)	Gravelly Clay (CL-CH) medium to high plasticity dark brown (10YR3/4), massive apedal granular loose soil structure, with 50% fine (Fe) gravel and s/r-s/a WR fragments (2-25 mm).	6.0	0.015	6	Suitable topsoil resource apart from coarse stone content.
0.25-0.5 (0.35)		B2-C	Gravelly Clay (GC) medium to high plasticity yellowish-red (5YR4/6), mod. strong fine to medium blocky-prismatic structure, friable (F. D. C.) with 50% s/r-s/a WR fragments (2-15 mm).	5.8	0.023	6	Non-dispersive, mod. strongly acidic.
0.5-1.0 +		C	Light Clayey Gravel (GC) with 30-40% clay fines of medium plasticity – EW-HW Rock.	7.0	0.015	6	EW mudstone.
Soil/ Landscape Notes:- #22 – Gently inclined footslope in terrain unit Cw5/5-7 with low open scrubby woodland with sparsely grasses surface and some scalded areas, with hardset silt loamy surface yellow duplex soil (Dy3.32) – Sodic Magnesic Yellow Chromosol							
0-0.1 (0.05)	5	A1-A2	Silt Loam (CL-ML) low plasticity brown (10YR5/3) when moist, light brownish-grey (10YR6/2) when dry, massive apedal soil structure with some cohesive lumps, crumbly (F.-St. D. C.).	5.6 (5.8)	0.035 (0.03)	5	Marginal for use as topsoil resource, sodic, magnesic, high silt content, hardset surface.
0.1-0.5 (0.4)		B1	Clay (CH) high plasticity, brownish-yellow (10YR6/8) diffusely mottled grey, mod. strong fine to medium blocky-prismatic structure (VSt. D. C.) with 30% s/a WR fragments.	5.7 (6.3)	0.346 (0.38)	5	Strongly sodic, low Ca , strongly magnesic.
0.5-1.0 (0.9)		B2	Clay (CH) high plasticity, light yellow-brown (10YR6/4) diffusely mottled grey, mod. strong fine to medium blocky-prismatic structure (VSt. D. C.) with 30% s/a EW rock fragments.	7.5	0.771	2(2)	Sodic, dispersive, mod. Saline.
1.0-1.5 (1.4)		C	HW Rock – clayey siltstone, mudstone with light yellow-brown clayey fines of medium plasticity.	7.7 (7.5)	0.634 (0.62)	2(2)	Very strongly sodic, mod. dispersive, magnesic, mod. Saline.

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Horizon/ (Sample) Depth (m)	Soil Group/ Soil Type	Soil Horizon	Soil Description	Soil pH (1:5 H_2O)	EC (1:5 H_2O) (mS/cm)	Dispersion Class No.	Comments
Soil/ Landscape Notes:- #23 – Head of narrow alluvial valley floor in terrain unit Qa2/6-7, with dense tall eucalypt woodland with a shrubby understorey and mid-high grasses, with deep loamy surface yellow duplex soil (Group 6), (Db2.23) – Subnatric Brown Sodosol.							
0-0.1 (0.05)	6	A	Clay Loam (CL) low to medium plasticity, very dark grey-brown (10YR3/2), weak fine prismatic tending to massive apedal loose with some cohesive aggregates, friable (F. D. C.) 15-20 % fine (Fe) gravel and s/r-s/a (Si) stone (2-10 mm).	6.2 (6.5)	0.023 (0.06)	6	Suitable topsoil resource.
0.1-0.3 (0.2)		B1	Clay (CH) high plasticity, dark grey-brown (10YR4/2) diffusely mottled yellow-brown (10YR5/6), weak fine to medium prismatic structure (St. M. C.) with 30% s/a EW rock fragments.	6.2 (6.5)	0.019 (0.07)	6	Suitable as topsoil supplement.
0.3-0.55 (0.4)		B21	Clay (CH) high plasticity, dark brown (10YR3/3) diffusely mottled yellow-brown (10YR4/4), weak fine to medium prismatic structure (VSt. D. C.).	6.5 (6.6)	0.161 (0.31)	2(1)	Slightly sodic, slightly saline, mod. Dispersive.
0.55-0.95 (0.8)		B22	Clay (CH) high plasticity, yellowish-brown (10YR5/8), massive, cohesive apedal (VSt. D.-M. C.) some flecks of soft EW rock.	7.9 (8.3)	0.415 (0.73)	2(1)	Slightly sodic, mod. saline and mod. Dispersive.
0.95-1.5 (1.3)		B-C	Clay (CL) medium plasticity, yellowish-brown (10YR5/8) weak fine blocky-prismatic structure, friable (St. D. C.) 25% s/r WR gravel.	7.9 (8.5)	0.335 (0.50)	6	Slightly sodic, slightly to mod. Saline.
Soil/ Landscape Notes:- #24 – Rounded hill crest in terrain unit Cw6/5 with medium dense eucalypt woodland with a dense shrubby under-storey and mid-high grasses, with loamy surface red duplex soils (Dr2.31) – Bleached-Ferric Red Chromosol							
0-0.2 (0.1)	5	A1	Gravelly Clay Loam (GC-CL),) low to medium plasticity, apedal massive granular loose, with 40-45% r-s/r-s/a (Fe) gravel and stone (2-25 mm).	5.8	0.014	6	Suitable topsoil resource.
0.2-0.4 (0.3)		A2 (Pale)	Clayey Gravel (GC) with 30-35% clay fines of medium plasticity, dark brown (10YR3/3), massive granular loose with 60% r-s/r (Fe) fine gravel and s/r-s/a stone (2-25 mm).	6.4	0.006	6	Excessively gravelly for topsoil use.

Soil Characterisation & Indicative Testing

Appendix A

Horizon/ (Sample) Depth (m)	Soil Group/ Soil Type	Soil Horizon	Soil Description	Soil pH (1:5 H_2O)	EC (1:5 H_2O) (mS/cm)	Dispersion Class No.	Comments
0.4-0.7 (0.6)		B-C	Clay (CL-CH) medium to high plasticity, yellowish-red (5YR5/8) , mod. strong fine prismatic structure, crumbly (St. D. C.) with 30% soft EW rock fragments.	6.1	0.020	6	Non-dispersive, rough ped fabric.
0.7-1.5+		C	EW-HW Rock – mudstone, with 30% sandy clay fines of medium to high plasticity, 70% s/r-s/a EW rock fragments (2-25 mm).	7.2	0.239	6	Non-dispersive, slightly saline.
Soil/ Landscape Notes:- #25 – Gently inclined footslope in terrain unit Cw5/5-7 with medium dense low shrubby woodland and mid-high grasses, with gravelly loamy surface brown duplex soils with a bleached subsurface (A2) horizon (Db1.41) – Bleached-Sodic Brown Kurosol.							
0-0.15 (0.1)	5	A1	Gravelly Silt Loam (CL-ML) low to medium plasticity, dark grey-brown (10YR4/2), massive apedal, granular loose with 30-40% fine (Fe) gravel and s/r-s/a (Si) stone (2-20 mm).	5.8	0.031	6	Marginal for topsoil use, high silt content will tend to develop bulldust when reworked.
0.15-0.25 (0.2)		A2 (bleach)	Gravelly Silt Loam-Loamy Gravel (GM-ML) low plasticity pale brown [10YR6/3 – 10YR7/2 (d)] massive apedal granular loose, with 50% fine (Fe) gravel and s/r-s/a (Si) stone (2-20 mm).	6.1	0.009	6	Unsuitable for use as topsoil due to high stone and silt content.
0.25-0.7 (0.4)		B21	Clay (CH) high plasticity, dark yellowish-brown (10YR4/6), mod. strong fine to medium blocky structure,(VSt. D. C.) with 10-15% fine rounded (Fe) gravel and HW rock fragments.	4.8	0.270	6	Very strongly acidic.
0.7-1.2 (0.9)		B-C	Clay (CH) high plasticity, yellowish-brown (10YR5/8) diffusely mottled brownish-grey, massive apedal cohesive (VSt. D.-M. C.), some HW rock gravelly inclusions.	4.9	0.592	6	Very strongly acidic. Non-dispersive, slightly to mod. Saline.
1.2-1.5+ (0.9)		C	EW-HW Rock – mudstone.	6.6	1.011	6	Mod. to high salinity.

Soil Characterisation & Indicative Testing

Appendix A

Horizon/ (Sample) Depth (m)	Soil Group/ Soil Type	Soil Horizon	Soil Description	Soil pH (1:5 H_2O)	EC (1:5 H_2O) (mS/cm)	Dispersion Class No.	Comments
Soil/ Landscape Notes:- #26 – Gently inclined footslope in the head of a narrow valley floor in terrain unit Cw5/5-7 with medium dense tall mixed melaleuca and eucalypt woodland with sparse to medium dense mid-high grasses, with medium deep stony loamy surface brown duplex soil (K-Db3.51 – Mottled Red Kurosol.							
0-0.15 (0.1)	5	A	Gravelly Loam (GC-CL),) low plasticity, dark brown (10YR3/3), massive apedal granular loose with 50% r-s/r (Fe) fine gravel and s/r-s/a stone (2-15 mm).	5.7	0.020	6	Marginal as a topsoil resource due to low PAWC and high gravel content.
0.15-0.5 (0.35)		B1	Clayey Gravel (GC) with 40% clay fines of medium to high plasticity, dark brown (10YR3/3), massive apedal granular loose with50-60% r-s/r (Fe) fine gravel and s/r-s/a stone (2-20 mm).	5.4	0.028	6	Strongly acidic, non-dispersive.
0.5-0.7 (0.6)		B2	Clayey Gravel (GC) with 25-30% clay fines of medium to high plasticity, yellowish-red (5YR5/6), massive apedal granular loose with 60-70% r-s/r (Fe) fine gravel and s/r-s/a stone (2-25 mm).	5.1	0.037	6	Strongly acidic, non-dispersive.
0.7-1.2 (1.0)		B-C	Clay (CH) high plasticity, variegated reddish-grey (5YR5/2) and dark red (2.5YR4/6) with inclusions of white cherty gravel.	4.6	0.281	6	Strongly acidic, non-dispersive.
1.2+		C	HW Rock – mudstone.				

Note: The data shown in parenthesis included in columns 5 and 6 is the equivalent analytical test result for the soil sample.

Abbreviations & Symbols Used in Table:

C.	Consistence	5YR4/6	Munsell Colour - (d) dry	Shape:	
VSt.	Very Strong	Mod.	Moderate or moderately	s/r	Sub-rounded
St.	Strong	EW	Extremely Weathered	r	Rounded
M.	Moist	HW	Highly Weathered	s/a	Sub-angular
D.	Dry	SM	Self-mulching	a	Angular
Sf.	Stiff	Fe	Ferruginous	Mn	Manganese
F.	Firm	Si	Siliceous		
S.	Soft	CO_3	Carbonate		

Soil Characterisation & Indicative Testing | Appendix A

Soil Plates

Plate A-1 **Site #1, Group 7 soil (Type 7.3) – uniform, acidic, saline clay in terrain unit Qe2/7.3**

Plate A-2 **Site #3, Group 4 soil - shallow uniform gravelly loam in terrain unit Cw4/4-7**

Plate A-3 Site #2, Group 5 soil - shallow acidic brown duplex soil in terrain unit Cw5/5-7

Plate A-4 Site #14, Group 7 soil (Type 7.3) – gradational acidic structured alluvial clay soil in terrain unit Cw5/5-7

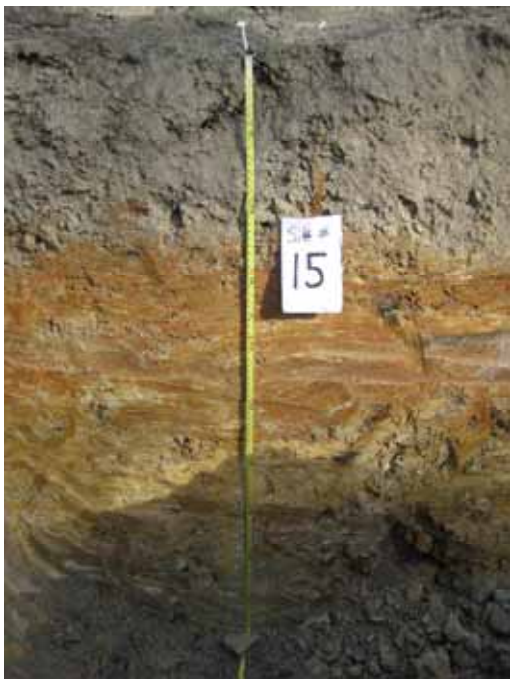

Plate A-5 **Site #15, Group 5 soil – gravelly red duplex soil in terrain unit Cw5/5-7**

Plate A-6 **Site #11, Group 5 soil – bleached red duplex soil in terrain unit Cw6/5**

Plate A-7 Site #24, Group 5 soil – loamy surface red duplex soil in terrain unit Cw6/5

Plate A-8 Site #6, Group 7 soil (Type 7.1) – shallow gravelly clay soil in terrain unit Cw7/4-7

Plate A-9 Site #17, Group 7 soil (Type 7.1) – shallow gradational gravelly clay soil in terrain unit Cw7/4-7

Plate A-10 Site #18, Group 4 soil – shallow uniform gravelly loam in terrain unit Cw7/4-7

Plate A-11 Site #5, Group 7 soil (Type 7.1) – gradational gravelly clay soil in terrain unit Cw8/7.1

Plate A-12 Site #9, Group 7 soil (Type 7.2) – uniform (non-cracking) pale grey clay soil in terrain unit Qa2/6-7

Plate A-13 **Site #13, Group 7 soil (Type 7.3) – uniform fine-textured stratified alluvial clay soil in terrain unit Qa2/6-7**

Plate A-14 **Site #23, Group 6 soil – loamy surface alkaline yellow duplex soil in terrain unit Qa2/6-7**

Description & Assessment of Terrain Units

Appendix B

Table B-1 Terrain Unit Descriptions and Assessment of Engineering and Environmental Attributes

Terrain Unit	Landform	Soils	Area (ha)	Reactive Soils	Soil Salinity	ESP	Drainage Status	Dispersion	Erosion Potential	Remarks
Geological Regime: - (Qe) Quaternary (Holocene) estuarine delta and coastal marine deposits (Qe), comprising saline silty clays, and clays, saline muds and sands.										
Qe0/9	Estuarine/marine tidal mangrove flats with mangroves fringing tidal inlets; slopes 1%	Uniform, gradational and weak duplex soils with a thin silty clay to silty clay loam surface soil over permanently saturated often gleyed saline clays, clayey silt, silty sand or sandy mud subsoils.	159.6	R1	H	2	F4	N	L-M	Subject to tidal inundation; deep soft saturated soils; includes potential acid sulfate soil (PASS) sediments
Qe1/7-9	Extra-tidal estuarine/ marine coastal flats and coastal mudflats; subject to periodic tidal inundation; overall slopes <1%	Thin silty clay or silt loamy surface soils with saturated gleyed, saline clays, clayey silt, silty sand, sandy mud subsoils, with some uniform acidic and mod. saline clays (Type 7.3) around the inland margins.	188.6	R1	H	2	F3	N	M (Wind)	Subject to periodic tidal inundation; may include PASS and actual acid sulfate soil sediments (ASS).
Qe2/7.3	Slightly elevated coastal plain locally adjacent to the landward fringe of the estuarine/coastal flats; slopes <1%	Deep uniform clay soils (Type 7.3), with acidic brown silty clay or heavy clay surface soils over red and grey diffusely mottled strongly acidic medium to heavy clay subsoils, with mod. to highly saline highly acidic heavy clay deep subsoils	11.7	R1	H (Subsoil)	2-3	F1	M	M	In places mod. dispersive and strongly acidic in the topsoil silty clay soils; strongly acidic, highly sodic and mod. to strongly saline in the deeper subsoils
Geological Regime: - (Qa) Quaternary Alluvium on tributary stream terraces, floodplains and older alluvial valley flats; sand, silt, clay and gravel deposits.										
Qa2/6-7	Flat to gently undulating alluvial valley flats with narrow stream terraces fringing narrow drainage slopes mostly <2%	Mixed association of thin brown clay loamy surface duplex soils with diffusely mottled brown and yellowish brown alkaline sodic and mod. saline heavy clay sub-soils, and, deep uniform clay soils (Type7.2) with blocky-prismatic structure becoming massive mottled grey and yellow-brown slightly acidic to alkaline, sodic and mod. saline heavy clay subsoils.	154.4	R1-R2	M-H (Subsoil)	2-3	F1-F2	M	M-H	Dispersive and slightly sodic, surficial soil layers becoming sodic to strongly sodic with depth; very low Ca and high Mg levels (low Ca/Mg ratio) throughout the profile

Description & Assessment of Terrain Units

Appendix B

Terrain Unit	Landform	Soils	Area (ha)	Reactive Soils	Soil Salinity	ESP	Drainage Status	Dispersion	Erosion Potential	Remarks
Geological Regime: - (Cw) Carboniferous Wandilla Formation comprising mudstone, lithic sandstone, quartz greywacke, siltstone, jasper, chert, slate and schist.										
Cw3/5-7	Undulating plains and lowlands, undulating valley floors; slopes 1-3%	Medium to deep (Group 5) clay loam and silt loamy surface duplex soils in association with gradational fine-textured clay soils (Type 7.3), - as for terrain unit Cw5/5-7	98.2	R1 (Subsoil)	L, M (On lower slopes)	N-1, 3 (Locally in lower – lying parts)	W	N, M (Locally)	L-M	The surficial soil hor-izons (0.5 m) typically contain 40-60% fine to coarse gravel and stone
Cw4/4-7	Undulating plains, dissection slope interfluves, low rises and locally low saddles between higher hilly lands; slopes3-7%	Shallow (<0.5 m) uniform brown friable to granular clay loam surface soils with 30% fine to coarse gravelly inclusions over gravelly loam-loamy gravel sub-soil (A2) horizons over HW rock on mid to lower slopes, together with shallow uniform clays or gravelly clay soils (Type7.1) with reddish-brown to yellow-brown medium to heavy clay or gravelly clay subsoils underlain by HW rock on broad rounded rises and on low saddles	139.9	L-R1	L	N-1	W	N, , M (Locally)	L-M	The surficial soil hor-izons (0.5 m) typically contain 40-60% fine to coarse gravel and stone which could be separated to improve topsoil quality and availability
Cw5/5-7	Gently to moderately inclined planar to concave intermediate to lower hill and ridge slopes and broadly rounded dissection slope interfluves; slopes variable mostly 5-12%	Medium to deep clay loam, silt loam and gravelly silt loamy surface duplex soils in places with a pale thin gravelly loam subsurface (A2) horizon over sandy clay, gravelly clay or medium to heavy or heavy acidic, sodic clay subsoils, locally occurring in association with medium to deep gradational fine-textured clay soils (Type 7.3) with apedal tending to granular clay loam surface soils over brown or red brown weakly structured, tending to massive acidic clay subsoils on some lower footslopes	350.5	R1 (Subsoil)	L, M (On some lower foot-slopes)	N-1, 3 (Locally in lower-lying parts)	I	N (Upper) M (Deeper subsoil)	M-H	The surficial soil hor-izons (0.5 m) typically contain 40-60% fine to coarse gravel and stone, In some narrow valley floors, silt loamy surface duplex soils occur in which, the clayey subsoils may be dispersive sodic to strongly sodic and mod. saline

Description & Assessment of Terrain Units

Appendix B

Terrain Unit	Landform	Soils	Area (ha)	Reactive Soils	Soil Salinity	ESP	Drainage Status	Dispersion	Erosion Potential	Remarks
Cw6/5	Low rounded hills and rises and low hilly lands mostly with broadly rounded crestal areas and hill slopes mostly in the range 12-25%;	Medium to deep (0.5-1.5 m) dark brown gravelly loam surface duplex soils with a pale gravelly loam or gravelly clay (A2) horizon, over red, red brown, yellow brown and pale grey variegated medium to heavy or heavy structured clay subsoils	240.5	R1 (Subsoil)	L	2 (Deeper subsoil)	W-I	Sl (Locally in surface soil),	M-H	The surficial soil horizons (0.5 m) have 40-60% fine to coarse gravel and stone. The HW rock substrate fines may be dispersive
Cw7/4-7	Steep hilly lands mostly with narrow rounded hill and ridge crests and steep irregular planar hill and ridge slopes in the range 20 to 40%	Shallow (<0.5 m) uniform dark grey gravelly silt loam (Group 4) soils, together with shallow gradational gravelly loam over gravelly medium to heavy clay soils (Type 7.1) on crests and upper marginal slopes; medium to deep uniform to weakly gradational (Type 7.3) soils with reddish brown gravelly clay loam to clayey gravel surface soils over reddish brown or yellowish brown medium to heavy acidic clay or gravelly clay subsoils, occur on the hill slopes	416.7	L-R1	L	2 (Deeper subsoil)	X	Sl-M (Surface soil),	M-H	The surficial soil horizons typically contain 40-60% fine to coarse gravel and stone which could be separated to provide better quality topsoil resources; the clayey fines and deeper clayey subsoils may locally be slightly to mod. dispersive
Cw8/7.1	Steep to very steep ridges and high hilly lands mostly with narrow rounded crests on ridges and spur with slopes typically in the range 30-50%,	Shallow to medium deep (0.5-0.8 m) weakly gradational to uniform fine-textured soils with dark brown clay loam or gravelly loam surface soils, with a paler (A2) sub-surface clayey gravel-gravelly clay horizon over yellowish red to red finely structured heavy clay subsoil underlain by HW rock	86.6	R1 (Subsoil)	L	1 (Deeper subsoil)	X	Sl (Surface soil), M (HW rock)	M-H	Sodic, mod. dispersive and highly magnesic in the deeper (B-C) horizon; the weathered rock substrate comprises mainly sandstone and clayey sandstone

B.1.1 Basis for the Assessment of Engineering / Environmental Attributes

Soil Reactivity

L – Nil or low soil reactivity, predominantly sandy coarse-textured soils with Kaolin clay minerals where present

R1 – Moderately reactive soils, i.e. soils which have medium to heavy clay subsoils, but are not subject to substantial soil swelling or shrinkage; mainly Illite clay minerals present

R2 – Shallow or medium deep, highly reactive (cracking) clay soils, underlain by low or non-reactive substrate soils or weathered rock;

R3 – Deep, highly reactive (cracking) clay soils subject to substantial swelling and shrinkage on wetting and drying; mainly Smectite clay minerals present.

Soil Salinity: (E.C. – 1:5 H_20)

Rating L – E.C (mS/cm) <0.25 (sand), <0.4 (loam), <0.55 (clay) – Nil to Low Salinity
Rating M – E.C (mS/cm) 0.25-0.47 (sand), 0.4-0.8 (loam), 0.55-1.15 (clay) – Medium Salinity
Rating H – E.C (mS/cm) >0.47 (sand), >0.8 (loam),>1.15 (clay) – High to Very High Salinity

Sodicity (ESP):

N – very low or non Sodic, ESP <6%
Rating 1 – Sodic, ESP 6-14%
Rating 2 – Strongly sodic, ESP 14-25%
Rating 3 - Very strongly sodic, ESP >25%

Drainage Status:

W - Moderately well to well drained, not floodprone.

I – Impeded drainage, subject to seasonally perched watertable, surface ponding in gilgai depressions.

X – Excessively well-drained (steep slopes, rapid runoff).

F1 – Subject to surface sheet flow/short term flash flooding; prone to tidal inundation on rare occasions.

F2 – Rarely floodprone but may be prone to local surface ponding of short-term duration (>10 year flooding frequency).

F3 – Occasionally floodprone and/or prone to surface water ponding (2-10 year flooding frequency); prone to tidal inundation due to extra high tides.

F4 – Subject to regular flooding (<2 year flooding frequency); frequently prone to tidal inundation. .

Dispersion Class:

Rating N – Non-dispersive [Dispersion Classes 4, 6, 7 and 8]
Rating Sl – Slightly Dispersive [Dispersion Classes 5, 3(1) & 3(2)]
Rating M – Moderately Dispersive [Dispersion Classes 3(3) to 2(2)]
Rating H – Strongly dispersive [Dispersion Classes 2(3) to 1]

* Dispersion Sub Classes (Charman, 1978)
(1) - Slight milkiness adjacent to the aggregates
(2) - Obvious milkiness, < 50% of the aggregates affected
(3) - Obvious milkiness, >50% of the aggregate affected
(4) - Total dispersion leaving only sand grains.

Erosion Potential: See Appendix 4.1 for the Basis of the Assessment of Erosion Potential

Rating L – Low; the combination of surface slope, run-on/run-off and soil erodibility is such that no appreciable erosion damage is anticipated.

Rating M – Moderate; significant short term erosion is likely to occur due to the combination of slope, soil erodibility factors and extent of run-on/run-off; some slight to moderately dispersive soil layers may be present.

Rating H -High to Very High; Erosion losses are likely due to steepness of slopes, soil erodibility factors and surface runon/runoff conditions. Intensive soil conservation works will be required to minimise the effects of erosion. Moderately high to highly dispersive soil layers may be present.

Soil Analytical Data Appendix C

Table C-1 Laboratory Analytical Data 1 of 2

Analysis	Site No.	1-1	1-2	1-3	5-1	5-2	5-3	5-4	9-1	9-2	9-3	9-4
	Depth (m)	0.15	0.45	1.30	0.10	0.30	0.65	1.05	0.06	0.20	0.50	0.85
	Terrain Unit	Qe2/7.3 (Coastal flat)			Cw8/7.1 (Mid slope)				Qa2/6-7 (Alluvial valley floor)			
pH (1:5 H_2O)	mg/kg	5.58	5.41	5.43	5.74	5.91	6.71	6.80	5.85	6.10	6.84	8.02
Nitrate Nitrogen	mg/kg	6	1	<1	18	1	<1	<1	3	2	<1	1
Phosphorus (P)	mg/kg	5	21	32	10	4	1	3	3	2	3	1
Potassium (K)	mg/kg	34	34	189	193	71	54	64	62	63	55	72
Sulphur (S)	mg/kg	7.1	63.1	126.5	11.2	11.7	6.5	5.5	8.4	5.5	37.5	75.8
Aluminium	mg/kg	14	29	17	21	56	26	41	62	153	8	9
Calcium	mg/kg	161	106	206	1373	236	23	17	624	696	1291	1354
Magnesium (Mg)	mg/kg	279	405	740	906	631	2814	4179	679	1000	1734	1678
Boron (B)	mg/kg	0.9	1.4	3.7	1.4	0.9	0.7	0.5	1.0	1.4	3.8	3.2
Copper (Cu)	mg/kg	3.4	1.8	2.3	11.5	7.3	3.3	7.0	4.1	3.7	2.2	1.0
Iron (Fe)	mg/kg	142	101	60	125	153	26	71	300	106	43	41
Manganese (Mn)	mg/kg	12	9	3	174	63	8	1	16	26	11	10
Zinc (Zn)	mg/kg	1.0	0.6	0.5	3.1	1.1	2.1	2.9	0.8	0.5	0.5	0.5
Organic Matter	%	0.8	0.7	0.4	6.8	3.8	0.9	0.6	1.8	1.4	1.4	0.7
EC (1:5 H_2O)	dS/m	0.25	0.25	1.36	0.12	0.06	0.05	0.14	0.08	0.06	0.37	0.95

Soil Analytical Data

Appendix C

Analysis	Site No.	1-1	1-2	1-3	5-1	5-2	5-3	5-4	9-1	9-2	9-3	9-4
	Depth (m)	0.15	0.45	1.30	0.10	0.30	0.65	1.05	0.06	0.20	0.50	0.85
	Terrain Unit	Qe2/7.3 (Coastal flat)			Cw8/7.1 (Mid slope)				Qa2/6-7 (Alluvial valley floor)			
Chloride (Cl)	mg/kg	346	303	1812	86	37	36	83	50	31	379	1080
Sodium (Na)	mg/kg	172	263	1426	116	72	283	996	160	253	1015	1693
Ex. Sodium	meq/100g	0.75	1.14	6.20	0.51	0.31	1.23	4.33	0.70	1.10	4.41	7.36
Ex. Potassium	meg/100g	0.09	0.09	0.48	0.50	0.18	0.14	0.17	0.16	0.16	.014	0.18
Ex. Calcium	meg/100g	0.81	0.53	1.03	6.86	1.18	0.12	0.08	3.12	3.48	6.45	6.77
Ex. Magnesium	meg/100g	2.33	3.37	6.17	7.55	5.25	23.45	34.83	5.66	8.33	14.45	13.98
Ex. Aluminium	meg/100g	-	0.33	0.19	-	-	-	-	-	-	-	-
CEC – (ECEC)	%	3.97	5.46	14.07	15.41	6.93	24.93	39.41	9.63	13.07	25.46	28.30
Ex. Na % (ESP)	%	18.9	20.9	44.1	3.3	4.5	4.9	11.0	7.2	8.4	17.3	26.0
Ex. %	%	2.2	1.6	3.4	3.2	2.6	0.6	0.4	1.6	1.2	0.6	0.7
Ex. Ca %	%	20.3	9.7	7.3	44.5	17.0	0.5	0.2	32.4	26.6	25.3	23.9
Ex. Mg %	%	58.6	61.7	43.8	49.0	75.8	94.0	88.4	58.7	63.7	56.8	49.4
Ex. Al %	%	-	6.0	1.3	-	-	-	-	-	-	-	-
Ca/Mg	Ratio	0.35	0.16	0.17	0.91	0.22	<0.01	<0.01	0.55	0.42	0.45	0.48

Soil Analytical Data Appendix C

Table C-2 Laboratory Analytical Data 2 of 2

Analysis	Site No.	14-1	14-2	14-3	14-4	22-1	22-2	22-3	23-1	23-2	23-3	23-4	23-5
	Depth (m)	0.08	0.20	0.35	1.0	0.05	0.40	1.40	0.05	0.18	0.40	0.80	1.30
	Terrain Unit	Cw5/5-7 – Qa2/6-7 (Footslope transition)				Cw5/5-7 (Footslope)			Qa2/6-7 (Alluvial valley floor)				
pH (1:5 H_2O)	mg/kg	6.09	5.95	6.04	6.10	5.83	6.25	7.46	6.52	6.47	6.56	8.30	8.53
Nitrate Nitrogen	mg/kg	13	5	2	<1	<1	<1	<1	6	<1	<1	15	1
Phosphorus (P)	mg/kg	4	2	1	20	3	2	5	4	2	8	3	3
Potassium (K)	mg/kg	117	63	59	49	105	78	67	211	200	100	74	45
Sulphur (S)	mg/kg	4.8	3.5	8.4	20.6	7.3	39.7	47.9	4.1	6.3	15.5	23.2	12.9
Aluminium	mg/kg	16	59	33	28	89	25	17	6	12	8	11	12
Calcium	mg/kg	455	45	30	96	112	36	45	1401	1904	2388	2989	2475
Magnesium (Mg)	mg/kg	359	260	360	630	424	1593	1160	883	1871	2270	2579	2210
Boron (B)	mg/kg	1.1	0.9	0.9	1.2	1.1	1.1	0.8	1.3	0.9	0.8	1.5	1.1
Copper (Cu)	mg/kg	2.6	3.0	1.8	0.8	1.7	0.9	0.7	3.0	3.5	3.2	0.7	0.4
Iron (Fe)	mg/kg	151	102	45	39	1201	43	107	134	83	68	28	16
Manganese (Mn)	mg/kg	66	45	36	5	12	<1	4	46	12	27	5	1
Zinc (Zn)	mg/kg	1.1	0.4	0.3	0.4	2.6	0.4	0.8	0.9	0.4	0.9	0.9	0.4
Organic Matter	%	3.6	1.9	0.9	1.7	2.6	1.4	0.5	2.7	2.0	1.7	0.8	0.3
EC (1:5 H_2O)	dS/m	0.06	0.03	0.03	0.04	0.07	0.38	0.62	0.06	0.07	0.31	0.73	0.50

Soil Analytical Data

Appendix C

Analysis	Site No.	14-1	14-2	14-3	14-4	22-1	22-2	22-3	23-1	23-2	23-3	23-4	23-5
	Depth (m)	0.08	0.20	0.35	1.0	0.05	0.40	1.40	0.05	0.18	0.40	0.80	1.30
	Terrain Unit	Cw5/5-7 – Qa2/6-7 (Footslope transition)				Cw5/5-7 (Footslope)			Qa2/6-7 (Alluvial valley floor)				
Chloride (Cl)	mg/kg	21	6	7	12	45	413	676	23	37	380	916	582
Sodium (Na)	mg/kg	49	39	34	95	108	800	1736	85	197	461	814	828
Ex. Sodium	meq/100g	0.21	0.17	0.15	0.41	0.47	3.48	7.55	0.37	0.86	2.00	3.54	3.60
Ex. Potassium	meg/100g	0.30	0.16	0.15	0.12	0.27	0.20	0.17	0.54	0.51	0.26	0.19	0.12
Ex. Calcium	meg/100g	2.28	0.23	0.15	0.48	0.56	0.18	0.22	7.01	9.52	11.94	14.95	12.38
Ex. Magnesium	meg/100g	3.00	2.17	3.00	5.25	3.53	13.28	9.67	7.36	15.59	18.91	21.49	18.42
Ex. Aluminium	meg/100g	-	-	-	-	-	-	-	-	-	-	-	-
CEC – (ECEC)	%	5.78	2.72	3.44	6.26	4.83	17.14	17.61	15.28	26.48	33.12	40.17	34.51
Ex. Na % (ESP)	%	3.7	6.2	4.2	6.6	9.7	20.3	42.9	2.4	3.2	6.1	8.8	10.4
Ex. %	%	5.2	6.0	4.4	2.0	5.6	1.2	1.0	3.5	1.9	0.8	0.5	0.3
Ex. Ca %	%	39.4	8.3	4.3	7.7	11.6	1.1	1.3	45.9	35.9	36.1	37.2	35.9
Ex. Mg %	%	51.8	79.6	87.0	83.8	73.1	77.5	54.9	48.2	58.9	57.1	53.5	53.4
Ex. Al %	%	-	-	-	-	-	-	-	-	-	-	-	-
Ca/Mg	Ratio	0.76	0.10	0.05	0.09	0.16	0.01	0.02	0.95	0.61	0.63	0.70	0.67

Soil Erosion Potential & Mitigation Measures

Appendix D

D.1 Basis of the Assessment for Erosion Potential

The susceptibility of different soil types to erosion (soil erodibility) is a function of soil texture, and physical and chemical properties. The extent to which an area may be subject to erosion (erosion potential) is a function of soil erodibility and other factors such as surface slope and form, topographic position in the landscape (runon/runoff), rainfall intensity, surface condition and surface/plant cover.

Soil erodibility classes identified by Mills and Murphy, (1977) are summarised as follows:

- *Low Erodibility* – soils with high amounts of organic matter (OM), with surficial soils comprising sand or loamy sand (permitting high infiltration), or aggregated non-dispersive clay surface and/or subsoils;
- *Moderate Erodibility*:- soils with medium levels of OM, with surface soils comprising medium amounts of sand, silt and clay i.e. medium-textured (loamy) surface soils, with slightly dispersive (Dispersion Class Nos. 3 or 5) or aggregated slightly dispersive clay surface and/or subsoils;
- *High Erodibility*:- soils with low levels of OM, soils with bleached (A2) subsoil horizons with high amounts of fine sand and/or silt, soils with a fine strongly structured (self-mulching) clayey surface horizon, or moderately to highly dispersive clayey surface and/or subsoils (Dispersion Class Nos. 1 or 2)

The potential for accelerated erosion to occur (erosion potential) due to construction activities in the project area as a result of clearing and/or surface disturbance has been assessed as follows:

- Low (L) - The combination of surface slope, run-on/run-off and soil erodibility is such that no appreciable erosion damage is anticipated.
- Moderate (M) - Significant short term erosion is likely to occur due to the combination of slope, soil erodibility factors and extent of run-on/run-off. Erosion control can be achieved using structural works, topsoiling and re-vegetation techniques, and other site specific intensive soil conservation works. Some slightly dispersive soil layers may be present in the profile.
- High (H) - High to very high erosion/sediment losses are likely, due to steepness of slopes, surface condition, soil texture and erodibility factors and surface runoff conditions. Intensive soil conservation works will be required to minimise the effects of erosion. Moderately high to highly dispersive soil layers are usually present within the soil profile.

D.2 Erosion Control Measures

The following erosion control measures and topsoil management strategies are based on the Engineering Guidelines for Queensland for Soil Erosion and Sediment Control (Institute of Engineers Australia et al. 1996). The Department of Conservation and Land Management (1992). Where appropriate, these strategies will be undertaken to reduce erosion and sediment loss from disturbed areas during the construction period and ongoing site operations.

Soil Erosion Potential & Mitigation Measures

Infrastructure and Development Areas

Erosion on construction areas cannot be eliminated completely, but measures can be taken to minimise the impact by:

- Limiting the area disturbed, and clearing progressively, immediately prior to construction activities commencing;
- Safeguarding the surface layer by stripping and stockpiling topsoil prior to construction;
- Using temporary soil diversion mounds to control runoff within and divert water away from the construction site where practicable;
- Minimising the period that bare soil is left exposed to erosion;
- Using sediment traps/silt fences etc. to minimise off-site effects of erosion;
- Where practicable organic mulching and/or planting of bare soil surfaces will be undertaken to reduce the effects of wind erosion and dust generation; and
- The site environmental officer will be responsible for maintaining a regular site monitoring program to ensure that the erosion control measures implemented are effective. Where necessary an environmental management plan will be implemented to address any new or ongoing problem areas.

The control of erosion and sediment movement throughout the site will be necessary both during the construction stage and subsequently during the operating life of the facility. Where access is required for temporary use only, disturbed areas will be lightly ripped, restored to a stable condition and re-vegetated or returned to their pre-disturbance land use condition as soon as practicable following the completion of construction. Particular attention will be paid to those areas known to include dispersive soils to ensure that if exposed do not remain untreated or unprotected

Pipelines, and Power Transmission Line Routes

The following erosion control measures are typically used to minimise the potential impact of erosion and to control sediment loss from the right-of-way:

- Disturbance of topsoil and vegetation along easements will be limited to the minimum practicable. The use of selective clearing techniques which cause a minimum of disturbance to surface conditions will be employed wherever practicable. Millable timber resources will be identified and salvaged where practicable and economically feasible.
- Where trenches are required for pipelines or buried services, useable topsoil material will be stripped and stockpiled separately adjacent to and along the trench. Subsurface materials will be excavated and stockpiled separately along the opposite side of the trench. Backfilling of the trench will be done in reverse order.
- In sloping ground and in particular on slopes to drainage lines where surface runoff or sub-surface drainage along the trench may erode the backfill material, trench-breakers (vertical barriers to flow) will be installed to reduce flow along the trench and promote seepage outflow to the groundwater. This will apply in particular where sodic and/or dispersive soils occur.

Soil Erosion Potential & Mitigation Measures

- Where significant disturbance of the ground surface is necessary, topsoil will be removed from the area to be disturbed and stockpiled as work commences. Upon completion of work, the topsoil will be re-spread over any exposed subsoil areas, and the areas of disturbance stabilized by establishing suitable species of vegetation.
- In areas where diversion channels and culverts are proposed to divert flow and control runoff, the outlets may be prone to erosion and require scour protection. This can be achieved by establishing vegetation growth at these outlets. The outlets will be formed to a broad dish shape before seeding, to minimise the concentration of run-off. Rock armouring may be required at some outlets to dissipate the force of water and so reduce erosion.
- Along the alignment right-of-way of line-of route facilities such as transmission lines or pipelines, where vegetation is required to be cleared for construction purposes, the cleared vegetation will be windrowed along the edge of the working area to help control runoff and to allow for efficient re-spreading of vegetation if appropriate, following the completion of construction.

Access Roads, Service Roads and Temporary Access Tracks

- Major access roads will normally be sealed and constructed to appropriate local engineering design standards.
- Unsealed or gravelled service tracks will be graded to a crown and provided with efficient surface drainage to prevent runoff eroding either the road surface or the adjacent land. Where necessary, low mounds angled across the track will be construction to divert runoff (at non-erosive velocity) into adjacent areas.
- Cut and fill batters associated with service tracks will be formed to a safe slope and stabilized by vegetation, stone or rock armouring, or by the use of geo-fabric where appropriate.
- Where table drains need to be established, they will be constructed to a broad dish shape, seeded and fertilized or lined appropriately, to prevent erosion. Table-drains will be slashed periodically to ensure vegetation growth is not restricting drainage flow.
- Approaches on service tracks to gully and creek crossings will be flat as practicable. The track will be sloped to direct runoff to a table-drain constructed as above. In some vulnerable areas, it may be necessary to spread and compact coarse aggregate along the approaches to the crossing to provide, permanent, stable access, and reduce erosion.
- Where provision of access across gullies or creeks cause disturbance, re-vegetation work will be undertaken.
- All temporary construction tracks and associated disturbed areas will be ripped, seeded and fertilized when construction is completed. Stockpiled topsoil will be re-spread before sowing. On steeper slopes the seeded areas will be protected if necessary.

Vegetation Clearing – General

- Disturbance of vegetation in construction areas will be limited to the minimum practicable.
- Selective clearing techniques will be used where practicable which will cause a minimum of disturbance to surface conditions.

Soil Erosion Potential & Mitigation Measures

Appendix D

- Chipping of smaller branches and foliage from the clearing operations in areas of high and very high erosion potential will provide a useful form of surface mulch to reduce surface erosion in the rehabilitation area.
- Any millable timber resources will be identified and salvaged during the site clearing process, if practicable and economically feasible.
- Clearing will be carried out in such a manner that seed/root stock is left in the ground and surface soils are disturbed as little as possible.

Land Suitability Classes & Limitations

Appendix E

E.1 Land Suitability Classes and Limitations for Rainfed Cropping and Grazing

[Tables (E-1-E3) present criteria used for determining land suitability for broadcare cropping and for beef cattle grazing in Queensland, based on criteria proposed in guidelines for agricultural land evaluation – QDPI (1990) & Schields and Williams (1991)

Table E-1 Suitability for Rainfed Broadacre Cropping

Limitation	Land Suitability Class				
	1	2	3	4	5
Water availability (m)	PAWC >150mm	PAWC 125-150mm	PAWC 100-125mm	PAWC 75-100mm	PAWC < 75mm
Nutrient deficiency (n)	Bicarb. P>10 ppm	Bicarb. P 5-10 ppm and Exchangeable (Exch.) K >0.3 meq.%	Bicarb. P 5-10 ppm, Exch. K ≤0.3 meq.% or pH <5 (60-90cm - bgl) or pH >9 (60-90 cm- bgl)	Bicarb. P<10 ppm, Exch. K ≤0.3 meq.%, Exch. Ca<3 meq.%;or pH<5(30-60cm bgl) or pH >9 (30-60 cm bgl)	pH<5 within 30cm of surface or pH>9 within 30cm of surface
Soil physical factors – Surface condition (p3)	Cracking clays with very fine self-mulch (peds<2mm),or Rigid soils with a loose, soft or firm surface when dry	Cracking clays with fine self-mulch (peds 2-10mm)	Cracking clays with coarse self-mulch (peds 10-20mm) or Rigid soils with a hard set surface when dry	Cracking clays with coarse peds at the surface (≥20mm)	
Soil texture (pt)	Surficial sandl and/or sandy loam texture to depths of:-				
		<450mm	450-900mm	>900mm	
Gravel beds (pg)	Gravel beds (cf>60%)	>150 mm thick		<450 mm below surface	
Soil type distribution (pd)	Surface texture/soil type changes occur within a distance of:-				
		>300m	150-300m	<150m	
Soil workability (k)	Friable cracking clays (indicated by very fine self-mulch), or Rigid soils with a loose, soft or firm surface when dry	Firm cracking clays (indicated by fine self-.mulch) or Rigid soils with a hard setting surface when dry	Stiff cracking clays (indicated by coarse self-mulch with peds >10 mm, crusting or hard setting surface		
Salinity (s)	Rootzone EC <0.15 S/cm or Rootzone Cl <300 ppm	Rootzone EC 0.15-0.3 mS/cm or Rootzone Cl 300-600ppm	Rootzone EC 0.3-0.9 mS/cm or Rootzone Cl 600-900 ppm	Rootzone EC 0.9-1.2 mS/cm, or Rootzone Cl 900-1500 ppm	Rootzone EC>1.2 mS/cm or Rootzone Cl≥1500ppm
Rockiness ®	<10% coarse surface gravel (>6 cm diam.) and rock outcrop	10-20% coarse surface gravel and rock outcrop	20-50% surface cobble (6-20 cm diam.) and rock outcrop	50-90% surface cobble and rock outcrop, or 20-50% stone and boulders (>20 cm diam.)	>90% surface cobble and rock outcrop, or >50% stone and boulders and rock outcrop
Microrelief (g)	No melonholes (semi-circular depressions) <30cm deep	Melonholes 30-60cm deep cover <20% of surface area or melonholes >60 cm deep, cover 10% surface area	Melonholes 30-60cm deep cover <20-50% of surface area or melonholes >60 cm deep, cover surface 10-20%	Melonholes 60-100cm deep, cover 50% surface area	Melonholes at least 100 cm deep, cover >50% surface area
Wetness (w)	Undulating terrain or elevated plains	Low-llying level plains with gilgal covering <25% of the surface area, or Rigid soils with sodic subsoil (ESP 6-14) within 60cm of the surface, or Non-sodic rigid soils with pale grey and yellow mottles < 75 cm below surface	Low-llying level plains with gilgai covering 25-50% of the surface area, or Rigid soils with strongly sodic subsoil (ESP≥15) within 60cm of the surface, or Non-sodic, rigid soils with coarse pale grey and yellow mottles within 50cm of the surface	Seasonal swamps and low-lying run-on areas	Permanent swamps and lakes
Topography (t)	No gully dissection	Occasional deep gullies impede	Many deep gullies reduce	Many deep gullies	Abundant deep

		cultivation slightly	arable area by <33%, cultivation severely restricted	make the arable areas too small to cultivate	gullies prevent any practical cultivation
Water Erosion (e)	Slopes <0.5% on non-gilgai cracking clays, or Slopes <1% on gilgaied clays, or Slopes <1% on non-sodic rigid soils, or Slopes <0.5% on sodic rigid soils	Slopes 0.5-1% on non-gilgaied cracking clays; or Slopes 1-3% on gilgaied clays, or Slopes 1-2% on non-sodic rigid soils, or Slopes 0.5-1% on sodic rigid soils	Slopes 1-3% on cracking clays without melonholes or Slopes 2-4% on non-sodic rigid soils, or Slopes 1-2% on sodic rigid soils	Slopes 3-5% on cracking clays or Slopes 4-6% on non-sodic rigid soils, or Slopes 2-3% on sodic rigid soils	Slopes <5% on cracking clays, or Slopes >6% on non-sodic rigid soils, or Slopes >3% on sodic rigid soils
Flooding (f)	No flooding	Rare flooding (only during abnormal (1 in >10 year events)	Infrequent flooding (1 in 2-10 year events)	Periodic flooding (1 in 2 year events	Frequent and/or erosive flooding

Land Suitability Classes & Limitations

Appendix E

Table E-2 Suitability for Beef Cattle Grazing

Limitation	Land suitability Class				
	1	2	3	4	5
Water availability (m)	PAWC >125mm	PAWC 100-125mm	PAWC 75-100mm	PAWC 50-75mm	PAWC ≤ 50mm
Nutrient deficiency (n)	Brigalow, gidgee, blackwood or softwood scrub soils and former scrub soils with Bicarb. P > 10 ppm	Eucalypt vegetation and downs, with Bicarb. P > 10 ppm and other major nutrients levels rated as low	Major soil nutrients rated very low,- or Bicarb. P 5-10 ppm excludes sands and loams >75 cm deep, .	Sands and loams >75 cm deep or overlying rock at shallow depth, with Bicarb. P ≤4 ppm	
Soil physical factors (p)	Cracking clays with very fine self-mulch (<2mm), or Rigid soils with a loose, soft or firm surface when dry	Cracking clays with fine self mulch (peds 2-10mm), or Rigid soils with a hard setting surface when dry	Cracking clays with coarse peds (≥10mm) or crust on the surface		
Salinity (s)	Rootzone EC <0.15 mS/cm or Rootzone Cl <300 ppm	Rootzone EC 0.15-0.3 mS/cm or Rootzone Cl 300-600ppm	Rootzone EC 0.3-0.9 mS/cm or Rootzone Cl 600-900 ppm	Rootzone EC 0.9-1.2 mS/cm, or Rootzone C1 900-1500 ppm	Rootzone EC>1.2 mS/cm or Rootzone Cl≥1500ppm
Rockiness ®	<20% coarse surface gravel (>6 cm diam.) and rock outcrop	20-50% coarse surface gravel and rock outcrop	50-90% surface cobble and rock outcrop	>90% surface cobble and rock outcrop	Rock outcrop and surface coarse fragments cover total area
Microrelief (g)	Melonholes (gilgai - semi-circular depressions at least 30cm deep and adjacent mounds) cover <20% surface area	Shallow gilgai (30-60cm deep) cover 20-50% surface area	Deep melonholes (>60 cm deep) cover 20-50% of surface area		
pH (1:5 H_2O) (a)	5.6-6.6	6.6-8.0 5.0-5.6	8.0-9.0 4.5-5.0	9.0-10.0 4.0-4.5	>10.0 <4.0
ESP (@10cm) (s)	<5.0	5-10	10-15	15-30	>30
Wetness (w)	Undulating terrain or elevated plains	Low-lying level plains; or plains with rigid soils with strongly sodic subsoil (ESP ≥15 at< 60 cm- bgl, or Non-sodic pale grey and yellow mottled rigid soils <50 cm bgl	Shallow seasonal and permanent swamps, or drainage ways		Permanent lakes and deep swamps
Topography (t)		Occasional deep gullies impede cultivation to some extent	Overall slopes 6-15%, some gullying makes cultivation for pasture improvement difficult	Many deep gullies make cultivation for sowing pastures impractical, or Slopes >15% make contour cultivation impratical	Strongly diss-ected terrain (>75% of area), preventing adequate herd management
Water erosion (e)	Slopes <1% on sodic rigid soils or Slopes <3% on all other soils	Slopes 1-3% on sodic rigid soils or Slopes 3-6% on cracking clays, or Slopes 3-12% on non-sodic rigid soils	Slopes 3-6% on sodic rigid soils or Slopes 6-9% on cracking clays, or Slopes 12-20% on non-sodic rigid soils	Slopes 6-12% on sodic rigid soils or Slopes 9-15% on cracking clays or Slopes 20-45% on non-sodic rigid soils	Slopes >45%
Flooding (f)	Nil or rare flooding (1 in >10 year events)	Periodic flooding (1 in 2-10 year events)	Regular flooding (1 in 2 year events	Very frequent (annual) and/or erosive flooding	
Vegetation Regrowth (management limitation) (v)	Softwood, brigalow, gidgee or blackwood scrub without melonholes, or Queensland bluegrass grasslands, or Mountain coolabah, bloodwood and ironbark open woodlands	Brigalow, gidgee or blackwood scrub with melonholes, or Box and ironbark woodlands without wattle understorey, or Coolabah woodlands on flooded country	Moderate regrowth and/or weed control management required	Eucalypt woodlands with wattle understorey or Broad-leaved teatree woodlands or Major management input required to control weed and/or regrowth	

Land Suitability Classes & Limitations

Appendix E

Table E-3 Surrogate Field Properties for Estimating Plan Available Water Capacity (PAWC)

PAWC ≥ 150mm	PAWC 125-150 mm	PAWC 100-125mm	PAWC 75-100mm	PAWC 50-75mm	PAWC ≤ 50mm
Cracking clays: ≥90cm depth to weathered or hard rock	Cracking clays:≥90cm depth to weathered or hard rock	Cracking clays: alkaline to neutral pH throughout and 60-90 cm depth to 1)HW or hard rock 2) Cl≥600 ppm or 3) ESP≥15	Cracking clays: alkaline pH throughout and 40-60cm depth to weathered or hard rock	Cracking clays: alkaline pH throughout and 20-40cm depth to HW or hard rock	Cracking clays: alkaline pH throughout and ≤20cm depth to HW or hard rock
and	and	or	or	or	or
Very fine self-mulch (ped size <2 mm)	fine self-mulch (ped size <2-10 mm)				
and	and				
Infrequent cracking at surface when dry (≤1 crack per m^2)	Dense cracking at surface when dry (>1 crack per square metre)	Acid to neutral pH at depth and 60-90 cm to salt bulge with EC≥0.9 mS/cm or Cl≥900 ppm	Acid to neutral pH at depth and 40-60 cm to salt bulge with EC≥0.9 mS/cm or C1≥900 ppm	Acid to neutral pH at depth and 20-40 cm to salt bulge with EC≥0.9 mS/cm or C1≥900 ppm	Acid to neutral pH at depth and ≤20cm to salt bulge with EC≥0.8 mS/cm or C1≥800 ppm
and	and	and	and	and	and
Alkaline to neutral pH throughout	Alkaline to neutral pH throughout				
and	and				
C1>600 ppm within 90cm of the surface	C1>600 ppm within 90cm of the surface				
and	and				
ESP < 15 (< 90 cm bgl)	ESP < 15 within 90 cm of the surface				
	and				
	Rigid soils (non-sodic)	Rigid soils (non-sodic)	Rigid soils (non-sodic)	Rigid soils (non-sodic)	Rigid soils (non-sodic)
	and				
	Loams, clay loams, non-cracking clays, duplex soils and gradational earths	Loams, clay loams, non-cracking clays, duplex soils and gradational earths	Loams, clay loams, non-cracking clays, duplex soils and gradational earths	Loams, clay loams, non-cracking clays, duplex soils and gradational earths	Loams, clay loams, non-cracking clays, duplex soils and gradational earths
	and	and	and	and	and
	>125 cm depth to HW or hard rock	75-125 cm depth to HW or hard rock	50-75 cm depTh to HW or hard rock	30-50 cm depth to HW or hard rock	≤30 cm depth to HW or hard rock
	or	or	or	or	or
	>125 cm to salt bulge with EC ≥ 0.9 mS/cm or C1≥900 ppm	75-125 cm to salt bulge with EC ≥ 0.9 mS/cm or C1≥900 ppm	50-75 cm to salt bulge with EC ≥ 0.9 mS/cm or C1≥900 ppm	30-50 cm to salt bulge with EC ≥ 0.9 mS/cm or C1≥900 ppm	
			Sands and sandy loams >90 cm deep	Sands and sandy loams 45-90cm deep	Shallow sands and sandy loams ≤45 deep
			Rigid soils (sodic)	Rigid soils (sodic)	Rigid soils (sodic)
			Duplex soils with subsoil becoming sodic (ESP 6-14) within 60 cm of the surface but not strongly sodic (ESP ≥15) within 90 cm	Duplex soils with sodic subsoil (ESP 6-14) becoming strongly sodic (ESP ≥15) < 60 cm below surface	Duplex soils with a strongly sodic (ESP ≥25) becoming within 45 cm of surface