TR9.1.V5

Geology, Soils and Land Resource Assessment



Middlemount Coal Project, Stage 2
Geology, Soils and Land Resource Assessment

October 2010

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Date: October 2010

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Attachment B Laboratory test results
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Glossary

A horizon	See topsoil.
Acid generating potential	Potential of spoil material to form acid conditions when oxidised (i.e. contact with air).
Alluvium	Any stream laid sediment deposit found in a stream channel and in low parts of a stream valley subject to flooding.
Anthropogenic	Caused or influenced by humans.
Australian Height Datum (AHD)	A level datum, uniform throughout Australia, based on an origin determined from observations of mean sea level at tide gauge stations, located at more than 30 points along the Australian coastline.
Borehole	A hole produced in the ground by drilling or driving.
Bushland	A functional, multi layered, semi-natural plant community including a permanent tree layer, natural or established (e. g. on spoil). The area would be capable of sustaining flora and fauna habitats.
CHPP	Coal handling and preparation plant
Chromosol	Soils with strong texture contrast between A horizons and B horizons, in which the B horizons are not strongly acid and are not sodic, as defined by Isbell (1998).
Clay	Particles with a diameter less than 0.002 mm (McDonald *et al.*1998) comprising of various clay minerals.
Competent spoil	Non acid, non dispersive durable spoil with potential characteristics to resist erosion.
Competent rock	Rock that is considered suitable for the intended use.
Cover material	Soil or other suitable plant growth medium placed on reshaped spoil surfaces; typically non crusting and low salinity.
Dermosol	Soil with a structured B2 horizon and lacking strong texture contrast between the A and B horizons, as defined by Isbell (1998).
Diversions/diversion channels	Structures for the controlled re-direction of drainage lines and watercourses around open cut pits and infrastructure areas.
DTPA	Diethylene triamine pentaacetic acid. A chemical used for the extraction of metal ions during chemical analysis.
Dyke	Sheet-like igneous intrusion cross cutting bedding planes, commonly sub-vertical.
EC	Electrical conductivity, an indirect measure of dissolved salts in a substance.
Erosional stability	The ability of a rehabilitated area to resist the natural forces of soil erosion.
Externally drained	Rainfall runoff water that reports to the external environment of a structure via local drainage systems.
Feldspar	A group of abundant rock forming minerals of the general formula MAl (Al, $Si)_3O_8$, where M can be potassium (K), sodium (Na), calcium (Ca), barium (Ba), rubidium (Rb), strontium (Sr) or iron (Fe).
FoS	Factor of Safety
Functional vegetation	Vegetation that consists of species able to survive and regenerate under specific conditions, providing soil erosion control and fauna habitat.
Geochemistry	The chemical characteristics of a soil or rock material.
Geomorphology	Study of the characteristics, origin and development of land forms and the processes that act on them.
Geotechnical stability	Resistance of a natural slope or earth structures to mass movement and erosion.

Gilgai	The phenomena of an irregular land surface with mounds and depressions formed due to clay horizons shrinking and swelling with alternate drying and wetting cycles.
Graded banks	Cross slope earthen banks constructed on reshaped spoil areas, typically at horizontal intervals of approximately 50 m and 1 to 1.5% longitudinal gradient, to reduce the effective slope length and control the runoff flow rate.
Holocene	The most recent epoch of geological time.
Hostile spoil	Acid, sodic or saline spoil deleterious to seed emergence, geotechnical and geochemical stability of spoil.
Incident register	A database of environmental incidents, causes and remedial actions.
Internal drainage	Drainage of rainfall runoff from reshaped spoil areas confined and ponded within the spoil area.
Leaching profile	Vertical change in chemical concentrations down the soil profile due to leaching.
MLA	Mining Lease Application
Mt/y	Million tonnes per year
NATA	National Association of Testing Authorities Australia
Overburden	The soil or other mineral matter which has to be removed to gain access to the underlying material.
PAWC	Plant available water capacity.
Permian	The geological period of time from 245 million to 290 million years ago.
Plan	Set of actions required to ensure the achievement of a stated objective/program.
Plant growth medium	Material which is typically non crusting and has low salinity levels, in which plant seed will germinate and establish.
Policy	Stated commitment to achieving objectives.
Program	Management supported work commitment, budget and time frame to achieve a stated objective.
Quaternary	The geological period of time from the present to two million years ago.
Refuse dump	Site to be used for the permanent placement of waste.
Rehabilitation	Reshaping of a disturbed area to a geotechnically and geochemically stable condition, followed by revegetation.
Regional ecosystems	A vegetation community, within a bioregion, that is consistently associated with a particular combination of geology, landform and soil, As defined by Sattler & Williams (1999) in *The Conservation Status of Queensland's Bioregional Ecosystems*.
Revegetation	Establishment of suitable plant species to support the agreed post mining land use and control soil erosion to sustainable levels.
Rock mulch	Durable or competent rock purposely placed on an area under rehabilitation to provide additional resistance to erosion.
Sand	Natural mineral particles with a diameter between 0.02 mm to 2.0 mm (McDonald *et al.*1998)
Saline	Presence of salts, in water or spoil, generally undrinkable or in sufficient concentration to impair plant growth.
Sediment dams	Large impoundment structures used to retain rainfall runoff to allow settlement of suspended particles, prior to discharge.
Sill	Sheet-like igneous intrusion within coal seams or along bedding planes.
Silt	Mineral particles with a diameter between 0.002 mm to 0.02 mm (McDonald *et al.*1998)
Silt traps	Small impoundment structures built within a drainage line, which retard water flow and allow suspended solids to settle out.

Sodic	A soil is considered sodic when the exchangeable sodium percent (ESP) is greater than six. Sodic conditions usually result in clay dispersion and surface crust formation.
Sodosol	Soils with a strong texture contrast between A horizons and sodic B horizons with are not strongly acid, as defined by Isbell (1998).
Soil	That part of the upper weathered layer of the earth's crust which can support plant growth
Soil horizons	Soil horizons as defined by McDonald *et al.* (1998) are: O — surface layer dominated by organic material in varying stages of decomposition A — one or more surface mineral horizons with some organic accumulation A1 — mineral horizon at or near the surface with some accumulation of humified organic matter. It is usually darker than underlying horizons A2 — mineral horizon having less organic matter, sesquioxides and/or silicate clay than immediately adjacent horizons. It is usually paler in colour than the A1 or B horizon. A3 — transition horizon between the A and B horizons, which is similar to the A horizon B — one or more mineral soil layers characterised by a concentration of silicate clay, iron, aluminium and/or organic material; and/or a differing structure, consistency or colour of the A horizon. B1 — transitional horizon between the A and B horizon which is similar to the B horizon B2 — horizon dominated by an illuvial, residual or other concentration of silicate clay, iron, aluminium and/or humus, and/or maximum development of pedological organisation. B3 — transitional horizon between the B and C horizon which is similar to the B horizon C — consolidated and unconsolidated material below the A and B horizon. Usually partially weathered and little affected by pedological processes.
Spoil area	Area where overburden has been dumped.
Sump	Temporary excavation for the storage of water.
Subsoil	The B horizon within the soil profile which lies immediately below the topsoil or A horizon. The subsoil is not enriched with organic material as is the topsoil. It may also be subject to clay and/or salt accumulation.
Suitably qualified person	A person whose professional training or experience is relevant to the matter being considered (EPA 2007)
Tension cracks	Cracks at the ground surface, which occurs due to tensional forces in the soil or rock mass.
Tertiary	The geological period of time from the 2 million to 65 million years ago.
Test pit	An excavation for examination of subsurface soil conditions
Topsoil	The uppermost horizon (or A horizon) of the soil profile which usually contains the organic matter, biota and a concentration of the nutrients.
Exploration track	Temporary vehicle traffic route used for exploration or infrequent access from which topsoil has not been removed.
Vertosol	Clay soil with high shrink swell properties as defined by Isbell (1998)
Waters	River, stream, lake, lagoon, pond, swamp, wetland, unconfined surface water, bed and bank of any waters, dams, non-tidal or tidal waters or any part-thereof.
Wetland	Areas of marsh, fen, peat or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt as defined by The National Committee on Soil and Terrain (2009).

Executive summary

This study was undertaken as a technical study to support the Environmental Impact Statement and identify the existing physical environment, including the characteristics of geology, soils, overburden and land resources for Stage 2 of the Middlemount Coal Project (the Project). This report also identifies potential impacts of the Project on the existing environment and mitigation measures related to those impacts.

The study identified and mapped the broad soil types and characterised overburden material within the Project area. Based on existing literature and findings of the field assessment including soil sampling and laboratory testing, the Project area appears to be covered by six different soils, derived from sedimentary or alluvial parent material. Assessment of land suitability was also conducted over the entire Project area.

Based on the findings of this assessment, overburden in the Project area is not anticipated to be acid forming nor is likely to produce heavy metal contamination. The overburden is considered dispersive, and will require specific management techniques to control the erosion potential. Rehabilitation planning should take into consideration these overburden characteristics as these materials are to form the substrate for future vegetation. Selection of revegetation strategies, including species mix, provision of growth media, early stage plant support and ecosystem planning, should be adjusted to enable successful and sustainable revegetation of these areas. Alternatively, some areas may require engineering solutions to achieve long term geotechnical stability.

Subsoils over much of the Project area are alkaline, sodic and dispersive will require specific management techniques, such as minimising exposure, to prevent erosion including tunnel erosion. Soils most susceptible to erosion include Yellow duplex, Grey-brown duplex and Alluvial soils.

It is anticipated that most topsoil from the proposed disturbed areas will be recovered and will be available for use in rehabilitation, although with limitations. Depth limitations exist in some soils, and slope gradient may impact the ease of stripping on steeper slopes. Topsoils from the Red lithosols are not considered appropriate for use in rehabilitation due to their surface rockiness.

Based on previous assessment and the results of the this investigation, the Project area is currently assessed to be within land suitability classes between Class 2 and 5 for both dry land cropping and cattle grazing but mostly is classified as Class 3 for beef cattle grazing and Class 4 for dry land cropping. The Project area is considered to be predominantly Class C good quality agricultural land (GQAL) except for the Red lithosols which are not considered GQAL and Brown uniform clays which are considered to be Class B GQAL, however the Brown uniform clays have limited extent within the Project area.

Following the assessment, it is understood that the undisturbed land will be returned to (or retained in) its pre-mining land suitability class. Land used for infrastructure components of the Project (roads, MIA, etc) will have limitations related to water availability (through compaction and breakdown of the subsoil structure), and will generally be Class 4 cropping land or Class 3 cattle grazing land. Spoil stockpiles and tailings storage facility will have limitations related to water availability, salinity, gradient, erosion and nutrient content, and will generally be Class 5 cropping land or Class 4 or 5 grazing land. The final void will be unsuitable for agricultural use (e.g. Class 5 for cropping and cattle grazing).

1. Introduction

1.1 Project background

The Middlemount Mine comprises the development of coal resources marketed as coking and pulverised injection coal in the central Bowen Basin, approximately 270 km north-west of Rockhampton and about 6 km south-west of Middlemount, a town built specifically for the coal mining industry (refer Figures 1.1 and 1.2). The Middlemount Mine is currently approved for production of 1.8 million tonnes per year (Mt/y) of run of mine (ROM) coal, designated under Mining Lease ML70379, and an amended Environmental Authority (Mining Activities) Non Code Compliant Level 1 MIN100646307 – Middlemount Coal Mine. A further amendment to the Environmental Authority has been applied for to include mining lease application area (MLA) 70417 to allow for placement of overburden spoil from the 1.8 Mt/y operation.

The approved Stage 1 of the Middlemount Mine has commenced with land clearing underway in for the construction of the Mine Infrastructure Area (MIA), the Coal Handling and Preparation Plant (CHPP), a water management system, and tailings storage facilities (TSF). A bulk sample program was also completed by taking a bulk sample of approximately 200,000 ROM tonnes of coal from the Pisces Upper seam using standard truck and excavator methods.

Stage 2 proposes to expand the mine to produce up to 5.4 Mt/y ROM coal. Stage 2 forms the basis of the Middlemount Coal Project (the Project) that is the focus of this report. The coal resources will continue to be developed as an open cut mine with related infrastructure.

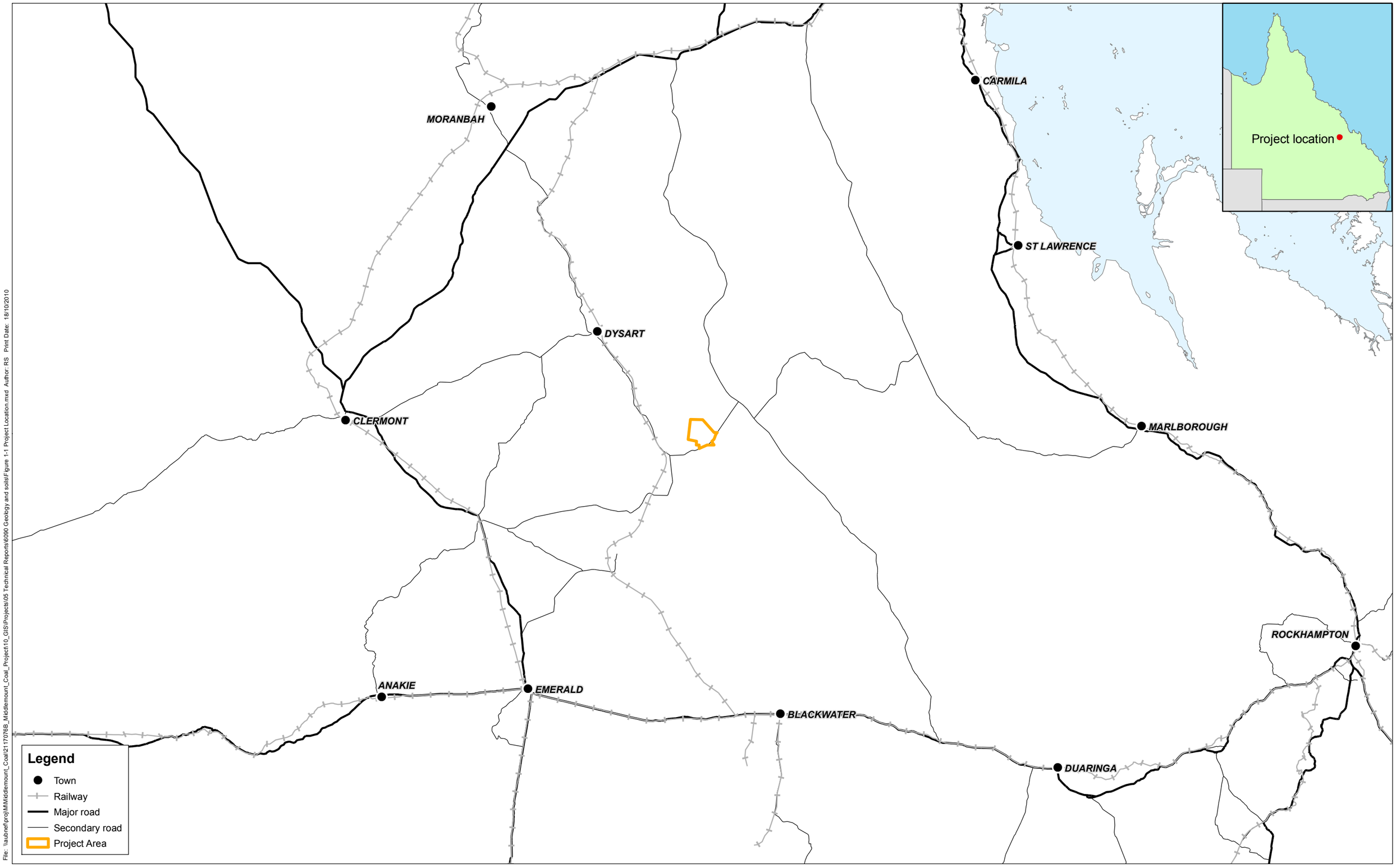
The Project is being developed by Middlemount Coal Pty Ltd (MCPL).

Parsons Brinkerhoff Pty Ltd (PB) has been commissioned by MCPL to prepare an Environmental Impact Statement (EIS) for the Project. This study was undertaken as a technical study to support the EIS and identify the existing physical environment, including the characteristics of geology, soils, overburden and land resources for Stage 2 of the Middlemount Coal Project (the Project). This report also identifies potential impacts of the Project on the existing environment and mitigation measures related to those impacts.

1.2 Description of Project area

The Project area for this geology, mineral resources, overburden and soils assessment includes the current mining lease area (ML70379) for Stage 1 of the mine and the footprint of Stage 2 (refer Figure 1.2).

The Project area is located in a landscape that has experienced some modification by past land uses, including clearing to allow limited agricultural activity (i.e. grazing and cropping), infrastructure corridors and the current construction for Stage 1 of Middlemount Mine. The landscape is relatively flat throughout the site with small rises and rocky elevated areas in the south of the Project area. Vegetation in the local area is cleared in areas of current construction and through infrastructure corridors in the Project area. The hydrology on the Project area is dominated by two creeks draining the site to the south-east via Roper Creek and Thirteen Mile Gully and ultimately into Mackenzie River further downstream.



File: \\aubnefprojMMiddlemount_Coal\21170768_Middlemount_Coal_Project\10_GIS\Projects\05 Technical Reports\6090 Geology and soils\Figure 1-1 Project Location.mxd Author: RS Print Date: 18/10/2010

PB PARSONS BRINCKERHOFF 125 YEARS

Source: Google Earth, 2010.
StreetPro Version 2008, Pitney Bowes Software, 2008.
1:250,000 Topographic Map, GeoScience Australia 2001.

0 12.5 25 50 75 100
Kilometres

Project Location

Figure 1.2

MIDDLEMOUNT

CENTENARY DRIVE NORTH

COCKATOO CREEK

THIRTEEN MILE GULLY

DYSART MIDDLEMOUNT ROAD

ROPER CREEK

PARROT CREEK

BARWON PARK MIDDLEMOUNT ROAD

Project location

Legend

- Project area
- Mining lease 70379
- Mining lease application 70417
- Road
- Creek
- Rail Loop

File: \\aubnetfp\proj\MM\Middlemount_Coal\21170768_Middlemount_Coal_Project\10_GIS\Projects\05 Technical Reports\6090 Geology and soils\Figure 1-2 Project Area.mxd Author: RS Print Date: 18/10/2010

PARSONS BRINCKERHOFF

Source: Google Earth, 2010.
StreetPro Version 2008, Pitney Bowes Software, 2008.
1:250,000 Topographic Map, GeoScience Australia 2001.

0 0.5 1 2 3 4 5
Kilometres

Project Area

The site is accessible via the sealed Dysart-Middlemount Road and unsealed farm tracks.

The Saraji water supply pipeline crosses the site diagonally from the south-east to the north-west, roughly parallel and north to the alignment of Thirteen Mile Gully.

2. Methodology

2.1 Relevant legislation and guidelines

2.1.1 Environmental Protection Act 1994

The *Environmental Protection Act 1994* (EP Act) is the key legislation for environmental management and protection in Queensland. The environmental values of land resources in Queensland are protected under the EP Act.

2.1.2 Protecting Queensland's strategic cropping land: A policy framework

The Policy Framework was formulated following a review of State Planning Policy 1/92. The Policy Framework is not a finalised government policy, and was open for comments until 30 September 2010.

Under the framework, legislative and planning instruments will be developed to implement the policy, being:

- a new act specifically for strategic cropping land resources. The legislation will describe how strategic cropping land is identified and will include an indicative map of where strategic cropping land resources may exist. Criteria will then be used for validating on-site whether the land is in fact strategic cropping land. The legislation will provide a consistent process for assessing and deciding whether development can proceed on strategic cropping land
- a new State Planning Policy under the *Sustainable Planning Act 2009*
- amendments to existing resources legislation. Amendments to resources legislation will be made to recognise the requirements of the new Act for strategic cropping land resources.

While the new laws are yet to be enacted, the Government expects that proponents will take this framework into account in advancing their projects (Page 9 of the Policy Framework).

2.1.3 State planning policy 1/92: Development and conservation of agricultural land 1992

State planning policy 1/92 is based on the principle that land suitable for agricultural purposes is limited in Queensland, and that suitable 'good quality' land should be protected for agricultural uses.

The state planning policy makes allowances for developments on high quality agricultural land where the project provides an overriding public benefit and there are no other suitable sites for the purpose.

The state planning policy 1/92 is largely implemented at the local government level, and requires local governments to include maps of good quality agricultural land (GQAL) in their planning schemes.

2.1.4 Planning guidelines: The identification of good quality agricultural land, 1993

The planning guidelines assists in the implementation of state planning policy 1/92, through the provision of a methodology for assessing and identifying agricultural land classes and subsequently GQAL.

Under the planning guidelines, land is classified into classes, ranging from Class A being cropping land with moderate to no production limitations, to Class D being land not suitable for agriculture due to extreme limitations. Which agricultural land classes are considered GQAL within each local government areas was established during the preparation of the planning guidelines in 1993, based on publicly available land resource mapping such as Department of Primary Industries manuals and CSIRO reports. The planning guidelines acknowledge that much of this mapping is at a broad scale, and that site-specific assessments may be needed to confirm the distribution of QGAL.

2.1.5 Environmental Protection (Water) Policy 2009

The Environmental Protection (Water) Policy (EPP (Water)) is a policy under the *Environmental Protection Act 1994*. The policy defines and protects environmental values of Queensland waterways.

2.1.6 Land suitability classification for cropping and grazing in the semi-arid sub-tropics of Queensland

The land suitability classification system used in this assessment was produced by the Department of Mines and Energy and was published as part of the *Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland* in 1995.

It provides a framework for the assessment of the suitability of land for cropping and grazing purposes, based on a range of soil and landscape characteristics. The guidelines were prepared for use in relation to mining and exploration projects for the assessment of pre-disturbance and post-disturbance land capability, but have now been widely adopted as a tool to assess land use potential relating to a range of infrastructure projects.

2.1.7 Draft guidelines for the assessment and management of contaminated land in Queensland

The draft guidelines for the assessment and management of contaminated land in Queensland were prepared to assist in the implementation of the *Environmental Protection Act 1994.* The draft guidelines contain trigger values for various contaminants including heavy metal concentrations that may indicate a hazard to human or environmental health, and above which site specific investigations are required.

2.1.8 Guideline 18 Rehabilitation requirements for mining projects (EPA 2008)

Guideline 18 was developed by the Environmental Protection Agency (EPA) to assist mining companies to establish rehabilitation outcomes and strategies, for the planning, operational and final rehabilitation stages of a mine. The guideline outlines rehabilitation goals, objectives and outcomes that are likely to be satisfactory to the EPA, and how the EPA accesses whether rehabilitation strategies are satisfactory.

2.2 Methodology of assessment

The soils and land suitability investigation comprised a review of available published data, fieldwork and laboratory testing. Locations of test pits were selected based on location of existing soil assessment sites, geological and topographic features of the landscape, access and land ownership issues and proposed layout of the mining operations. A laboratory testing program was carried out to determine chemical and physical characteristics of soils relevant for land suitability assessment, construction design and rehabilitation.

2.2.1 Previous investigations

Previous investigations that provided information for this report regarding soil and landscape characteristics in the Middlemount area have included:

- *Burgess, J 2003, The Land Resource Assessment of the Windereyers Hill Area, Isaac – Connors and Mackenzie River Catchments, Central Queensland, Queensland Government, Brisbane.*
- *GSS Environmental 2007, Draft Middlemount Project, Soil Survey and Land Resource Assessment Report, Hamilton.*
- *Parsons Brinckerhoff (PB) 2005, Lake Lindsay Project – Overburden, soils and land capability assessment report, Brisbane.*

2.2.2 Field work

The field work for the assessment was undertaken between 11 and 13 May 2010 and comprised:

- excavation and sampling of 12 test pits within the Project area
- walk-over survey to observe soil types/characteristics and landform of the site
- selection of overburden samples for laboratory assessment.

2.2.2.1 Test pits

Locations of test pits were surveyed by use of a Garmin hand held GPS unit, and checked against site features and map readings. The accuracy of this surveying method is considered to be within approximately 7 m in plan. Details of test pit locations are shown on Figure 2.1.

Test pits were excavated using either a 20 tonne Komatsu track mounted excavator or 25 tonne Hitachi track mounted excavator. Test pits were identified MM01 to MM13, except MM05. Test pit logs and explanatory notes are contained in Attachment A.

Test pits were excavated to between about 1.8 m and 6.0 m depth. Selected disturbed samples of surface and subsurface soils were obtained at regular intervals or at the change of strata for material identification and laboratory testing.

Test pit log records are attached in Attachment A, together with a set of explanatory notes, which define the terms and symbols used in their preparation. Topsoil (A1) consistency and pedality descriptions used were in accordance with those used in *Australian Soil and Land Survey, Field Handbook* (*The National Committee on Soil and Terrain* 2009).

MIDDLEMOUNT

CENTENARY DRIVE NORTH

COCKATOO CREEK

DYSART/MIDDLEMOUNT ROAD

BARWON PARK/MIDDLEMOUNT ROAD

THIRTEEN MILE GULLY

ROPER CREEK

PARROT CREEK

Project location

MW5P

MM11

MM10

MM12

MM09

MM08

MM07

MM06

MM04

MM03

MM02

MM01

MM13

MW9A

MW9M

9048

9049

9020

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

Legend

- PB groundwater borehole (2010)
- Burgess (2003)
- PB test pit (2010)
- GSS Environmental test pit (2007)
- Project area
- Mining lease 70379
- Mining lease application 70417
- Road
- Creek
- Rail Loop
- No spoil dumping area

File: \\aubnefs\proj\MM\Middlemount_Coal\21170768_Middlemount_Coal_Project\10_GIS\Projects\05 Technical Reports\6090 Geology and soils\Figure 2-1 Test Pit Locations.mxd Author: RS Print Date: 04/10/2010

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Source: Google Earth, 2010.
StreetPro Version 2008, Pitney Bowes Software, 2008.
1:250,000 Topographic Map, GeoScience Australia 2001.

0 0.5 1 2 3 4 5
Kilometres

Test pit locations

2.2.3 Soil mapping and classification

Classification of soils for the Project area was based on field observations, laboratory analytical data, aerial photography, and published soil classification data as listed in Section 2.2.1 of this report. Mapping included reference to soil profiles assessed by GSS Environmental (2007) and Burgess (2003). Soil log profiles within the Project area from Burgess (2003) are included in Attachment D.

The adopted soil classification system is based on the Australian Soils Classification (Isbell 1996). Where soil descriptions correlate with soil types in the references in Section 2.2.1, soil names from these references have been adopted. Soil names outlined by GSS Environmental (2007) have been adopted to provide easy correlation between the assessment for Stage 1 of Middlemount Mine and the current assessment.

2.2.4 Laboratory testing methods

Selected soil and rock samples were tested in a National Association of Testing Authorities. (NATA) registered laboratory for the following physical and chemical properties:

- electronic conductivity (EC)
- pH
- total nitrogen and phosphorous
- cation exchange capacity (CEC)
- exchangeable sodium percentage (ESP) of soil
- total sulphate (SO_4)
- total organic carbon
- heavy metals
- net acid generation (NAG)
- net acid production potential (NAPP).

All laboratory tests were conducted using verified test methods.

Detailed laboratory test result sheets are attached in Attachment B and a summary is provided in Table 3.4.

2.2.5 Overburden assessment

An overburden assessment was conducted to characterise overburden material within the Project area. The following characteristics of the overburden and interburden were assessed:

- erosion potential
- acid generation potential and heavy metal content.

The overburden and interburden assessment included laboratory analysis of rock chip samples from three boreholes that were drilled as part of the groundwater investigation program as well as overburden samples collected from the bulk sample pit and test pits. Sampling locations are shown in Figure 3.1.

Heavy metal concentrations within the overburden were assessed against the *Draft Guidelines for the Assessment of Contaminated Land in Queensland* (Environmental Protection Agency 1998) for environmental investigation levels and health-based investigation levels (Department of the Environment 1998).

The potential for acid drainage was based on the requirements of the *Assessment and Management of Acid Drainage* (Department of Mines and Energy 1995b).

2.2.6 Land suitability assessment

A land suitability assessment was carried out over the Stage 1 portion of Middlemount Mine by GSS Environmental (2007). A land suitability assessment was also carried out as part of this investigation, incorporating the Stage 2 area, based on the requirements of the *Attachment 2 of Land Suitability Assessment Techniques* (Department of Mines and Energy 1995a).

The Project area was assessed for its suitability for various uses including dry-land cropping and cattle grazing on improved pasture. The criteria used for assessing the suitability of land for specific agricultural uses are included in Attachment C. The land was then classified into one of five land suitability classes for each potential land use assessed, relating to the land use limitations.

The land suitability classes and their definitions are shown in Table 2.1 below:

Table 2.1 Land suitability classes

Land suitability class	Description
Class 1	suitable land with negligible limitations and is highly productive requiring only simple management practices
Class 2	suitable land with minor limitations which either reduce production or require more than simple management practices to sustain the use
Class 3	suitable land with moderate limitations — land which is moderately suited to a proposed use but which requires significant inputs to ensure sustainable use
Class 4	marginal land with severe limitations which make it doubtful whether the inputs required to achieve and maintain production outweigh the benefits in the long-term
Class 5	unsuitable land with extreme limitations that preclude its use.

There is no existing GQAL mapping covering the Project area. An assessment of GQAL was undertaken as part of this investigation, in accordance with *Planning Guidelines: The Identification of Good Quality Agricultural Land* (Department of Primary Industry and Department of Housing, Local Government and Planning 1993).

A post-mining land suitability assessment was also conducted based on the proposed final landform, as indicated on concept stage mine plans. However, developments in mine rehabilitation techniques, changes in legislative requirements and other developments not foreseen in this report could influence the proportion of various land suitability classes that could be achieved through rehabilitation over the life of the Project.

Consideration has been given to the draft *Protecting Queensland's strategic cropping land: A policy framework* (Department of Environment and Resource Management 2010).

2.3 Limitations

The assessment has been based on the excavation of 12 test pits, field observations, and review of existing information, including 18 test pits reported by GSS Environmental (2007) and three test locations and regional mapping reported by Burgess (2003).

Soils have been classified into broad soil types. Soils are not discrete units, and variation of properties will occur within each of these soil types. The scale of mapping also will not identify small isolated occurrences of difference soils within each mapped unit.

Boundaries between soil units have been assigned based on test pit profiles and landscape features such as topography, gradient and drainage lines. Soil boundaries are not discrete, and may grade between soil types over a distance of a few hundred metres, in these areas soils could display properties of all or none of adjacent soil types.

The overburden assessment has been conducted to provide a broad overview of overburden properties within the Project area to identify potential risk during operation and rehabilitation of the mine. The assessment does not detail the horizontal or vertical distribution of overburden substrates (e.g. siltstone, mudstone), and does not differentiate the properties of individual substrates. Ongoing assessment work during the operational phase of the Project, such as overburden sampling and testing for material characterisation will be required to adequately delineate various overburden units which may occur locally and may require different management techniques. For the purpose of this assessment the term 'overburden' refers to all overburden and interburden within the Project area.

3. Existing environment

3.1 Topography

The topography map of the Project area is shown on Figure 3.1. The majority of the Project area is relatively flat to very gently undulating terrain (refer Photo 3.1). Slope lengths are very long and gradients are generally less than 5% (refer Photo 3.2). Surface levels (RL) are between approximately 140 m to 160 m Australian height datum (AHD) with a gentle down-slope gradient from the north-west towards the south-east. The site is within a broad alluvial valley of Roper Creek. The northern and southern edges of the valley are near the northern and southern lease boundaries.

The southern valley edge is marked by topographically slightly higher areas consisting of a rocky escarpment where elevations rise up to about 15 m above the alluvial plain. The CHPP and other infrastructure elements are located on these topographically higher areas in the south.

The Project area is drained by Roper Creek and Thirteen Mile Gully. The creek channels are defined and incised into the landscape with some steep banks. Evidence of lateral channel migration via meanders was noted. Flood outs and localised erosion channels due to flooding are also common. Riparian vegetation is present along the creek and gully lines.

Vegetation

Low density grazing land and infrastructure corridors (i.e. Saraji water supply pipeline) have been cleared in the past, before mining activities began on-site. Current construction of Stage 1 of the Project required land clearing in the southern sections of the ML70379. Some areas of the Project area for Stage 2 have been cleared to create grazing land.

According to descriptions by Burgess (2003) and the Terrestrial Ecology technical report TR17.1.V5, the majority of the Project area is dominated by Eucalypt woodland vegetation communities. The topographically higher areas in the south of the Project area are characterised by Lancewood and Eucalypt woodland with Bull Oak. Brigalow regrowth was reported within the central Project area on clay flats north of Roper Creek.

The improved pastures over the grazing land are mainly covered with buffel grass and other grasses.

A detailed description of the vegetation in the Project area is also found in Chapter 17 Terrestrial Ecology of the EIS.

MIDDLEMOUNT

CENTENARY DRIVE NORTH

COCKATOO CREEK

DYSART/MIDDLEMOUNT ROAD

BARWON PARK/MIDDLEMOUNT ROAD

THIRTEEN MILE GULLY

ROPER CREEK

PARROT CREEK

MM01
MM02
MM03
MM04
MM06
MM07
MM08
MM09
MM10
MM11
MM12
MM13
MW5P
MW9M
MW9A

Project location

Legend

- Project area
- Mining lease 70379
- Mining lease application 70417
- Road
- Creek
- Rail Loop
- GSS Environmental test pit (2007)
- PB Groundwater Boreholes (2010)
- Burgess (2003)
- PB test pit (2010)
- Contours 10m
- No spoil dumping area

File: \\aubnet\proj\MM\Middlemount_Coal\21170786_Middlemount_Coal_Project\10_GIS\Projects\05 Technical Reports\6090 Geology and soils\Figure 3-1 Topography of the Project Area.mxd Author: RS Print Date: 04/10/2010

PB PARSONS BRINCKERHOFF 125 YEARS

Source: Google Earth, 2010.
StreetPro Version 2008, Pitney Bowes Software, 2008.
1:250,000 Topographic Map, GeoScience Australia 2001.

0 0.5 1 2 3 4 5
Kilometres

Topography of the project area



Photo 3.1 Flat terrain in western section of the Project area



Photo 3.2 Flat to gently undulating terrain in eastern section of site showing long slope length and low gradient

3.2 Geology

3.2.1 Regional geology

Reference to the Geological Survey of Queensland's 1:250,000 series St Lawrence sheets, Queensland Department of Employment, Economic Development and Innovation interactive resource and tenure map (*http://www.webgis.dme.qld.gov.au-/mines/tenure_maps.cfm*, accessed on 2 June 2010) and previous investigations indicate that soils and rocks of Project area are from the following main geological units:

- Fort Cooper Coal Measures/Burngrove Formation – Late Permian age sedimentary rocks comprising feldspathic and lithic sandstone, siltstone, carbonaceous mudstone, siliceous siltstone, banded coal seams, and tuff. These rocks do not outcrop within the site and were encountered only in the existing exploration boreholes.

- Rangal Coal Measures – Late Permian age sedimentary rocks comprising carbonaceous mudstone, siltstone, coal, feldspathic and lithic sandstone, and tuff. These rocks do not outcrop within the site and were encountered in the existing trial pit and exploration boreholes.

- Early Tertiary age sandstone, siltstone, claystone, conglomerate, oil shale and minor basalt.

- Tertiary/Quaternary age clay, sand and gravel that is likely to be reworked (colluvial and high level alluvial) laterite.

- Quaternary age alluvial sediments comprising silt, sand and gravel.

The field investigation confirmed the presence of these units. The sedimentary rocks encountered underlying the Rangal Coal Measures could be part of either the Fort Cooper Coal Measures or the Burngrove Formation, which are similar but occur in the northern and central Bowen Basin respectively.

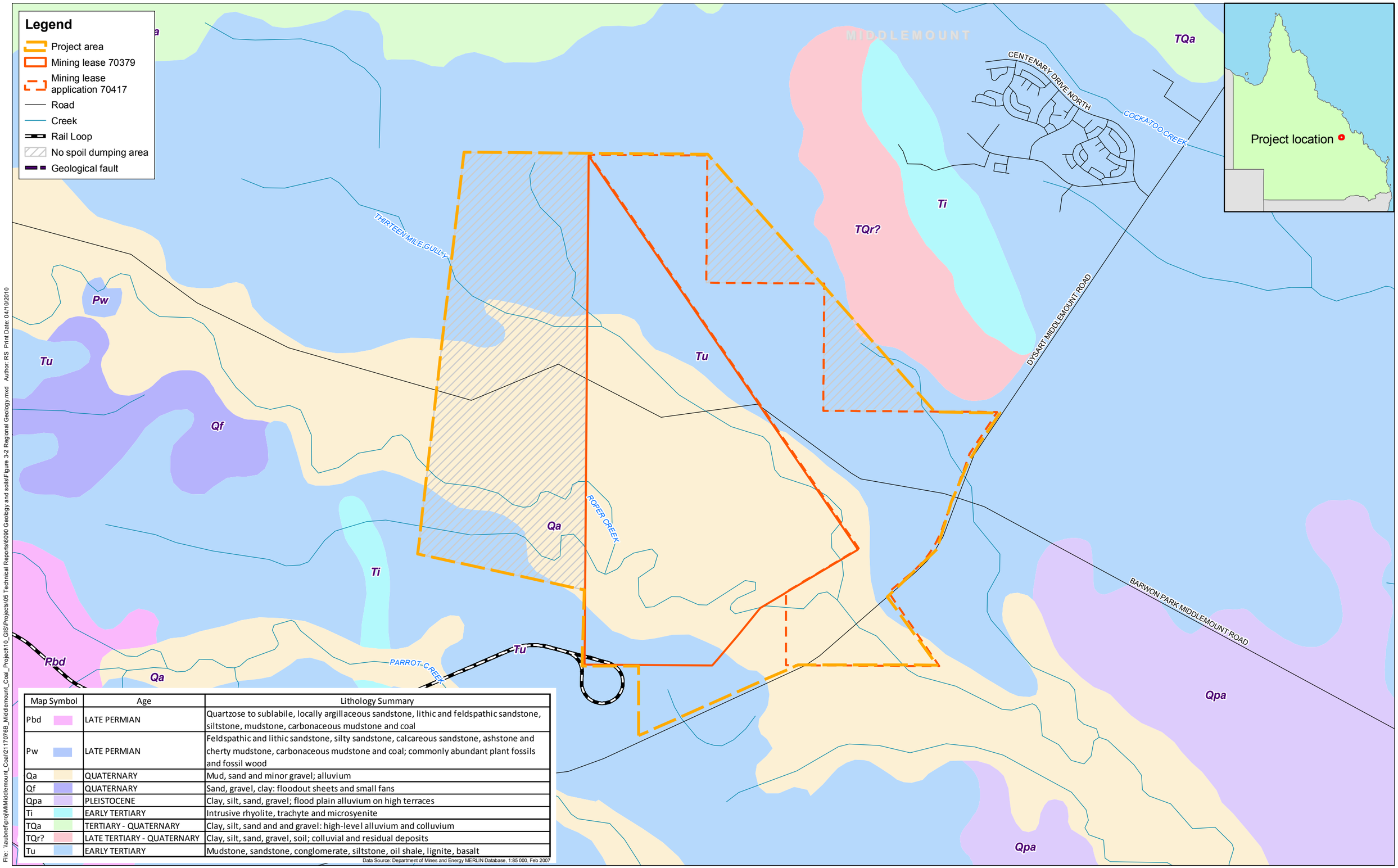
The major regional geological structure is the north-north-west trending Jellinbah Fault, a thrust fault with a throw of up to several hundreds of metres. This fault is interpreted to be located in the eastern portion of the Project area.

A map illustrating the geology of the Project area is shown on Figure 3.2, and schematic stratigraphic column is provided in Figure 3.3.

3.2.2 Local geology

Existing published geology data indicates that over the Project area, the Quaternary age alluvial sediments are distributed in a 2 km to 3 km wide belt on the southern and northern side of Roper Creek. However, field work indicated that the Recent alluvium is mainly present in a few hundred metres wide belt along the northern banks of Roper Creek and in isolated patches elsewhere within the floodplain. In the north and south, the generally less than about 5 m thick alluvium onlaps onto the Tertiary sedimentary rocks and reworked laterites.

Locally, especially in the south-western portion of ML70379, the Tertiary age sedimentary rocks are lateritised with hard caprock and form topographic high areas. Thickness of the Tertiary cover is generally between about 15 m and 35 m.



Map Symbol	Age	Lithology Summary
Pbd	LATE PERMIAN	Quartzose to sublabile, locally argillaceous sandstone, lithic and feldspathic sandstone, siltstone, mudstone, carbonaceous mudstone and coal
Pw	LATE PERMIAN	Feldspathic and lithic sandstone, silty sandstone, calcareous sandstone, ashstone and cherty mudstone, carbonaceous mudstone and coal; commonly abundant plant fossils and fossil wood
Qa	QUATERNARY	Mud, sand and minor gravel; alluvium
Qf	QUATERNARY	Sand, gravel, clay: floodout sheets and small fans
Qpa	PLEISTOCENE	Clay, silt, sand, gravel; flood plain alluvium on high terraces
Ti	EARLY TERTIARY	Intrusive rhyolite, trachyte and microsyenite
TQa	TERTIARY - QUATERNARY	Clay, silt, sand and and gravel: high-level alluvium and colluvium
TQr?	LATE TERTIARY - QUATERNARY	Clay, silt, sand, gravel, soil; colluvial and residual deposits
Tu	EARLY TERTIARY	Mudstone, sandstone, conglomerate, siltstone, oil shale, lignite, basalt

Data Source: Department of Mines and Energy MERLIN Database, 1:85 000, Feb 2007

File: \\aubnefpro\MMiddlemount_Coal\21\7078B_Middlemount_Coal_Project\10_GIS\Projects\05 Technical Reports\6090 Geology and soils\Figure 3-2 Regional Geology.mxd Author: RS Print Date: 04/10/2010

PB PARSONS BRINCKERHOFF 125 YEARS

Source: Google Earth, 2010.
StreetPro Version 2008, Pitney Bowes Software, 2008.
1:250,000 Topographic Map, GeoScience Australia 2001.

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Kilometres

Regional geology

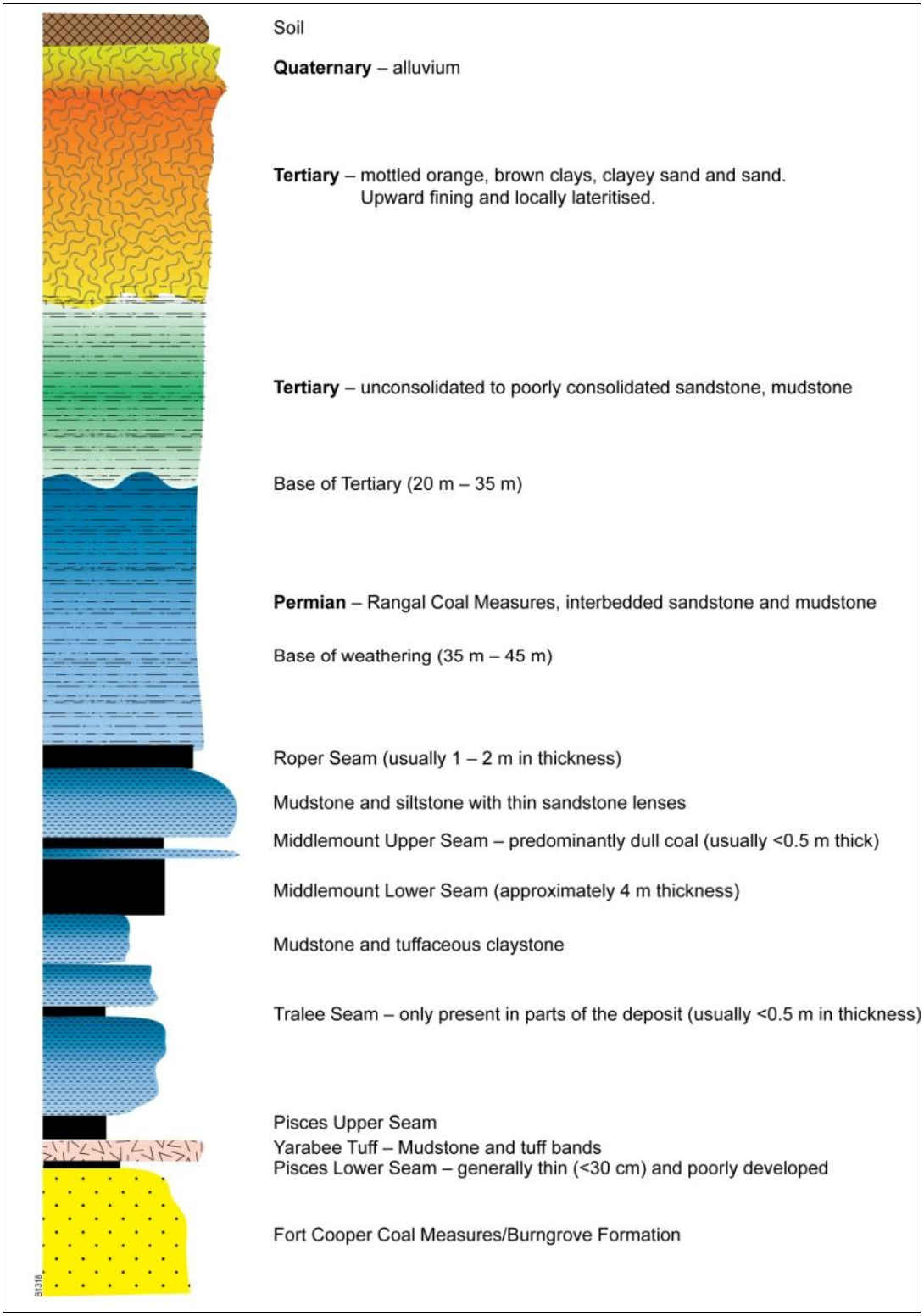


Figure 3.3 Schematic geological cross section

Coal targeted in ML 70379 occurs within the Rangal Coal Measures and Burngrove Formation. The Roper, Middlemount Lower and Upper, Tralee and Pisces Upper seams (in descending order) belong to the Rangal Coal Measures, while the Pisces Lower seam belongs to the Burngrove Formation.

Seams strike north-northwest and dip to the east-north-east, generally at less than seven degrees (Ward, 2010). Locally steeply dipping coals seams are anticipated to occur adjacent to the Jellinbah Fault.

Depth of weathering is generally between about 35 m and 45 m.

3.3 Mineral resources

A number of individual coal tenures are present within the Project area as shown on Figure 3.4 below. Exploration permits for coal (EPC), and mining leases (MLs) exist over the Project area. The Project will involve the extraction of coal from mining tenements ML70379 (granted) and MLA70417 (application).

Two Petroleum exploration permits overlap the mining tenements, with both held by Arrow Energy.

3.4 Geomorphology

The Project area is within the Mackenzie River catchment in the Bowen Basin. Drainage over the Project area is generally towards the south-east through Roper Creek and Thirteen Mile Gully towards Oakey Creek and then the Mackenzie River.

The wide floodplain, gentle slopes and meanders of drainage lines suggest the landscape within the Project area is geologically stable. The creeks are slowly cutting into and eroding the landscape, with lateral erosion of the valleys being the main large-scale landscape altering activity, together with channel deepening. Temporary deposition of eroded material occurs in the creek channels and on the floodplain during large rainfall and flood events before moving further downstream. Erosion rates are anticipated to be low due to the low topographic gradient and relatively dry climate. Most erosion will occur during high rainfall events.

The Project area is considered ‘erosional’ with temporary sediment storage on the alluvial plains.

Figure 3.4

MIDDLEMOUNT

CENTENARY DRIVE NORTH

COCKATOO CREEK

Project location

EPC747

EPP1031

EPP364

EPP811

EPC1033

EPC1014

THIRTEEN MILE GULLY

EPC1225

DYSART MIDDLEMOUNT ROAD

ML70417

ML70379

ML1831

ROPER CREEK

EPP688

EPP748

EPP364

BARWON PARK MIDDLEMOUNT ROAD

MDL282

EPC855

EPC1139

PARROT CREEK

ML70429

EPC747

EPC1669

EPC1455

ML1998

ML70310

EPC726

EPC1669

Legend

- Project area
- Mining lease 70379
- Mining lease application 70417
- Road
- Creek
- Rail Loop
- MDL
- EPC
- ML
- EPP
- No spoil dumping area

File: \\aubnet\proj\MM\Middlemount_Coal\21170768_Middlemount_Coal_Project\10_GIS\Projects\05 Technical Reports\6090 Geology and soils\Figure 3-4 Mineral Resources.mxd Author: RS Print Date: 18/10/2010

PARSONS BRINCKERHOFF

Source: Google Earth, 2010.
StreetPro Version 2008, Pitney Bowes Software, 2008.
1:250,000 Topographic Map, GeoScience Australia 2001.

0 0.5 1 2 3 4 5
Kilometres

Mineral resources

3.5 Overburden

Overburden in the Project area has not been previously investigated.

Overburden in the Project area consists mostly of weathered and fresh sandstone, siltstone, mudstone and claystone of Tertiary and Permian age, together with Tertiary and Quaternary unconsolidated clayey and sandy sediments. Upward fining sequences are common in each geological unit, and vertical and lateral changes of facies were observed, indicating a terrestrial, fluvial sedimentary environment.

For the purpose of this investigation, for the remainder of this report it is considered that the term 'overburden' refers to all overburden and interburden within the Project area. Interburden is defined as rocks between mineable coal seams.

Based on published data and PB's experience in the southern and central Bowen Basin, the siltstones and the lithic or feldspathic sandstones of both Tertiary and Permian age are anticipated to produce soil material high in clay content and possibly dispersive. The sodic and potentially dispersive clays are anticipated to be also present in the reworked unconsolidated sediments.

The unconsolidated sediments are generally removed during pre-stripping while the weathered and fresh rocks are drilled and blasted prior to excavations. This method allows the separate management of the two main overburden types, if required.

3.5.1 Acid production potential

The oxidation of sulfidic material is a natural process resulting from the exposure of minerals such as pyrite (iron sulfide) to atmospheric conditions (Environment Australia 1997), and is calculated as the acid producing potential and expressed in kg H_2SO_4/t (H_2SO_4 = sulphuric acid). This process can be accelerated during mining operations if large volumes of sulfidic material are exposed. The resulting acidity may also dissolve metals within overburden rock. Transport by water can generate highly acidic runoff with high concentrations of dissolved salts of heavy metals. The acidic runoff or leachate is referred to as acid mine drainage (AMD). Solubility of most metals is increased in low pH environment.

Carbonate minerals and exchangeable bases, on the other hand, have the ability to neutralise acid (calculated as the acid neutralising capacity in kg H_2SO_4/t). Carbonate minerals (mainly calcite, aragonite and dolomite) have the most significant acid neutralising capacity.

Selected overburden samples were tested for AMD generating potential, actual acidity and electrical conductivity. The parameters assessed and their brief description is detailed below:

- **pH – Actual acidity –** The acidity of the soil or rock as it occurs (i.e. without any induced oxidation or treatment).
- **pH after oxidation** – Actual acidity of the sample is determined after rapid oxidation by hydrogen peroxide. The process is simulating prolonged exposure to atmospheric conditions. Materials with values below pH 4.0 are considered acid producing and above pH 4.0 not acid producing.
- **Acid production potential (APP)** – This is measured by oxidation of a sample using hydrogen peroxide and measuring the acidity by titration.

- **Acid neutralising capacity (ANC)** – This is due to the presence of carbonate minerals, exchangeable bases and silicate minerals that may break down in the subsurface material. Carbonate minerals (calcite, aragonite and dolomite) are the most significant in terms of acid neutralisation.

  Laboratory test involves digesting the sample in hot acid and then titrating with a base to determine how much acid was consumed.

- **Net acid producing potential (NAPP)** – NAPP is the difference between APP and ANC (i.e. NAPP=APP-ANC) and gives an indication of subsurface materials potential to generate acid. A positive result shows acid generating potential and a negative result indicates that the material is non-acid producing.

- **Total Sulphur (%)** – Total sulphur is the measure of the total sulphur content of the rock. Materials with more than 0.5% total sulphur could have a potential to produce acidic materials.

- **Net acid generation (at pH 4.5 and pH 7) (NAG)** – NAG differs from NAPP by measuring actual acid production and neutralisation of the rock and not the total theoretical potential.

- **Acidity and conductivity** – Actual field acidity and electrical conductivity was determined on selected overburden samples. Electrical conductivity is used as a proxy for salinity of the assessed rocks.

Laboratory test results (refer Table 3.1 below) indicated that all overburden samples tested have near zero or negative NAPP in the range of 0.8 to -122 kg H_2SO_4/t. These results indicate that the maximum theoretical acid production potential is equal or less than the theoretical capacity of the rock to neutralise the produced acid.

All overburden samples tested have some ANC, ranging between very low (i.e. <0.5 kg H_2SO_4/t) to high (i.e. up to 122 kg H_2SO_4/t). The samples with low ANC correspond with the near zero NAPP results.

NAG results of overburden samples indicate that when exposed to oxidising conditions the spoil material will not generate acid or the generated acid will be neutralised by other materials present in the rock. NAG results of tested samples are <0.1 kg H_2SO_4/t for NAG at pH 4.5 and vary between <0.1 kg H_2SO_4/t and 2.9 kg H_2SO_4/t for NAG at pH 7. These NAG results are considered very low and are supported by the after oxidation pH values measured to be between 6.0 and 10.7. The after oxidation pH values indicate that the rocks have no or negligible potential to produce AMD.

The chart shown in Figure 3.5 below is used for estimating overburden characteristics and resulting potential for acid production. All results for samples tested as part of this investigation plot in the upper and lower right quadrant, indicating that the overburden has negligible to low acid forming potential.

Non acid forming high sulphur high neutralising capacity >0.5 %S	<0.5 %S Not acid forming low sulphur; high neutralising capacity
Potential acid forming low neutralising capacity high suphur	Low acid forming potential low neutralising capacity low sulphur

Figure 3.5 Classification of acid production potential

Table 3.1 Analytical test results of typical overburden materials from each geological unit

	Unconsolidated Quaternary sediments	Unconsolidated/weathered Tertiary sediments				Fresh Tertiary sedimentary rocks	Weathered Permian sediments	Fresh Permian sediments		
Sample origin and ID (depth below ground level) Parameter	**MM01 5.9-6.0 m**	**Bulk sample pit ~10 m**	**MW5P 18.0-19.0 m**	**MW9A 19.0-20.0 m**	**MW9A 40.0-41.0 m**	**Bulk sample pit ~35 m**	**MW9A 49.0-50.0 m**	**Bulk sample pit ~45-50 m**	**MW9M 69.0-70.0 m**	**MW5P 78.0-79.0 m**
pH	8.2	8.7	9.6	8.2	8.4	7.6	9.7	7.6	10.0	9.8
Electrical conductivity – **EC** (µS/cm)	202	334	567	878	537	2080	610	2440	331	523
Net Acid Production Potential – **NAPP** (kg H_2SO_4/t)	-4.9	-3.5	-122	<0.5	-6.8	0.8	-14.4	0.7	-28.2	-52.2
Net acid generation (pH 4.5) – **NAG** (kg H_2SO_4/t)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Net acid generation (pH 7.0) – **NAG** (kg H_2SO_4/t)	1.1	1.0	<0.1	2.9	1.9	1.6	<0.1	0.9	<0.1	<0.1
pH after oxidation	6.1	5.9	9.1	6.0	5.6	6.0	7.3	6.2	9.2	10.7
Acid neutralising capacity – **ANC** (kg H_2SO_4/t)	4.9	4.0	122	2.2	7.6	<0.5	14.9	<0.5	28.7	53.6
Total Sulphur (%)	<0.01	0.02	<0.01	0.06	0.03	0.03	0.02	0.02	0.02	0.04

3.5.2 Dispersion, salinity and erosion potential

Salinity and acidity/alkalinity data of overburden materials is used as indication of their erosion, slaking and dispersion potential. Mildly alkaline to very strongly alkaline overburden materials (pH values above 7.6), as encountered on site, are considered as sodic materials. Sodium dominated multi-layer clays tend to disperse when in contact with water. Dispersion is when the clays form colloids and remain in suspension in water.

The laboratory pH test results (Table 3.1 above) indicates that the clay component of the overburden has a high potential to be dispersive. Dispersive clays are anticipated to be present both in the Tertiary soils and weathered rocks and in the weathered Permian age rocks.

The dispersion potential of the soils and weathered rocks was also indicated by laboratory slake tests results reported by Ward (2010). The Durability Index (I) test results reported varied between 0% and 97.8%. Rocks with 'I' value below about 60% are considered to have low durability and are anticipated to disintegrate upon exposure to surface conditions and water. While not all rocks with low durability are dispersive, the erosion potential of low durability rocks is also high.

It is assumed that the overburden has moderate to high dispersion potential as observed during the site visit in the existing bulk sample pit. Existing soils and geology information for the Middlemount area (Minserve 2004, PB 2005), also suggests the overburden is likely to be highly dispersive and highly susceptible to erosion. Signs of existing erosion, interpreted to be present due to dispersive characteristics of exposed clays and non-cohesive, Tertiary age, and sands at the bulk sample pit, were noted and are shown in Photo 3.3 below.

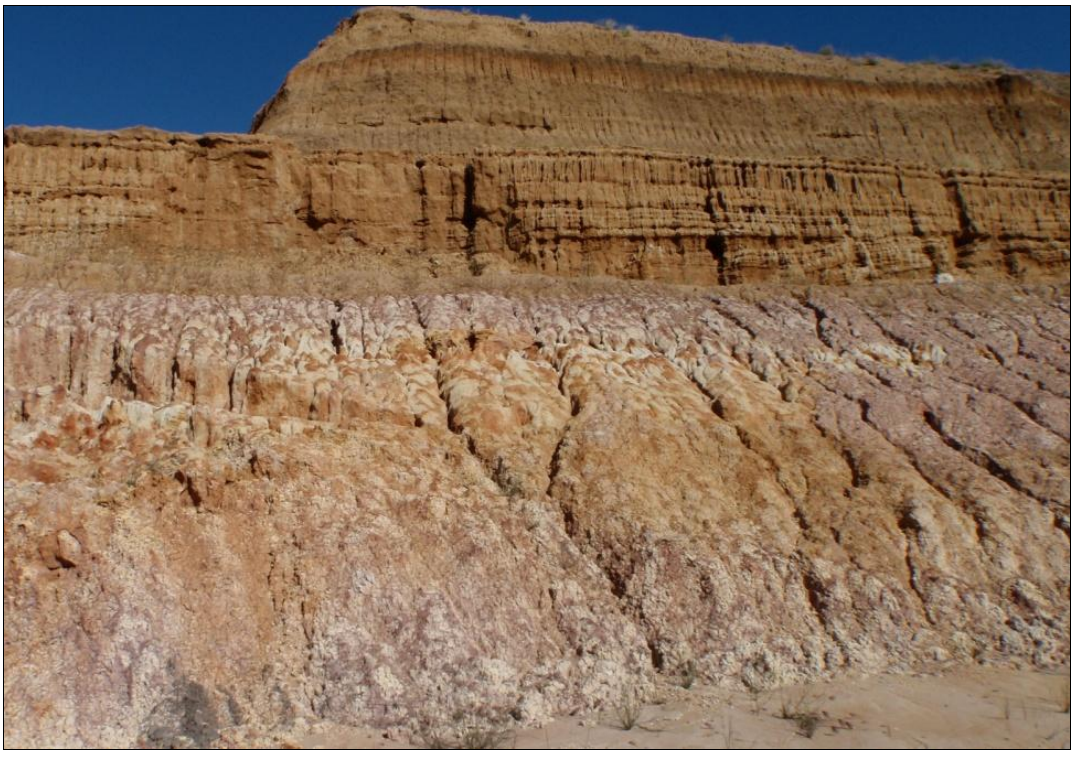


Photo 3.3 Existing rill erosion in the bulk sample pit; the clayey soils appear to be dispersive and the sands are non-cohesive

Low to extreme salinity values, between 202 µS/cm and 2,440 µS/cm, were recorded for the various overburden samples (refer Tables 3.1 and 3.8). The highest values appear to be related to fresh Tertiary and Permian age rocks and the lowest value was recorded for a sample from the unconsolidated surficial sediments. The low salinity values in the surficial unconsolidated sediments were also similar to the low EC values reported for the surface soils (refer Table 3.5).

3.5.3 Heavy metals

Schedule B (1) 'Guideline on the Investigation Levels for Soil and Groundwater' in *The National Environment Protection (Assessment of Site Contamination) Measure 1999* (National Environment Protection Council (NEPC) 1999) suggests trigger 'investigation level' concentrations for various heavy metals. If concentrations are higher than the investigation level, there is a need for additional, site specific detailed assessment.

Laboratory heavy metal concentration results of the overburden samples were assessed against the 'environmental investigation levels' and 'health-based investigation levels' (National Environment Protection Council, 1999) to provide an indication of the potential for overburden dumps to be a source of heavy metal contaminated leachate, based on the concentrations in the in-situ overburden material.

Relevant environmental and health-based investigation levels are shown in Table 3.2 below.

Table 3.2 Investigation thresholds for heavy metal contaminants in soil

Substance	Typical background levels (mg/kg)	Environmental investigation level (mg/kg)	Health-based investigation level[1] (mg/kg)
Arsenic	1–50	20	100
Cadmium	1	3	20
Copper	2–100	100	1,000
Chromium (III)	5–1,000	400	12%[2]
Chromium (VI)	–	1	100
Lead	2–200	600	300
Nickel	5–500	60	600
Zinc	10–300	200	7,000

Source: National Environment Protection Council 1999, Table 5-A.

Notes: 1. based on 'Standard' residential use as defined in Department of the Environment 1998. This includes garden/accessible soil (home-grown produce contributing less than 10% of fruit and vegetable intake; no poultry); this category includes children's day-care centres, preschools and primary schools.

2. % of total chromium in all speciations.

The Queensland Department of the Environment (1998) recommend a site specific assessment of land with levels above the environmental investigation level, and remediation or a detailed environmental and health risk assessment if levels are above the health based investigation levels.

The laboratory results for heavy metal analysis in overburden are provided in Attachment B and a summary is provided in Table 3.3 below.

As shown in Table 3.3, heavy metal concentrations within the overburden are below the concentrations requiring investigating under the National Environment Protection (Assessment of Site Contamination) Measure 1999 (NEPC 1999).

Table 3.3 Heavy metal concentrations in overburden samples

Substance	Number of samples analysed	Minimum concentration (mg/kg)	Maximum concentration (mg/kg)	Samples exceeding environmental investigation level[1]
Arsenic	5	<5	7	None
Cadmium	5	<1	<1	None
Copper	5	<5	47	None
Chromium III	5	5	38	None
Chromium VI	5	<0.5	<0.5	None
Lead	5	<5	13	None
Nickel	5	7	42	None
Zinc	5	12	81	None

1. based on 'Standard' residential use of soil as defined in Department of the Environment, 1998 (QLD). This includes garden/accessible soil (home-grown produce contributing less than 10% of fruit and vegetable intake; no poultry); this category includes children's day-care centres, preschools and primary schools.

The above results indicate that overburden materials do not contain levels of heavy metals, which exceed the environmental investigation limits set out by the Queensland Department of Environment (1998). Based on the above test results the risk for overburden dumps to be a source of heavy metal contaminated leachate is considered negligible.

3.5.4 Nutrients and trace elements

The nutrient and trace element content of overburden material was not assessed as part of this study. Laboratory pH values of overburden material indicates that it is alkaline and sodic (refer Table 3.1) and it is considered poor growth media for plants due to low nutrient availability. High alkalinity and sodicity renders the nutrients present in the rock mass unavailable to plants.

All disturbed areas are anticipated to be covered with topsoil to achieve rehabilitation. No overburden is proposed to be used as plant growth media.

3.5.5 Fossil material

As discussed in Section 3.3.1, the coal bearing strata present in the Project area together with the overlying rock are of Permian, Tertiary and Quaternary age and of sedimentary origin. There is a potential for fossils to be present. However, based on experience in other open cut coal mines in the area the potential for location of significant fossils is expected to be low.

3.6 Soils

3.6.1 Soil description and mapping

Classification of soils in the Project area was based on field observations, laboratory analytical data and re-interpretation of previous classifications (e.g. by GSS Environmental 2007).

The adopted soil classification system is based on the classification by GSS Environmental (2007) and *The Land Resource Assessment of the Windeyers Hill Area, Isaac – Connors and Mackenzie River Catchments, Central Queensland* (Burgess 2003). However, soils have also been correlated with the *Australian Soil Classification System* (Isbell 1996).

Soils encountered on site by the current investigation and assessed by GSS Environmental (2007) have mainly developed on either reworked Tertiary/Quaternary age unconsolidated sediments or on Quaternary age alluvial sediments as mapped by Burgess (2003). Based on the field investigation and review of existing information, six soil types have been adopted from previous investigations by GSS Environmental (2007) and Burgess (2003) to allow easy correlation between previous assessments and this work. The identified soil types are as follows:

- yellow duplex
- alluvial soils
- grey brown duplex
- brown uniform clay
- red lithosol
- warwick.

These soil units are discussed in the following sections and presented on Figure 3.6. There were some variations to those soils described by GSS Environmental encountered in this investigation which have been described in following sections. Three test locations from Burgess (2003) and 18 locations from GSS Environmental (2007) were also included in this assessment and are shown on Figure 3.6.

Figure 3.6

MIDDLEMOUNT

CENTENARY DRIVE NORTH

COCKATOO CREEK

DYSART MIDDLEMOUNT ROAD

BARWON PARK MIDDLEMOUNT ROAD

THIRTEEN MILE GULLY

ROPER CREEK

PARROT CREEK

Project location

MW5P
MW9A
MW9M
9048
9049
9020
MM01
MM02
MM03
MM04
MM06
MM07
MM08
MM09
MM10
MM11
MM12
MM13
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18

Legend

- Project area
- Mining lease 70379
- Mining lease application 70417
- Road
- Creek
- Rail Loop
- Saraji Pipeline

Saraji Proposed Realignment

- Option 1
- Option 2
- Option 3
- PB groundwater borehole (2010)
- Burgess (2003)
- PB test pit (2010)
- GSS Environmental test pit (2007)
- No spoil dumping area

Soil types

- Yellow Duplex
- Grey-Brown Duplex
- Brown Uniform Clay
- Red Lithosol
- Alluvial Soils
- Warwick Soils

File: \\aubnet\proj\MM\Middlemount_Coal\21170768_Middlemount_Coal_Project\10_GIS\Projects\05 Technical Reports\6090 Geology and soils\Figure 3-6 Soil Types.mxd Author: RS Print Date: 18/10/2010

PB PARSONS BRINCKERHOFF 125 YEARS

Source: Google Earth, 2010.
StreetPro Version 2008, Pitney Bowes Software, 2008.
1:250,000 Topographic Map, GeoScience Australia 2001.

0 0.5 1 2 3 4 5
Kilometres

Soil types

Where possible, soils have been correlated with those described in the assessment by GSS Environmental (2007) and the Australian Soil Classification (Isbell 1996). Relationship between soil types is outlined in Table 3.4 below.

Soils with similar physical or chemical properties have been grouped together as soil associations as shown in Figure 3.6 to make the map easier to use and more practical for soil management planning. While Figure 3.6 shows discrete boundaries between soil types, the soils actually grade into each other (i.e. properties of both soils occur) over a distance of a few hundred metres.

Abrupt boundaries between soils types generally do not occur in the Project area, except occasionally along drainage lines (Roper Creek and Thirteen Mile Gully).

Table 3.4 Interpreted relationship between soils described by Burgess (2003), GSS Environmental (2007) and the Australian Soil Classification (Isbell 1996)

Classification Systems		
GSS Environmental (2007)	**Burgess (2003)**	**Isbell (1996)**
Yellow duplex	Foxleigh and Foxleigh Loam	Yellow-brown sodosol
Grey-brown duplex	Parrot	Grey-brown sodosol
Brown uniform clay	Tralee	Grey-brown vertosol
Alluvial soils	Roper	Grey-brown chromosol
Red lithosols	Bellarine	Leptic rudosol
Not mapped	Warwick	Grey-brown vertosol

The mapped soils are described in detail in Section 3.7.3 below.

3.6.2 Laboratory results

Selected near surface soil samples were tested to assess their acidity, salinity, dispersion potential, and nutrient content. The results were used to aid classification of individual soil types and to assess reuse potential of soils for future rehabilitation purposes. The analytical results are summarised in Table 3.5 and the ratings used in the assessment are provided in Tables 3.6, 3.7 and 3.8. Laboratory test report sheets are in Attachment B.

Descriptions of some of the parameters assessed include:

- exchangeable sodium percentage (ESP) – Chemically exchangeable sodium can weaken the bonds between clay particles thus acts as a dispersing agent. Soils with an ESP of more than 15% are considered dispersive and soils with an ESP less than 5% are commonly considered as non-dispersive

- cation exchange capacity (CEC) – The soil's capacity to hold nutrients is estimated by CEC. Low values (below 5) indicate the soil is infertile and prone to leaching and therefore is likely to be a poor growth medium requiring nutrient application.

Tables 3.6 to 3.8 below provide values related to the fertility, acidity and salinity of soil. Values shaded in Table 3.5, representing land suitability and rehabilitation constraints have been based on values contained in Tables 3.6 to 3.8.

Table 3.5 Soil nutrient and chemical analytical test results

Analyte/Sample (depth)	MM01 (0.0-0.1)	MM01 (0.1-0.2)	MM01 (0.32-0.4)	MM02 (0.0-0.1)	MM02 (0.15-0.25)	MM02 (0.7-0.8)	MM03 (0.0-0.1)	MM04 (0.15-0.25)
pH	6.3	6.7	6.4	6.8	7.2	6.9	6.0	7.1
Electrical conductivity (µS/cm)	22	38	113	7.5	44	37	25	23
Moisture Content (%)	5.9	5.3	11.7	5.7	7.4	12.2	6.1	6.9
Exchangeable calcium (meq/100g)	7.9	4.3	3.7	8.6	6.6	11.1	4.4	12.6
Exchangeable magnesium (meq/100g)	6.8	2.7	4.5	1.7	1.8	3.6	1.6	4.6
Exchangeable potassium (meq/100g)	0.6	1.2	0.5	1.4	1.4	1.2	1.5	1.3
Exchangeable sodium (meq/100g)	4.5	0.3	2.6	0.2	0.2	0.2	0.2	0.2
CEC (meq/100g)	19.8	8.5	11.2	11.8	10.0	16.2	7.6	18.7
ESP (%)	22.6	3.5	22.8	1.4	2.0	1.4	2.2	1.0
Sulphur as SO_4 (mg/kg)	130	120	110	200	150	160	150	190
Chloride (mg/kg)	220	270	490	130	130	290	220	220
Total Kjeldahl nitrogen (mg/kg)	460	520	530	1350	550	490	650	860
Total phosphorus (mg/kg)	280	289	216	315	285	302	262	537
Organic Matter (%)	1.3	1.4	0.9	3.1	1.4	1.0	1.9	2.4
Total Organic Carbon (%)	0.8	0.8	0.5	1.8	0.8	0.6	1.1	1.4

Note: Shaded results represent samples that are either strong pH, contain excessive amount of dissolved solids (i.e. salts, EC > 600 µS/cm or Cl^-:SO_4 ratio more than 600) or are considered having moderate to high potential for dispersivity (ESP >10).

Table 3.5 Soil nutrient and chemical analytical test results

Analyte/Sample (depth)	MM06 (0.0-0.1)	MM06 (0.45-0.55)	MM07 (0.0-0.1)	MM07 (0.2-0.3)	MM08 (0.0-0.1)	MM08 (0.2-0.3)	MM09 (0.0-0.1)	MM10 (0.0-0.1)
pH	6.4	8.7	6.7	6.7	6.6	6.2	6.1	5.9
Electrical conductivity (µS/cm)	20	422	17	8	20	3	10	8
Moisture Content (%)	1.8	10.2	2.9	3.6	2.1	2.1	1.7	1.4
Exchangeable calcium (meq/100g)	1.6	8.7	3.0	1.3	2.8	0.8	1.4	1.6
Exchangeable magnesium (meq/100g)	0.7	5.8	0.6	0.3	0.6	0.6	0.4	0.5
Exchangeable potassium (meq/100g)	0.5	0.3	0.4	0.2	0.3	0.3	0.2	0.2
Exchangeable sodium (meq/100g)	<0.1	3.3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
CEC (meq/100g)	2.9	18.2	4.2	1.8	3.7	1.7	2.1	2.4
ESP (%)	1.6	18.0	2.0	1.5	0.6	2.1	2.3	1.4
Sulphur as SO_4 (mg/kg)	<100	200	<100	<100	<100	<100	<100	<100
Chloride (mg/kg)	50	560	50	20	130	<10	20	50
Total Kjeldahl nitrogen (mg/kg)	310	140	220	110	340	100	190	180
Total phosphorus (mg/kg)	122	89	139	73	87	62	58	127
Organic Matter (%)	0.9	<0.5	0.5	<0.5	0.9	0.9	0.5	<0.5
Total Organic Carbon (%)	0.5	<0.5	<0.5	<0.5	0.5	0.5	<0.5	<0.5

Note: Shaded results represent samples that are either strong pH, contain excessive amount of dissolved solids (i.e. salts, EC > 600 µS/cm or Cl^-:SO_4 ratio more than 600) or are considered having moderate to high potential for dispersivity (ESP >10)

Table 3.5 Soil nutrient and chemical analytical test results

Analyte/Sample (depth)	MM11 (0.0-0.1)	MM12 (0.15-0.25)	MM12 (0.4-0.5)	MM13 (0.0-0.1)	MM13 (0.2-0.3)
pH	6.6	6.7	8.6	5.4	5.3
Electrical conductivity (µS/cm)	14	8	243	9	20
Moisture Content (%)	2.6	3.3	9.4	2.1	5.2
Exchangeable calcium (meq/100g)	1.8	1.9	11.6	1.4	1.4
Exchangeable magnesium (meq/100g)	0.4	1.0	6.6	1.8	2.4
Exchangeable potassium (meq/100g)	0.3	0.4	0.6	0.3	0.1
Exchangeable sodium (meq/100g)	<0.1	<0.1	1.9	0.1	0.2
CEC (meq/100g)	2.5	3.4	20.7	3.6	4.1
ESP (%)	1.1	1.9	9.0	4.1	5.6
Sulphur as SO_4 (mg/kg)	<100	<100	120	<100	120
Chloride (mg/kg)	20	50	250	100	130
Total Kjeldahl nitrogen (mg/kg)	250	170	180	350	940
Total phosphorus (mg/kg)	54	78	116	163	135
Organic Matter (%)	1.0	0.5	<0.5	0.9	0.9
Total Organic Carbon (%)	0.6	<0.5	<0.5	0.5	0.5

Note:Shaded results represent samples that are either strong pH, contain excessive amount of dissolved solids (i.e. salts, EC > 600 µS/cm or chloride:sulfate ratio more than 600) or are considered having moderate to high potential for dispersivity (ESP >10).

Table 3.6 Ratings used for interpretation of soil analyses

	Ratings				
Soil test (units)	**Very low**	**Low**	**Medium**	**High**	**Very high**
Total nitrogen (mg/kg)	<500	500 – 1,500	1500 – 2,500	2500 – 5,000	>5,000
Total phosphorus (mg/kg)	<50	50 – 200	200 – 500	500 – 1,000	>1,000
Extractable potassium (meq%)	<0.1	0.1 – 0.2	0.2 – 0.5	0.05 – 1.0	>1.0
SO_4 (mg/kg)	—	<4	4 – 10	>10	—
Cl- (mg/kg)	<100	100 – 300	300 – 600	600 – 2,000	>2,000
Cu (mg/kg)	<0.1	0.1 – 0.3	0.3 – 5	5 – 15	>15
Mn (mg/kg)	<1	1 – 2	2 – 50	50 – 500	>500
Zn (mg/kg) pH >7	<0.3	0.3 – 0.8	0.8 – 5	5 – 15	>15
Zn (mg/kg) pH <7	<0.2	0.2 – 0.5	0.5 – 5	5 – 15	>15
Total organic carbon (%)	<0.5	0.5 – 1.6	1.5 – 2.5	2.5 – 5.0	>5.0

(after Biggs, Coutts and Harris 1999)

Note: For total nitrogen, total phosphorus, extractable potassium and total organic matter, low values represent a nutrient deficiency, and medium to high values are preferential. For other parameters in the above table, high to very high values represent levels at which plant toxicities may occur, and low to medium values are preferential. Very low values may result in deficiencies in some plants

Table 3.7 Ratings used for interpretation of pH

Rating	pH
Extremely acid	<4.5
Very strongly acid	4.5–5.0
Strongly acid	5.1–5.5
Medium acid	5.6–6.0
Slightly acid	6.1–6.5
Neutral	6.6–7.3
Mildly alkaline	7.4–7.8
Moderately alkaline	7.9–8.4
Strongly alkaline	8.5–9.0
Very strongly alkaline	>9.0

(after Biggs, Coutts and Harris, 1999)

Table 3.8 Ratings for interpretation of electrical conductivity

Salinity rating	Root zone salinity (EC µS/cm)			
	10–20% clay	20–40% clay	40–60% clay	60–80% clay
Very low	<50	<80	<120	<180
Low	100	165	250	370
Medium	250	400	580	850
High	450	670	1,000	1,500
Very high	700	1,050	1,580	2,400
Extreme	>700	>1,050	>1,580	>2,400

(after Biggs, Coutts and Harris, 1999)

3.6.3 Soil types

Soil types encountered on site during this or previous investigations (refer Table 3.4) are described in detail below.

3.6.3.1 Yellow duplex

This soil was encountered on the flat plains away from drainage lines and on very gently inclined slopes associated with Poplar box (*Eucalyptus populnea*) vegetation community. Under the Australian Soil Classification, this soil type is classified as yellow-brown sodosol and is similar to the soil descried by Burgess (2003) as the Foxleigh and Foxleigh Loam soil.

This soil was encountered at test locations MM07 to MM12 from the current investigation and soils mapped as 'Yellow duplex' soils according to GSS Environmental (2007). One test location with this soil type was identified by Burgess within the Project area (refer site 9020 on Figures 2.1 and 3.6).

The soil profile of the Yellow duplex soils is described below.

The approximately 0.3 m to 0.45 m deep topsoil comprises pale brown and yellow-brown to brown sandy loam or sand, with blocky or platy peds in the A1 and A2 horizons (refer Photo 3.4).

The B2 horizon generally consists of grey or brown and yellow-brown sandy clay with orange and black mottles and blocky peds. Locally, in poorly drained areas, calcareous concretions may be present. Fine grained gravel size, rounded, ferruginous nodules in a sandy clay matrix were encountered in test pits MM07 to MM09 and MM10 forming a layer of between 0.1 m and 0.25 m thick at the top of the B2 horizon. In test pits MM11 and MM12 the top of the B horizon comprised sand or clay with sand and the ferruginous nodules were encountered lower in the profile not in a distinct horizon. Cementation and fissures with polished surfaces were common in the lower B horizons.

The C horizon, when encountered, occurred from below 1.5 m depth comprising sandy or silty clay. The encountered soil profiles correlate well with the Foxleigh/Foxleigh Loam and Yellow duplex soil described by Burgess (2003) and GSS Environmental (2007).

Laboratory test results indicate that the topsoil of the Yellow duplex is neutral to moderately acidic, has very low salinity levels and very low organic carbon content. This soil also has very low nitrogen and low phosphorous content. These topsoils are considered to have a negligible or slight potential for dispersivity but moderate to high potential for erosion due to their non-cohesive characteristics.

The B horizon soils are strongly alkaline, have low salinity, high CEC and are considered to have a moderate to high potential for dispersivity.



Photo 3.4 **Typical view of a Yellow duplex (site MM12), including the vegetation community (i.e. poplar box) and landscape in which the soil mostly occurred**

3.6.3.2 Grey-brown duplex

This soil occurs on flat plains and on very gently inclined slopes (<2%–5%), associated with scattered re-growth of Poplar box woodland vegetation in improved pastures with grass cover in north-west to south-east trending belts, sub-parallel with the streams. The grey-brown duplex appears to be mainly located between the alluvial soils and Yellow duplex soils. This soil was encountered at test locations MM01, MM03, MM06 and MM13 during the current investigation and was mapped as 'Grey-brown duplex' soils previously (GSS Environmental 2007). Under the Australian Soil Classification, this soil type is classified as Brown-grey sodosol and correlates well with the description of the 'Parrot' soils mapped by Burgess (2003).

The soil profile of the Grey-brown duplex soil is described below.

The topsoil is between about 0.30 m to 0.45 m deep, and consists of pale brown to grey-brown sandy loam to clayey loam, with blocky or platy peds in the A1 and A2 horizons (Photo 3.5).

The upper B horizons generally comprise pale grey or brown silty or sandy clay with prismatic, blocky or platy peds. The lower B horizons comprise sandy or silty clay, grey to dark brown with orange-brown, brown or black mottles with prismatic peds. Calcareous concretions and fissures with polished surfaces are common in lower subsoils.

The C horizon encountered in MM01, MM03 and MM13 comprised sandy or silty clay or clay with sand, grey, red-orange and brown in colour. These materials are of inferred Tertiary age reworked sediments origin. In test pit MM06 the C horizon comprised extremely weathered, extremely low strength, fine to medium grained sandstone of inferred Tertiary age.



Photo 3.5 Typical view of a Grey-brown duplex soil (site MM03), including the vegetation community and landscape in which the soil mostly occurred

Laboratory test results indicate that the topsoil of the Grey-brown duplex is neutral to slightly acidic, has very low salinity and low organic carbon content. This soil also has very low to low nitrogen and low to medium phosphorous content. These topsoils are considered to have a slight to moderate potential for dispersivity but moderate to high potential for erosion due to their non-cohesive characteristics.

Subsoils are strongly alkaline, have low to moderate salinity, high CEC and are considered to have a moderate to high potential for dispersivity. Due to the strong alkalinity of the subsoils the plant available nutrient level of this soil horizon is considered low.

3.6.3.3 Brown uniform clay

This soil occurs on the generally flat plain between Roper Creek and Thirteen Mile Gully, just upstream from their confluence, in a poorly drained area. The soil is associated with open Poplar box woodland vegetation cleared areas covered by buffel grass. Poorly developed gilgai may be present within this soil.

Under the Australian Soil Classification, this soil type is classified as Brown-grey vertosol and correlates well with the Tralee soils, as described and mapped by Burgess (2003). This soil was not encountered within the area of this investigation but was mapped as 'Brown uniform clay' soils in the report by GSS Environmental (2007). This soil is not anticipated to occur in the areas of Stage 2 however, its description is provided here for completeness.

The following soil profile was provided in the previous assessments (Burgess and GSS Environmental) (Burgess and GSS Environmental) for Brown uniform clay soils and Tralee soils:

- the topsoil is between 0.10 m to 0.15 m deep, and consists of brown to dark coloured sandy clay with angular-blocky peds
- dark brown or dark grey-brown sand clay subsoils with angular blocky peds underlay the topsoil to about 0.28 m to 0.45 m depth. The lower subsoil, below about 0.45 m depth, comprises brown to dark brown massive heavy clay.

Laboratory test results from previous assessments (Burgess 2003; and GSS Environmental 2007) indicate that the topsoils of the brown uniform clay is mildly to moderately alkaline and has very low salinity. Topsoils are also considered to have very high potassium and phosphorous content, with high CEC. Based on ESP results the subsoils are strongly alkaline and are considered to have a high potential for dispersivity. The salinity and the alkalinity increases in the subsoil with high chloride content. Due to the strong alkalinity of the subsoils the plant available nutrient level of this soil horizon is considered low.

3.6.3.4 Alluvial soils

This soil occurs on the flat alluvial plain surrounding Roper Creek and some sections of Thirteen Mile Gully, associated with remnant riparian vegetation dominated by buffel grass pasture cover and open Poplar box woodland (GSS Environmental 2007). Under the Australian Soil Classification, this soil type is classified as Grey-brown chromosol and roughly matches the description and mapping by Burgess (2003) for the Roper soil. This soil was encountered at test location MM02 and MM04 from the current investigation and soils mapped as 'Alluvial soils' according to GSS Environmental (2007).

The Alluvial soils encountered had the following generalised soil profile:

The topsoil is between about 0.35 m to 0.45 m deep, comprising pale brown or grey-brown sandy loam, with angular blocky or platy peds in the A1 and A2 horizons (Photo 3.6).

Underlying the topsoil is a clayey B horizon of inferred alluvial origin, generally comprising dark brown silty clay with prismatic peds. The lower B horizon in test pit MM02 comprised sandy clay. Black (mangano-ferrugionous) mottling was common in the lower B horizons, which graded into alluvial material not affected by soil forming processes (C horizon).



Photo 3.6 Example of an alluvial soil (site MM04), including the vegetation community and landscape in which the soil mostly occurred

Laboratory test results indicate that the topsoil of the alluvial soils is neutral, has very low salinity and medium organic carbon content. This soil also has low to medium nitrogen and medium phosphorous content with very high potassium content in the topsoil horizons. These topsoils have low to medium CEC and are considered to have a negligible potential for dispersivity but high erosion potential due to dominance of non-cohesive sands.

The subsoils of the alluvial soils are neutral, have very low salinity, and are considered to have a negligible to slight potential for dispersivity.

3.6.3.5 Red lithosol soils

A Red lithosol was identified by GSS Environmental (2007), on the topographically higher areas in the south and south-western corner of Project area, associated with native trees and shrubs, including Narrow-leafed ironbark (*Eucalyptus crebra*), Lancewood (*Acacia shirleyi*) and grasses.

Under the Australian Soil Classification, this soil type is classified as Leptic Rudosol and roughly matches the description and mapping by Burgess (2003) for the Bellarine soil and mapped by GSS Environmental (2007) as a 'Red lithosol.' This soil was not encountered during the current investigation.

The following soil profile was provided in the previous assessments (Burgess and GSS Environmental) for Red lithosols and Bellarine soils:

- the topsoil is between 0.05 m to 0.15 m deep, and comprises of pale brown to brown granular clay sandy loam to clay loam. A surficial gravel armour layer comprising weathered rock fragments is generally present and the rock fragments are present throughout the profile

- underlying the topsoil is either weathered rock substrate or a residual B2 or C horizon generally consists of sandy clay to clay loam, white, grey and red with massive structure.

According to previous assessments (Burgess 2003; and GSS Environmental 2007) laboratory test results indicate that the topsoils of the red lithosol is neutral to very strongly acidic and has very low salinity. These soils are considered to have a negligible or slight potential for dispersivity. Subsoils are very strongly acidic, have very low salinity, and are considered to have a negligible to slight potential for dispersivity.

3.6.3.6 Warwick

This soil is classified by profiles encountered by Burgess (2003) at locations labelled 9048 and 9049 as shown on Figure 3.6. The Warwick soil occurs on the topographically higher areas in the north-west of Project area, associated with Brigalow (*Acacia harpophylla*) vegetation communities (Burgess 2003). Under the Australian Soil Classification, this soil type is classified as Brown-grey vertosol. This soil was not encountered in other portions of the site during this investigation.

The following soil profile was described by Burgess (2003) for the Warwick soil:

- the topsoil is between 0.03 m to 0.20 m deep, and consists of grey-brown to dark brown sandy clay to clay, with platy and blocky structure in the A1 and A2 horizons

- underlying the topsoil is a residual B2 horizon generally consists of clay, brown with lenticular and blocky peds. Calcareous concretions are also common in this layer.

According to previous assessments Burgess (2003), laboratory test results indicate that the topsoils of the Warwick soil is neutral to very strongly acidic and has very low salinity. These soils are also considered to have a negligible or slight potential for dispersivity. Subsoils are strongly acidic, have very low salinity, and are considered to have a moderate to high potential for dispersivity.

3.7 Land suitability assessment

At the time of the field investigation the Project area was used for low intensity cattle grazing. The infrastructure of Stage 1 of Middlemount Mine was also under construction in the southern portion of the site. The Project area is generally cleared or has been cleared in the past and mostly covered with pasture grasses and re-growth vegetation.

A land suitability assessment for Stage 1 of Middlemount Mine was undertaken by GSS Environmental (2007) to assess the land suitability for beef cattle grazing. A land suitability classification has been undertaken as part of this assessment for beef cattle grazing and dry land cropping for the encountered soils over both stages of the Project to create a uniform classification for the entire site.

The classification was based on the assessment technique described in *'Land Suitability Assessment Techniques'* (Department of Mines and Energy 1995a). The results of the assessment are shown in Tables 3.9 and 3.10 below:

Table 3.9 Land suitability assessment for dry land cropping

	Yellow duplex	Grey-brown duplex	Brown uniform clay	Alluvial soils	Red lithosol	Warwick
Water availability	4	4	3	2	5	4
Nutrient deficiency	4	3	1	1	4	3
soil physical factors	2	2	2	2	2	2
workability	2	2	2	2	2	2
salinity	1	1	1	1	1	1
rockiness	1	1	1	1	5	2
wetness	2	2	2	2	1	3
topography	2	2	2	3	1	2
Water erosion	2	2	2	4	3	2
Flooding	2	2	2	4	1	3
Land suitability class	**4**	**4**	**3**	**4**	**5**	**4**

Table 3.10 Land suitability assessment for beef cattle grazing

	Yellow duplex	Grey-brown duplex	Brown uniform clay	Alluvial soils	Red lithosol	Warwick
Water availability	4	3	2	1	5	3
Nutrient deficiency	2	2	1	2	4	1
soil physical factors	1	1	2	1	1	2
salinity	1	1	2	1	2	3
rockiness	1	1	1	1	4	1
micro relief	1	1	2	1	1	2
pH	2	3	2	2	3	2
ESP	3	3	1	2	1	2
wetness	2	2	2	2	1	2
topography	1	1	1	4	4	1
Water erosion	2	2	2	3	4	2
Flooding	2	2	2	2	1	2
vegetation regrowth	2	2	2	2	2	2
Land suitability class	**3**	**3**	**2**	**3**	**5**	**3**

The land suitability classes for the current assessment were derived from a combination of the identified soil types and geomorphic/topographic position, and not simply a reflection of spatial distribution of the various soils. Tables showing all criteria are provided in Attachment C.

This assessment incorporates results of the current field assessment, data from GSS Environmental (2007) and Burgess (2003). In most cases the land suitability class for a soil/landscape position relates to the highest (i.e. poorest) ranking criteria for the assessment. Land suitability maps of the Project area for dry land cropping and beef cattle grazing are shown in Figures 3.7 and 3.8 respectively.

The Yellow duplex, Grey-brown duplex, Alluvial soils and Warwick soils have been classified as Class 4 soils for dry land cropping due to their low plant available water capacity and nutrient deficiency. Class 4 soils are considered marginal land with severe limitations which make it doubtful whether the inputs required to achieve and maintain production outweigh the benefits in the long term.

The Alluvial soils are classified as Cass 3 for beef cattle grazing due to the topographic position and high erosion potential. The Yellow duplex, Grey-brown duplex and Warwick soils have been classified as Class 3 for beef cattle grazing due to their poor plant available water capacity, high pH and sodic subsoils.

The Brown uniform clays were classified Class 3 for dry land cropping and Class 2 for beef cattle grazing. This differs to GSS Environmental (2007) classification of Class 2 soils as the Tralee soils, reported by Burgess (2003) as included in the assessment of the Brown uniform clays, have a reported lower plant available water capacity. Class 3 is suitable land with moderate limitations – land which is mostly suited to a proposed use but which requires significant inputs to ensure sustainable use. Class 2 is suitable land with minor limitations which either reduce production or require more than simple management practices to sustain the use.

The Red lithosols are Class 5 for both dry land cropping and cattle grazing due to surface rockiness, poor plant available water capacity, shallow soils with weathered substrate close to the surface and nutrient deficiency. Class 5 soils are unsuitable land with extreme limitations that preclude its use.

MIDDLEMOUNT

CENTENARY DRIVE NORTH

COCKATOO CREEK

DYSART MIDDLEMOUNT ROAD

BARWON PARK MIDDLEMOUNT ROAD

THIRTEEN MILE GULLY

ROPER CREEK

PARROT CREEK

Project location

MM01
MM02
MM03
MM04
MM06
MM07
MM08
MM09
MM10
MM11
MM12
MM13
9020
9048
9049
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18

Legend

- Project area
- Mining lease 70379
- Mining lease application 70417
- Road
- Creek
- Rail Loop
- Saraji Pipeline

Saraji Proposed Realignment

- Option 3
- Burgess (2003)
- PB test pit (2010)
- GSS Environmental test pit (2007)
- No spoil dumping area

Land suitability for dry land cropping

- Class 3
- Class 4
- Class 5

File: \\aubnefproj\MM\Middlemount_Coal\21\17076B_Middlemount_Coal_Project\10_GIS\Projects\05 Technical Reports\6090 Geology and soils\Figure 3-7 Land Suitability Classes for Dry Land Cropping.mxd Author: RS Print Date: 18/10/2010

PB PARSONS BRINCKERHOFF 125 YEARS

Source: Google Earth, 2010.
StreetPro Version 2008, Pitney Bowes Software, 2008.
1:250,000 Topographic Map, GeoScience Australia 2001.

0 0.5 1 2 3 4 5
Kilometres

Land suitability classes for dry land cropping

Figure 3.8

MIDDLEMOUNT

CENTENARY DRIVE NORTH

COCKATOO CREEK

THIRTEEN MILE GULLY

DYSART MIDDLEMOUNT ROAD

BARWON PARK MIDDLEMOUNT ROAD

ROPER CREEK

PARROT CREEK

Project location

MM01 MM02 MM03 MM04 MM06 MM07 MM08 MM09 MM10 MM11 MM12 MM13

9048 9049 9020

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

Legend

- Project area
- Mining lease 70379
- Mining lease application 70417
- Road
- Creek
- Rail Loop
- Saraji Pipeline

Saraji Proposed Realignment

- Option 3
- Burgess (2003)
- PB test pit (2010)
- GSS Environmental test pit (2007)
- No spoil dumping area

Land suitability for Beef Cattle Grazing

- Class 2
- Class 3
- Class 5

File: \\aubnefpro\MM\Middlemount_Coal\21\17076B_Middlemount_Coal_Project\10_GIS\Projects\05 Technical Reports\6090 Geology and soils\Figure 3-8 Land Suitability Classes for Beef Cattle Grazing.mxd Author: RS Print Date: 18/10/2010

PB PARSONS BRINCKERHOFF 125 YEARS

Source: Google Earth, 2010.
StreetPro Version 2008, Pitney Bowes Software, 2008.
1:250,000 Topographic Map, GeoScience Australia 2001.

0 0.5 1 2 3 4 5
Kilometres

Land suitability classes for beef cattle grazing

3.8 Good quality agricultural land

In accordance with Section 2 and Attachment 2 of '*The Planning Guidelines: The Identification of Good Quality Agricultural Land*' (Department of Primary Industries and Department of Housing, Local Government and Planning Queensland 1993), agricultural land Classes A, B and C are considered GQAL in the Project area. A GQAL map is shown on Figure 3.9 below.

Agricultural land Classes are defined as follows:

- **Class A**: **crop land** — land that is suitable for current and potential cropping with limitations to production which range from none to moderate level.
- **Class B**: **limited crop land** — land that is marginal for current and potential cropping due to severe limitations, and suitable for pastures. Engineering and/or agronomic improvements may be required before the land is considered for cropping.
- **Class C**: **pasture land** — land that is suitable only for improved or native pastures due to limitations which preclude continuous cultivation for crop production, but some areas may tolerate a short period of ground disturbance for pasture establishment.
- **Class D**: **non-agricultural land**.

Current GQAL mapping does not cover the Project area however; GSS Environmental (2007) undertook a GQAL assessment for Stage 1 area of Middlemount Mine. The findings of that assessment classify Brown uniform clay soils as Class B, the Yellow duplex, Grey-brown duplex, Alluvial soils are considered to be Class C and the rocky Red lithosol soils are considered Class D.

The findings of this land suitability assessment presented in Section 3.8 above confirm the existing GSS Environmental GQAL assessment for Stage 1 area of Middlemount Mine. The Warwick soil was not assessed by GSS Environmental however, based on the findings of this land suitability assessment it is considered to be Class C.

From all soils encountered within the Project area the Brown uniform clay soil is considered as GQAL.

No Brown uniform clay soils are anticipated to be encountered within Stage 2 area.

3.9 Strategic cropping land

In accordance with *Protecting Queensland's strategic cropping land: A policy framework* (Department of Environment and Resource Management 2010), the Project area was assessed for presence of strategic cropping land.

According to Strategic Cropping Land – Draft Trigger Map C4 (Department of Environment and Resource Management 2010) the Project area is not considered strategic cropping land. Therefore, no further action or assessment is required under the *Sustainable Planning Act 2009.*

MIDDLEMOUNT

CENTENARY DRIVE NORTH

COCKATOO CREEK

DYSART/MIDDLEMOUNT ROAD

BARWON PARK/MIDDLEMOUNT ROAD

THIRTEEN MILE GULLY

ROPER CREEK

PARROT CREEK

Project location

MM01 MM02 MM03 MM04 MM06 MM07 MM08 MM09 MM10 MM11 MM12 MM13

9048 9049 9020

4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

Legend

- Project area
- Mining lease 70379
- Mining lease application 70417
- Road
- Creek
- Rail Loop
- Saraji Pipeline

Saraji Proposed Realignment

- Option 3
- Burgess (2003)
- PB test pit (2010)
- GSS Environmental test pit (2007)
- No spoil dumping area

Good Quality Agricultural Land

- Class B
- Class C
- Class D

File: \\aubnefprojMM\Middlemount_Coal\21170760B_MMiddlemount_Coal_Project\10_GIS\Projects\05 Technical Reports\6090 Geology and soils\Figure 3-9 Good Quality Agricultural Land of the Project area.mxd Author: RS Print Date: 18/10/2010

PB PARSONS BRINCKERHOFF 125 YEARS

Source: Google Earth, 2010.
StreetPro Version 2008, Pitney Bowes Software, 2008.
1:250,000 Topographic Map, GeoScience Australia 2001.

0 0.5 1 2 3 4 5
Kilometres

Good Quality Agricultural Land of the Project area

4. Description of the Project

The Middlemount Coal Project involves the development of an open cut pit over an expected lifespan of about 22 to 23 years. Stage 1 of the Project has already commenced and Stage 2 involves an extended mine plan and Project area. Mining will occur by strip mining and will target the Middlemount and Pisces coal seams. Overburden, interburden and coal will generally be removed by truck and shovel methods. At the time collation of this report, an alternative mining method involving use of a dragline to remove the Pisces interburden was also considered.

In addition to the mine pit, the Project includes various items of infrastructure as described in Chapters 5 Project Construction and 6 Project Operations of the EIS.

The open cut mining pit will be excavated to target the Pisces and Middlemount coal seams to depths up to and potentially exceeding approximately 100–120 m below natural surface. Prior to the initial box cut, vegetation will be cleared, and topsoil will be stripped and stockpiled for use in future rehabilitation and revegetation. Mine benches are generally proposed to be up to 300 m wide and bench heights are proposed to be a maximum of 35 m high.

As mining progresses, void space will be filled with overburden and interburden, however a final void will remain at the end of mining. Over the life of the mine, overburden and interburden will be placed in in-pit overburden dumps (ML70379) and out-of-pit overburden dumps (MLA70417). Overburden spoil dumps will be progressively levelled, shaped, capped and rehabilitated as the mine progresses. Rehabilitation and revegetation of the landform is anticipated to commence within two years following a pit strip being mined.

A single final void will remain after completion of mining of the pit. The final void will be shaped to increase the pit floor towards the natural topographical surface. Chapter 26 Rehabilitation and Decommissioning of the EIS outlines of the proposed final void and landscape design. Depths of the final void will vary across the pit. A final landform will be developed for approval by relevant administrative authorities closer to the proposed closure of the mine.

5. Potential impacts

5.1 Topography

As discussed in Section 3.1, the site currently consists of flat to very gently undulating hills generally less than 1% and alluvial floodplains varying in width between 500 m and 2 km.

The mining activities will result in topographical changes to the Project area during mine operation and post-mining, through the disturbance of existing topographical relief during overburden stripping and mining, the creation of new topographic highs through the placement of overburden dumps, and topographic lows in the form of the void. Changes to the location and width of the floodplains will also occur as a result of mining and creek diversions.

5.2 Overburden

Overburden material was assessed for acid mine drainage, heavy metal leaching and erosion potential in relation to their suitability for use as capping or rock cladding layer for overburden dumps, and suitability as a sub-soil growth medium in stockpile capping layers.

5.2.1 Acid production potential

The overburden rocks are generally not acid forming material (refer Table 3.1) and are not expected to pose a risk in forming acid mine drainage.

5.2.2 Heavy metals

Heavy metal concentrations in all overburden samples tested were below environmental investigation levels (refer Table 3.2 and Table 3.3). The excavation and dumping of overburden is expected to have a low risk of producing heavy metal contamination from leachate seepage or surface runoff from the overburden dumps.

5.2.3 Dispersion, slaking and erosion potential

When environmental factors (e.g. vegetation cover, climate etc) are equal, the erosion potential of dumped overburden is dependent on the chemical and physical characteristics of the material and the topography (natural or created) of the terrain.

As discussed in section 3.6.4, the overburden is considered to be highly dispersive and therefore will readily disperse when left exposed on the soil surface or otherwise exposed to water, which will lead to erosion, including tunnel erosion. The greater the period bare spoil is exposed, the higher its erosion potential. Sandy, non-cohesive materials are also considered to have moderate to high potential for erosion by flowing water.

5.2.4 Uncovering fossil material

There is potential for fossilised material to be discovered during drilling, excavation and mining activities. These activities have the potential to damage or destroy fossils.

Most fossils uncovered by the mining activities will be common. The significance of a fossil is not indicated by the fossil size, with fossils such as budding plants, uncommon plants or insects being of interest to the Queensland Museum. See Section 6.3 of this report which deals with the measures to be implemented upon the discovery of fossil materials.

5.3 Soils

5.3.1 Alkalinity, sodicity and dispersivity

Yellow duplex, grey-brown duplex soils have moderate alkalinity and sodicity within the subsoils and are moderately to highly dispersive. Brown uniform clays have strongly alkaline subsoils, but are not considered dispersive, whereas the Warwick soils are considered to have subsoils with high dispersivity potential.

Alkaline and sodic soils are generally dispersive, and have high erosion potential if exposed. Sodic, alkaline soils are also poor plant growth mediums due to low nutrient availability, and should not be used as such in rehabilitation of disturbed areas. The topsoil portion of all encountered soils, other than the Red lithosol, are considered suitable for use in rehabilitation however, all soils have some limitations.

5.3.2 Erosion

All soils in the Project area will be subject to erosion if vegetation is removed and rehabilitation is not undertaken within an appropriate timeframe. Soils most susceptible to wind erosion are soils with sandy or loamy topsoils, which include yellow duplex, grey-brown duplex, alluvial soils and some red lithosols.

Soils most susceptible to erosion by flowing water are those with dispersive (sodic) topsoil or upper subsoil as discussed in Section 5.3.1 above. Soils on steep and moderate upper slopes, as occur on the undulating terrain and overburden dumps, have higher risk from erosion by water than soils on gentle slopes and floodplain. Exposure of dispersive subsoils as described in Section 5.4.1 has the potential to cause gully erosion problems, even if only small areas of subsoil are exposed.

5.3.3 Salinity

Soil salinity in the Project area is of limited extent and is not considered a high risk. However, the subsoils of brown-grey duplex are moderately saline and changes to the soil moisture regime due to vegetation removal or other impacts may increase near surface soil salinity.

5.4 Land suitability

During the operation of the mine, existing land uses, such as cattle grazing and broad acre cropping, may be able to continue within the Project area in areas not directly impacted by mining. Areas required for the operation of mining and associated activities will be excluded from agricultural purposes during the operation of the mine.

Land disturbed by mining will be rehabilitated following mining. Without mitigation measures, long term impacts to the land suitability classes, as defined in Section 3.5, are expected as follows:

- undisturbed land will be returned to (or retained in) its pre-mining land suitability class

- land used for infrastructure components of the Project (roads, MIA, etc) will have limitations related to water availability (through compaction and breakdown of the subsoil structure), and will generally be Class 4 cropping land or Class 3 cattle grazing land

- overburden dumps and the tailings storage facility (TSF) will have limitations related to water availability, salinity, gradient, erosion and nutrient content, and will generally be Class 5 cropping land or Class 4 or 5 grazing land

- final voids will be unsuitable for agricultural use (e.g. Class 5 for cropping and cattle grazing).

Planned rehabilitation and mitigation measures to obtain better land suitability classification are detailed in Chapter 26 of the EIS.

6. Mitigation measures

6.1 Topography

The design of the post-mining landform should consider, and where practicable to replicate, the topographic elements discussed in Section 3.1 of this report. This does not infer that the topography should be returned to the pre-mining profile, but where hills (e.g. overburden dumps) are formed, they should be constructed to a similar height, slope angle and profile (shape) as occur naturally in the area, and if floodplains are formed as part of the final landform, they should be of similar width and slope angle to those in the Project area pre-mining if practicable. In general, these measures can be described as:

- concave slope profile
- average slope gradients of around 4% (the erosion potential of longer slopes will need to be considered)
- irregular dump shapes (e.g. with uneven heights, ridgelines and spurs)
- overburden dump relief (height) of up to 64 m between the floor of the floodplain and the hill crest
- less than 2% gradient in floodplains.

The area of the final void should be minimised. Rehabilitation and landform design should consider access ramps to the final voids suitable for wildlife.

6.2 Overburden

6.2.1 Acid production potential

As discussed in Section 5.2.1 of this report, there is a low to negligible risk of development of acid mine drainage from the overburden. Despite this, the following measures should be implemented:

- laboratory characterisation of selected samples of overburden material should be conducted during overburden stripping to confirm the acid generation potential prior to removal. This characterisation should be in accordance with the *Assessment and Management of Acid Drainage* (Department of Primary Industries 1995)
- coarse rejects should be fully characterised and a management strategy for this material developed with regards to potential acid production potential
- layers of coal roof and floor material, partings, coarse rejects and any material that is visually assessed at the time of mining as containing pyrite, should be assessed for acid producing potential prior to placing within the overburden dump
- layers of coal roof and floor material, partings, coarse coal rejects and any material that is visually assessed at the time of mining as containing pyrite should not be placed near the surface of the overburden dumps unless laboratory testing confirms that the material is non acid forming

- any potentially acid forming material, as identified by visual assessment or laboratory characterisation, should not be used as capping material and should be buried within the overburden dump together with waste rock that has a positive acid neutralising capacity.

6.2.2 Dispersion

As discussed in Section 5.2.4, much of the overburden is considered to have high susceptibility to dispersive behaviour and erosion prone. The following measures should be implemented in regard to overburden:

- testing of dispersion and slaking potential should be conducted during overburden stripping. Less dispersive overburden should be managed for use as capping material
- appropriate designs and locations for overburden dump erosion and drainage control measures should be established based on the results of dispersion and slaking testing, spoil management plans, and through the use of drainage and erosion potential trials. Designs may include the use of 'durable rock' lined drains, or the encouragement of water infiltration into the overburden dumps (subject to overburden characteristics)
- rock mulching techniques should be used during rehabilitation to reduce impacts of dispersion. Rock mulching is described extensively in Chapter 26 Rehabilitation and Decommissioning of the EIS.
- due to the potential susceptibility of the overburden to tunnel erosion, the detailed design and management of benches and/or contour banks on overburden dumps should consider this risk, and should be undertaken by a suitably qualified person
- trials at varying slope angles should be conducted in relation to erosion from dispersion and slaking. These trials will assist in establishing suitable final landform gradients
- sediment control structures should be used to control surface runoff from all rehabilitated and disturbed areas to reduce the amount of final sediment loads. An assessment of available technologies should be undertaken prior to selection of sediment control structures
- all out of pit overburden dumps should be shaped, topsoiled and re-vegetated to reduce potential for concentration of surface runoff and erosion of dumped material
- rehabilitation strategies should be monitored and adjusted as required to reduce the risk of spoil erosion and destabilisation of spoil stockpiles.

6.3 Uncovering fossil material

As discussed in Section 5.3 of this report, there is potential for fossils to be located during mining activities. In the event potentially significant fossilised material is located, the following measures should be implemented:

- if potentially significant fossils, such as large dinosaur bones, are discovered during mining activities, then work in the vicinity of the find should stop, to preserve the potential fossil
- the Queensland Museum is immediately alerted to the find.

6.4 Soils

6.4.1 Dispersivity and erosion

As discussed in Section 5.4.2 of this report, Yellow duplex and Grey-brown duplex have moderate to extreme alkalinity and sodicity within the subsoils and are moderately to highly dispersive and the Warwick soils are considered to have highly dispersive subsoils. Generally wind and water erosion control measures should be applied to all soils in the Project area, which include:

- a sediment and erosion control plan should be prepared and implemented for Middlemount Mine prior to the commencement of mining, specifying the locations and types of sediment and erosion control measures to be used, and consider the changes to the mine water management system as part of Stage 2
- design of all drainage around proposed structures and permanent landforms should consider the presence of dispersive soils and apply suitable erosion reduction methods. All disturbed areas should be revegetated, or covered with material that has low erosion potential, to minimise the potential for erosion
- for disturbed or cleared land, including infrastructure areas:
  - unnecessary exposure of alkaline or sodic subsoils should be avoided, and should be limited to the minimal amount of time practicable. Any exposure should be covered with non-dispersive soil or other suitable material to minimise the infiltration of water into these soils. Sub-soils from these areas should be buried within the overburden dumps and covered in accordance with site overburden management procedures
  - clear the minimal amount of vegetation (including grass cover) required for Project works
  - minimise disturbance of the ground layer of vegetation by controlled operation of machinery and equipment selection
  - site drainage, and erosion and sediment controls should be implemented and in place prior to, or as soon as possible, following the removal of vegetation
  - water runoff should be directed around topsoil stockpile areas using diversion bunds, contours, and catch drains as appropriate
  - divert clean water away from disturbed areas
  - revegetate exposed soils as soon as practical after works have been completed. This includes the rehabilitation of overburden dumps
  - use watering trucks during windy conditions for dust suppression
  - install temporary and permanent erosion and sediment control measures such as rock mulching (refer Chapter 26 of the EIS), contour banks, etc. on disturbed natural or constructed slopes to minimise erosion and sediment released into waterways. This is especially important for soils with dispersive subsoils.

- for infrastructure areas:
  - sediment and erosion control should be implemented in accordance with Middlemount Coal' s Sediment and Erosion Control Management Plan (Middlemount Coal 2010) and Erosion and Sediment Control (Site Practice) (Middlemount Coal 2009) for each area of infrastructure to be constructed. This plan should specify the locations and types of sediment and erosion control measures to be used
  - minimise areas cleared during earthworks, by delineating areas to be cleared with survey markers or other suitable marking
  - install sediment traps and silt fences or other suitable sediment control measures where overland runoff cannot be diverted to sediment dams
  - confine traffic to maintained roads
  - minimise slope grade within infrastructure areas where possible based on results of geotechnical data obtained during detailed design phase
  - construct hardstands from erosion resistant material
  - install scouring protection works in drains and intensely gullied areas adjacent to proposed infrastructure
  - revegetate disturbed areas surrounding infrastructure sites
  - control drainage and divert away from infrastructure.
- for stockpiles and dumps:
  - long-term stockpiles of topsoil and overburden should be planted with vegetation to minimise entrainment of soil particles into the air and minimise erosion through raindrop impact
  - when areas with topsoil susceptible to wind erosion (e.g. yellow duplex and grey-brown duplex) are stripped and stockpiled, even if for only a few months, the stockpiles should be covered by grass, other vegetation, geofabric or less erosive topsoil to minimise wind erosion
  - divert clean water from areas upslope of all topsoil, subsoil and overburden stockpiles/dumps around stockpile areas using contour banks or diversion channels, thereby reducing water flowing into the stockpile area
  - all topsoil, subsoil and overburden stockpiles/dumps should be bunded by earthen bunds or similar, with sediment dams installed downslope of stockpiles to prevent eroded sediment entering waterways.
- dispersive, clayey soils are suitable for use as embankment materials for water management structures, provided strict construction quality control measures are implemented

- gypsum or lime could be considered in the treatment of sodic alkaline soils to improve geotechnical/rehabilitation characteristics.

6.4.2 Salinity

As discussed in Section 5.4.3 of this report, saline topsoils are unlikely to be encountered in the Project area, high salinity levels are toxic to many plant species, and rehabilitation of saline soils can be difficult and costly. The subsoils of Grey-brown duplex soils are saline and should be buried within overburden dumps and covered with materials that are more stable. The subsoils of Grey-brown duplex should not be used in rehabilitation.

6.4.3 Compaction

The compaction of soil increases the potential for rainwater induced erosion, and reduces seed germination and root establishment of vegetation. The following measures should be applied in relation to compaction:

- compaction of topsoil can be reduced by selection of appropriate earthmoving machinery when working with these soils (i.e. light weight vehicles with large wheel/track size)
- soils that will be trafficked or compacted during the operation of the mine should have water control measures and sediment dams installed to minimise potential erosion and sediment entering into waterways
- previously compacted areas that are to be rehabilitated should be remediated by ripping the top layer of soil/overburden material, and then applying layers of subsoil and topsoil as required to establish a suitable plant growth environment. The depth of ripping/reworking required is dependent on the impact, and should be assessed at the time or rehabilitation
- ripping the top layer of soil breaks down the soil structure, and as a result protection of these areas from re-compaction (i.e. vehicles or grazing animals) after ripping is required to allow the soil structure to reform.

6.4.4 Topsoil reuse

Topsoils and subsoils are anticipated to be stripped from all disturbed areas and should be stockpiled for use in rehabilitation of disturbed areas. Suggested stripping depths and identified constraints for various encountered soil types are provided in Table 6.1 below.

Table 6.1 Topsoil stripping depths and potential constraints for reuse

Soil type	Surface soil composition	Topsoil stripping depth (m)	Potential constraints
Yellow duplex	Sandy loam or sand	0.3	▪ highly alkaline subsoil ▪ dispersive subsoil
Grey-brown duplex	Sandy to clay loam	0.1	▪ acidic A2 horizon in some locations ▪ low nutrient availability in topsoil ▪ highly alkaline subsoil ▪ dispersive subsoil

Soil type	Surface soil composition	Topsoil stripping depth (m)	Potential constraints
Brown uniform clay	Loamy Clay	0.2	▪ high clay content topsoil ▪ poor workability when wet ▪ sodic subsoil
Alluvial soil	Clay loam	0.3	▪ patches of high clay content topsoil
Red lithosol	Clay	Unsuitable for re-use	▪ surface rockiness ▪ weathered rock at shallow depth
Warwick	Clay	0.3	▪ alkaline topsoil ▪ high clay content topsoil

Topsoil stripping may be affected by localised topographic constraints such as incised gullies and shallow soil depth, especially in the upper slope area of the undulating terrain. However, it is anticipated that most topsoil from the proposed disturbed areas will be recovered and will be available for use in rehabilitation of disturbed areas.

Considering the topsoil and subsoil properties identified above, the following measures should be applied in relation to topsoil:

- the stripping of topsoil should be conducted in accordance with the existing Middlemount Coal Topsoil Management Plan (2010) and Topsoil Management Site Practice (2010)
- topsoil should be stripped separately from subsoil and stockpiled during clearing
- topsoil should be stored in stockpiles no more than 2 m–3 m high to retain seed germination potential (EPA 2001)
- topsoil should be stored for the shortest period practicable, and/or reused as soon as possible to maximise the retention of the seed bank in the soil
- the placement of topsoil should consider the landscape position the topsoil was stripped from, with soils of the undulating topography, used on slopes and hilltops, and the alluvial soils used in lower slopes and areas where water accumulation may occur
- the site topsoil register should be kept up to date for the Project, recording the locations and volumes of topsoil stockpiles

7. Recommended changes to existing environmental management plan

An existing environmental management plan (EM Plan) has been compiled for Stage 1 of the Project (2009). Based on this geology, soils and land suitability assessment, changes are proposed to be included in the 'Land Management' section of an amended EM Plan to cover both Stage 1 and Stage 2 of the Project. This assessment should be included as an appendix to the EM Plan to cover both stages of the Project.

These changes are outlined in sections 7.1 to 7.3 below.

7.1 Changes to description of environmental values described in current EM Plan

The following changes to the existing 'description of environmental values' section of the EM Plan are also recommended:

- updated pre-mine land suitability to refer to this assessment in the appendix of the EM Plan
- update soils assessment details to include six soil types that are identified in this report and include updated map into EM Plan

  A total of six soil types were identified as Yellow duplex, Alluvial soils, Grey-brown duplex, Brown uniform clay, Red lithosols and Warwick. The spatial distribution of these soil types is shown in Figure 3.6 of this report.
- land suitability assessment described in the EM Plan should reflect the findings of Section 3.8 of this report

  A detailed assessment of land suitability classes for both stages of Middlemount Mine was undertaken for beef cattle grazing and dry land cropping. In general the Project area is Class 3 beef cattle grazing and Class 4 dry land cropping. Details of the assessment are contained within this report.
- topsoil stripping depths should be updated in the EM Plan (Table 16) and should include potential limitations for each soil type according to Table 6.1 of this report.

7.2 Changes to potential impacts on environmental values described in current EM Plan

The following changes to the *existing 'Potential impacts on environmental values – land management'* section of the EM Plan are recommended:

- include impacts on topography and landform as in Section 5.1 of this report

  The mining activities will result in topographical changes to the Project area during mine operation and post-mining, through the disturbance of existing topographical relief during overburden stripping and mining, the creation of new topographic highs through the placement of overburden dumps, and topographic lows in the form of the void.

Changes to the location and width of the floodplains will also occur as a result of mining and creek diversions.

- include impacts related to overburden and interburden material as described in section 5.2 of this report including:
  - acid production potential
  - heavy metals
  - dispersion, slaking and erosion potential.

  The overburden rocks are generally not acid forming material and are not expected to pose a risk in forming acid mine drainage.

  Heavy metal concentrations in all overburden samples tested were below environmental investigation levels. The excavation and dumping of overburden is expected to have a low risk of producing heavy metal contamination from leachate seepage or surface runoff from the overburden dumps.

  When environmental factors (e.g. vegetation cover, climate etc) are equal, the erosion potential of dumped overburden is dependent on the chemical and physical characteristics of the material and the topography (natural or created) of the terrain.

  The overburden is considered to be highly dispersive and therefore will readily disperse when left exposed on the soil surface or otherwise exposed to water, which will lead to erosion, including tunnel erosion. The greater the period bare spoil is exposed, the higher its erosion potential. Sandy, non-cohesive materials are also considered to have moderate to high potential for erosion by flowing water.

7.3 Changes to commitments (control strategies) described in current EM Plan

All mitigation measures described in Section 6 above are recommended to be incorporated into this section of the EM Plan. Some of these are already incorporated however, Section 6 contains further detail on these as well as some additional control measures not currently considered in the EMP and therefore are recommended to be adopted/included into an updated EMP for the Project as follows.

Topsoil Management

- *topsoil should be stored in stockpiles no more than 2 m–3 m high to retain seed germination potential (EPA 2001)*
- *topsoil should be stored for the shortest period practicable, and/or reused as soon as possible to maximise the retention of the seed bank in the soil*
- *the placement of topsoil should consider the landscape position the topsoil was stripped from, with soils of the undulating topography, used on slopes and hilltops, and the alluvial soils used in lower slopes and areas where water accumulation may occur*
- *the site topsoil register should be kept up to date for the Project, recording the locations and volumes of topsoil stockpiles*

Land Management

- *target landform slopes should be 1(V):3(H) as outlined in Chapter 26 Rehabilitation and Decommissioning of the EIS*
- *testing of dispersion and slaking potential should be conducted during overburden stripping. Less dispersive overburden should be managed for use as capping material*
- *appropriate designs and locations for overburden dump erosion and drainage control measures should be established based on the results of dispersion and slaking testing, spoil management plans, and through the use of drainage and erosion potential trials. Designs may include the use of 'durable rock' lined drains, or the encouragement of water infiltration into the overburden dumps (subject to overburden characteristics)*
- *sediment control structures should be used to control surface runoff from all rehabilitated and disturbed areas to reduce the amount of final sediment loads. An assessment of available technologies should be undertaken prior to selection of sediment control structures*
- *rehabilitation strategies should be monitored and adjusted as required to reduce the risk of spoil erosion and destabilisation of spoil stockpiles*
- *soils that will be trafficked or compacted during the operation of the mine should have water control measures and sediment dams installed to minimise potential erosion and sediment entering into waterways*
- *previously compacted areas that are to be rehabilitated should be remediated by ripping the top layer of soil/overburden material, and then applying layers of subsoil and topsoil as required to establish a suitable plant growth environment. The depth of ripping/reworking required is dependent on the impact, and should be assessed at the time or rehabilitation*
- *for disturbed or cleared land, including infrastructure areas:*
    - *unnecessary exposure of alkaline or sodic subsoils should be avoided, and should be limited to the minimal amount of time practicable. Any exposure should be covered with non-dispersive soil or other suitable material to minimise the infiltration of water into these soils. Sub-soils from these areas should be buried within the overburden dumps and covered in accordance with site overburden management procedures*
    - *clear the minimal amount of vegetation (including grass cover) required for Project works*
    - *minimise disturbance of the ground layer of vegetation by controlled operation of machinery and equipment selection*
    - *site drainage, and erosion and sediment controls should be implemented and in place prior to, or as soon as possible, following the removal of vegetation*
    - *water runoff should be directed around topsoil stockpile areas using diversion bunds, contours, and catch drains as appropriate*
    - *divert clean water away from disturbed areas*

- *revegetate exposed soils as soon as practical after works have been completed. This includes the rehabilitation of overburden dumps*
- *use watering trucks during windy conditions for dust suppression*
- *install erosion and sediment control measures such as rock mulching (refer Chapter 26 of the EIS) on disturbed natural or constructed slopes to minimise erosion and sediment released into waterways. This is especially important for soils with dispersive subsoils.*

- *for infrastructure areas:*
  - *sediment and erosion control should be implemented in accordance with Middlemount Coal's Sediment and Erosion Control Managment Plan (Middlemount Coal 2010) and Erosion and Sediment Contol (Site Practice) (Middlemount Coal 2009) for each area of infrastructure to be constructed. This plan should specify the locations and types of sediment and erosion control measures to be used*
  - *minimise areas cleared during earthworks, by delineating areas to be cleared with survey markers or other suitable marking*
  - *install sediment traps and silt fences or other suitable sediment control measures where overland runoff cannot be diverted to sediment dams*
  - *confine traffic to maintained roads*
  - *minimise slope grade within infrastructure areas where possible based on results of geotechnical data obtained during detailed design phase*
  - *construct hardstands from erosion resistant material*
  - *install scouring protection works in drains and intensely gullied areas adjacent to proposed infrastructure*
  - *revegetate disturbed areas surrounding infrastructure sites*
  - *control drainage and divert away from infrastructure.*
- *for stockpiles and dumps:*
  - *long-term stockpiles of topsoil and overburden should be planted with vegetation to minimise entrainment of soil particles into the air and minimise erosion through raindrop impact*
  - *when areas with topsoil susceptible to wind erosion (e.g. yellow duplex and grey-brown duplex) are stripped and stockpiled, even if for only a few months, the stockpiles should be covered by grass, other vegetation, geofabric or less erosive topsoil to minimise wind erosion*

- *divert clean water from areas upslope of all topsoil, subsoil and overburden stockpiles/dumps around stockpile areas using contour banks or diversion channels, thereby reducing water flowing into the stockpile area*

- *all topsoil, subsoil and overburden stockpiles/dumps should be bunded by earthen bunds or similar, with sediment dams installed downslope of stockpiles to prevent eroded sediment entering waterways.*

- *dispersive, clayey soils are suitable for use as embankment materials for water management structures, provided strict construction quality control measures are implemented*

- *gypsum or lime could be considered in the treatment of sodic alkaline soils to improve geotechnical/rehabilitation characteristics.*

8. Recommended amendments to the existing environmental authority

There are currently two conditions in the current environmental authority (EA) directly relating to this assessment. These two conditions both relate to topsoil management as follows:

1. Topsoil must be strategically stripped ahead of mining in accordance with a Topsoil Management Plan (condition F1).

2. A topsoil inventory which identifies the topsoil requirements for the Middlemount Mine Project and availability of suitable topsoil on site must be detailed in the Plan of Operations (condition F2).

Based on the findings of this assessment, the existing EA conditions are achievable. No changes to the existing EA are recommended.

9. Residual impacts

Following mitigation, the residual impacts are anticipated to be as follows:

- change to the land use, both during the mine operation and post-mining. The main post mining land uses are envisaged to be nature conservation with some cattle grazing compared to mainly cattle grazing pre-mining
- redistribution of existing landforms diversion of sections of Roper Creek and Thirteen Mile Gully that traverse the mining tenements, including change in landscape form
- addition of a final void into the landscape. This may fill with some water and become wetlands.

10. Conclusions

This study has identified and mapped the broad soil types and characterised overburden material within the Middlemount Coal Project area. Based on existing literature and findings of the field assessment, the Project contains six different soils derived from sedimentary or alluvial parent material.

Overburden in the Project area is not anticipated to be acid forming or pose a risk of heavy metal contamination. The overburden is considered dispersive, and will require specific management techniques to control the erosion potential. Rehabilitation planning should take into considerations these overburden characteristics as these materials are to form the substrate for future vegetation. Selection of revegetation strategies, including species mix, provision of growth media, early stage plant support and ecosystem planning, should be adjusted to enable successful and sustainable revegetation of these areas.

Alternatively, some areas may require engineering solutions to achieve long term geotechnical stability.

Subsoils over much of the Project area are alkaline, sodic and dispersive (refer sections 5.3.1 and 5.3.3) and will require specific management techniques, such as minimising exposure, to prevent erosion including tunnel erosion. Soils most susceptible to erosion include yellow duplex, grey-brown duplex and some alluvial soils.

It is anticipated that most topsoil from the proposed disturbed areas will be recovered and will be available for use in rehabilitation, although with limitations. Depth limitations exist in some soils, and slope gradient may impact the ease of stripping on steeper slopes. Topsoil from the red lithosols were not considered appropriate for use in rehabilitation due to their surface rockiness.

Based on previous assessment and the results of the this investigation, the Project area is currently assessed to be within land suitability classes between Classes 2 and 5 for both dry land cropping and cattle grazing, but mostly is classified as Class 3 for beef cattle grazing and Class 4 for dry land cropping. The Project area is considered to be predominantly Class C good quality agricultural land (GQAL), except for the Red lithosols which are not considered GQAL, and Brown uniform clays which are considered to be Class B GQAL. However the Brown uniform clays have limited extent within the Project area.

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Attachment A

Test pit logs, borehole logs and explanatory notes

TEST PIT ENGINEERING LOG

TEST PIT NO.

MM01

SHEET 1 OF 1

Client:	**Middlemount Coal Pty Ltd**	Date Commenced:	**13/5/10**
Project:	**Middlemount Coal EIS**	Date Completed:	**13/5/10**
Test Pit Location:	**Flat terrain adjacent to spoil pile north-west of trial pit**	Recorded By:	**RB**
Project Number:	**2117076B**	Log Checked By:	IW
Excavation Method:	**Hitachi 250 excavator**	Surface RL:	
		Co-ords:	**E 667725 N 7471236 MGA***

Test Pit Information				Field Material Description						
1	2	3	4	5	6	7	8	9	10	11
WATER	RL(m) / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
N F G W E	0.10		D			**TOPSOIL (Clay LOAM):** pale brown, fine grained sand, grass rootlets	D			TOPSOIL
	0.30		D			**TOPSOIL (LOAM):** pale brown, fine grained sand, platy peds				A_1
					CH	**CLAY with Sand**: medium to high plasticity, brown, fine grained sand, prismatic peds	MC<PL			A_2
	0.65		D			... 0.65 m: colour change to dark brown, fissured				TERTIARY B_{21}
	1.00		D		CL	**Sandy CLAY:** medium plasticity, brown with orange-brown and grey mottling, calcareous concretions, massive				B_{22}
	2.50		D		CL	**Sandy CLAY:** medium plasticity, grey, red-orange and brown, fine to medium grained sand				B_{23}
										C
			D							
			D							
			D							* Horizontal survey determined using hand held GPS
						END OF TEST PIT AT 6.00 m				Limit of investigation

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

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TEST PIT ENGINEERING LOG

TEST PIT NO.

MM02

SHEET 1 OF 1

Client:	**Middlemount Coal Pty Ltd**	Date Commenced:	**12/5/10**
Project:	**Middlemount Coal EIS**	Date Completed:	**12/5/10**
Test Pit Location:	**Flat to gently undulating terrain, 10 m from banks of Roper Creek**	Recorded By:	**RB**
Project Number:	**2117076B**	Log Checked By:	KW
Excavation Method:	**Hitachi 250 excavator**	Surface RL:	
		Co-ords:	**E 668343 N 7470183 MGA***

Test Pit Information						Field Material Description				
1	2	3	4	5	6	7	8	9	10	11
WATER	RL(m) / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
	0		D			**TOPSOIL (Sandy LOAM):** fine grained sand, pale brown, platy peds, grass rootlets	D			TOPSOIL A_1
	0.45		D			... 0.45 m: colour change to brown, trace tree roots				A_3
	0.70		D		CH	**Silty CLAY:** medium to high plasticity, dark brown with brown mottling, prismatic peds	MC<PL			ALLUVIUM B_{21}
	1									
	1.80				CL	**Sandy CLAY:** low plasticity, brown with dark brown and black mottling, fine grained sand				B_{22}
	2		D							
						... 2.6 m: no black mottling	MC~PL			B_{23}
	3		D							
						... 3.5 m: colour change to interbedded dark brown and brown				C
	4		D							
	5.00		D		CH	**CLAY:** medium to high plasticity, grey with orange mottling, medium to high plasticity	MC<PL			TERTIARY C
						END OF TEST PIT AT 5.10 m				Limit of Investigation * Horizontal survey determined using hand held GPS

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

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TEST PIT ENGINEERING LOG

TEST PIT NO.

MM03

SHEET 1 OF 1

Client:	**Middlemount Coal Pty Ltd**	Date Commenced:	**11/5/10**
Project:	**Middlemount Coal EIS**	Date Completed:	**11/5/10**
Test Pit Location:	**Flat to gently undulating terrain, south of Roper Creek**	Recorded By:	**RB**
Project Number:	**2117076B**	Log Checked By:	RW
Excavation Method:	**Komatsu 20 tonne excavator**	Surface RL:	
		Co-ords:	**E 669733 N 7468871 MGA***

Test Pit Information				Field Material Description						
1	2	3	4	5	6	7	8	9	10	11
WATER	RL(m) / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (FB VS, VL S, L F, MD ST, D VST, VD H)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
N F G W E	0.15		D			**TOPSOIL (Sandy LOAM):** fine grained sand, brown, small blocky peds, grass rootlets	D-M			TOPSOIL A_1
			D			**TOPSOIL (Sandy CLAY):** high plasticity, brown, fine grained sand, massive, fissured with polished surfaces, grass rootlets	MC<PL			A_2
	0.40		D		CH	**CLAY with Sand:** low to medium plasticity, orange-brown, prismatic and blocky peds, fissured with polished surfaces				TERTIARY B_1
	0.80		D		CH	**Silty CLAY:** medium plasticity, brown, massive ... 0.9 m - 1.1 m: calcareous concretions				$B_{21\ k}$
	1		D			... 1.2 m: black and orange mottling				$B_{22\ s/h}$
	2									
						END OF TEST PIT AT 2.60 m				Limit of Investigation * Horizontal survey determined using hand held GPS
	3									

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

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TEST PIT ENVIRONMENTAL LOG

TEST PIT NO.
MM04
SHEET 1 OF 1

Client:	**Middlemount Coal Pty Ltd**	Date Commenced:	**12/5/10**
Project:	**Middlemount Coal EIS**	Date Completed:	**12/5/10**
Test Pit Location:	**Flat to gently undulating terrain, north of Roper Creek**	Recorded By:	**RB**
Project Number:	**2117076B**	Log Checked By:	KW
Excavation Method:	**Hitachi 250 excavator**	Surface RL:	
		Co-ords:	**E 676576 N 7469674 MGA***

Test Pit Information				Field Material Description						
1	2	3	4	5	6	7	8	9	10	11
WATER	RL(m) / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS FB, S VL, F L, ST MD, VST D, H VD)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
			D			**TOPSOIL (Sandy LOAM):** grey-brown, angular blocky and platy peds, grass rootlets, trace fine grained sand	MC<PL			TOPSOIL A_1 Gradational Change
	0.35		D		CH	**Silty CLAY:** medium to high plasticity, pale grey, blocky peds, bleached				ALLUVIUM B_{21e}
	0.50				CH	**Silty CLAY:** high plasticity, dark brown, blocky and prismatic peds				B_{22}
	1					... 1.1 m: colour change to brown and pale grey				B_{23} Gradational Change
	1.30				CH	**Silty CLAY:** high plasticity, dark grey and brown, massive, horizontal laminations of sandy clay, fine grained sand, appears very stiff to hard				C
	2		D							
						END OF TEST PIT AT 2.30 m				Limit of Investigation * Horizontal survey determined using hand held GPS
	3									

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

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TEST PIT ENVIRONMENTAL LOG

TEST PIT NO.
MM06
SHEET 1 OF 1

Client:	**Middlemount Coal Pty Ltd**	Date Commenced:	**12/5/10**
Project:	**Middlemount Coal EIS**	Date Completed:	**12/5/10**
Test Pit Location:	**Flat to gently undulating terrain, east of Thirteen Mile Gully**	Recorded By:	**RB**
Project Number:	**2117076B**	Log Checked By:	RW
Excavation Method:	**Hitachi 250 excavator**	Surface RL:	
		Co-ords:	**E 671832 N 7470419 MGA***

Test Pit Information				Field Material Description						
1	2	3	4	5	6	7	8	9	10	11
WATER	RL(m) / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS FB, S VL, F L, ST MD, VST D, H VD)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
N F G W E	0.10		D			**TOPSOIL (Sandy LOAM):** fine grained sand, pale brown, platy peds	D			TOPSOIL A_1
			D			**TOPSOIL: (Clayey SAND):** fine grained, pale brown-grey, poorly developed peds, low plasticity fines, grass rootlets				A_2
			D			... 0.25 m: colour change to pale grey, bleached				$A_{3\,e}$
	0.32		D		CL	**Sandy CLAY:** medium plasticity, grey, prismatic peds	MC<PL			RESIDUAL SOIL B_1
	0.45		D		CH	**CLAY with Sand:** medium to high plasticity, brown-grey with black mottling, prismatic peds				$B_{21\,s/h}$
	1.00 1				CL	**Sandy CLAY:** medium plasticity, brown, fissured with polished surfaces, calcareous concretions, massive, vertical cracking, appears hard				$B_{22\,k}$
	2.00 2		D			**SANDSTONE:** fine grained, orange-brown with grey mottling, extremely weathered, extremely low strength, consistency of clayey sand, low plasticity fines				WEATHERED ROCK C
	3					END OF TEST PIT AT 2.20 m				Limit of Investigation * Horizontal survey determined using hand held GPS

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

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TEST PIT ENVIRONMENTAL LOG

TEST PIT NO.

MM07

SHEET 1 OF 1

Client:	**Middlemount Coal Pty Ltd**	Date Commenced:	**12/5/10**
Project:	**Middlemount Coal EIS**	Date Completed:	**12/5/10**
Test Pit Location:	**Flat to gently undulating terrain, east**	Recorded By:	**RB**
Project Number:	**2117076B**	Log Checked By:	KW

Excavation Method: **Hitachi 250 excavator**

Surface RL:

Co-ords: **E 672327 N 7472294 MGA***

Test Pit Information						Field Material Description				
1	2	3	4	5	6	7	8	9	10	11
WATER	RL(m) / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
N F G W E	0.20		D			**TOPSOIL (Clay LOAM):** fine grained sand, pale brown, small angular blocky peds, grass rootlets	D-M			TOPSOIL A_1
	0.35		D			**TOPSOIL (Sandy LOAM):** fine grained sand, pale brown, platy peds, grass rootlets				A_2
	0.45					... 0.35 m: fine grained gravel, rounded ferruginous nodules, purple and black				B_{21c}
			D		CL	**Sandy CLAY:** medium plasticity, orange-brown and grey, fine grained sand	MC<PL			TERTIARY B_{22}
	1.00 1				CL	**Sandy CLAY:** medium plasticity, grey-brown with black mottling, massive, fine to medium grained sand, calcareous concretions, fissured with polished surfaces				B_{23k}
			D							
			D			... 1.8 m: colour change to grey with black, orange and white mottling				C
	2					END OF TEST PIT AT 2.00 m				Limit of Investigation * Horizontal survey determined using hand held GPS
	3									

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TEST PIT ENVIRONMENTAL LOG

TEST PIT NO.
MM08
SHEET 1 OF 1

Client:	**Middlemount Coal Pty Ltd**	Date Commenced:	**12/5/10**
Project:	**Middlemount Coal EIS**	Date Completed:	**12/5/10**
Test Pit Location:	**Flat to gently undulating terrain, eastern "no spoil dump"**	Recorded By:	**RB**
Project Number:	**2117076B**	Log Checked By:	KW

Excavation Method: **Hitachi 250 excavator**

Surface RL:
Co-ords: **E 671080 N 7472610 MGA***

Test Pit Information						Field Material Description				
1	2	3	4	5	6	7	8	9	10	11
WATER	RL(m) / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS FB, S VL, F L, ST MD, VST D, H VD)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
N F G W E	0.20		D			**TOPSOIL (Sandy LOAM):** fine grained sand, angular blocky peds, grass rootlets	D			TOPSOIL A_1
	0.45		D			**TOPSOIL (Sandy LOAM):** fine grained sand, blocky peds	D			A_2
	0.55		D			... 0.45 m - 0.55 m: fine to medium grained gravel size, rounded ferruginous nodules, black and purple				B_{1c}
	1		D		CH	**Silty CLAY:** medium to high plasticity, grey and orange-brown, prismatic peds	MC<PL			TERTIARY B_{21}
						... 1.6 m: trace calcareous concretions				B_{22k}
	1.75		D		CH	**Silty CLAY:** medium to high plasticity, grey with white and orange-brown mottling, massive				C
	2					END OF TEST PIT AT 1.90 m				Limit of Investigation * Horizontal survey determined using hand held GPS
	3									

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

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TEST PIT ENVIRONMENTAL LOG

TEST PIT NO.

MM09

SHEET 1 OF 1

Client:	**Middlemount Coal Pty Ltd**	Date Commenced:	**11/5/10**
Project:	**Middlemount Coal EIS**	Date Completed:	**11/5/10**
Test Pit Location:	**Flat to gently undulating terrain, eastern "no spoil dump"**	Recorded By:	**RB**
Project Number:	**2117076B**	Log Checked By:	IW
Excavation Method:	**Komatsu 20 tonne excavator**	Surface RL:	
		Co-ords:	**E 670319 N 7473392 MGA***

Test Pit Information				Field Material Description						
1	2	3	4	5	6	7	8	9	10	11
WATER	RL(m) / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
N F G W E	0.15		D			**TOPSOIL (Sandy LOAM):** fine grained, pale brown, blocky peds, grass rootlets	D			TOPSOIL A_1
	0.35		D			**TOPSOIL (SAND with Clay and Gravel):** fine grained, pale brown-grey, with low plasticity fines and fine grained, rounded ferruginized rock fragments				A_{2c}
	1		D		CH	**Sandy CLAY:** medium to high plasticity, grey with orange-brown mottling, small blocky peds, appears hard	MC<PL			TERTIARY B_{21}
						... 1.65 m: colour change to grey-brown and black, with calcareous concretions				B_{22k}
	2					END OF TEST PIT AT 1.80 m				Limit of Investigation * Horizontal survey determined using hand held GPS
	3									

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

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TEST PIT ENGINEERING LOG

TEST PIT NO.

MM10

SHEET 1 OF 1

Client:	**Middlemount Coal Pty Ltd**	Date Commenced:	**11/5/10**
Project:	**Middlemount Coal EIS**	Date Completed:	**11/5/10**
Test Pit Location:	**Flat to gently undulating terrain, north-eastern "no spoil dump"**	Recorded By:	**RB**
Project Number:	**2117076B**	Log Checked By:	RW
Excavation Method:	**Komatsu 20 tonne excavator**	Surface RL:	
		Co-ords:	**E 669377 N 7474460 MGA***

Test Pit Information						Field Material Description				
1	2	3	4	5	6	7	8	9	10	11
WATER	RL(m) / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS FB, S VL, F L, ST MD, VST D, H VD)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
N F G W E			D			**TOPSOIL (Sandy LOAM):** fine to medium grained sand, grey, thin platy peds	D			TOPSOIL, surface crust A_1
	0.45		D		CH	**Sandy CLAY:** medium to high plasticity, grey-brown and orange with black mottling, trace black rounded gravel size ferruginous nodules, fine grained sand, small blocky peds	MC<PL			TERTIARY $B_{21\ c}$
	0.60				CH	**Silty CLAY:** medium to high plasticity, grey and brown-orange with black mottling, trace calcareous concretions, fissured				$B_{22\ s/h\ k}$
	1									
	1.50		D		CH	**Silty CLAY:** medium plasticity, grey, black, white and orange, massive, fissured with polished surfaces				C
						END OF TEST PIT AT 1.80 m				Limit of Investigation * Horizontal survey determined using hand held GPS
	2									
	3									

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

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TEST PIT ENVIRONMENTAL LOG

TEST PIT NO.

MM11

SHEET 1 OF 1

Client:	**Middlemount Coal Pty Ltd**	Date Commenced:	**11/5/10**
Project:	**Middlemount Coal EIS**	Date Completed:	**11/5/10**
Test Pit Location:	**Flat to gently undulating terrain, north-east**	Recorded By:	**RB**
Project Number:	**2117076B**	Log Checked By:	KW
Excavation Method:	**Komatsu 20 tonne excavator**	Surface RL:	
		Co-ords:	**E 668874 N 7475078 MGA***

Test Pit Information				Field Material Description						
1	2	3	4	5	6	7	8	9	10	11
WATER	RL(m) / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
N F G W E			D			**TOPSOIL (SAND with Clay):** fine grained, pale grey, small blocky peds	D			TOPSOIL A_1
						... 0.15 m: colour change to grey, granular				A_2
	0.30		D		SP	**SAND:** fine grained, pale brown, apedal, granular	M			TERTIARY B_{21}
	0.70				CH	**Sandy CLAY:** medium to high plasticity, grey and orange-brown, trace fine grained sand, sub-rounded, fine grained gravel size ferruginous nodules	MC<PL			$B_{22\,k}$
			D							
	1					... 1.0 m: colour change to grey with orange and red mottling				B_{23}
						... 1.8 m: colour change to grey with white and red mottling				C
	2					END OF TEST PIT AT 2.00 m				Limit of Investigation * Horizontal survey determined using hand held GPS
	3									

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

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TEST PIT ENVIRONMENTAL LOG

TEST PIT NO.

MM12

SHEET 1 OF 1

Client:	**Middlemount Coal Pty Ltd**	Date Commenced:	**11/5/10**
Project:	**Middlemount Coal EIS**	Date Completed:	**11/5/10**
Test Pit Location:	**Flat to gently undulating terrain, east of Thirteen Mile Gully, north**	Recorded By:	**RB**
Project Number:	**2117076B**	Log Checked By:	KW
Excavation Method:	**Komatsu 20 tonne excavator**	Surface RL:	
		Co-ords:	**E 667830 N 7473884 MGA***

Test Pit Information				Field Material Description						
1	2	3	4	5	6	7	8	9	10	11
WATER	RL(m) / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
N F G W E			D			**TOPSOIL (Sandy LOAM):** fine grained sand, pale brown, poorly developed blocky peds	M			TOPSOIL A_1
			D							
	0.40		D		CL	**CLAY with Sand:** low to medium plasticity, brown with black mottling, fine grained sand, small prismatic peds, fissured with polished surfaces	MC<PL			ALLUVIUM/TERTIARY(?) $B_{21\ s/h}$
	0.70				CL	**Sandy CLAY:** low to medium pasticity, brown with black mottling, calcareous concretions, fissured with poliched surfaces				$B_{22\ k\ s}$
	1		D							
	1.70				CL	**Silty CLAY:** medium plasticity, grey				C
	2					END OF TEST PIT AT 2.00 m				Limit of Investigation * Horizontal survey determined using hand held GPS
	3									

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

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TEST PIT ENVIRONMENTAL LOG

TEST PIT NO.

MM13

SHEET 1 OF 1

Client:	**Middlemount Coal Pty Ltd**	Date Commenced:	**11/5/10**
Project:	**Middlemount Coal EIS**	Date Completed:	**11/5/10**
Test Pit Location:	**Gently undulating terrain, bottom of raw water dam spillway**	Recorded By:	**RB**
Project Number:	**2117076B**	Log Checked By:	KW
Excavation Method:	**Komatsu 20 tonne excavator**	Surface RL:	
		Co-ords:	**E 667702 N 7469430 MGA***

Test Pit Information						Field Material Description				
1	2	3	4	5	6	7	8	9	10	11
WATER	RL(m) / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
N F G W E	0.20		D			**TOPSOIL (Sandy LOAM):** fine grained sand, low plasticity fines, pale brown, irregular blocky peds, grass rootlets	D			TOPSOIL (Patchy Gravel Armour) Surface cracks A_1
			D			**TOPSOIL (Sandy CLAY):** medium plasticity, pale brown, platy peds, appears poorly cemented, fine grained sand ... 0.3 m: with medium gravel size, rounded, ferruginous nodules	MC<PL			A_2 B_{21c}
	0.40				CH	**CLAY with Sand:** medium to high plasticity, brown with red and orange mottling, fine grained sand				TERTIARY B_{22}
	1		D			... 1.1 m: colour change to grey with red and orange mottling				B_{23}
	2		D			END OF TEST PIT AT 1.70 m				Limit of Investigation * Horizontal survey determined using hand held GPS
	3									

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

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GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW5P

SHEET 1 OF 4

Client:	MACARTHUR COAL	PB Borehole No.:	Date Commenced: 06.07.2010
Project:	MIDDLEMOUNT COAL PROJECT		Date Completed: 24.07.2010
Borehole Location:	MW5P - MIDDLEMOUNT MINE		Recorded By: Malcolm Graham
Project Number:	2117076B		Log Checked By:

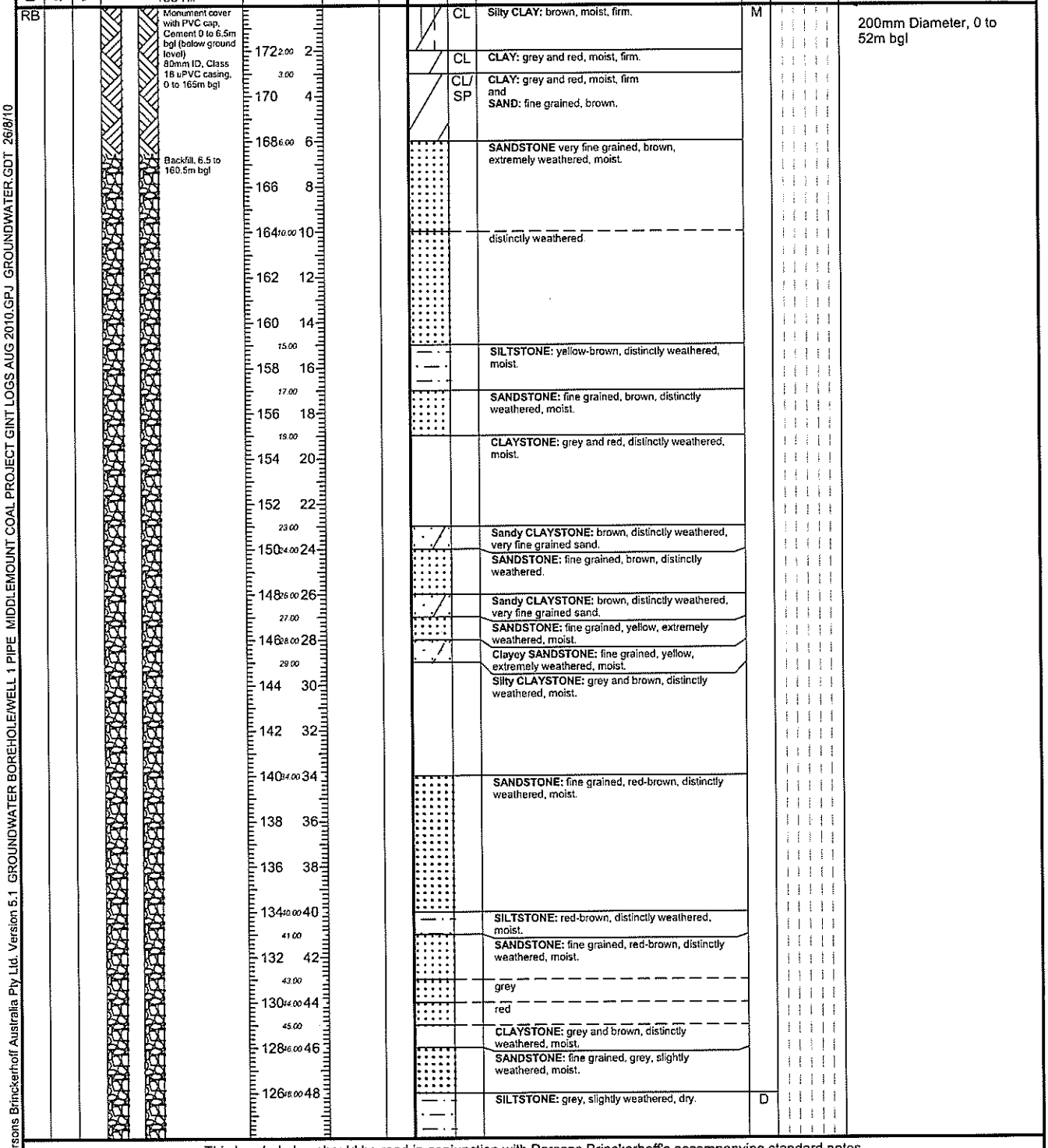
Drill Model/Mounting:	IRTH 60	Driller: S Baker	Surface RL: 174 m AHD
Borehole Diameter:	200mm to 140mm	Driller Lic No: 3046	Co-ords: E 667796 N 7475130 MGA94 Zone 55
		TOC (RL): 175 m AHD	Local Co-ords:

Borehole Information

1	2	3	4	5	6	7
METHOD	SUPPORT	WATER	WELL CONSTRUCTION (TOC 1 m)	RL(m) AHD / DEPTH(m)	FIELD TEST	SAMPLE

Field Material Description

8	9	10	11	12	13
GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS FB, S VL, F L, ST MD, VST D, H VD)	STRUCTURE AND ADDITIONAL OBSERVATIONS



This borehole log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

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GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW5P

SHEET 2 OF 4

Client:	MACARTHUR COAL	PB Borehole No.:	Date Commenced: 06.07.2010
Project:	MIDDLEMOUNT COAL PROJECT		Date Completed: 24.07.2010
Borehole Location:	MW5P - MIDDLEMOUNT MINE		Recorded By: Malcolm Graham
Project Number:	2117076B		Log Checked By:

Drill Model/Mounting:	IRTH 60	Driller: S Baker	Surface RL: 174 m AHD
Borehole Diameter:	200mm to 140mm	Driller Lic No: 3046	Co-ords: E 667796 N 7475130 MGA94 Zone 55
		TOC (RL): 175 m AHD	Local Co-ords:

Borehole Information

1	2	3	4	5		6	7
METHOD	SUPPORT	WATER	WELL CONSTRUCTION (TOC 1 m)	RL(m) AHD	DEPTH(m)	FIELD TEST	SAMPLE
RB / RAB				122 (52.00)	52		
				(53.00)			
				120	54		
				(55.00)			
				118	56		
				(57.00)			
				116 (58.00)	58		
				114	60		
				112 (62.00)	62		
				(63.00)			
				110	64		
				108	66		
				106	68		
				(69.00)			
				104	70		
				102	72		
				(73.00)			
				100 (74.00)	74		
				98	76		
				96 (78.00)	78		
				94 (80.00)	80		
				92	82		
				90 (84.00)	84		
				88	86		
				(87.00)			
				86 (88.00)	88		
				84 (90.00)	90		
				82	92		
				80	94		
				78 (96.00)	96		
				76 (98.00)	98		
				(99.00)			

Field Material Description

8	9	10	11	12	13
GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL MD D VD)	STRUCTURE AND ADDITIONAL OBSERVATIONS
		SILTSTONE: grey, slightly weathered, dry. *(continued)*	D		140mm Diameter, 52 to 174m bgl
		SANDSTONE: fine grained, grey, slightly weathered, dry.			
		SILTSTONE: grey, slightly weathered, dry.			
		SANDSTONE: fine grained, grey, fresh, dry.			
		SILTSTONE: grey, fresh, dry.			
		SANDSTONE: fine grained, grey, fresh, dry.			
		SILTSTONE: grey, fresh, dry.			
		SANDSTONE: very fine grained, grey, fresh, dry.			
		SILTSTONE: grey, fresh, dry.			
		SANDSTONE: fine grained, grey, dry.			
		SILTSTONE: grey, fresh, dry.			
		SANDSTONE: fine grained, grey, fresh, dry.			
		slightly weathered, wet.	W		
		fresh, wet.			
		SILTSTONE: grey, fresh, wet.			
		SANDSTONE: fine grained, fresh, wet.			
		SILTSTONE: dark grey, fresh, wet.			
		SANDSTONE: fine grained, grey, fresh, wet.			
		SILTSTONE: dark grey, fresh, wet.			
		SANDSTONE: fine grained, grey, fresh, wet.			

This borehole log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

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GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW5P

SHEET 3 OF 4

Client:	MACARTHUR COAL	PB Borehole No.:	Date Commenced: 06.07.2010
Project:	MIDDLEMOUNT COAL PROJECT		Date Completed: 24.07.2010
Borehole Location:	MW5P - MIDDLEMOUNT MINE		Recorded By: Malcolm Graham
Project Number:	2117076B		Log Checked By:

Drill Model/Mounting:	IRTH 60	Driller: S Baker	Surface RL: 174 m AHD
Borehole Diameter:	200mm to 140mm	Driller Lic No: 3046	Co-ords: E 667796 N 7475130 MGA94 Zone 55
		TOC (RL): 175 m AHD	Local Co-ords:

Borehole Information / Field Material Description

1 METHOD	2 SUPPORT	3 WATER	4 WELL CONSTRUCTION (TOC 1 m)	5 RL(m) AHD / DEPTH(m)	6 FIELD TEST	7 SAMPLE	8 GRAPHIC LOG	9 USC SYMBOL	10 SOIL/ROCK MATERIAL FIELD DESCRIPTION	11 MOISTURE	12 RELATIVE DENSITY /CONSISTENCY (VS FB, S VL, F L, ST MD, VST D, H VD)	13 STRUCTURE AND ADDITIONAL OBSERVATIONS
RAB				101.00					**SANDSTONE:** fine grained, grey, fresh, wet. *(continued)*	W		
				72 102					**SILTSTONE:** dark grey, fresh, wet.			
				70 104								
				105.00					**CLAYSTONE:** black, fresh, carbonaceous, wet.			
				68 106					**SANDSTONE:** fine grained, grey, fresh, wet.			
				66 108								
				64 110								
				112.00					**SILTSTONE:** dark grey, fresh, wet.			
				62 112					**SANDSTONE:** fine grained, grey, fresh, wet.			
				113.00								
				60 114								
				58 116					fine grained.			
				56 118								
				54 120								
				52 122								
				50 124					**SILTSTONE:** dark grey, fresh, wet.			
				125.00					**CLAYSTONE:** black, fresh, carbonaceous, wet.			
				48 126					**SILTY COAL:** black, fresh, wet, (Middlemount Seam).			Airlift yield: 0.12 L/S
				127.00					**COAL:** black, fresh, wet.			
				46 128								
				44 130								
				131.00					**SILTSTONE:** dark grey, fresh.			
				42 132								Airlift yield: 0.14 L/S
				133.00					**SANDSTONE:** fine grained, grey, fresh, wet.			
				40 134								
				38 136								
				36 138								Airlift yield: 0.14 L/S
				34 140								
				32 142								
				30 144								
				28 146								
				26 148								
				149.00					**SILTSTONE:** black, fresh, wet.			

This borehole log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

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GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW5P

SHEET 4 OF 4

Client:	MACARTHUR COAL	PB Borehole No.:		Date Commenced:	06.07.2010
Project:	MIDDLEMOUNT COAL PROJECT			Date Completed:	24.07.2010
Borehole Location:	MW5P - MIDDLEMOUNT MINE			Recorded By:	Malcolm Graham
Project Number:	2117076B			Log Checked By:	

Drill Model/Mounting:	IRTH 60	Driller:	S Baker	Surface RL:	174 m AHD
Borehole Diameter:	200mm to 140mm	Driller Lic No:	3046	Co-ords:	E 667796 N 7475130 MGA94 Zone 55
		TOC (RL):	175 m AHD	Local Co-ords:	

Borehole Information

Field Material Description

1	2	3	4	5	6	7	8	9	10	11	12	13
METHOD	SUPPORT	WATER	WELL CONSTRUCTION (TOC 1 m)	RL(m) AHD / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD)	STRUCTURE AND ADDITIONAL OBSERVATIONS
RAB			Bentonite, 160.5 to 164m bgl; 3mm Filter gravel, 164 to 169m bgl; 80mm ID, Class 18 uPVC, 0.5mm Slotted screen from 165 to 168m bgl, 1m uPVC sump; Bentonite, 169 to 171m bgl; Backfill, 171 to 174m bgl	22 152; 20 154; 18 156; 16 158; 14 160; 12 162; 10 164; 8 166; 6 168; 4 170; 2 172; 0 174; -2 176; -4 178; -6 180; -8 182; -10 184; -12 186; -14 188; -16 190; -18 192; -20 194; -22 196; -24 198					**SILTSTONE:** black, fresh, wet. *(continued)*	W		
									SANDSTONE: fine grained, dark grey, fresh, wet.			
				164.00					**CLAYSTONE:** black, fresh, carbonaceous, wet.			Airlift yield: 0.29 L/S
				165.00					**COAL:** black, fresh, wet, (Pisces Seam).			Airlift yield: 0.31 L/S
				169.00					**SILTSTONE:** dark grey, fresh, carbonaceous, wet.			
									SANDSTONE: very fine grained, grey, fresh, wet. fine grained.			Airlift yield: 0.34 L/S
									END OF BOREHOLE AT 174.00 m			

This borehole log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

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GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW9A

SHEET 1 OF 2

Client:	MACARTHUR COAL	PB Borehole No.:	Date Commenced: 05.07.2010
Project:	MIDDLEMOUNT COAL PROJECT		Date Completed: 27.07.2010
Borehole Location:	MW9A -MIDDLEMOUNT MINE		Recorded By: Malcolm Graham
Project Number:	2117076B		Log Checked By:

Drill Model/Mounting:	IRTH 60	Driller:	S Baker	Surface RL:	156 m AHD
Borehole Diameter:	143mm	Driller Lic No:	3046	Co-ords:	E 670246 N 7469610 MGA94 Zone 55
		TOC (RL):	157 m AHD	Local Co-ords:	

Borehole Information

Field Material Description

1 METHOD	2 SUPPORT	3 WATER	4 WELL CONSTRUCTION	5 RL(m) AHD / DEPTH(m)	6 FIELD TEST	7 SAMPLE	8 GRAPHIC LOG	9 USC SYMBOL	10 SOIL/ROCK MATERIAL FIELD DESCRIPTION	11 MOISTURE	12 RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD)	13 STRUCTURE AND ADDITIONAL OBSERVATIONS
RB			TOC 1 m Monument cover with PVC cap, Cement 0 to 6.5m bgl (below ground level) 50mm ID, Class 12 uPVC casing, 0 to 40m bgl Backfill, 6.5 to 31m bgl Bentonite, 31 to 34m bgl 3mm Filter gravel, 34 to 52m bgl 50mm ID, Class 12 uPVC, 0.5mm Slotted screen from 40 to 52m bgl	154 2.00 / 2 3.00 152 / 4 5.00 150 6.00 / 6 7.00 148 8.00 / 8 9.00 146 / 10 11.00 144 / 12 13.00 142 / 14 140 16.00 / 16 138 / 18 136 / 20 134 / 22 132 / 24 130 / 26 128 / 28 126 / 30 124 32.00 / 32 33.00 122 34.00 / 34 120 36.00 / 36 118 / 38 116 / 40 114 / 42 112 44.00 / 44 110 / 46 108 48.00 / 48			CL	**Silty CLAY:** brown, dry, firm.	D		143mm Diameter, 0 to 52m bgl
									moist.	M		
								CL	**CLAY:** brown	D		
								SC	**Clayey SAND:** fine grained, pale brown, moist.	M		
								SP	**SAND:** fine grained, pale brown, dry.	D		
								SC	with clay, moist.	M		
								CL	**CLAY:** pale grey, moist, firm			
								CL / SC	and **Sandy CLAY:** brown, fine grained sand, moist.			
								SC	**Clayey SAND:** fine to medium grained, grey and orange, moist.			
								CL / ML	**CLAY:** grey, moist, firm and **Clayey SAND:** fine grained, orange, moist.			
								CL	**CLAY:** grey, orange and pink, firm, trace very fine grained pink sand, moist.			
								CL / ML	**Clay:** pale grey, pink and orange, moist, firm and **SAND:** very fine grained, pink, moist.			
								ML / CL	**SAND:** very fine grained, yellow, moist and **CLAY:** yellow brown, moist, firm.			
								CL	**CLAY:** brown, with pale brown silt, moist, firm.			
								ML	**SILT:** yellow, with firm grey clay, moist.			
									SANDSTONE: very fine grained, yellow brown, extremely weathered, moist.			
									grey, distinctly weathered, moist.			
									SILTSTONE: dark grey, slightly weathered, moist.			

This borehole log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

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GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW9A

SHEET 2 OF 2

Client:	MACARTHUR COAL	PB Borehole No.:	Date Commenced: 05.07.2010
Project:	MIDDLEMOUNT COAL PROJECT		Date Completed: 27.07.2010
Borehole Location:	MW9A -MIDDLEMOUNT MINE		Recorded By: Malcolm Graham
Project Number:	2117076B		Log Checked By:

Drill Model/Mounting:	IRTH 60	Driller:	S Baker	Surface RL:	156 m AHD
Borehole Diameter:	143mm	Driller Lic No:	3046	Co-ords:	E 670246 N 7469610 MGA94 Zone 55
		TOC (RL):	157 m AHD	Local Co-ords:	

Borehole Information

1	2	3	4	5		6	7
METHOD	SUPPORT	WATER	WELL CONSTRUCTION	RL(m) AHD	DEPTH(m)	FIELD TEST	SAMPLE
RB			TOC 1 m	104	52		
				102	54		
				100	56		
				98	58		
				96	60		
				94	62		
				92	64		
				90	66		
				88	68		
				86	70		
				84	72		
				82	74		
				80	76		
				78	78		
				76	80		
				74	82		
				72	84		
				70	86		
				68	88		
				66	90		
				64	92		
				62	94		
				60	96		
				58	98		

Field Material Description

8	9	10	11	12	13
GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY VS S F ST VST H FB VL L MD D VD	STRUCTURE AND ADDITIONAL OBSERVATIONS
		SILTSTONE: dark grey, slightly weathered, moist. *(continued)*	M		Airlift yield: 0.01 L/S
		END OF BOREHOLE AT 52.00 m			

This borehole log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

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GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW9M

SHEET 1 OF 3

Client:	MACARTHUR COAL	PB Borehole No.:	Date Commenced: 30.06.2010
Project:	MIDDLEMOUNT COAL PROJECT		Date Completed: 27.07.2010
Borehole Location:	MW9M - MIDDLEMOUNT MINE		Recorded By: Malcolm Graham
Project Number:	2117076B		Log Checked By:

Drill Model/Mounting:	IRTH 60	Driller: S Baker	Surface RL: 156 m AHD
Borehole Diameter:	200mm to 140mm	Driller Lic No: 3046	Co-ords: E 670244 N 7469619 MGA94 Zone 55
		TOC (RL): 157 m AHD	Local Co-ords:

Borehole Information

1	2	3	4	5		6	7
METHOD	SUPPORT	WATER	WELL CONSTRUCTION (TOC 1 m)	RL(m) AHD	DEPTH(m)	FIELD TEST	SAMPLE
RB			Monument cover with PVC cap, Cement 0 to 6m bgl (below ground level) 80mm ID, Class 12 uPVC casing, 0 to 135m bgl	154	2		
				152	4		
			Backfill, 6 to 129m bgl	150	6		
				148	8		
				146	10		
				144	12		
				142	14		
				140	16		
				138	18		
				136	20		
				134	22		
				132	24		
				130	26		
				128	28		
				126	30		
				124	32		
				122	34		
				120	36		
				118	38		
				116	40		
				114	42		
				112	44		
				110	46		
				108	48		

Field Material Description

8	9	10	11	12	13
GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD)	STRUCTURE AND ADDITIONAL OBSERVATIONS
	CL	**Silty CLAY:** brown, dry, firm.	D		200mm Diameter, 0 to 51m bgl
	SL	**CLAY:** brown, dry, firm.			
	SC	**Clayey SAND:** medium grained, brown, moist.	M		
	CL/SC	**CLAY:** grey, moist, firm and **Sandy CLAY:** brown, fine grained sand, moist.			
	SC	**Clayey SAND:** fine to medium grained, grey and orange, moist.			
	CL/ML	**CLAY:** grey, moist, firm and **Clayey SAND:** fine grained, orange, moist.			
	CL	**CLAY:** pale grey, orange and pink, moist, firm, trace very fine grained pink sand.			
	CL/ML	**CLAY:** grey, pink and orange, moist, firm and **SAND:** very fine grained, pink, moist.			
	CL	**CLAY:** brown, moist, firm.			
	ML	**SILT:** yellow-brown, with firm grey clay, moist.			
		SANDSTONE: very fine grained, yellow-brown, extremely weathered, moist.			
		red, distinctly weathered.			
		CLAYSTONE: brown and orange, distinctly weathered, moist.			
		SILTSTONE: grey-brown, distinctly weathered, carbonaceous, moist.			
		SANDSTONE: very fine grained, grey, slightly weathered, moist.			

This borehole log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

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GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW9M

SHEET 2 OF 3

Client:	MACARTHUR COAL	PB Borehole No.:	Date Commenced: 30.06.2010
Project:	MIDDLEMOUNT COAL PROJECT		Date Completed: 27.07.2010
Borehole Location:	MW9M - MIDDLEMOUNT MINE		Recorded By: Malcolm Graham
Project Number:	2117076B		Log Checked By:

Drill Model/Mounting:	IRTH 60	Driller: S Baker	Surface RL: 156 m AHD
Borehole Diameter:	200mm to 140mm	Driller Lic No: 3046	Co-ords: E 670244 N 7469619 MGA94 Zone 55
		TOC (RL): 157 m AHD	Local Co-ords:

Borehole Information							Field Material Description					
1	2	3	4	5	6	7	8	9	10	11	12	13
METHOD	SUPPORT	WATER	WELL CONSTRUCTION (TOC 1 m)	RL(m) AHD / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS S FB VL L MD ST VST D VD H)	STRUCTURE AND ADDITIONAL OBSERVATIONS
RB / RAB				104 52					**CLAYSTONE:** grey, distinctly weathered, moist.	M		140mm Diameter, 51 to 144m bgl
				53.00								
				102 54					**SANDSTONE:** very fine grained, grey, fresh, dry.	D		
				100 56								
				57.00					**CLAYSTONE:** dark grey, fresh, dry.			
				98 58.00 58					**SILTSTONE:** dark grey, fresh, carbonaceous, dry.			
				96 60								
				94 62								
				92 64.00 64					**SANDSTONE:** very fine grained, dark grey, fresh, carbonaceous, dry.			
				90 66.00 66					**SILTSTONE:** dark grey, fresh, carbonaceous, dry.			
				88 68								
				86 70.00 70					**SANDSTONE:** very fine grained, dark grey, fresh, carbonaceous, dry.			
				71.00					**SILTSTONE:** dark grey, fresh, carbonaceous, dry.			
				84 72								
				73.00					**CLAYSTONE:** dark grey, distinctly weathered, carbonaceous, dry.			
				82 74.00 74					**SILTSTONE:** dark grey, fresh, carbonaceous, dry.			
				80 76								
				77.00					extremely weathered, clayey, wet.	W		
				78 78.00 78					slightly weathered, clayey, wet.			
				76 80								
				74 82								
				72 84								
				70 86								
				87.00					**SANDSTONE:** very fine grained, dark grey, fresh, wet.			
				68 88.00 88					fine grained.			
				66 90								
				64 92								
				62 94								
				60 96.00 96					very fine grained.			
				97.00					**SILTSTONE:** dark grey, fresh, wet.			
				58 98.00 98					**SANDSTONE:** very fine grained, dark grey, fresh, wet.			

This borehole log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

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GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW9M

SHEET 3 OF 3

Client:	MACARTHUR COAL	PB Borehole No.:	Date Commenced: 30.06.2010
Project:	MIDDLEMOUNT COAL PROJECT		Date Completed: 27.07.2010
Borehole Location:	MW9M - MIDDLEMOUNT MINE		Recorded By: Malcolm Graham
Project Number:	2117076B		Log Checked By:

Drill Model/Mounting:	IRTH 60	Driller:	S Baker	Surface RL:	156 m AHD
Borehole Diameter:	200mm to 140mm	Driller Lic No:	3046	Co-ords:	E 670244 N 7469619 MGA94 Zone 55
		TOC (RL):	157 m AHD	Local Co-ords:	

Borehole Information

1 METHOD	2 SUPPORT	3 WATER	4 WELL CONSTRUCTION (TOC 1 m)	5 RL(m) AHD	5 DEPTH(m)	6 FIELD TEST	7 SAMPLE
RAB			Bentonite, 129 to 134m bgl 3mm Filter gravel, 134 to 139.5m bgl 80mm ID, Class 12 uPVC, 0.5mm Slotted screen from 135 to 138m bgl, 1.5m uPVC sump Bentonite, 139.5 to 142m bgl Backfill, 142 to 144m bgl	54 52 50 48 46 44 42 40 38 36 34 32 30 28 26 24 22 20 18 16 14 12 10 8	102.00 104 105.00 106.00 106 107.00 108.00 108 109.00 110 112 114 116.00 116 118 119.00 120.00 120 121.00 122 124 126 128 130 132 133.00 134.00 134 136 138.00 138 140.00 140 142 144 146 148		

Field Material Description

8 GRAPHIC LOG	9 USC SYMBOL	10 SOIL/ROCK MATERIAL FIELD DESCRIPTION	11 MOISTURE	12 RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD)	13 STRUCTURE AND ADDITIONAL OBSERVATIONS
		SANDSTONE: very fine grained, dark grey, fresh, wet. *(continued)*	W		
		SILTSTONE: dark grey, fresh, wet.			
		SANDSTONE: very fine grained, dark grey, fresh, wet.			
		SILTSTONE: dark grey, fresh, wet.			
		SHALE: black, fresh, carbonaceous, wet.			
		STONY COAL: fresh, carbonaceous, wet, (Roper Seam).			
		SANDSTONE: fine to medium grained, pale grey, fresh, bands of carbonaceous, claystone and quartz veins, wet.			
		SILTSTONE: dark grey, fresh, carbonaceous, wet.			
		SANDSTONE: very fine grained, grey, fresh, wet.			
		SILTSTONE: dark grey, fresh, carbonaceous, wet.			
		SANDSTONE: very fine grained, grey, fresh, wet and **SILTSTONE:** dark grey, fresh, carbonaceous, wet.			Airlift yield: 0.014 L/S
		CLAYSTONE: black, fresh, carbonaceous, wet.			
		COAL: black, fresh, wet, (Middlemount Seam)			
		SILTSTONE: black, fresh, carbonaceous, wet.			
		SANDSTONE: very fine grained, grey, fresh, wet.			Airlift yield: 0.017 L/S
		END OF BOREHOLE AT 144.00 m			

This borehole log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

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Explanatory Notes - Soil Description

In engineering terms soil includes every type of uncemented or partially cemented inorganic material found in the ground. In practice, if the material can be remoulded by hand in its field condition or in water it is described as a soil. The dominant soil constituent is given in capital letters, with secondary textures in lower case. The dominant feature is assessed from the Unified Soil Classification system and a soil symbol is used to define a soil layer .

METHOD

Method	Description
AS	Auger Screwing
BH	Backhoe
CT	Cable Tool Rig
EE	Existing Excavation/Cutting
EX	Excavator
HA	Hand Auger
HQ	Diamond Core-63mm
JET	Jetting
NMLC	Diamond Core –52mm
NQ	Diamond Core –47mm
PT	Push Tube
RAB	Rotary Air Blast
RB	Rotary Blade
RT	Rotary Tricone Bit
TC	Auger TC Bit
V	Auger V Bit
WB	Washbore
DT	Diatube

WATER


Water level at date shown


Partial water loss


Water inflow


Complete water loss

NFGWO: The observation of groundwater, whether present or not, was not possible due to drilling water, surface seepage or cave in of the borehole/test pit.

NFGWE: The borehole/test pit was dry soon after excavation. Inflow may have been observed had the borehole/test pit been left open for a longer period.

SAMPLING

Sample	Description
B	Bulk Disturbed Sample
D	Disturbed Sample
Jar	Jar Sample
SPT	Standard Penetration Test
U50	Undisturbed Sample –50mm
U75	Undisturbed Sample –75mm

UNIFIED SOIL CLASSIFICATION

The appropriate symbols are selected on the result of visual examination, field tests and available laboratory tests, such as, sieve analysis, liquid limit and plasticity index.

USC Symbol	Description
GW	Well graded gravel
GP	Poorly graded gravel
GM	Silty gravel
GC	Clayey gravel
SW	Well graded sand
SP	Poorly graded sand
SM	Silty sand
SC	Clayey sand
ML	Silt of low plasticity
CL	Clay of low plasticity
OL	Organic soil of low plasticity
MH	Silt of high plasticity
CH	Clay of high plasticity
OH	Organic soil of high plasticity
Pt	Peaty Soil

MOISTURE CONDITION

Dry - Cohesive soils are friable or powdery
Cohesionless soil grains are free-running

Moist - Soil feels cool, darkened in colour
Cohesive soils can be moulded
Cohesionless soil grains tend to adhere

Wet - Cohesive soils usually weakened
Free water forms on hands when handling

For cohesive soils the following codes may also be used:

MC>PL Moisture Content greater than the Plastic Limit.
MC~PL Moisture Content near the Plastic Limit.
MC<PL Moisture Content less than the Plastic Limit.

PLASTICITY

The potential for soil to undergo change in volume with moisture change is assessed from its degree of plasticity. The classification of the degree of plasticity in terms of the Liquid Limit (LL) is as follows:

Description of Plasticity	LL (%)
Low	<35
Medium	35 to 50
High	>50

COHESIVE SOILS - CONSISTENCY

The consistency of a cohesive soil is defined by descriptive terminology such as very soft, soft, firm, stiff, very stiff and hard. These terms are assessed by the shear strength of the soil as observed visually, by hand penetrometer values and by resistance to deformation to hand moulding.

A Hand Penetrometer may be used in the field or the laboratory to provide an approximate assessment of the unconfined compressive strength (UCS) of cohesive soils. The undrained shear strength of cohesive soils is approximately half the UCS. The values are recorded in kPa as follows:

Strength	Symbol	Undrained Shear Strength, C_u (kPa)
Very Soft	VS	< 12
Soft	S	12 to 25
Firm	F	25 to 50
Stiff	St	50 to 100
Very Stiff	VSt	100 to 200
Hard	H	> 200

COHESIONLESS SOILS - RELATIVE DENSITY

Relative density terms such as very loose, loose, medium, dense and very dense are used to describe silty and sandy material, and these are usually based on resistance to drilling penetration or the Standard Penetration Test (SPT) 'N' values. Other condition terms, such as friable, powdery or crumbly may also be used.

Term	Symbol	Density Index	N Value (blows/0.3 m)
Very Loose	VL	0 to 15	0 to 4
Loose	L	15 to 35	4 to 10
Medium Dense	MD	35 to 65	10 to 30
Dense	D	65 to 85	30 to 50
Very Dense	VD	>85	>50

COHESIONLESS SOILS PARTICLE SIZE DESCRIPTIVE TERMS

Name	Subdivision	Size
Boulders		>200 mm
Cobbles		63 mm to 200 mm
Gravel	coarse	20 mm to 63 mm
	medium	6 mm to 20 mm
	fine	2.36 mm to 6 mm
Sand	coarse	600 μm to 2.36 mm
	medium	200 μm to 600 μm
	fine	75 μm to 200 μm

Rock Description

The rock is described with strength and weathering symbols as shown below. Other features such as bedding and dip angle are given.

METHOD

Refer soil description sheet

WATER

Refer soil description sheet

ROCK QUALITY

The fracture spacing is shown where applicable and the Rock Quality Designation (RQD) or Total Core Recovery (TCR) is given where:

$$\text{TCR (\%)} = \frac{\text{length of core recovered}}{\text{length of core run}}$$

$$\text{RQD (\%)} = \frac{\text{Sum of Axial lengths of core > 100mm long}}{\text{length of core run}}$$

ROCK MATERIAL WEATHERING

Rock weathering is described using the abbreviations and definitions used in AS1726. AS1726 suggests the term "Distinctly Weathered" (DW) to cover the range of substance weathering conditions between (but not including) XW and SW. For projects where it is not practical to delineate between HW and MW or it is deemed that there is no advantage in making such a distinction, DW may be used with the definition given in AS1726.

Symbol	Term	Definition
RS	Residual Soil	Soil definition on extremely weathered rock; the mass structure and substance are no longer evident; there is a large change in volume but the soil has not been significantly transported
XW	Extremely Weathered	Rock is weathered to such an extent that it has 'soil' properties, ie. It either disintegrates or can be remoulded in water
HW	Highly Weathered	The rock substance is affected by weathering to the extent that limonite staining or bleaching affects the whole rock substance and other signs of chemical or physical decomposition are evident. Porosity and strength is usually decreased compared to the fresh rock. The colour and strength of the fresh rock is no longer recognisable.
DW	*Distinctly Weathered (see AS1726 Definition below)*	
MW	Moderately Weathered	The whole of the rock substance is discoloured, usually by iron staining or bleaching, to the extent that the colour of the fresh rock is no longer recognisable
SW	Slightly Weathered	Rock is slightly discoloured but shows little or no change of strength from fresh rock
FR	Fresh	Rock shows no sign of decomposition or staining

"Distinctly Weathered: Rock strength usually changed by weathering. The rock may be highly discoloured, usually by iron staining. Porosity may be increased by leaching, or may be decreased due to the deposition of weathering products in pores." (AS1726)

ROCK STRENGTH

Rock strength is described using AS1726 and ISRM - Commission on Standardisation of Laboratory and Field Tests, "Suggested method of determining the Uniaxial Compressive Strength of Rock materials and the Point Load Index", as follows:

Term	Symbol	Point Load Index $Is_{(50)}$ (MPa)
Extremely Low	EL	<0.03
Very Low	VL	0.03 to 0.1
Low	L	0.1 to 0.3
Medium	M	0.3 to 1
High	H	1 to 3
Very High	VH	3 to 10
Extremely High	EH	>10

● Diametral Point Load Index test

■ Axial Point Load Index test

DEFECT SPACING/BEDDING THICKNESS

Measured at right angles to defects of same set or bedding.

Term	Defect Spacing	Bedding
Extremely closely spaced	<6 mm	Thinly Laminated
	6 to 20 mm	Laminated
Very closely spaced	20 to 60 mm	Very Thin
Closely spaced	0.06 to 0.2 m	Thin
Moderately widely spaced	0.2 to 0.6 m	Medium
Widely spaced	0.6 to 2 m	Thick
Very widely spaced	>2 m	Very Thick

DEFECT DESCRIPTION

Type:	Definition:
B	Bedding
BP	Bedding Parting
F	Fault
C	Cleavage
J	Joint
SZ	Shear Zone
CZ	Crushed Zone
DB	Drill Break

Planarity:	Roughness:
P – Planar	R – Rough
Ir – Irregular	S – Smooth
St – Stepped	Sl – Slickensides
U – Undulating	Po – Polished

Coating or Infill:	Description
Clean	No visible coating or infilling
Stain	No visible coating or infilling but surfaces are discoloured by mineral staining
Veneer	A visible coating or infilling of soil or mineral substance but usually unable to be measured (<1mm). If discontinuous over the plane, patchy veneer
Coating	A visible coating or infilling of soil or mineral substance, >1mm thick. Describe composition and thickness

The inclinations of defects are measured from perpendicular to the core axis.

Graphic Symbols for Soil and Rock

Graphic symbols used on borehole and test pit reports for soil and rock are as follows. Combinations of these symbols may be used to indicate mixed materials such as clayey sand.

Soil Symbols

Main Components


CLAY


SILT


SAND


GRAVEL


BOULDERS / COBBLES


PEAT (Organic)

Minor Components


Clayey


Silty


Sandy


Gravelly

Other Symbols


TOPSOIL


FILL


ASPHALT


CONCRETE


NO CORE

Rock Symbols

Sedimentary Rocks


SANDSTONE


SILTSTONE


CLAYSTONE, MUDSTONE


SHALE


LAMINITE


CONGLOMERATE


BRECCIA


TILL


COAL


LIMESTONE

Igneous Rocks


PLUTONIC IGNEOUS (eg: Granite)


VOLCANIC IGNEOUS (eg: Basalt)


PYROCLASTIC IGNEOUS (eg: Ignimbrite)

Metamorphic Rocks


SLATE, PHYLLITE, SCHIST


GNEISS


QUARTZITE

List of abbreviations used in bore logs

D	Dry
ID	Internal Diameter
L/s	Litres per second
M	Moist
mAHD	metres Australian Height Datum
mBGL	metres Below Ground Level
MGA94	Map Grid of Australia 1994
RAB	Rotary Air Blast
RB	Rotary Blade
RL	Reduced Level (height relative to given datum)
TOC	Top Of Casing
W	Wet

Attachment B

Laboratory test results

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: **EB1009101**	Page	: 1 of 9
Client	: **PARSONS BRINCKERHOFF AUST P/L (QLD)**	Laboratory	: Environmental Division Brisbane
Contact	: MR R BARLOW	Contact	: Greg Vogel
Address	: GPO BOX 2907 BRISBANE QLD, AUSTRALIA 4000	Address	: 32 Shand Street Stafford QLD Australia 4053
E-mail	: rbarlow@pb.com.au	E-mail	: Services.Brisbane@alsenviro.com
Telephone	: +61 07 3854 6456	Telephone	: +61-7-3243 7222
Facsimile	: +61 07 38314223	Facsimile	: +61-7-3243 7218
Project	: 2117076B	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: 7490		
C-O-C number	: ----	Date Samples Received	: 20-MAY-2010
Sampler	: Rhys Barlow	Issue Date	: 04-JUN-2010
Site	: Middlemount Coal Mine		
		No. of samples received	: 25
Quote number	: EN/008/10	No. of samples analysed	: 25

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Inorganics
Kim McCabe	Senior Inorganic Chemist	Stafford Minerals - AY
Myles.Clark	Acid Sulfate Soils Supervisor	Bne Acid Sulphate Soils
Myles.Clark	Acid Sulfate Soils Supervisor	Inorganics
Stephen Hislop	Senior Inorganic Chemist	Inorganics

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insuffient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When date(s) and/or time(s) are shown bracketed, these have been assumed by the laboratory for processing purposes. If the sampling time is displayed as 0:00 the information was not provided by client.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

- **EG005T (Total Metals): Sample EB1009029-001 shows poor duplicate results for Zinc due to sample heterogeneity. Confirmed by visual inspection.**
- **EK067G (Total Phosphorus): Sample MM10 0.0-0.1 shows poor matrix spike recovery due to matrix interference. Confirmed by visual inspection.**

Analytical Results

Sub-Matrix: **SOIL**

Compound	CAS Number	LOR	Unit	Client sample ID	Trial Pit- Weathered Tertiary	Trial Pit-Fresh Tertiary	Trial Pit-Fresh Permian	MM01 5.9-6.0	MM01 0.0-0.1
				Client sampling date / time	11-MAY-2010 11:00	11-MAY-2010 11:00	13-MAY-2010 11:00	13-MAY-2010 11:00	13-MAY-2010 11:00
					EB1009101-001	EB1009101-002	EB1009101-003	EB1009101-004	EB1009101-005
EA002 : pH (Soils)									
pH Value	---	0.1	pH Unit		8.7	7.6	7.6	8.2	6.3
EA009: Nett Acid Production Potential									
^ Net Acid Production Potential	---	0.5	kg H2SO4/t		-3.5	0.8	0.7	-4.9	---
EA010: Conductivity									
Electrical Conductivity @ 25°C	---	1	µS/cm		334	2080	2440	202	22
EA011: Net Acid Generation									
pH (OX)	---	0.1	pH Unit		5.9	6.0	6.2	6.1	---
NAG (pH 4.5)	---	0.1	kg H2SO4/t		<0.1	<0.1	<0.1	<0.1	---
NAG (pH 7.0)	---	0.1	kg H2SO4/t		1.9	1.6	0.9	1.1	---
EA013: Acid Neutralising Capacity									
ANC as H2SO4	---	0.5	kg H2SO4 equiv./t		4.0	<0.5	<0.5	4.9	---
^ ANC as CaCO3	---	0.1	% CaCO3		0.4	<0.1	<0.1	0.5	---
Fizz Rating	---	0	Fizz Unit		0	0	0	0	---
EA055: Moisture Content									
^ Moisture Content (dried @ 103°C)	---	1.0	%		2.3	---	---	3.8	5.9
ED007: Exchangeable Cations									
^ Exchangeable Calcium	---	0.1	meq/100g		---	---	---	---	7.9
^ Exchangeable Magnesium	---	0.1	meq/100g		---	---	---	---	6.8
^ Exchangeable Potassium	---	0.1	meq/100g		---	---	---	---	0.6
^ Exchangeable Sodium	---	0.1	meq/100g		---	---	---	---	4.5
^ Cation Exchange Capacity	---	0.1	meq/100g		---	---	---	---	19.8
^ Exchangeable Sodium Percent	---	0.1	%		---	---	---	---	22.6
ED040: Sulfur as SO4 2-									
Sulfate as SO4 2-	14808-79-8	100	mg/kg		---	---	---	---	130
ED042T: Total Sulfur by LECO									
Sulfur - Total as S (LECO)	---	0.01	%		0.02	0.03	0.02	<0.01	---
ED045: Chloride									
Chloride	16887-00-6	10	mg/kg		---	---	---	---	220
EG005T: Total Metals by ICP-AES									
Arsenic	7440-38-2	5	mg/kg		6	---	---	<5	---
Cadmium	7440-43-9	1	mg/kg		<1	---	---	<1	---
Chromium	7440-47-3	2	mg/kg		18	---	---	6	---
Copper	7440-50-8	5	mg/kg		9	---	---	<5	---

Analytical Results

Sub-Matrix: SOIL				Client sample ID	Trial Pit- Weathered Tertiary	Trial Pit-Fresh Permian (Ferruginised)	Trial Pit-Fresh Permian	MM01 5.9-6.0	MM01 0.0-0.1
				Client sampling date / time	11-MAY-2010 11:00	11-MAY-2010 11:00	13-MAY-2010 11:00	13-MAY-2010 11:00	13-MAY-2010 11:00
Compound	CAS Number	LOR	Unit		EB1009101-001	EB1009101-002	EB1009101-003	EB1009101-004	EB1009101-005
EG005T: Total Metals by ICP-AES - Continued									
Lead	7439-92-1	5	mg/kg		10	----	----	<5	----
Nickel	7440-02-0	2	mg/kg		18	----	----	7	----
Zinc	7440-66-6	5	mg/kg		34	----	----	12	----
EK059G: NOX as N by Discrete Analyser									
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg		----	----	----	----	<0.1
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	20	mg/kg		----	----	----	----	460
EK062: Total Nitrogen as N (TKN + NOx)									
^ Total Nitrogen as N	----	20	mg/kg		----	----	----	----	460
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	2	mg/kg		----	----	----	----	280
EP004: Organic Matter									
Organic Matter	----	0.5	%		----	----	----	----	1.3
^ Total Organic Carbon	----	0.5	%		----	----	----	----	0.8

Analytical Results

Sub-Matrix: **SOIL**

Compound	CAS Number	LOR	Unit	Client sample ID: MM01 0.1-0.2	MM02 0.0-0.1	MM02 0.15-0.25	MM03 0.0-0.1	MM04 0.15-0.25
Client sampling date / time				13-MAY-2010 11:00	12-MAY-2010 15:00	12-MAY-2010 15:00	11-MAY-2010 15:00	12-MAY-2010 15:00
				EB1009101-006	EB1009101-007	EB1009101-008	EB1009101-009	EB1009101-010
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	6.7	6.8	7.2	6.0	7.1
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	38	75	44	25	23
EA055: Moisture Content								
^ Moisture Content (dried @ 103°C)	----	1.0	%	5.3	5.7	7.4	6.1	6.9
ED007: Exchangeable Cations								
^ Exchangeable Calcium	----	0.1	meq/100g	4.3	8.6	6.6	4.4	12.6
^ Exchangeable Magnesium	----	0.1	meq/100g	2.7	1.7	1.8	1.6	4.6
^ Exchangeable Potassium	----	0.1	meq/100g	1.2	1.4	1.4	1.5	1.3
^ Exchangeable Sodium	----	0.1	meq/100g	0.3	0.2	0.2	0.2	0.2
^ Cation Exchange Capacity	----	0.1	meq/100g	8.5	11.8	10.0	7.6	18.7
^ Exchangeable Sodium Percent	----	0.1	%	3.5	1.4	2.0	2.2	1.0
ED040: Sulfur as SO4 2-								
Sulfate as SO4 2-	14808-79-8	100	mg/kg	120	200	150	150	190
ED045: Chloride								
Chloride	16887-00-6	10	mg/kg	270	130	130	220	220
EK059G: NOX as N by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	<0.1	5.7	0.6	0.1	0.1
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	20	mg/kg	520	1350	550	650	860
EK062: Total Nitrogen as N (TKN + NOx)								
^ Total Nitrogen as N	----	20	mg/kg	520	1360	550	650	860
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	2	mg/kg	289	315	285	262	537
EP004: Organic Matter								
Organic Matter	----	0.5	%	1.4	3.1	1.4	1.9	2.4
^ Total Organic Carbon	----	0.5	%	0.8	1.8	0.8	1.1	1.4

Analytical Results

Sub-Matrix: **SOIL**

Compound	CAS Number	LOR	Unit	Client sample ID	MM06 0.0-0.1	MM07 0.0-0.1	MM07 0.2-0.3	MM11 0.0-0.1	MM08 0.2-0.3
				Client sampling date / time	12-MAY-2010 15:00	12-MAY-2010 11:00	12-MAY-2010 11:00	11-MAY-2010 11:00	12-MAY-2010 11:00
					EB1009101-011	EB1009101-012	EB1009101-013	EB1009101-014	EB1009101-015
EA002 : pH (Soils)									
pH Value	----	0.1	pH Unit		**6.4**	**6.7**	**6.7**	**6.6**	**6.2**
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm		**20**	**17**	**8**	**14**	**3**
EA055: Moisture Content									
^ Moisture Content (dried @ 103°C)	----	1.0	%		**1.8**	**2.9**	**3.6**	**2.6**	**2.1**
ED007: Exchangeable Cations									
^ Exchangeable Calcium	----	0.1	meq/100g		**1.6**	**3.0**	**1.3**	**1.8**	**0.8**
^ Exchangeable Magnesium	----	0.1	meq/100g		**0.7**	**0.6**	**0.3**	**0.4**	**0.6**
^ Exchangeable Potassium	----	0.1	meq/100g		**0.5**	**0.4**	**0.2**	**0.3**	**0.3**
^ Exchangeable Sodium	----	0.1	meq/100g		<0.1	<0.1	<0.1	<0.1	<0.1
^ Cation Exchange Capacity	----	0.1	meq/100g		**2.9**	**4.2**	**1.8**	**2.5**	**1.7**
^ Exchangeable Sodium Percent	----	0.1	%		**1.6**	**2.0**	**1.5**	**1.1**	**2.1**
ED040: Sulfur as SO4 2-									
Sulfate as SO4 2-	14808-79-8	100	mg/kg		<100	<100	<100	<100	<100
ED045: Chloride									
Chloride	16887-00-6	10	mg/kg		**50**	**50**	**20**	**20**	<10
EK059G: NOX as N by Discrete Analyser									
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg		**0.7**	**1.2**	**0.2**	**1.5**	<0.1
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	20	mg/kg		**310**	**220**	**110**	**250**	**100**
EK062: Total Nitrogen as N (TKN + NOx)									
^ Total Nitrogen as N	----	20	mg/kg		**310**	**220**	**110**	**250**	**100**
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	2	mg/kg		**122**	**139**	**73**	**54**	**62**
EP004: Organic Matter									
Organic Matter	----	0.5	%		**0.9**	**0.5**	<0.5	**1.0**	**0.9**
^ Total Organic Carbon	----	0.5	%		**0.5**	<0.5	<0.5	**0.6**	**0.5**

Analytical Results

Sub-Matrix: **SOIL**

Compound	CAS Number	LOR	Unit	Client sample ID: MM09 0.0-0.1	MM12 0.15-0.25	MM10 0.0-0.1	MM13 0.0-0.1	MM13 0.2-0.3
				Client sampling date / time: 11-MAY-2010 15:00	11-MAY-2010 15:00	11-MAY-2010 15:00	11-MAY-2010 11:00	11-MAY-2010 11:00
				EB1009101-016	EB1009101-017	EB1009101-018	EB1009101-019	EB1009101-020
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	6.1	6.7	5.9	5.4	5.3
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	10	8	8	9	20
EA055: Moisture Content								
^ Moisture Content (dried @ 103°C)	----	1.0	%	1.7	3.3	1.4	2.1	5.2
ED007: Exchangeable Cations								
^ Exchangeable Calcium	----	0.1	meq/100g	1.4	1.9	1.6	1.4	1.4
^ Exchangeable Magnesium	----	0.1	meq/100g	0.4	1.0	0.5	1.8	2.4
^ Exchangeable Potassium	----	0.1	meq/100g	0.2	0.4	0.2	0.3	0.1
^ Exchangeable Sodium	----	0.1	meq/100g	<0.1	<0.1	<0.1	0.1	0.2
^ Cation Exchange Capacity	----	0.1	meq/100g	2.1	3.4	2.4	3.6	4.1
^ Exchangeable Sodium Percent	----	0.1	%	2.3	1.9	1.4	4.1	5.6
ED040: Sulfur as SO4 2-								
Sulfate as SO4 2-	14808-79-8	100	mg/kg	<100	<100	<100	<100	120
ED045: Chloride								
Chloride	16887-00-6	10	mg/kg	20	50	50	100	130
EK059G: NOX as N by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	0.4	<0.1	<0.1	0.3	0.1
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	20	mg/kg	190	170	180	350	940
EK062: Total Nitrogen as N (TKN + NOx)								
^ Total Nitrogen as N	----	20	mg/kg	190	170	180	350	940
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	2	mg/kg	58	78	127	163	135
EP004: Organic Matter								
Organic Matter	----	0.5	%	0.5	0.5	<0.5	0.9	0.9
^ Total Organic Carbon	----	0.5	%	<0.5	<0.5	<0.5	0.5	0.5

Analytical Results

Sub-Matrix: SOIL			Client sample ID	MM06 0.45-0.55	MM02 0.7-0.8	MM12 0.4-0.5	MM01 0.32-0.4	MM08 0.0-0.1
			Client sampling date / time	12-MAY-2010 15:00	12-MAY-2010 15:00	11-MAY-2010 15:00	13-MAY-2010 11:00	13-MAY-2010 11:00
Compound	CAS Number	LOR	Unit	EB1009101-021	EB1009101-022	EB1009101-023	EB1009101-024	EB1009101-025
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	8.7	6.9	8.6	6.4	6.6
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	422	37	243	113	20
EA055: Moisture Content								
^ Moisture Content (dried @ 103°C)	----	1.0	%	10.2	12.2	9.4	11.7	2.1
ED007: Exchangeable Cations								
^ Exchangeable Calcium	----	0.1	meq/100g	8.7	11.1	11.6	3.7	2.8
^ Exchangeable Magnesium	----	0.1	meq/100g	5.8	3.6	6.6	4.5	0.6
^ Exchangeable Potassium	----	0.1	meq/100g	0.3	1.2	0.6	0.5	0.3
^ Exchangeable Sodium	----	0.1	meq/100g	3.3	0.2	1.9	2.6	<0.1
^ Cation Exchange Capacity	----	0.1	meq/100g	18.2	16.2	20.7	11.2	3.7
^ Exchangeable Sodium Percent	----	0.1	%	18.0	1.4	9.0	22.8	0.6
ED040: Sulfur as SO4 2-								
Sulfate as SO4 2-	14808-79-8	100	mg/kg	200	160	120	110	<100
ED045: Chloride								
Chloride	16887-00-6	10	mg/kg	560	290	250	490	130
EK059G: NOX as N by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	<0.1	0.2	0.7	0.5	1.4
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	20	mg/kg	140	490	180	530	340
EK062: Total Nitrogen as N (TKN + NOx)								
^ Total Nitrogen as N	----	20	mg/kg	140	490	180	530	340
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	2	mg/kg	89	302	116	216	87
EP004: Organic Matter								
Organic Matter	----	0.5	%	<0.5	1.0	<0.5	0.9	0.9
^ Total Organic Carbon	----	0.5	%	<0.5	0.6	<0.5	0.5	0.5

Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: **EB1013621**	Page	: 1 of 4
Client	: **PARSONS BRINCKERHOFF AUST P/L (QLD)**	Laboratory	: Environmental Division Brisbane
Contact	: MR RHYS BARLOW	Contact	: Greg Vogel
Address	: GPO BOX 2907 BRISBANE QLD, AUSTRALIA 4000	Address	: 32 Shand Street Stafford QLD Australia 4053
E-mail	: rbarlow@pb.com.au	E-mail	: brisbane.enviro.services@alsglobal.com
Telephone	: +61 07 3854 6456	Telephone	: +61 7 3243 7222
Facsimile	: +61 07 38314223	Facsimile	: +61 7 3243 7218
Project	: 2117076B	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: 7490		
C-O-C number	: ----	Date Samples Received	: 03-AUG-2010
Sampler	: Rhys Barlow	Issue Date	: 10-AUG-2010
Site	: Middlemount Coal Mine		
		No. of samples received	: 6
Quote number	: EN/008/10	No. of samples analysed	: 6

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Cass Sealby	Senior Chemist - Acid Sulphate Soils	Inorganics
Myles.Clark	Acid Sulfate Soils Supervisor	Bne Acid Sulphate Soils
Stephen Hislop	Senior Inorganic Chemist	Inorganics
Stephen Hislop	Senior Inorganic Chemist	Stafford Minerals - AY

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insuffient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When date(s) and/or time(s) are shown bracketed, these have been assumed by the laboratory for processing purposes. If the sampling time is displayed as 0:00 the information was not provided by client.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

- **ANC Fizz Rating: 0- None; 1- Slight; 2- Moderate; 3- Strong; 4- Very Strong.**
- **EG005T (Total Metals): Sample EB1013524-026 shows poor duplicate results due to sample heterogeneity. Confirmed by visual inspection.**

Analytical Results

Sub-Matrix: **SOIL**

Compound	CAS Number	LOR	Unit	Client sample ID: MW9A 19.0-20.0m Client sampling date / time: 05-JUL-2010 15:00 EB1013621-001	Client sample ID: MW9A 40.0-41.0m Client sampling date / time: 05-JUL-2010 15:00 EB1013621-002	Client sample ID: MW9A 49.0-50.0m Client sampling date / time: 05-JUL-2010 15:00 EB1013621-003	Client sample ID: MW9M 69.0-70.0m Client sampling date / time: 30-JUN-2010 15:00 EB1013621-004	Client sample ID: MW5P 18.0-19.0m Client sampling date / time: 06-JUL-2010 15:00 EB1013621-005
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	**8.2**	**8.4**	**9.7**	**10.0**	**9.6**
EA009: Nett Acid Production Potential								
^ Net Acid Production Potential	----	0.5	kg H2SO4/t	<0.5	**-6.8**	**-14.4**	**-52.2**	**-122**
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	**878**	**537**	**610**	**523**	**567**
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	**6.0**	**5.6**	**7.3**	**10.7**	**9.1**
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t	**2.9**	**1.9**	<0.1	<0.1	<0.1
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	**2.2**	**7.6**	**14.9**	**53.6**	**122**
^ ANC as CaCO3	----	0.1	% CaCO3	**0.2**	**0.8**	**1.5**	**5.5**	**12.4**
Fizz Rating	----	0	Fizz Unit	**0**	**0**	**0**	**2**	**2**
EA055: Moisture Content								
^ Moisture Content (dried @ 103°C)	----	1.0	%	**11.3**	----	**6.5**	----	----
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	**0.06**	**0.03**	**0.02**	**0.04**	<0.01
EG005T: Total Metals by ICP-AES								
Arsenic	7440-38-2	5	mg/kg	**7**	----	<5	----	----
Cadmium	7440-43-9	1	mg/kg	<1	----	<1	----	----
Chromium	7440-47-3	2	mg/kg	**42**	----	**21**	----	----
Copper	7440-50-8	5	mg/kg	**17**	----	**45**	----	----
Lead	7439-92-1	5	mg/kg	<5	----	**10**	----	----
Nickel	7440-02-0	2	mg/kg	**19**	----	**42**	----	----
Zinc	7440-66-6	5	mg/kg	**23**	----	**78**	----	----

Analytical Results

Sub-Matrix: **SOIL**

Compound	CAS Number	LOR	Unit	Client sample ID: MW5P 78.0-79.0m	----	----	----	----
				Client sampling date / time: 06-JUL-2010 15:00	----	----	----	----
				EB1013621-006	----	----	----	----
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	**9.8**	----	----	----	----
EA009: Nett Acid Production Potential								
^ Net Acid Production Potential	----	0.5	kg H2SO4/t	**-28.2**	----	----	----	----
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	**331**	----	----	----	----
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	**9.2**	----	----	----	----
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	----	----	----	----
NAG (pH 7.0)	----	0.1	kg H2SO4/t	<0.1	----	----	----	----
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	**28.7**	----	----	----	----
^ ANC as CaCO3	----	0.1	% CaCO3	**2.9**	----	----	----	----
Fizz Rating	----	0	Fizz Unit	**2**	----	----	----	----
EA055: Moisture Content								
^ Moisture Content (dried @ 103°C)	----	1.0	%	**3.3**	----	----	----	----
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	**0.02**	----	----	----	----
EG005T: Total Metals by ICP-AES								
Arsenic	7440-38-2	5	mg/kg	<5	----	----	----	----
Cadmium	7440-43-9	1	mg/kg	<1	----	----	----	----
Chromium	7440-47-3	2	mg/kg	**25**	----	----	----	----
Copper	7440-50-8	5	mg/kg	**47**	----	----	----	----
Lead	7439-92-1	5	mg/kg	**13**	----	----	----	----
Nickel	7440-02-0	2	mg/kg	**37**	----	----	----	----
Zinc	7440-66-6	5	mg/kg	**81**	----	----	----	----

Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: **EB1015092**	Page	: 1 of 3
Client	: **PARSONS BRINCKERHOFF AUST P/L (QLD)**	Laboratory	: Environmental Division Brisbane
Contact	: MR RHYS BARLOW	Contact	: Bryn Stephens
Address	: GPO BOX 2907 BRISBANE QLD, AUSTRALIA 4000	Address	: 32 Shand Street Stafford QLD Australia 4053
E-mail	: rbarlow@pb.com.au	E-mail	: Bryn.Stephens@alsglobal.com
Telephone	: +61 07 3854 6456	Telephone	: +617 3243 7125
Facsimile	: +61 07 38314223	Facsimile	: +617 3243 7181
Project	: 2117076B	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: 7490		
C-O-C number	: ----	Date Samples Received	: 20-AUG-2010
Sampler	: R.Barlow	Issue Date	: 01-SEP-2010
Site	: Middlemount Coal Mine		
		No. of samples received	: 5
Quote number	: EN/008/10	No. of samples analysed	: 5

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

NATA Accredited Laboratory 825

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Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Nikki Stepniewski	Non-metallic Supervisor	Inorganics

General Comments

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Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

- **EG048: EB1015092 #2 matrix spike failed for Total Hexavalent Chromium by Alkaline Digestion due to possible sample matrix interference. This has been confirmed by re-digestion and re-analysis.**

Analytical Results

Sub-Matrix: **SOIL**

Compound	CAS Number	LOR	Unit	Client sample ID	MW9A 19.0-20.0	MW9A 49.0-50.0	MW5P 78.0-79.0	Trial Pit Weathered Tertiary (~10m)	MM01 5.9-6.0
				Client sampling date / time	05-JUL-2010 15:00	05-JUL-2010 15:00	06-JUL-2010 15:00	13-MAY-2010 15:00	13-MAY-2010 15:00
					EB1015092-001	EB1015092-002	EB1015092-003	EB1015092-004	EB1015092-005
EA055: Moisture Content									
^ Moisture Content (dried @ 103°C)	----	1.0	%		**11.3**	**5.8**	**4.5**	**1.8**	**3.2**
EG005T: Total Metals by ICP-AES									
Chromium	7440-47-3	2	mg/kg		**38**	**16**	**16**	**13**	**5**
EG048: Hexavalent Chromium (Alkaline Digest)									
Hexavalent Chromium	18540-29-9	0.5	mg/kg		<0.5	<0.5	<0.5	<0.5	<0.5
EG049: Trivalent Chromium									
^ Trivalent Chromium	16065-83-1	2	mg/kg		**38**	**16**	**16**	**13**	**5**

Attachment C

Land suitability assessment criteria

Attachment C – Land suitability criteria

Table D.1 Suitability criteria for rainfed broadacre cropping

Limitation	Land suitability class				
	1	2	3	4	5
Water availability	PAWC >150 mm	PAWC 125-150 mm	PAWC 100-125 mm	PAWC 75-100 mm	PAWC <75 mm
Nutrient deficiency	Bicarbonate P >10 ppm	Bicarbonate P 5-10 ppm and Exchangeable K >0.3 meq. %	Bicarbonate P 5-10 ppm and Exchangeable K ≤0.3 meq. % or pH <5 60-90 cm below surface or pH >9 60-90 cm below surface	Bicarbonate P <10 ppm and Exchangeable K ≤0.3 meq. %, and Exchangeable Ca <3 meq.%, or pH <5 30-60 cm below surface, or pH >9 30-60 cm below surface	pH <5 within 30 cm of surface or pH >9 within 30 cm of surface
Soil physical factors	Cracking clays with very fine self-mulch (peds <2 mm), or Rigid soils with a loose, soft or firm surface when dry	Cracking clays with fine self-mulch (peds 2-10 mm)	Cracking clays with coarse self-mulch (peds 10-20 mm) or Rigid soils with a hard setting surface when dry	Cracking clays with coarse peds at the surface (≥20 mm)	
Soil workability	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	Rootzone EC <0.15 mS/cm or Rootzone Cl <300 ppm	Rootzone EC 0.15 -0.3 mS/cm or Rootzone Cl 300-600 ppm	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 900-1,500 ppm	Rootzone EC >1.2 mS/cm or Rootzone Cl ≥1,500 ppm
Rockiness	<10% coarse surface gravel (>6 cm diameter) and rock outcrop	10-20% coarse surface gravel and rock outcrop	20-50% surface cobble (6-20 cm diameter) and rock outcrop	50-90% surface cobble and rock outcrop, or 20-50% stone and boulders (>20 cm diameter)	>90% surface cobble and rock outcrop, or >50% stone and boulders and rock outcrop
Microrelief	No melonholes (semi-circular depressions <30 cm deep and usually	Melonholes 30-60 cm deep cover <20% surface area or	Melonholes 30-60 cm deep cover 20-50% of surface area or	Melonholes 60-100 cm deep cover 50% surface area	Melonholes at least 100 cm deep cover 50% surface area

Limitation	Land suitability class				
	1	**2**	**3**	**4**	**5**
	surrounded by mounds)	Melonholes >60 cm deep cover <10% surface area	Melonholes >60 cm deep cover 10-20% surface area		
Wetness	Undulating terrain or elevated plains	Low-lying level plains with melonholes covering <25% surface area, or Rigid soils with sodic subsoil (ESP 6-14) within 60 cm of the surface, or Non-sodic rigid soils with coarse pale grey and yellow mottles within 75 cm of the surface	Low-lying level plains with melonholes covering 25-50% surface area, or Rigid soils with strongly sodic subsoil (ESP≥15) within 60 cm of the surface, or Non-sodic rigid soils with coarse pale grey and yellow mottles within 50 cm of the surface	Seasonal swamps and lowlying run-on areas	Permanent swamps and lakes
Topography	No gully dissection	Occasional deep gullies impede cultivation slightly	Many deep gullies reduce arable area by <33% or require major changes to cultivation practices	Many deep gullies make the arable areas too small to cultivate	Abundant deep gullies prevent any practical cultivation
Water erosion	Slopes <0.5% on cracking clays without melonholes, or Slopes <1% on melonhole clays, or Slopes <1% on nonsodic rigid soils, or Slopes <0.5% on sodic rigid soils	Slopes 0.5-1% on cracking clays without melonholes or Slopes 1-3% on melonhole 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 all cracking clays or Slopes 4-6% on non-sodic rigid soils or Slopes 2-3% on sodic rigid soils	Slopes >5% on all cracking clays or Slopes >6% on nonsodic rigid soils or Slopes >3% on sodic rigid soils
Flooding	No flooding	Rare flooding (only during abnormal 1 in 50 to 100 year events)	Infrequent flooding (inundation occurs <half the times that stream flow increases)	Occasional flooding (inundation occurs ≥half the times that stream flow increases)	Regular flooding (inundation occurs whenever stream flow increases)

Table D.2 Suitability criteria for beef cattle grazing

Limitation	Land suitability class				
	1	2	3	4	5
Water availability	PAWC >125 mm	PAWC 100-125 mm	PAWC 75-100 mm	PAWC 50-75 mm	PAWC ≤50 mm
Nutrient deficiency	Brigalow, gidgee, blackwood or softwood scrub soils and former scrub soils with Bicarbonate P >10 ppm	Eucalypt vegetation and downs with Bicarbonate P >10 ppm	Other soils with Bicarbonate P 5-10 ppm except Sands and loams at least 75 cm deep or overlying rock at shallow depth	Sands and loams at least 75 cm deep or overlying rock at shallow depth, with Bicarbonate P 5-10 ppm, or Bicarbonate P ≤4 ppm	
Soil physical factors	Cracking clays with very fine self-mulch (peds <2 mm), or Rigid soils with a loose, soft or firm surface when dry	Cracking clays with fine self-mulch (peds 2-10 mm), or Rigid soils with a hard setting surface when dry	Cracking clays with coarse peds (peds ≥10 mm) or crust on the surface		
Salinity	Rootzone EC < 0.15 mS/cm or Rootzone Cl <300 ppm	Rootzone EC 0.15-0.3 mS/cm or Rootzone Cl 300-600 ppm	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 ≥1500 ppm
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	Melonholes cover <20% surface area (semi-circular depressions at least 30 cm deep and usually surrounded by mounds)	Shallow melonholes (30-60 cm deep) cover 20-50% surface area	Deep melonholes (>60 cm deep) cover 20-50% of surface area		
pH (1:5)	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 (10 cm)% Exchangable Sodium Percentage	<5.0	5-10	10-15	15-30	>30
Wetness	Undulating terrain or elevated plains	Low-lying level plains , or Rigid soils with strongly sodic subsoil	Shallow seasonal and permanent swamps		Permanent lakes and deep swamps

Limitation	Land suitability class				
	1	2	3	4	5
		(ESP≥15) within 60 cm of the surface, or Non-sodic rigid soils with coarse pale grey and yellow mottles within 50 cm of the surface			
Topography				Many deep gullies make cultivation for sowing pastures impractical, or Slopes >15% make cultivation along contours impractical	Strongly dissected terrain over ≥75% of the area preventing adequate herd management
Water erosion	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 nonsodic 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	No flooding	Periodic flooding (from once in 50 years to whenever stream flow increases)			
Vegetation regrowth (management limitation)	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		Eucalypt woodlands with wattle understorey or Broad-leaved teatree woodlands	

Attachment D

Representative profiles of soils from Burgess (2003)

Appendix 3 – Profile morphology, landscape characteristics, vegetation & analytical data (continued)

Representative Profile: 9020

Soil Name: **Foxleigh (Fx)**

Location: 665700 mE 7473300 mN ZONE 55
Described By: Burgess, J **Date:** 18–Jun–1992

Landscape:

Geology: TQa – unconsolidated sediments (sedimentary origins)
Landform Pattern: plain
Runoff: slow
Microrelief: absent
Drainage: moderately well drained
Surface Coarse Fragments: no coarse fragments
Surface Condition: firm, hard setting
Substrate Lithology: unconsolidated material (relict)
Element: hillcrest
Permeability: very slowly permeable
Microrelief Component: absent
Slope: 1 %

Classifications:

ASC: Hypercalcic, Subnatric, Brown, SODOSOL, Thick, Non Gravelly, Sandy, Clayey, Very Deep
GSG: Solodized solonetz **PPF:** Dy5.43

Vegetation:

Tallest Stratum: Tall woodland (12.01–20m)
Eucalyptus populnea (poplar box); *Acacia excelsa* (ironwood)

Mid Stratum: Low open woodland (3.01–6m)
Eremophila mitchellii (false sandalwood); *Cassia brewsteri* (Leichhardt bean, bean bush)

Lower Stratum: Low sparse tussock grassland (<0.25)
Chrysopogon fallax (golden beardgrass); *Aristida* species

Veg. Association: Poplar box (VA20) – uncleared

Profile Morphology:

Horizon	Depth (m)	Description
A11	0.00 to 0.15	Dark yellowish brown (10YR34) moist colour; loamy sand; very few < 2% small pebbles 2–6mm subrounded ironstone and quartz coarse fragments; weak 10–20mm platy parting to massive structure; dry weak; dry when sampled; diffuse to;
A12	0.15 to 0.32	Brown (10YR43) moist colour; loamy sand; very few < 2% small pebbles 2–6mm subrounded ironstone and quartz coarse fragments; massive structure; dry weak; dry when sampled; clear to;
A2e	0.32 to 0.35	Brown (10YR43) moist colour, very pale brown (10YR73) dry colour; loamy sand; very few < 2% small pebbles 2–6mm subrounded ironstone and quartz coarse fragments; massive structure; dry weak; dry when sampled; abrupt to;
B21t	0.35 to 0.70	Light olive brown (2.5Y54) moist colour; common 10–20% fine < 5mm faint orange mottles; fine sandy medium clay (heavy); very few < 2% small pebbles 2–6mm rounded ironstone coarse fragments; strong 100–200mm columnar parting to weak 20–50mm angular blocky structure; few 2–10% fine <2mm manganiferous soft segregations; dry strong; diffuse to;
B22	0.70 to 1.00	Yellowish brown (10YR54) moist colour; fine sandy light medium clay; weak 10–20mm angular blocky structure; few 2–10% medium 2–6mm calcareous soft segregations, very few < 2% fine <2mm manganiferous soft segregations; dry strong; dry when sampled; clear to;
B23k	1.00 to 1.30	Yellowish brown (10YR54) moist colour; few 2–10% fine < 5mm faint grey mottles; fine sandy light medium clay; moderate 10–20mm angular blocky structure; many 20–50% coarse 6–20mm calcareous soft segregations, few 2–10% medium 2–6mm calcareous nodules; dry strong; dry when sampled; clear to;
B24	1.30 to 1.55	Brown (10YR43) moist colour; few 2–10% fine < 5mm faint orange, few 2–10% fine < 5mm faint grey mottles; fine sandy light clay; moderate 10–20mm angular blocky structure; few 2–10% medium 2–6mm calcareous soft segregations, very few < 2% medium 2–6mm calcareous nodules; moderately moist strong; moderately moist when sampled.

Effective Rooting Depth (ERD): 0.35 m (strong columnar structure)

Plant Available Water Capacity (PAWC): 40 mm

Analytical Data:

Horizon	Upper Depth (m)	Lower Depth (m)	1:5 Soil/Water			Cation Exchange Capacity/Exchangeable Cations # (meq/100g)					Exchange Acidity (meq/100g)		Cation Dominance		Dispersion	Particle Size (%)				Moisture (%)	Clay Mineralogy	Total Elements (%)		
			pH	EC (dS/m)	Cl (mg/kg)	CEC/ECEC	Ca	Mg	Na	K	Al	H	ESP (%)	Ca/Mg Ratio	R1 Ratio	Coarse Sand	Fine Sand	Silt	Clay	15 Bar	CEC/Clay% Ratio	P	K	S
			@ 40 C			@ 105 C					@ 105 C					@ 105 C				@ 105 C		@ 65 C		
A11	0	0.1	6.7	0.02	10	5	3.2	1.1	0.09	0.39			1.8	2.91	0.51	22	66	4	10	3	0.50	0.027	0.288	0.019
	0.1	0.2	6.5	0.01	10																			
A12	0.2	0.3	6.5	0.01	10	3	1.4	1.0	0.01	0.25			0.3	1.40	0.64	24	64	5	9	2	0.33	0.023	0.287	0.016
A2e	0.3	0.35	7	0.02	10																			
B21t	0.35	0.4	7.5	0.07	50																			
	0.4	0.5	8.1	0.10	76	16	5.5	7.2	1.6	0.43			10.0	0.76	0.72	13	36	2	50	16	0.32	0.023	0.728	0.017
	0.5	0.6	8.6	0.12	105	14	4.7	7.0	1.6	0.36			11.4	0.67	0.81	14	40	4	42	14	0.33	0.022	0.666	0.018
	0.6	0.7	8.8	0.13	102																			
B22	0.7	0.8	9.1	0.27	169																			
	0.8	0.9	9.3	0.37	222	12	3.7	7.4	2.1	0.29			17.5	0.50	0.92	17	48	5	30	10	0.40	0.021	0.556	0.019
	0.9	1	9.4	0.44	294																			
B23k	1	1.1	9.5	0.50	341																			
	1.1	1.2	9.4	0.57	432	14	3.6	9.8	3.4	0.37			24.3	0.37	–	14	47	6	32	–	0.44	0.019	0.620	0.026
	1.2	1.3	9.4	0.59	447																			
B24	1.3	1.4	9.4	0.62	466																			
	1.4	1.5	9.5	0.63	478	17	3.2	10	4.0	0.34			23.5	0.32	0.99	18	42	8	30	12	0.57	0.021	0.724	0.028
	1.5	1.6	9.3	0.58	404																			

CEC/Alcoholic Cations @ pH 8.5 [Methods 15I3,15C1 – Rayment and Higginson (1992)]

Site #	Upper Depth (m)	Lower Depth (m)	pH (1:5)	Org. C (%)	Tot. N (%)	C/N Ratio	Extr. P (mg/kg)		Acid Extr. K (meq/100g)	DTPA Extr. Micronutrientients (mg/kg)				Phos. Extr. S (mg/kg)	Water Sol. NO3–N (mg/kg)
							Acid P	Bicarb. P		Fe	Mn	Cu	Zn		
9020	0	0.10	6.6	0.60	0.03	20	–	4	0.35	19	17	0.46	0.21	–	2

Air dry data @ 40 C

Appendix 3 – Profile morphology, landscape characteristics, vegetation & analytical data (continued)

Representative Profile: 9048

Soil Name: **Warwick (Ww)**

Location: 665710 mE 7474710 mN ZONE 55
Described By: Burgess, J **Date:** 20–Apr–1994

Landscape:

Geology: TQa – unconsolidated sediments (sedimentary origins) **Substrate Lithology:** unconsolidated material (relict)
Landform Pattern: plain **Element:** plain
Runoff: slow **Permeability:** very slowly permeable
Microrelief: normal gilgai – VI 0.3 m, HI 8 m **Microrelief Component:** mound
Drainage: moderately well drained **Slope:** 0.5 %
Surface Coarse Fragments: very few < 2%, medium pebbles 6–20mm, quartz and silcrete
Surface Condition: hard setting, firm, periodic cracking

Classifications:

ASC: Episodic–endoacidic, Epipedal, Brown, VERTOSOL, Non Gravelly, Fine, Medium Fine, Very Deep
GSG: Brown clay **PPF:** Ug5.34

Vegetation:

Tallest Stratum: Mid-high closed forest (6.01–12m)
Acacia harpophylla (brigalow)

Mid Stratum: Tall sparse shrubland (1.01–3m)
Carissa ovata (currant bush, baroom bush); *Terminalia oblongata* (yellowwood)

Lower Stratum: Mid-high sparse tussock grassland (0.26–0.5m)
Cenchrus ciliaris (buffel grass); *Enteropogon acicularis* (curly windmill grass); *Paspalidium caespitosum* (brigalow grass); *Bothriochloa bladhii* (forest bluegrass)

Veg. Association: Brigalow (VA1) – uncleared

Profile Morphology:

Horizon	Depth (m)	Description
A11	0.00 to 0.03	Very dark greyish brown (10YR32) moist colour; fine sandy light medium clay; very few < 2% medium pebbles 6–20mm subrounded quartz and silcrete coarse fragments; weak 10–20mm platy parting to moderate 2–5mm angular blocky structure; dry strong; dry when sampled; clear to;
A12	0.03 to 0.20	Dark brown (10YR33) moist colour; medium heavy clay; strong 10–20mm angular blocky parting to moderate 2–5mm angular blocky structure; moderately moist strong; moderately moist when sampled; gradual to;
B21	0.20 to 0.70	Brown (10YR43) moist colour; medium heavy clay; moderate 10–20mm lenticular structure; moderately moist very strong; moderately moist when sampled; diffuse to;
B22	0.70 to 1.60	Brown (10YR43) moist colour; few 2–10% fine < 5mm faint grey, very few < 2% fine < 5mm faint red mottles; medium heavy clay; moderate 20–50mm lenticular structure; moderately moist rigid; moderately moist when sampled.

Effective Rooting Depth (ERD): 0.2 m (Cl >1000 ppm, ESP >20%)

Plant Available Water Capacity (PAWC): 35 mm

Analytical Data:

Horizon	Upper Depth (m)	Lower Depth (m)	1:5 Soil/Water			Cation Exchange Capacity/Exchangeable Cations # (meq/100g)					Exchange Acidity (meq/100g)		Cation Dominance		Dispersion	Particle Size (%)				Moisture (%)	Clay Mineralogy	Total Elements (%)		
			pH	EC (dS/m)	Cl (mg/kg)	CEC/ECEC	Ca	Mg	Na	K	Al	H	ESP (%)	Ca/Mg Ratio	R1 Ratio	Coarse Sand	Fine Sand	Silt	Clay	15 Bar	CEC/Clay % Ratio	P	K	S
			@ 40 C			@ 105 C					@ 105 C					@ 105 C				@ 105 C		@ 65 C		
A11	0	0.03	6.6	0.07	21	17	7.9	6.2	0.56	0.49			3.3	1.27	0.55	16	45	12	30	10	0.57	0.038	0.305	0.046
A12	0.03	0.1	7.5	0.20	142	28	11	14	3.0	0.35			10.7	0.79	0.82	11	33	10	45	17	0.62	0.028	0.349	0.047
	0.1	0.2	8.7	0.67	621																			
B21	0.2	0.3	8.8	0.92	1106	31	9.1	16	6.2	0.31			20.0	0.57	0.91	9	30	12	50	19	0.62	0.024	0.354	0.044
	0.3	0.4	8.5	0.93	1251																			
	0.4	0.5	8	0.92	1310																			
	0.5	0.6	6.6	0.88	1256	33	6.9	16	7.3	0.35			22.1	0.43	0.99	5	28	12	54	21	0.61	0.021	0.378	0.031
	0.6	0.7	5.7	0.87	1280																			
B22	0.7	0.8	5.4	0.88	1305																			
	0.8	0.9	5.3	0.91	1359	34	5.8	15	8.3	0.31			24.4	0.39	0.99	5	27	13	56	22	0.61	0.021	0.404	0.025
	0.9	1	5.2	0.88	1325																			
	1	1.1	5.1	0.92	1374																			
	1.1	1.2	5.1	0.92	1376	33	5.4	15	8.9	0.34			27.0	0.36	–	4	26	14	56	–	0.59	0.021	0.404	0.024
	1.2	1.3	5	0.93	1376																			
	1.3	1.4	5	0.93	1361																			
	1.4	1.5	5	0.95	1381																			
	1.5	1.6	5	0.94	1374																			

CEC/Alcoholic Cations @ pH 8.5 [Methods 15I3,15C1 – Rayment and Higginson (1992)]

Site #	Upper Depth (m)	Lower Depth (m)	pH (1:5)	Org. C (%)	Tot. N (%)	C/N Ratio	Extr. P (mg/kg)		Acid Extr. K (meq/100g)	DTPA Extr. Micronutrientients (mg/kg)				Phos. Extr. S (mg/kg)	Water Sol. NO3–N (mg/kg)
							Acid P	Bicarb. P		Fe	Mn	Cu	Zn		
9048	0	0.10	7.5	0.84	0.06	14	–	3	0.62	21	16	0.66	0.21	19	13

Air dry data @ 40 C

Appendix 3 – Profile morphology, landscape characteristics, vegetation & analytical data (continued)

Representative Profile: 9049

Soil Name: **Warwick (Ww)**

Location: 665710 mE 7474710 mN ZONE 55

Described By: Burgess, J **Date:** 20–Apr–1994

Landscape:

Geology: TQa – unconsolidated sediments (sedimentary origins) **Substrate Lithology:** unconsolidated material (relict)

Landform Pattern: plain **Element:** plain

Runoff: very slow **Permeability:** very slowly permeable

Microrelief: normal gilgai – VI 0.3 m, HI 8 m **Microrelief Component:** depression

Drainage: moderately well drained **Slope:** 0.5 %

Surface Coarse Fragments: no coarse fragments

Surface Condition: firm, self-mulching, surface flake, periodic cracking

Classifications:

ASC: Endoacidic, Epipedal, Grey, VERTOSOL, Non Gravelly, Fine, Fine, Very Deep

GSG: Grey clay **PPF:** Ug5.25

Vegetation:

Tallest Stratum: Mid-high closed forest (6.01–12m)
Acacia harpophylla (brigalow)

Mid Stratum: Tall sparse shrubland (1.01–3m)
Carissa ovata (currant bush, baroom bush); *Terminalia oblongata* (yellowwood)

Lower Stratum: Mid-high sparse tussock grassland (0.26–0.5m)
Cyperus species

Veg. Association: Brigalow (VA1) – uncleared

Profile Morphology:

Horizon	Depth (m)	Description
A1	0.00 to 0.03	Very dark greyish brown (10YR32) moist colour; fine sandy medium clay; moderate <2mm granular structure; dry firm; dry when sampled; clear to;
B21	0.03 to 0.40	Dark greyish brown (10YR42) moist colour; medium heavy clay; moderate 10–20mm lenticular structure; moderately moist very firm; moderately moist when sampled; gradual to;
B22	0.40 to 0.80	Brown (10YR43) moist colour; sandy medium heavy clay; weak 20–50mm lenticular structure; very few < 2% fine <2mm manganiferous veins; moderately moist strong; moderately moist when sampled; diffuse to;
B23	0.80 to 1.60	Dark yellowish brown (10YR44) moist colour; sandy medium heavy clay; moderate 20–50mm lenticular structure; dry very strong; dry when sampled.

Effective Rooting Depth (ERD): 0.7 m (profile salinity in equilibrium)

Plant Available Water Capacity (PAWC): 90 mm

Analytical Data:

Horizon	Upper Depth (m)	Lower Depth (m)	1:5 Soil/Water			Cation Exchange Capacity/Exchangeable Cations # (meq/100g)					Exchange Acidity (meq/100g)		Cation Dominance		Dispersion	Particle Size (%)				Moisture (%)	Clay Mineralogy	Total Elements (%)		
			pH	EC (dS/m)	Cl (mg/kg)	CEC/ECEC	Ca	Mg	Na	K	Al	H	ESP (%)	Ca/Mg Ratio	R1 Ratio	Coarse Sand	Fine Sand	Silt	Clay	15 Bar	CEC/Clay% Ratio	P	K	S
			@ 40 C			@ 105 C					@ 105 C					@ 105 C				@ 105 C		@ 65 C		
A1	0	0.03	6.6	0.07	11	20	10	9.0	0.24	0.85			1.2	1.11	0.61	13	32	13	42	13	0.48	0.034	0.365	0.044
B21	0.03	0.1	6.4	0.07	8	22	10	10	1.0	0.55			4.5	1.00	0.74	12	31	12	45	16	0.49	0.029	0.323	0.039
	0.1	0.2	6.8	0.14	70																			
	0.2	0.3	6.7	0.32	334	23	8.9	11	2.3	0.38			10.0	0.81	0.89	14	33	10	44	15	0.52	0.023	0.328	0.037
	0.3	0.4	6.4	0.51	623																			
B22	0.4	0.5	6.2	0.48	622																			
	0.5	0.6	6.2	0.47	660	21	6.1	11	4.0	0.32			19.0	0.55	0.99	15	33	7	43	16	0.49	0.022	0.322	0.031
	0.6	0.7	5.9	0.46	677																			
	0.7	0.8	5.6	0.52	805																			
B23	0.8	0.9	5.6	0.52	787	19	4.9	10	3.1	0.30	0.31	0.31	16.3	0.49	0.99	16	35	7	41	15	0.46	0.020	0.332	0.025
	0.9	1	5.5	0.55	810																			
	1	1.1	5.4	0.55	805																			
	1.1	1.2	5.5	0.56	810	16	4.0	8.6	2.8	0.28	0.41	0.51	17.5	0.47	–	17	36	7	40	–	0.40	0.019	0.323	0.026
	1.2	1.3	5.2	0.59	810																			
	1.3	1.4	5.1	0.61	810																			
	1.4	1.5	5.1	0.61	796																			
	1.5	1.6	5.2	0.57	694																			

ECEC/Aqueous Cations @ pH 7 [Methods 15J1,15A1 – Rayment and Higginson (1992)]

Site #	Upper Depth (m)	Lower Depth (m)	pH (1:5)	Org. C (%)	Tot. N (%)	C/N Ratio	Extr. P (mg/kg)		Acid Extr. K (meq/100g)	DTPA Extr. Micronutrientients (mg/kg)				Phos. Extr. S (mg/kg)	Water Sol. NO3–N (mg/kg)
							Acid P	Bicarb. P		Fe	Mn	Cu	Zn		
9049	0	0.10	6.1	1.5	0.10	15	–	19	0.47	114	45	1.5	0.69	12	15

Air dry data @ 40 C