PART C

Environmental assessment

6 Geochemistry

6.1 Assessment objectives

The DGRs for the Cobbora Coal Project that relate specifically to mine wastes are:

Waste – including:

- accurate estimates of the quantity and nature of the potential waste streams of the project, including tailings and coarse reject; and
- a detailed description of the measures that would be implemented to minimise the production of waste on site, and ensure that any waste produced is appropriately handled and disposed of.

The DGRs do not specifically refer to the need to consider acid and metalliferous drainage (AMD). However, they do require:

- a description of the existing environment, using sufficient baseline data;
- an assessment of the potential impacts of the project, including any cumulative impacts, taking into consideration any relevant guidelines, policies, plans and statutory provisions; and
- a description of the measures that would be implemented to avoid, minimise and if necessary, offset the potential impacts of the project, including detailed contingency plans for managing any significant risks to the environment.

They also require:

- detailed modelling of the potential surface and groundwater impacts of the project;
- a detailed assessment of potential impacts on:
    - the quality and quantity of existing surface and ground water resources; and
- a detailed description of the proposed water management system and water monitoring program for the project and other measures to mitigate surface and groundwater impacts.

Such assessments necessarily include consideration of AMD.

6.2 Assessment method

The acid mine drainage (AMD) assessment for the Project has been prepared by Geoterra Pty Ltd (Geoterra) (Appendix C 'Acid and metalliferous drainage assessment') and the results are summarised in this chapter.

All laboratory testwork and data analysis was conducted according to procedures outlined in the Australian Coal Association Research Project C15034 (Environmental Geochemistry International et al. 2008), as well as AMIRA (2002) and Price (2009). Descriptions of the various tests and analytical procedures are contained in Appendix C ('Acid and metalliferous drainage assessment'). Leachate water quality was assessed by reference to ANZECC/ARMCANZ (2000a).

Numerous drill logs across the mining areas were reviewed as part of the assessment with a subsequent detailed inspection of drill core from four bores (DDH47, 49, 51 and 97) that represent in-pit (DDH47 and DDH 49), along strike (DDH51) and down dip (DDH97) locations. Since the coal had been removed for metallurgical testing from the DDH drill core, a split of coal samples was obtained from two open hole hammer-drilled bores (FEH001, located within Mining Area A, and FEH002, located down dip of Mining Area B) that were drilled for further metallurgical testwork.

A total of 59 discrete lithological core intervals were obtained from the four DDH bores. These represented the waste rock stratigraphy in the proposed pits. They were subjected to geochemical analysis after being crushed and split into <75 micro meters (µm) and <4 mm size fractions. Nine composite coal seam samples from the FEH bores were similarly crushed and split into <75 µm and <4 mm size fractions before laboratory analysis, as were two additional samples from the initial washability testing (ie spiral reject and 0.063 mm raw coal). The geochemical testing program analysed for:

- total sulfur (S) by the Leco method (for all waste rock, coal seam, seam roof, seam floor and CHPP waste samples);
- $pH_{1:2}$ and electrical conductivity ($EC_{1:2}$) (on crushed 4 mm waste rock and CHPP reject samples using deionised water extracts at a ratio of 1 part solids to 2 parts water);
- pH, total dissolved solids (TDS), sulfate and selected metals (on crushed 4 mm waste rock and CHPP reject deionised water leachates);
- acid neutralising capacity (ANC), net acid production potential (NAPP) and standard single addition net acid generation (NAG) tests (on selected waste rock samples containing at least 0.05% total sulfur); and
- total organic carbon (TOC), extended boil NAG tests, calculated NAG tests and chromium reducible sulfur (to differentiate acid-forming from non acid-forming sulfur species) (on samples that had a high organic carbon content or required further assessment).

6.3 Existing environment

i Waste rock

Geochemical characterisation of the waste rock at each bore location showed the following (ranges of values reflect the results from different bores):

- 57 to 66% of the material are 'non acid-forming' (NAF);
- 7 to 25% are 'uncertain to non acid-forming' (UC NAF);
- 6 to 17% are 'uncertain to potentially acid-forming' (UC PAF);
- 0 to 11% are 'potentially acid-forming low capacity' (PAF-LC); and
- 0 to 9% are 'potentially acid-forming' (PAF).

In total, about 70% of waste rock samples were classified as NAF or UC NAF, with 30% classified as PAF, PAF-LC or UC PAF. Samples classified as PAF or UC PAF were predominantly associated with coal and, to a lesser degree, carbonaceous lithologies, and were located immediately next to coal seam roof and floor horizons. The PAF waste rock samples have potentially low overall acid production capacity, with less than 13 kg Sulfuric acid (H_2SO_4/t) (based on total S) and less than 7.5 kg H_2SO_4/t when only pyritic sulfur is used in the assessment. Only one non-coal/carbonaceous sample (DDH97 54.57 to 54.69 mbgl – conglomerate) was indicated as being PAF.

The distributions of PAF, PAF-LC and UC PAF in waste rock layers (strata) from bores DDH47, DDH49, DDH51 and DDH97 are shown in Figure 6.1. Samples were selected to provide an indication of any waste rock lithologies (ie types of rocks based on their visible physical characteristics) of potential geochemical concern. They were also selected to provide an indication of the volume of waste rock with AMD charactistics.

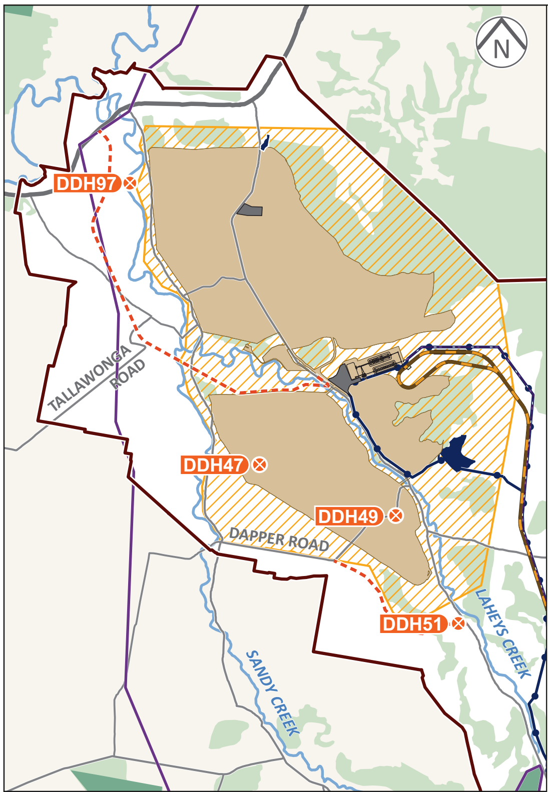
The volume of material above the coal seams in the deposit that will be as PAF, PAF-LC or UC PAF has been estimated based on the geochemical testwork presented in Appendix C. The estimate applied the distribution of AMD characteristics shown in Figure 6.1 to the lithologies in the deposit which are based on 500 exploration boreholes. The total amount of PAF, PAF-LC or UC PAF material based on the AMD results for each waste rock lithology are provided in Table 6.1.

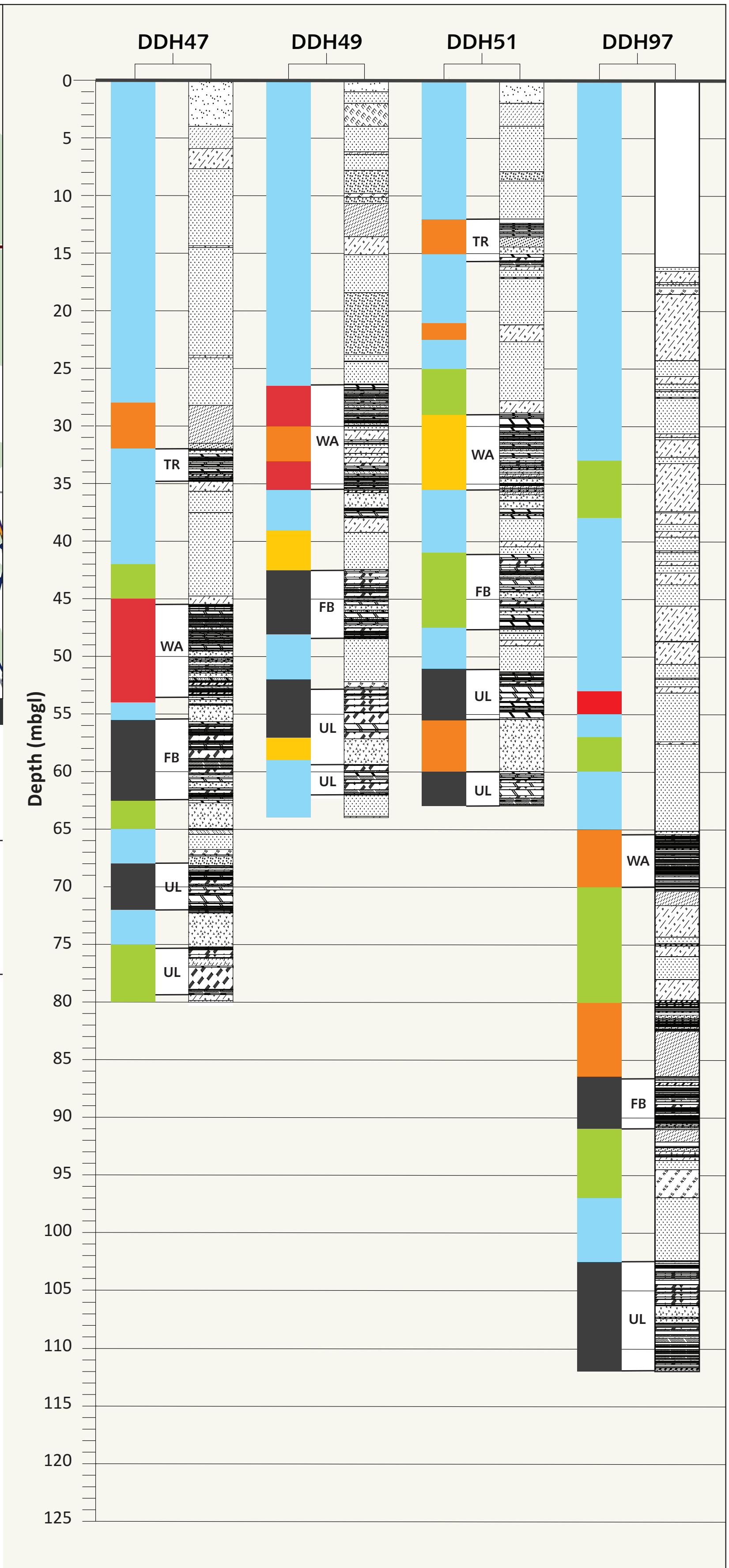
Table 6.1 Waste rock AMD classification

Strata	Waste rock[1] (Mbcm)	Waste rock with PAF, PAF-LC or UC PAF classification (Mbcm)	Waste rock with PAF, PAF-LC or UC PAF classification (%)
Waste rock above Trinkey seam	803	28	3.5
Waste rock above Whaka seam	163	90	55.2
Waste rock above Flyblower seam	88	43	48.8
Waste rock above Ulan seam	251	16	6.4
Total	**1,305**	**177**	**13.5**

Notes: 1.based on deposit, rather than waste rock to be removed.

Although 30% of the waste rock samples were classified as PAF, PAF-LC or UC PAF, the actual volume of waste rock in one of these categories is estimated to be less than 13.5% of the total volume of waste material. This includes uneconomic coal from the Whaka and Trinkey seams. Most of the PAF material is associated with the unweathered, uneconomic Whaka coal seam, which has the highest sulfur level of 0.43% total S. Coal from the economic Flyblowers and Ulan coal seams, and their associated carbonaceous lithologies with the higher total sulfur content, will be either exported off-site as product coal or placed in the rejects emplacements after processing. The remainder of the weathered, uneconomic coal and carbonaceous units from the Whaka and Trinkey seams and the associated waste rock have a median total sulfur concentration of 0.04%. These units have a low overall risk of AMD generation and will be placed on the waste rock emplacements. Mixing of waste rock will further limit any isolated AMD that may be generated and further reduce the potential for dissolved metals or elevated salinity in surface runoff and seepage.





KEY

Seam plys

TR	Trinkey
WA	Whaka
FB	Flyblower
UL	Ulan

AMD

- NAF
- UC NAF
- UC PAF
- PAF - LC
- PAF
- Coal Seam

Lithography

- Agglomerate
- Acid Intrusive
- Alluvium
- Acid Volcanic
- Coal Bright with Dull Bands
- Coal Interbedded Dull and Bright
- Volcanic Breccia
- Basic Intrusive
- Coal Bright
- Basalt
- Basic Volcanic
- Calcite
- Carbonate
- Coal Cindered
- Cannel Coal
- Coal Fusainous
- Conglomerate
- Chert
- Clay
- Coal Stony
- Coal
- Claystone
- Coal Undifferentiated
- Coal Weathered
- Coal Sooty
- Coal Dull with Bright Bands
- Coal Dull
- Diamictite
- Coal Dull Silky
- Coal Dull Lustrous
- Coal Dull with Minor Bright
- Coal Dull Tending to Stony
- Fault Breccia
- Granite
- Gravel
- Coal Heat Affected
- Igneous Rock
- Ironstone
- Core Loss
- Mud
- Mudstone
- Not Cored
- Not Logged
- No Recovery
- Phyllite
- Possible Tuff
- Quartz
- Sand
- Schist
- Siderite
- Silcrete
- Silt
- Shale
- Siltstone
- Soil
- Sandrock
- Sandstone
- Tuff
- Volcanic Undifferentiated
- Carb. Claystone
- Carb. Mudstone
- Carb. Siltstone
- Claystone Coaly
- Mudstone Coaly
- Siltstone Coaly

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Acid Generation Potential

Cobbora Coal Project - Acid and metaliferous drainage assessment

Figure 6.1

It is expected that further analysis of PAF LC and UC PAF samples, should result in more of these samples being classified as NAF or UC-NAF. It is likely that the actual volume of PAF, PAF-LC or UC PAF waste rock will be close to 9% of the total volume of waste material (pers comm Andrew Dawkins). This test work will be undertaken in late 2012.

Based on the cation exchange capacity (CEC), the waste rock samples that were tested had a low capacity to adsorb nutrients, major ions or metallic cations. The waste rock is unlikely to be sodic and may be suitable for revegetation and rehabilitation activities in final landform surfaces or as a growth medium (albeit with potentially low levels of exchangeable Ca and K that may reduce their usefulness). The waste rock emplacements are therefore likely to be pH neutral to slightly alkaline, with low to moderate EC/salinity and low CEC values.

ii CHPP waste

About 64% of CHPP waste samples were classified as NAF or UC NAF and 36% were classified as PAF, PAF-LC or UC(PAF). These results reflect the low total S concentrations and very low chromium reducible sulfur (ie pyrite) concentrations, with most of the sulfur present as low risk organic and non-acid sulfate forms. The PAF material had a low overall acid production capacity, being less than 14 kg H_2SO_4/t when the calculations are based on total S and less than 0.8 kg H_2SO_4/t when only pyritic sulfur is used in the assessment. These materials are unlikely to result in AMD due to operational mixing with surrounding NAF CHPP waste, even though the ANC in this material is not high.

The CEC in the CHPP waste stream samples was low and indicative of material that has a low capacity to adsorb cations. The CHPP waste would therefore have only a low adsorptive capacity with respect to metallic cations contained in any leachate that may be produced.

6.4 Environmental management

The waste rock and pit floor materials are expected to be generally NAF and should not require special management for AMD control. Although some PAF pyritic material is present, most of this is associated with the unweathered and uneconomic Whaka coal seam, and this source is expected to have limited AMD potential.

Similarly, CHPP waste material is expected to be NAF and should not require special handling for AMD control. Minor sulfuric acid drainage from oxidation of pyritic material may occur. However, such occurrences are likely to be isolated and mixing of the material, as will occur during normal operations, is expected to limit any AMD that may be generated.

The ROM and product coal stockpiles are also not expected to generate AMD, and provision for capture of runoff/leachate, monitoring and lime treatment is not necessary or proposed.

A waste management plan will be prepared to detail measures to minimise the likelihood of AMD occurring, to detail the AMD monitoring program and to describe how PAF material that may cause AMD will be managed. These measures will include:

- controlling isolated AMD through the mixing of mined waste material that will occur as part of normal operations. This is expected to be effective even though the NAF waste has little excess alkalinity; and
- should the presence of unblended PAF materials become apparent, blending such material as required and appropriately managing on site.

If the findings from AMD monitoring (see Section 6.6) are inconsistent with the findings of the AMD assessment (Appendix C), particularly for the Whaka coal seam, management measures for PAF material could include limestone treatment, placing PAF material in mined-out areas below the water table, or construction of a NAF cover zone. The waste management plan will be amended accordingly if this occurs.

6.5 Impacts

Consistent with the generally NAF nature of the waste rock, the pH of waste rock emplacement leachate is expected to be close to neutral (testwork median pH = 6.26). Similarly, the leachate is expected to have low salinity (testwork median = 238 µS/cm).

Given the near neutral pH of leachate, dissolved metal concentrations are expected to be low due to the generally low solubility of metals at these pHs. Occasional aluminium, copper, lead, nickel and zinc (Al, Cu, Pb, Ni and Zn concentrations generated during the testwork program (as well as some pH and TDS values) were outside assessment criteria. However, the testwork was conservative, in that pulverised samples were used where the surface area in contact with water is much greater than typically occurs in waste rock emplacements. Additional dilution from rainfall and natural attenuation is likely to occur in the field. This means that dissolved metal concentrations in bulk runoff or seepage from the waste rock emplacements are unlikely to present significant environmental issues, as determined by comparison with relevant water quality guidelines contained in ANZECC/ARMCANZ (2000a).

The CHPP rejects leachate pH is also expected to be close to neutral (testwork median pH = 6.39) and have low salinity (testwork median = 206 µS/cm). Occasional Ni and Zn concentrations (and pH values) exceeded assessment criteria. Dissolved metal concentrations in bulk runoff or seepage from the CHPP reject material are therefore unlikely to present significant environmental issues, as determined by comparison with ANZECC/ARMCANZ (2000a).

Overall, the waste rock and pit floor materials are likely to be NAF and should not require special handling for AMD control. The CHPP wastes are similarly likely to be NAF and are not expected to need special handling for AMD control. AMD is therefore not anticipated to be an issue of concern at the Project site.

6.6 Monitoring

A program of routine sampling and testing of waste rock and CHPP waste materials will be developed in consultation with DITIRIS and implemented during active placement to monitor variation in acid generating potential as the mine is developed.

Monitoring of ambient water quality upstream and downstream of the mine site, as well as various water storages that are part of the mine's water management system, will be undertaken (see Section 8.6 'Surface Water Monitoring'). In particular, seepage and surface water runoff from pit walls and floors, waste rock emplacements, ROM stockpiles and CHPP waste disposal areas will be monitored for parameters indicative of AMD: pH, electrical conductivity (EC), TSS, acidity/alkalinity, sulfate and selected dissolved metals (Al, As, Co, Cu, Fe, Mn, Ni and Zn).