WorleyParsons
Consulting

Queensland Government

DEPARTMENT OF STATE DEVELOPMENT

Soil Assessment and Management Plan

Abbot Point Growth Gateway Project

301001-01956 – EN-REP-0005

12 July 2015

Level 3, 60 Albert Street
Brisbane
QLD 4000
Australia
Telephone: +61 7 3221 7444
Facsimile: +61 7 3221 7791
www.worleyparsons.com
ABN 61 001 279 812

Disclaimer

This report has been prepared on behalf of and for the exclusive use of Department of State Development, and is subject to and issued in accordance with the agreement between Department of State Development and WorleyParsons. WorleyParsons accepts no liability or responsibility whatsoever for it in respect of any use of or reliance upon this report by any third party.

Copying this report without the permission of Department of State Development or WorleyParsons is not permitted.

PROJECT 301001-01956 - SOIL ASSESSMENT AND MANAGEMENT PLAN

REV	DESCRIPTION	ORIG	REVIEW	WORLEY-PARSONS APPROVAL	DATE	CUSTOMER APPROVAL	DATE
0	Issued for Use	PP G Holz	A Hanly	A Hanly	12 Jul 15	N/A	

CONTENTS

Table of Figures

Table of TABLES

ABBREVIATIONS

Abbreviation/ Acronym	Description
AHD	Australian Height Datum
AS	Australian Standard
ASC	Australian Soil Classification (Isbell, 2002)
ASRIS	Australian Soil Resource Information System
BGL	Below ground level
CEC	Cation exchange capacity
Cl^-	Chloride
Colwell P	Colwell phosphorous
CP-d	Late Carboniferous-Early Permian intrusives (diorite, gabbro, quartz diorite, norite, tonalite)
CPg	Late Carboniferous-Early Permian Connors Subprovince – intrusives (adamellite, granite, granodiorite)
DMCP	Dredged Material Containment Pond
DSDIP	Department of State Development Infrastructure and Planning
DPI	Queensland Department of Primary Industries
E&SCP	Erosion and sediment control plan
EC	Electrical conductivity
EHP	Queensland Department of Environment and Heritage Protection
EIS	Environmental impact study / statement
ESP	Exchangeable sodium percentage
LRA	Land Resource Area
MCF	Multi Cargo Facility
NATA	National Association of Testing Authorities
NQBP	North Queensland Bulk Ports
PAWC	Plant available water capacity
PSA / PSD	Particle size analysis / particle size distribution
Qa	Quaternary alluvium
Qm	Quaternary coastal deposits (clay, silt and sand)
Qr	Quaternary dune deposits

Abbreviation/ Acronym	Description
SAMP	Soil Assessment and Management Plan
SDA	State Development Area
SMU	Soil management unit
TKN	Total Kjeldahl nitrogen
TO	Terminal 0 – coal terminal developed by Adani at Abbot Point
T2	Terminal 2 – coal terminal to be developed at Abbot Point
T3	Terminal 3 – coal terminal developed by Hancock Coal at Abbot Point

GLOSSARY

<table>
<tr><th>Term</th><th>Definition</th></tr>
<tr><td>A horizon</td><td>Mineral horizon at or near the surface with some accumulation of humified organic matter, usually darker in colour than underlying horizons and with maximum biological activity for any given soil profile (NCST, 2009)</td></tr>
<tr><td>A2 horizon</td><td>Mineral horizon having either, alone or in combination, less organic matter, sesquioxides or silicate clay than immediately adjacent horizons. It is usually differentiated from the A1 horizon by its paler colour (NCST, 2009)</td></tr>
<tr><td>Acid soil</td><td>Soil with a pH of less than 6.5 (Rayment and Lyons, 2011)</td></tr>
<tr><td>Alkaline soil</td><td>Soil with a pH greater than 7.4 (Rayment and Lyons, 2011)</td></tr>
<tr><td>Alluvium</td><td>Sediment deposited by channelled or over-bank stream flow</td></tr>
<tr><td>Australian Soil Classification (ASC)</td><td>This is a multi-category scheme with classes defined on the basis of diagnostic horizons or materials and their arrangement in vertical sequence as seen in an exposed soil profile (Isbell, 2002)</td></tr>
<tr><td>B horizon</td><td>Horizons consisting of one or more mineral soil layers characterised by one or more of the following: a concentration of silicate clay, iron, aluminium, organic material or several of these; a structure and/or consistence unlike that of the A horizons above or of any horizons below; stronger colours, usually expressed as higher chroma and/or redder hue, than those of the A horizons above or of those horizons below (NCST, 2009)</td></tr>
<tr><td>Boundaries between horizons (soil)</td><td>NCST (2009) defines the boundary between soil horizons by width and shape. These are follows:
<table>
<tr><th>Boundary type</th><th>Width</th></tr>
<tr><td>Sharp</td><td><5 mm</td></tr>
<tr><td>Abrupt</td><td>5-20 mm</td></tr>
<tr><td>Clear</td><td>20-50 mm</td></tr>
<tr><td>Gradual</td><td>50-100 mm</td></tr>
<tr><td>Diffuse</td><td>>100 mm</td></tr>
</table>
<table>
<tr><th>Boundary shape</th><th>Description</th></tr>
<tr><td>Smooth</td><td>Almost a plane surface</td></tr>
<tr><td>Wavy</td><td>Undulations with depressions wider than they are deep</td></tr>
<tr><td>Irregular</td><td>Undulations with depressions deeper than they are wide</td></tr>
<tr><td>Tongued</td><td>Depressions considerably deeper than they are wide</td></tr>
<tr><td>Broken</td><td>Discontinuous</td></tr>
</table></td></tr>
</table>

<table>
<tr><th>Term</th><th>Definition</th></tr>
<tr><td>C horizon</td><td>Layers below the solum (AB profile) of consolidated or unconsolidated material, usually partially weathered, little affected by pedogenic processes, and either like or unlike the material from which the solum presumably formed</td></tr>
<tr><td>Ca:Mg</td><td>Ratios of exchangeable calcium (Ca) to exchangeable magnesium (Mg) are used to support assessments of subsoil dispersibility where Ca:Mg <0.1 are often associated with highly dispersive subsoils.
Ca:Mg ratings
<table>
<tr><th>Ratio</th><th>Rating</th></tr>
<tr><td><0.1</td><td>Very low</td></tr>
<tr><td>0.1-1</td><td>Low</td></tr>
<tr><td>1–2</td><td>Medium</td></tr>
<tr><td>>2</td><td>High</td></tr>
</table></td></tr>
<tr><td>Cation exchange capacity</td><td>CEC is a measure of a soils capacity to hold and exchange cations influenced by factors such as organic matter, clay percentage and clay type and pH.
CEC ratings
Exchangeable cations classification (Hazelton and Murphy, 2007)
<table>
<tr><th>Cations</th><th>Very low</th><th>Low</th><th>Moderate</th><th>High</th><th>Very l</th></tr>
<tr><td>Na (meq/100g)</td><td>0–0.1</td><td>0.1-0.3</td><td>0.3–0.7</td><td>0.7–2.0</td><td>>2</td></tr>
<tr><td>K (meq/100g)</td><td>0–0.2</td><td>0.2–0.3</td><td>0.3–0.7</td><td>0.7–2.0</td><td>>2</td></tr>
<tr><td>Ca (meq/100g)</td><td>0–2</td><td>2–5</td><td>5-10</td><td>10–20</td><td>>20</td></tr>
<tr><td>Mg (meq/100g)</td><td>0–0.3</td><td>0.3–1.0</td><td>1-3</td><td>3-8</td><td>>8</td></tr>
</table></td></tr>
<tr><td>Chromosols</td><td>ASC Soil Order – Soils with strong texture contrast between A and B horizons. The latter are not strongly acid and are not sodic (Isbell, 2002)</td></tr>
<tr><td>Colluvium</td><td>Unconsolidated, poorly sorted soil and rock material transported largely by gravity (i.e. mass movement), deposited on lower slopes</td></tr>
<tr><td>Colwell phosphorus</td><td>A measure of available soil phosphorus using a bicarbonate extract</td></tr>
<tr><td>Cultivation</td><td>Turning and breaking soil into smaller aggregates and aerating it prior to planting crops or pastures using implements such as disc ploughs and tynes</td></tr>
<tr><td>Dermosols</td><td>ASC Soil Order classification – Soils with structured B2 horizons and lacking strong texture contrast between A and B horizons (Isbell, 2002)</td></tr>
<tr><td>Dispersion potential</td><td>The dispersion potential of subsoil is an indicative rating based on factors including ESP, Ca:Mg ratios, salinity, pH, particle size, Emerson Class numbers and clay mineralogy where available</td></tr>
<tr><td>Electrical conductivity</td><td>Measure of concentration of electrically charged water soluble salts (in a 1:5) soil water suspension. Used to quantify soil salinity</td></tr>
</table>

Term	Definition	
Emerson class test	Clay dispersion is semi-quantitatively measured using the Emerson class test. This test measures the instability of soil structure when immersed in water.	
	Definition of Emerson class (AS1289.3.8.1—2006)	
	Emerson class	**Definition**
	Class 1	Air-dried crumbs of soil show a strong dispersing reaction, i.e. a colloidal cloud covers nearly the whole of the bottom of the beaker, usually in a very thin layer. The reaction should be evident within 10 min. In extreme cases all the water in the beaker becomes cloudy, leaving only a coarse residue in a cloud of clay
	Class 2	Air-dried crumbs of soil show a moderate to slight reaction. A moderate reaction consists of an easily recognizable cloud of colloids in suspension, usually spreading in thin streaks on the bottom of the beaker. A slight reaction consists of the bare hint of cloud in water at the surface of the crumbs
	Class 3	The soil remoulded at the plastic limit disperses in water
	Class 4	The remoulded soil does not disperse in water. Calcium carbonate (calcite) or calcium sulfate (gypsum) is present
	Class 5	The remoulded soil does not disperse in water and the 1:5 soil / water suspension remains dispersed after 5 min
	Class 6	The remoulded soil does not disperse in water and the 1:5 soil / water suspension begins to flocculate within 5 min
	Class 7	The air-dried crumbs of soil remain coherent (do not disperse) in water and swells
	Class 8	The air-dried crumbs of soil remain coherent (do not disperse) in water and do not swell

Term	Definition
Erosion hazard	The degree of erosion hazard is defined within Hazelton and Murphy (2007) as follows:

Erosion Hazard (Hazelton and Murphy, 2007)

Class of erosion hazard	Description of classes
Low	The combination of slope, run-off / run-on and erodibility is such that no appreciable erosion damage will take place, i.e. no scalding (no wind or water erosion)
Moderate	Significant short-term erosion (i.e. occasional rills, no gullies) will occur as a result of the combination of slope, soil erodibility, and run-off/run-on factors. Control can be obtained with structural works, topsoiling, vegetative techniques and by phasing development
High	Major erosion and in some cases long-term erosion (i.e. formation of rills and gullies is common), can be expected to take place. Control of this erosion will require the adoption of intensive soil conservation works
Very high	Major short-term and long-term erosion losses can be expected with this land (i.e. numerous rills, gullies). The combination of slope, soil erodibility and run-off/run-on ratings make intensive soil conservation works necessary
Extreme	Even with intensive short-term and long-term soil conservation works, significant erosion and soil loss would occur from this class of land. This may include numerous rills forming corrugated ground surface, continuous or discontinuous gullies which tend to either branch away from primary drainage lines and on foot slopes or have multiple branches within drainage lines

Term	Definition
Ferromanganiferous nodules	Iron and manganese segregations (NCST, 2009)

Term	Definition
Fertility	Soil fertility (the capacity of the soil to support plant growth in a given climatic regime) is a function of the physical, chemical and biological characteristics of the soil. Indices used include Organic Carbon, Cation Exchange Capacity (CEC), exchangeable cations, Total Kjeldahl nitrogen (TKN) and available phosphorus (P).

Some soil nutrient level ratings from Rayment and Lyons (2011) include:

Analyte	Very low	Low	Moderate	High	Very l
TKN (%)	<0.05	0.05–0.15	0.15–0.25	0.25–0.5	>0.5
Colwell P (mg/kg)	<10	10-20	>20-40	>40-100	>100
Organic Carbon (%)	<0.5	0.5-1.5	>1.5-2.5	>2.5-5.0	>5.0

Term	Definition
Gravelly	Over 10% of surface cover consists of gravel (2 – 60 mm)
Horizon	A layer within the soil profile with morphological characteristics and properties different from layers below and /or above it
Kandosols	ASC Soil Order - Soils which lack strong texture contrast, have massive or only weakly structured B horizons, and are not calcareous throughout (Isbell, 2002)
Kurosols	ASC Soil Order – Soils with strong texture contrast between A horizons and strongly acid B horizons (Isbell, 2002)
Mottled horizon	A horizon in which mottle abundance is greater than 10% (visual abundance estimate) and contrast between colours is distinct and prominent
Mottles	The presence of more than one soil colour in the same soil horizon, not including segregations or cutan colours
NH_4Cl	Ammonium chloride
Ped	An individual natural soil aggregate consisting of a cluster of primary particles.
Quaternary	Period of geological time including the Holocene and Pleistocene; up to approx. 2 million years BP
Ripping	Deep cultivation with a tyned implement to a depth of >300 mm
Rudosols	ASC Soil Order – soils with negligible pedologic organisation; they are usually young soils in the sense that the soil forming factors have had little time to pedologically modify parent rocks or sediments; the component soils can vary widely in terms of texture and depth (Isbell, 2002)

Term	Definition
Salinity	Salinity is the presence of soluble salts in soils, mainly Ca^{2+}, Mg^{2+}, Na^{+}, Cl^{-}, SO_4^{2-} and HCO_3.

Salinity ratings (Rayment and Lyons, 2011)

Soil salinity rating	$EC_{1:5}$ (dSm^{-1})			
	10-20% clay	**20-40% clay**	**40-60% clay**	**60-80% clay**
Very low	<0.07	<0.09	<0.12	<0.15
Low	0.07-0.15	0.09-0.19	0.12-0.24	0.15-0.3
Medium	0.15-0.34	0.19-0.45	0.24-0.56	0.3-0.7
High	0.34-0.63	0.45-0.76	0.56-0.96	0.7-1.18
Very high	0.63-0.93	0.76-1.21	0.96-1.53	1.18-1.87
Extreme	>0.93	>1.21	>1.53	>1.87

Term	Definition
Scarify	Shallow cultivation usually with a tyned implement to a depth of <300 mm
Sheet erosion	The removal of a thin layer of soil by raindrop splash and run-off
Silt	Fine soil particles in the size range 0.02 - 0.002 mm
Sodic soil / sodicity	Sodicity is a measure of exchangeable sodium (Na) in proportion to other exchangeable cations. Fine earth material with an ESP of 6 or greater is defined as sodic.

Sodicity / ESP ratings (Northcote and Skene, 1972)

Sodicity rating	ESPs proposed for Australian soils (%)
Non-sodic	0-6
Sodic	6-15
Strongly sodic	>15

Term	Definition
Sodosols	ASC Soil Order – soils with strong texture contrast between A horizons and sodic B horizons which are not strongly acid (Isbell, 2002)
Soil horizon	A soil horizon is a layer of soil, approximately parallel to the surface, with morphological properties different from layers below and/or above it

Term	Definition
Soil pH	Soil pH can be used as an indicator of the chemical processes that occur in a soil – that is, can indicate certain nutrient deficiencies and toxic effects, which may have implications for soil management and rehabilitation measures. **pH classification (Rayment and Lyons, 2011)** **pH** – **Rating** >9.0 – Very strongly alkaline 9.0–8.5 – Strongly alkaline 8.4–7.9 – Moderately alkaline 7.8–7.4 – Mildly alkaline 7.3–6.6 – Neutral 6.5–6.1 – Slightly acid 6.0–5.6 – Moderately acid 5.5–5.1 – Strongly acid 5.0–4.5 – Very strongly acid
Soil Structure	Soil structure refers to the distinctness, size and shape of natural soil aggregates
Soil texture (field)	The size distribution of particles finer than 2 mm as reflected in the behaviour of a small handful of soil when moistened and kneaded into a ball
Subsoil	Subsoil is a commonly used term used to identify soil material below the topsoil (A horizons) and is usually comprised of B horizons
Tenosols	ASC Soil Order – Soils with generally only weak pedologic organisation apart from the A horizons (Isbell, 2002)
Tertiary	Geological period approx. 65 – 2.0 million years ago
Texture contrast (or duplex) soil profiles	Soils with clear or abrupt textural B horizons as defined in Isbell (2002)

Term	Definition
Topsoil	Topsoil is a commonly used term to identify soil horizons designated as A horizon(s) and is described as the mineral horizon at or near the soil surface with some accumulation of humified organic matter, usually darker in colour than underlying horizons with maximum biologic activity for any given soil profile. For the purposes of this report, topsoil is defined as that proportion of the soil profile that is suitable for stockpiling and rehabilitation. **Topsoil thickness classification (Maher, 1996)** **Horizon thickness (mm)** – **A horizon thickness rating** < 150 – Thin 150 - 300 – Medium 300 - 600 – Thick > 600 – Very thick
Vertosols	ASC Soil Order – Clay soils with shrink-swell properties that exhibit strong cracking when dry and at depth have slickensides and/or lenticular structural aggregates (Isbell, 2002)

Topsoil thickness classification (Maher, 1996)

Horizon thickness (mm)	A horizon thickness rating
< 150	Thin
150 - 300	Medium
300 - 600	Thick
> 600	Very thick

1 INTRODUCTION

This report is a soil assessment and management plan (SAMP) for the Abbot Point Growth Gateway Project. The plan is separated into two parts – Part A being the soil assessment and Part B being soil management.

The Abbot Point Growth Gateway Project will develop infrastructure to support development at the Port of Abbot Point. The current Project relates to the development of infrastructure to support development of planned and approved Terminal 0 (T0). Dredging of berth pockets and arrival/departure apron is required to provide safe shipping access to the T0 offshore facility. The scope of the approved T0 project does not directly include dredging of the required berth pockets or apron areas.

WorleyParsons has been commissioned by the Department of State Development (DSD) to project manage and undertake studies to assess environmental values and the potential impacts of the onshore construction of dredged material containment ponds (DMCPs). This includes an investigation of terrestrial soils (this report) within the Project study area to develop an inventory of the soil and land resources and form soil management specifications.

1.1 Purpose

The purpose of this SAMP is to provide an inventory of the soil and land resources within the Project study area and form soil management specifications relevant to construction and rehabilitation. In addition, it will be used to provide baseline information for other management plans, including, but not limited to, site specific erosion and sediment control plans.

1.2 Scope

The scope of works involved a high intensity terrestrial soil survey in accordance with McKenzie et al. (2008) including the following:

- Undertaking a desktop assessment collating all existing information including soils, land system and geology mapping
- Conducting Aerial Photograph Interpretation (API) to identify soil boundaries and potential soil sampling locations
- Undertaking field survey involving soil sampling and recording observations to identify soil mapping units and confirm soil boundaries
- Laboratory analysis of representative profiles
- Refining soil mapping boundaries based on field survey

- Assessing baseline soils characteristics and identifying problem soils (i.e. saline, erosive and dispersive soils)
- Outlining soil management measures to be adopted during site development.

1.3 Legislative framework and other requirements

The following acts, policies and guideline documents are instrumental to the management requirements of soils for the specified purposes stated above:

- *Environmental Protection Act (1994)* (referred to as the EP Act)
- *Soil Conservation Act (1986)*
- *Strategic Cropping Land Act (2011)*
- *Environmental Protection (Water) Policy (2009)*
- *State Planning Policy (SPP) 1/92 Development and the Conservation of Agricultural Land*
- Protecting Queensland's strategic cropping land: Proposed criteria for identifying strategic cropping land, Queensland Department of Environment and Resource Management (2011)
- Planning guidelines: the identification of good quality agricultural land, State of Queensland (Department of Primary Industries and Department of Housing, Local Government and Planning, 1993)
- Guidelines for Surveying Soil and Land Resources, 2nd Edition (McKenzie et al., 2008)
- Australian Soil and Land Survey Handbook, 3rd Edition (NCST, 2009)
- The Australian Soil Classification (Isbell, 2002).

2 PROJECT DESCRIPTION

The proposed Project involves:

- Construction of a DMCP within the area previously allocated for the development of Terminal 2 (T2) and adjoining industrial land
- Capital dredging of approximately 1.1 million m^3 (Mm^3) in situ volume of previously undisturbed seabed for new berth pockets and ship apron areas required to support the development of T0
- Relocation of the dredged material to the DMCP and offshore discharge of return water
- Ongoing management of the dredged material including its removal, treatment, and beneficial reuse within the port area and the Abbot Point State Development Area (APSDA), where appropriate.

3 PART A – SOIL ASSESSMENT

3.1 Methodology for establishing baseline information

Desktop assessment of the soils within the Abbot Point Growth Gateway study area was undertaken to establish baseline soil information for the generation of a SAMP.

Baseline soils information was established by:

- Undertaking a desktop review of existing soils and landform information relevant to the study area
- Collecting detailed soils information about the DMCP, which is based on the information presented in the Abbot Point Wetland Project, Soil Assessment and Management Plan of November 2014
- Assessing sampling intensities recommended in McKenzie et al. (2008), including soil description and classification.

3.1.1 Desktop review and information sources

This report is informed by previous reports presented below. In particular, this report is based on the WorleyParsons Soil Assessment and Management Plan (2014). No new field work or analyses were undertaken.

The desktop investigations included a review of:

- Abbot Point Wetland Project. Soil Assessment and Management Plan 301001-01895-01-EN-PLN-0001 (WorleyParsons, 2014)
- Abbot Point Growth Gateway Project. Stormwater Management Plan for the Dredge Material Containment Pond. 1525905-019-R-RevA (Golder Associates, 2015)
- Adani Abbot Point Coal Terminal 0 Environmental Impact Study (EIS) (CDM Smith, 2012)
- Alpha Coal Project Environmental Impact Statement for Hancock Prospecting Pty Ltd (GHD, 2010)
- NQBP – Abbot Point Multi Cargo Facility (MCF) (GHD, 2010)
- NQBP – Abbot Point Coal Terminal – X80 and X110 Acid Sulfate Soil Investigation and Management Plan (Aurecon Hatch, 2009)
- North Queensland Bulk Ports (NQBP) - Abbot Point Coal Terminal Stage 3 (T3) Expansion (WBM, 2006)

- Survey of the Townsville-Bowen Region, North Queensland 1950, CSIRO Land Research Series No. 2 (Christian et al, 1953)
- Atlas of Australian Soils (Northcote et al, 1960-68)
- CSIRO's Australian Soil Resource Information System (ASRIS)
- Aerial photograph interpretation to identify soil/landscape units.

The proposed development, a dredged material management area, is considered to be a moderately high intensity land use. Under the guidelines for Surveying Soil and Land Resources (McKenzie et al., 2008), a high intensity soil survey at 1:25,000 (i.e. a soil observation every 5 to 25ha) is required. A preliminary estimate of the area of the DMCP is 79.1ha.

According to McKenzie et al., 2008, an area of this size would require a minimum of 3 to 20 observations with one representative soil profile sampled and analysed. Previous field work (WorleyParsons, 2014) included inspection and recording of observations at 11 sites in and adjacent to the DMCP, and on the same geological unit as the DMCP. Eight sites were excavated using a hand auger and described, three of those were sampled every 10cm and samples sent to the laboratory for analysis. Observations were made at an additional three sites checking and confirming salient soil properties. Analysis of two soil profiles was undertaken.

3.2 Baseline land and soil information

3.2.1 Classification and nomenclature

In this report, soils have been grouped based on parent material, geomorphic unit and soil profile properties. The soil groups are consistent with soil profile classes and classified according to the Australian Soil Classification (Isbell, 2002).

3.2.2 Geology and landform

The Ayr 1:250,000 geological mapping indicated that the DMCP occurs in only one mapping unit, Qr, shown in Figure 3-1. These Quaternary sediments are comprised of low linear dunes composed predominantly of sand with some interbedded silt.

The field assessment found that the geological mapping was consistent with observations given the scale of the mapping and it provides a sound basis for the soils assessment.

The majority of the area mapped as Qr is a sand plain that is 3 to 4m above the Caley Wetlands to the south. The sand plain has poorly sorted sands (likely formed as a series of beach ridges) and finer and better sorted sands that have probably been reworked by aeolian activity. This means that the sandy clay in the subsoils found on the sand plain was likely formed by pedogenesis rather than deposited as a sedimentary feature.

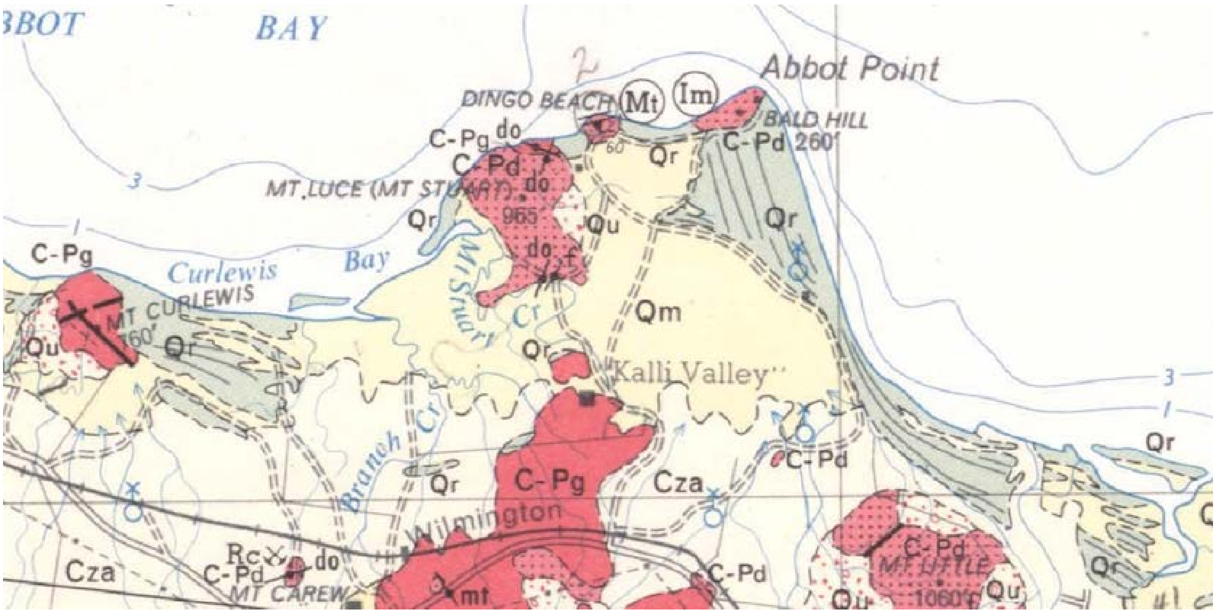


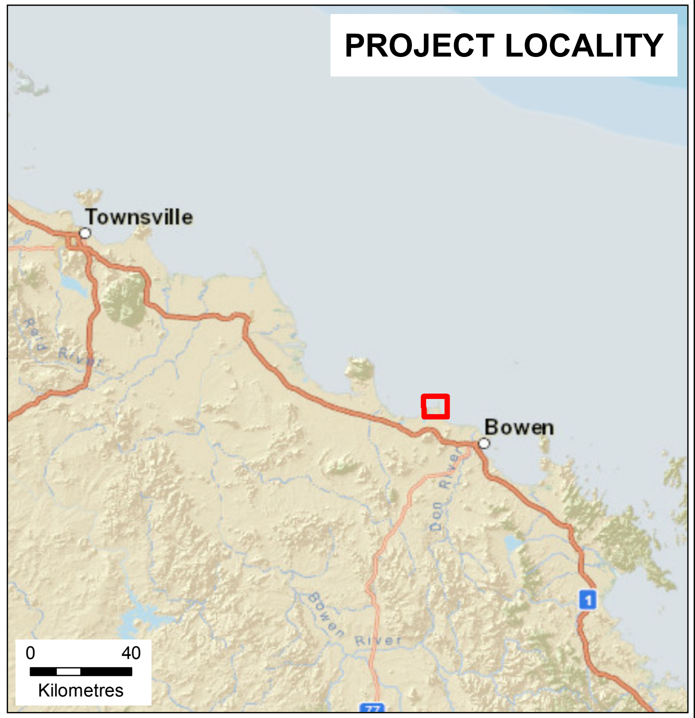
Figure 3-1 Regional geology from Ayr 1:250,000 Geological Series sheet SE 55-15

3.2.3 Soils occurring within the study area

Two soils units were identified and described in and adjacent to the DMCP and these are described in Table 3-1 and shown in Figure 3-2.

Table 3-1 Concepts of Soil Mapping Units, Australian Soil Classification and WorleyParsons Representative Sites

Major Soils Groups	Soil Mapping Unit	Profile Description	Australian Soil Classification (ASC)	WorleyParsons Representative Sites
1 Soils developed on dunes and beach ridges (Qr)	Qr1	Texture contrast soils with deep bleached sands overlying grey and yellow mottled sandy clays	CHROMOSOL	AP08
	Qr2	Texture contrast soils with moderately deep to deep light brown sands overlying brown to reddish brown sandy clays	CHROMOSOL	AP01, AP11



Service Layer Credits: Sources: Esri, DeLorme, HERE, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom

LEGEND

- Dredged material pipeline (indicative)
- Return water pipeline (indicative)
- Dredged material containment pond
- Dredged material containment pond study area
- Abbot Point Rd (Private road)
- Access track
- Dingo Beach (Prohibited access)
- Lot Type Parcel
- Easement
- Observation and soil representative sample site

Soil Type

- Qr1
- Qr2
- No access

Source information:
Dredging study area
Setout points derived from coordinates on NQBP/Aurecon figure 242770-0000-DRG-SK-0021-A supplied by NQBP
Dredged material and return water pipelines
Digitised from BMT JFA Drg. No. BMT JFA 275.02-50-03 A, dated 17/12/2014 and Golder Associates Drg. No. 1525905-027-002A, dated 12/06/2015, with some minor adjustments to avoid clashes with existing infrastructure visible in the 2013 aerial imagery and to avoid any potential clashes with the proposed MOF expansion
Dredged material containment pond
Supplied by Golder Associates 23/06/2015
Dredged material containment pond study area
Department of State Development, Infrastructure and Planning, (DSDIP)
Existing transport network
Physical Road Network - Queensland, Physical Rail Network - Queensland
Queensland Government - Department of Environment and Resource Management
2013 Imagery
Queensland Government - Department of State Development, Infrastructure and Planning 2015
Cadastral Boundaries
Downloaded 08/06/2015 -
http://qldspatial.information.qld.gov.au/catalogue/custom/detail.page?fid={4091CAF1-50E6-4BC3-B3D4-229AA318231A}
Queensland Government - Department of Natural Resources and Mines

REV	DATE	REVISION DESCRIPTION	DRN	CHK	ENG	CHK ENG	APPD
0	13/07/2015	Issued for information	MH	KM	GH		

Queensland Government

QUEENSLAND GOVERNMENT

ABBOT POINT GROWTH GATEWAY PROJECT

Figure 3-2
Locality, soil mapping units, observations and soil representative sample sites

Figure: 301001-01956-00-GM-SKT-0062 | Rev: 0

\\aubriwpdfs02\vbrisbane\Projects\301001\01956 PROJ - Abbot Point Growth Gateway\10.0 Engineering\10 GM-Geomatics\Output\301001-01956-00-GM-SKT-0062-0 (Land Soil Map Units).mxd

Compiled by BRISBANE GEOMATICS

3.2.3.1 SOILS DEVELOPED ON QUATERNARY BEACH RIDGES / DUNES (QR)

The Qr1 soil has developed on the Qr and occurs over most of the DMCP. Qr1 has a shallow (10cm) sand A1 horizon overlying a deep conspicuously bleached coarse to medium sand A2 horizon to 60 to 90cm below ground level. The base of the A2 may include few to abundant cemented ferro-manganiferous nodules, some to >5cm. The B horizon is a medium to coarse sandy clay to sandy clay loam (27% to 30% clay) that is mottled light brownish grey and brownish yellow. The vegetation is mostly *Melaleuca viridiflora* and together with the profile features, indicates these soils are poorly drained. It is likely that there is a perched water table in the A2 horizons during the wet season that subsequently dries in the dry season. The sands have a very low water holding capacity. Each year, vegetation must survive both wet, probably anaerobic conditions, during the wet season in the summer months and then drought conditions during the late winter and spring months. The clayey subsoils are likely to be pedogenic and not sedimentary. While geotechnical borelog descriptions of texture are not directly comparable to the pedological descriptions within this report, an interpretation of the geotechnical information available at the time of writing suggests that this layer of sandy clay/clayey sand occurs at around 1m, maybe up to 2m thick, and is underlain by sand.

The Qr2 soils occur on the edges of the sand plain at around 3m above the wetlands and occur along the southern boundary of the DMCP. The profiles are derived from the same parent material as the Qr1 soils but the A horizons are reddish brown sands overlying reddish brown to red sandy clay subsoils. There is a high degree of variability among these soils as they grade in profile properties towards the Qr1 soils that occur further from the edge of the sand plain. A possible explanation for the better profile properties is that being on the edge of the elevated sand plain, these profiles drain during the wet season and do not experience the same anaerobic conditions as the Qr1 soils further from the edge. These better drained soils support *Corymbia tesselaris* and a shrub understory compared to the *Melaleuca viridiflora* of the Qr1 soils, though significant areas have been cleared.

Photographs of the Qr soils encountered are provided in **Plate 1** to **Plate 4**.

Plate 1 A Qr1 profile (site AP08) showing the deep conspicuously bleached sand A2 horizon with ferromanganiferous nodules overlying the mottled sandy clay B horizon

Plate 2 Typical *Melaleuca viridiflora* on the Qr1 soils at site AP09.

Plate 3 A Qr2 profile at site AP11 showing the deep sandy A horizons overlying a reddish brown sandy clay B horizon.

Plate 4 *Corymbia tesselaris* on a Qr2 soil at site AP11.

3.2.3.2 Soil chemistry

The locations of the representative profiles analysed and used to characterise the soils found in the DMCP are shown in Figure 3-2.

The soils developed on the sand plain have slightly acid to neutral pH throughout the profile (Figure 3-3).

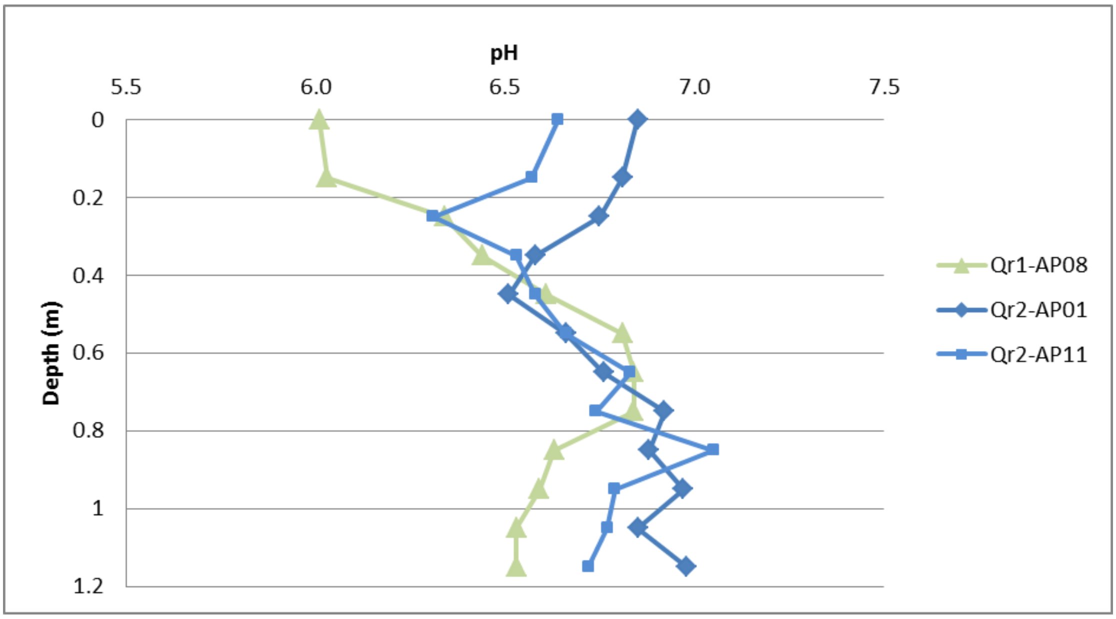


Figure 3-3 pH depth functions for each of the representative profiles (from WorleyParsons, 2014)

The soils developed on the sands have very low salinity, some showing slightly higher concentrations in the surface layers probably due to aerosolic salt blown in from the nearby coast. The slight increase in salinity with depth in AP08 may be due to impeded drainage above the clayey subsoil but levels are very low. Salinity profiles for the representative soils are shown in Figure 3-4.

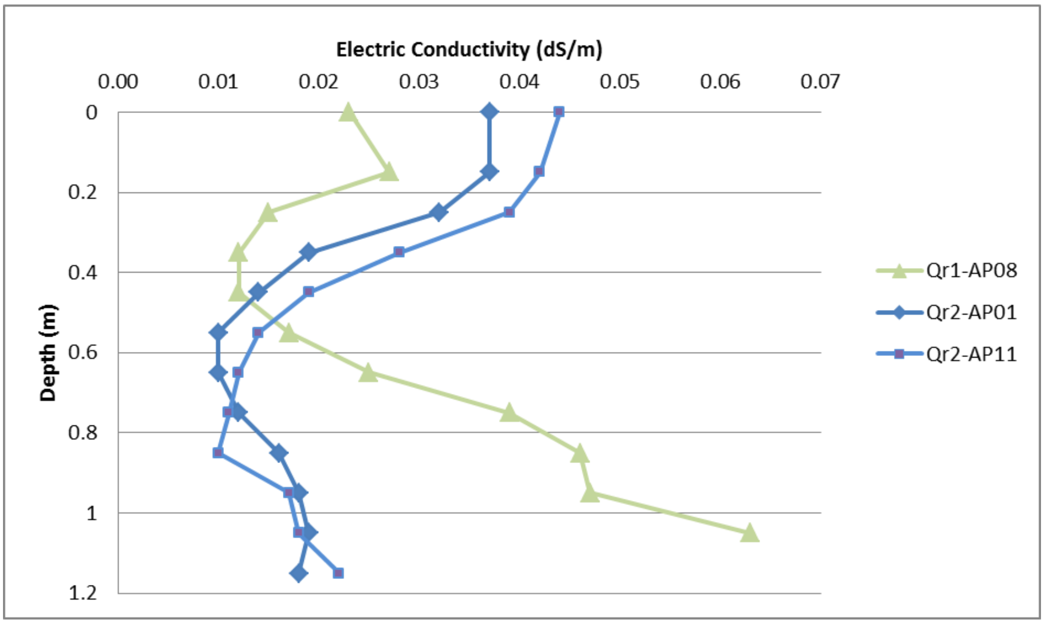


Figure 3-4 EC depth functions for each of the representative profiles (from WorleyParsons, 2014)

Soil fertility is very low for the soils developed on the Qr. Fertility indices including exchangeable cations, Colwell P, total N and organic carbon percentage are all low to very low. Almost all nutrients of both soils will be within the upper 0.1m and there are almost no nutrients in the bleached A2 horizons. Stripping topsoils of the Qr1 soils that cover most of the DMCP to >100mm will dilute nutrients and biological capital when used for rehabilitation. However, the material in the A2 horizons is relatively inert and may be useful for fill and as a substrate for root development.

Clayey subsoil samples at one site (AP08, Qr1) had ESPs of between 9 and 12 but this ratio is of little bearing given the low concentrations of exchangeable cations and low CEC. Emerson tests of these samples suggest the subsoil materials are not potentially dispersive and likely to be stable. However, subsoil materials (in particular the grey and yellow sandy clays of the Qr1 soils) are best not exposed subaerially because they do not provide an effective substrate for vegetative rehabilitation/stabilisation and the clay fines may be elutriated by rainfall and increase turbidity in runoff.

4 PART B – SOIL MANAGEMENT

4.1 Management objectives

Soil management recommendations are informed by the Abbot Point Growth Gateway Project, Stormwater Management Plan for the Dredge Material Containment Pond (June 2015).

Land disturbance activities will include vegetation clearing, topsoil stripping, soil excavation, stockpiling and rehabilitation. In particular, soil materials will be required for building the DMCP embankments, for erosion and sediment control structures and for establishing vegetation on rehabilitated areas. Specific recommendations for each soil management unit are provided in Section 4.2. General recommendations to minimise impacts from construction activities are outlined in the sections which follow. The main objective of these recommendations is to leave disturbed areas as stable landforms supporting viable vegetation communities by:

- Avoiding, minimising or mitigating impacts to soils
- Maintaining topsoil quantity and quality
- Providing appropriate erosion and sediment control
- Minimising dust.

4.1.1 Construction activities

Table 4-1 Vegetation clearing management

Environmental objective	• To minimise the amount of vegetation cleared for construction • To avoid impacts on other environmental values.
Control strategies	• Store woody material with care not to mix woody vegetation stockpiles with topsoil stockpiles • Windrows of cleared vegetation will be oriented to avoid diversion or concentration of overland flows • Mulching and stockpiling of vegetation • Cleared vegetation will be stockpiled separately with a distinct break between the undisturbed vegetation and soil stockpiles, and in a manner that facilitates re-spreading or salvaging and fire management.

Table 4-2 Topsoil management

Environmental objective	• Preserve sufficient topsoil to enable effective rehabilitation • Ensure topsoil is segregated from other materials • Ensure topsoil is not degraded during storage and reinstatement.
Control strategies	• Topsoil to be stripped to at least the minimum specified depth but should extend down to the maximum possible with every effort made to preserve as much topsoil as is practical following vegetation clearing • Subsoil that is required to be excavated and stored, will be removed and stockpiled separately from topsoil to prevent mixing with topsoil and, ideally, stockpiles will be located close to where they are sourced • Vegetation that is cleared and chipped may be used to provide a thin surface mulch to improve the topsoil productivity and mitigate erosion hazards • Care will be taken during stripping, stockpiling and/or re-spreading to ensure that structural degradation of the soil is minimal and to minimise soil compaction.

Table 4-3 Topsoil stockpile management

Environmental objective	• Minimise degradation and maintain fertility of stockpiled material • Ensure stockpiles have minimal impact on surrounding environmental values.
Control strategies	• Topsoil stockpiles should be stockpiled to minimise degradation of topsoil, maintain biological capital and maintain fertility • Stockpiles should be placed away from discharge zones where they are not disturbed by other activities; topsoil should not be stockpiled against fences or vegetation and should be retained separately from mulch (apart from a surface layer) • Stockpiles exposed for extended periods (longer than three months) should be monitored and managed to maintain biological activity and prevent weed invasion; a competitive vegetative cover such as grasses could be used to discourage invasion by weed species • Topsoil stockpile location should be recorded such as in a GIS or on construction drawings and where required clearly sign-posted for easy identification and to avoid any inadvertent losses • Control of weeds on the stockpiles needs to be carefully managed so as to prevent significantly reducing vegetative cover and exposing stockpiled soils to erosion • Prior to re-spreading, topsoil in stockpiles should be turned and loosened • Topsoil should be re-spread to depths adequate for revegetation • The topsoil should be spread to cover any disturbed area that is to be revegetated so that there is no exposed sub-surface material.

Table 4-4 Subsoil management

Environmental objective	• Prevent contamination of topsoil (note: subsoil here refers to the sandy clay B horizons that occur from 60-90cm BGL and the lower part of the A2 horizon mostly just above the B horizon that may contain ferromanganiferrous nodules).
Control strategies	• Subsoil should be removed and stockpiled separately from topsoil to prevent mixing with topsoil and, ideally, stockpiles should be located close to where they are sourced.

4.1.2 Water diversion, erosion and sediment control

Table 4-5 Water diversion, erosion and sediment control management

Environmental objective	• Minimise erosion on the site • Control or divert surface drainage entering the site • Minimise sediment laden run-off entering adjoining areas, watercourses, drains and dams • Minimise soil loss from disturbed and stockpile areas.
Control strategies	• Establish a cover of vegetation and/or mulch on stockpiles to minimise surface soil erosion • Erosion and sediment control measures (such as stormwater diversion drains and sediment fencing) should be implemented around stockpile areas • Erosion and sediment control measures and areas receiving concentrated flows should be inspected on a regular basis, replaced where damaged, and emptied following rainfall events, where required • Point source discharges of run-off should be directed into stable areas and/or drainage lines with engineering controls, such as scour protection and flow velocity limits, where required • Where necessary, erosion and sediment control devices should be constructed with reference to the International Erosion Control Association 'Best Practice Erosion and Sediment Control Guidelines, 2008' and the Institute of Engineers Australia 'Soil Erosion and Sediment Control Engineering Guidelines for Queensland Construction Sites, 1996'.

4.1.3 Rehabilitation

Table 4-6 Rehabilitation

Environmental objective	• Stabilise landforms • Ensure erosion control measures remain effective • Ensure stormwater run-off and seepage from rehabilitated areas does not adversely affect the environmental values of any waters • Ensure plants show healthy growth and recruitment is occurring • Control declared weeds within rehabilitated areas.

Control strategies	• Progressive reinstatement of disturbed areas should commence as soon as practicable following the completion of construction activities • Topsoil application will only take place following initial reinstatement of the subsoil • The duration of topsoil stockpiling should be as minimal as practicable. However, topsoils stockpiled for periods longer than three months should be monitored and managed to maintain biological activity and prevent weed invasion. A competitive vegetative cover such as grasses could be used to discourage invasion by weed species. Analysis of pH, EC and soil fertility parameters (including pH, EC, organic carbon, total nitrogen and Colwell phosphorus) may be required after 12 months.

4.1.4 Monitoring

The primary objective of monitoring in the soil management plan is to ensure soil has been appropriately managed during all activities associated with the construction. This includes adopting appropriate remediation where environmental targets are not met.

The monitoring plan includes environmental parameters to be monitored, targets for those parameters and frequency of monitoring.

Table 4-7 Monitoring procedure

Parameters and targets – topsoil depth	• Topsoil should be reinstated to as close as possible to pre-disturbance depths.
Parameters and targets – exposure of subsoil	• In general, no exposure of subsoil material at depths shallower than the pre-disturbance topsoil depth • No evidence of accelerated erosion on construction sites or at locations downstream due to increased run-off from construction activities or from concentrated/diverted run-off. • Structures are functioning correctly. Visual inspections and maintenance (removal of litter, sediment and repair damage) of erosion and sediment control devices • Deposition of sediment • No evidence of sediment deposited from construction activities.
Frequency	• During construction, daily inspections of integrity of structures • Following rehabilitation for 12 months using a checklist and photographic records to ensure minimal incidences of soil degradation (e.g. subsidence or erosion) resulting from construction activities (where landowner access permits).

4.1.5 Corrective action

Corrective actions should be defined by the outcomes and recommendations of weekly environmental inspections and should be undertaken as soon as practicable to avoid or minimise environmental harm. Corrective actions may include:

Table 4-8 Corrective actions

Corrective actions	• Relocating or re-positioning stockpiles to prevent contamination between topsoil and subsoil materials • Re-shaping stockpiles to achieve appropriate the height of stockpiles • Undertaking any necessary revegetation or weed management to preserve topsoil stockpile properties • Cleaning, repairing, re-positioning or replacing erosion and sediment control devices whenever inspections indicate they are ineffective • Amending the type, position and arrangement of erosion and sediment controls to improve performance • Removing deposited sediment where inspections of adjoining roadways, access tracks, waterways and properties indicate the presence of sediment from the site is accumulating in sediment traps.

4.2 General soil management objectives and procedures

Soil mapping units are grouped into soil management units (SMUs) in order to manage the landscape and the inherent properties of each soil as affected by construction activities. SMUs are combinations of soil mapping units grouped because they have similar management requirements for specific uses, e.g. these might include topsoil stripping depth, erosion hazard and dust generating potential. The two soils identified in and adjacent to the DMCP have similar management requirements in the context of the proposed activities and form one SMU.

Table 4-9 Description of SMU and specific management requirements

Soil Management Unit	Soil Mapping Unit	Description	Management Measure
General management applicable to all SMUs	All	Topsoil and subsoil to be stripped in separate operations to prevent mixing and contamination of topsoil Topsoil stripping will be supervised, maximise the harvesting of topsoil and ensure subsoil is not stripped with topsoil Minimise dust production on susceptible soils by regular watering during construction activities Implement appropriate surface drainage and water control measures to minimise erosion impacts Topsoil stripping depths must be confirmed onsite taking into account typical depths specified below and taking care to identify changes in topsoil depths within a site	
SMU - A	Qr1, Qr2	These soils have 600-900+mm of sandy A horizon materials overlying sandy clay subsoil around1-2m thick overlying sands. Almost all the nutrients and biological capital will be in the top 100mm ie., the topsoil. These soils have very low levels of fertility. The Qr2 soils have properties (subsoils) likely to be more conducive to plant growth and so of more value in rehabilitation than the Qr1 soils.	Topsoil stripping depth is nominally 100 mm but there are some areas where the topsoil is deeper. Bleached A2 material is relatively inert but the impact of salvaging it with the topsoil is in diluting the biological capital and nutrients. Plants used in rehabilitation are likely to respond to N:P:K fertiliser. The sands are generally not coherent and susceptible to wind and water erosion.

5 CONCLUSIONS

The soils investigation reports on the soils in the 79.1ha DMCP and is based on existing available information, including field and laboratory assessments undertaken for the Abbot Point Wetlands Project (WorleyParsons, 2014).

Part A of this report includes a land and soil assessment that describes and characterises the soils, while Part B uses that information as the basis of a soil management plan.

The DMCP is located on coastal sands that form a sand plain at around 3 to 5m AHD. Two soils have been identified on the sand plain in and adjacent to the DMCP. The Qr1 soil is a Chromosol with a10 cm sand to coarse loamy sand A1 horizon overlying a conspicuously bleached sand to coarse sand A2 horizon to around 90cm. Ferromanganiferous nodules up to 5cm may occur in the lower A2 horizon that overlies a yellow and grey mottled coarse sandy clay B horizon around 1 to 2m thick, overlying sands. These soils support mainly *Melaleuca viridifolia* and are seasonally waterlogged (during summer months) then drought affected during late winter spring. These soils have very low fertility. Exchangeable cations and Emerson ratings suggest the clay subsoils are not dispersive despite some ESPs that are above 6%. Although the clay subsoil materials are likely to be non-dispersive, they are not recommended to be exposed subaerially because they do not provide an effective substrate for vegetative rehabilitation/stabilisation and the clay fines may be elutriated by rainfall and increase turbidity in runoff.

The Qr2 soils (Chromosols) occur on the edges of the sand plain above the wetlands and occur along the southern boundary of the DMCP. These soils have developed on similar sandy materials as the Qr1 but are better drained. Reddish brown sandy clay B horizons occur from 90cm and the overlying A horizons are brown and not bleached. There will be many intergrades between the Qr1 and Qr2 soils depending on the drainage conditions. The Qr2 soils support *Corymbia tesselaris* with a shrub understory and provide a more conducive edaphic environment for plant growth than the Qr1 soils. They have very low fertility. Clay subsoil materials are likely to be non-dispersive if exposed subaerially though may be subject elutriation and loss of fines.

The soil materials to be managed across the DMCP are mostly sands. They are relatively robust materials but require that topsoils (and the biological capital) are harvested and carefully stored so that these materials can then be used in rehabilitation/revegetation. The sands are not coherent and may be susceptible to wind and water erosion once disturbed.

6 REFERENCES

Aurecon Hatch, (2009). *Acid Sulfate Soil Investigation Report and Management Plan, Abbot Point Coal Terminal – X80 and X110.* Prepared for North Queensland Bulk Ports

CDM Smith (2012). *Adani Abbot Point Coal Terminal 0 Environmental Impact Study, Environmental Impact Statement – Contaminated Land and Land Disturbance.*

Christian, C.S., Patersom, S.J., Perry, R.A., Slatyer, R.O., Stewart, G.A. and Traves, D.M. (1953). *Survey of the Townsville-Bowen Region, North Queensland 1950.* CSIRO Land Research Series No. 2, Melbourne, VIC

GHD (2009). *Report for Proposed Multi Cargo Facility, Abbot Point Preliminary Sediment Quality Assessment.* Prepared for North Queensland Bulk Ports

GHD (2010). *Alpha Coal Project - Environmental Impact Statement Soils Report*. Prepared for GVK Hancock

Golder Associates (2015). *Abbot Point Growth Gateway Project. Stormwater Management Plan for the Dredge Material Containment Pond*. 1525905-019-R-RevA

Gregory, C.M. (1969). 1*:250,000 Geological Series – Explanatory Notes Sheet SE/55-15 Bureau of Mineral Resources*. Canberra, ACT

Hazelton, P. and Murphy, B. (2007). *Interpreting Soil Test Results – What do all the Numbers Mean?* CSIRO Publication, Collingwood, VIC

Isbell, R. (2002). *The Australian Soil Classification.* 2nd Edition, CSIRO Publication, Collingwood, VIC.

McKenzie, N.J., Grundy, M.J., Webster, R. and Ringrose-Voase, A.J. (2008). *Guidelines for Surveying Soil and Land Resources.* 2nd Edition, CSIRO Publication, Collingwood, VIC

Northcote, K.H. and Skene, J.K.M. (1972). *Australian Soils with saline and sodic properties.* Soil Publication No. 27, CSIRO Publication, Melbourne, VIC

Northcote, K. H. with Beckmann, G. G., Bettenay, E., Churchward, H. M., Van Dijk, D. C., Dimmock, G. M., Hubble, G. D., Isbell, R. F., McArthur, W. M., Murtha, G. G., Nicolls, K. D., Paton, T. R., Thompson, C. H., Webb, A. A. and Wright, M. J. (1960-68). *Atlas of Australian Soils - Australian Soil Resource Information System (ASRIS).* CSIRO Publication

Paine, A. G. L., Gregory, C. M., Clarke, D. E. (1961). *Australian 1:250,000 Geological Series Ayr Sheet SE55-15.* Bureau of Mineral Resources, Geology and Geophysics, Department of National Development and Geological Survey of Queensland, Canberra

QLDBMT WBM (2006). *Abbot Point Coal Terminal Stage 3 (T3) Expansion*. Prepared for North Queensland Bulk Ports

Rayment, G.E. and Lyons, D.J. (2011). *Soil Chemical Methods – Australasia.* CSIRO Publication, Collingwood, VIC

The National Committee on Soil and Terrain (2009). *Australian Soil and Land Survey Field Handbook.* 3rd Edition, CSIRO Publication, Collingwood, VIC

WorleyParsons (2014). *Abbot Point Wetland Project. Soil Assessment and Management Plan.* 301001-01895-01-EN-PLN-0001