10. Waste

This section describes the waste generated and the potential impacts identified, in regards to the Project (Mine) during construction and operation. The assessment was undertaken in accordance with the requirements of the Terms of Reference (ToR) and a table cross-referencing these requirements is provided in Volume 4 Appendix C ToR Cross Reference Table. A detailed acid mine drainage report is included in Volume 4 Appendix V Mine Acid Mine Drainage Report.

10.1 General Waste Management

The Queensland *Environmental Protection Act 1994* (EP Act) defines "waste" as anything that is:

- left over or unwanted by-product from an industrial, commercial, domestic or other activity; or
- surplus to the industrial, commercial, domestic or other activity generating wastes.

Waste will be generated during the construction, operation and decommissioning phases of the Project (Mine). These phases are described in detail in Volume 2 Section 2 Project Description. Waste material outputs may be in solid, liquid or gaseous form and are described in terms of their physical and chemical characteristics, variability of composition and generation rates within their waste stream.

The waste management hierarchy for the Project (Mine) follows a framework for prioritising waste management practices to achieve the best environmental outcomes possible, following a strategy of waste avoidance, re-use, recycling, energy recovery, treatment and disposal.

10.1.1 Methodology

The methodology employed to identify likely wastes generated through the Project (Mine) and the most appropriate waste management approach included:

- A review of the National, State and local regulatory framework relating to waste classification and management
- Identification of the waste streams relevant to the project components during the construction, operation and decommissioning of the Project (Mine)
- An assessment of the physical and chemical characteristics of the waste and any associated risk to relevant environmental and community values
- Calculation of the approximate quantity of waste likely to be generated during each phase of the Project (Mine)
- Assessment of the potential impacts of waste from the Project (Mine) and the mitigation of those impacts during each phase of the Project (Mine)
- Consideration of the application of Waste Management Hierarchy for the Project (Mine) covering each waste stream during each phase
- Inclusion of waste management requirements in the Environmental Management Plan (EM Plan)

10.1.2 Legislation Framework

10.1.2.1 Commonwealth Legislation and Policy Requirements

The Project (Mine) will operate within the Commonwealth legislative framework, however, much of the Commonwealth legislation does not have a direct impact on day to day operations of the mine. However Australia's *National Waste Policy* and the *National Pollutant Inventory* are Commonwealth lead and administered initiatives which have relevance to the management of the Project's (Mine) waste.

National Waste Policy

Australia's *National Waste Policy: Less Waste, More Resources* (2009), seeks to reduce the impact to the environment from waste disposal. It also seeks to enhance, build on or complement existing policy and actions at all levels of government. This policy sets the direction for Australia over a 10 year period to produce less waste for disposal and manage waste as a resource to deliver economic, environmental and social benefits. The policy establishes a program for national co-ordinated action on waste across six key areas:

1. Provide a coherent, comprehensive national framework for waste management, resource recovery and the avoidance of waste over the next decade.
2. Enable Australia to meet its international obligations in regards to the management of hazardous wastes and substances and persistent organic pollutants into the future and reduce the risk and legacy for future generations.
3. Address market impediments and streamline the regulatory frameworks so that national companies and small businesses can operate effectively and efficiently and manage products and materials responsibly during and at end of life.
4. Provide national leadership on waste and resource recovery where it is needed and facilitate collaboration between the states on national issues.
5. Contribute to climate change, sustainability, innovation and employment opportunities.
6. Be high impact and cost effective by setting clear national directions and through collaborative, carefully targeted action that incrementally builds on the existing efforts of governments over a ten year period.

The overall objectives of implementing the *National Waste Policy* are that all wastes, including hazardous wastes, are managed consistent with Australia's international obligations, and for the protection of human health and the environment. The policy also seeks to ensure that the risks associated with waste are understood and managed in the future to minimise intergenerational legacy issues.

National Pollutant Inventory

The *National Pollution Inventory* (NPI), established as a National Environmental Protection Measure (NEPC, 2008) and administered by the Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) is Australia's national database of pollutants emitted into the environment. Facilities are required to estimate and report annually their emissions of certain substances to air, land and water. Currently there are 93 NPI substances in the program. These substances are classified by category, with each category having different thresholds. Annual reporting of relevant Project (Mine) waste emissions above the respective thresholds to land, air and water will be conducted in accordance with the NPI requirements. The NPI Guide (DSEWPaC, 2012)

provides guidance and trigger levels for reporting on emissions and contains Emission Estimation Techniques for specific activities. Emissions throughout the life of the Project (Mine) will be reported to DSEWPaC and be made publicly available on the NPI database (www.npi.gov.au) in accordance with the most current version of the NPI Guide.

Reporting requirements under the *National Greenhouse and Energy Reporting Act 2007* are discussed in Volume 2 Section 8 Greenhouse Gas Assessment.

10.1.2.2 State Requirements

The legislative and regulatory requirements governing waste management in Queensland are principally provided within the following documents:

- *Environmental Protection Act 1994*
- *Environmental Protection Regulation 2008*
- *Environmental Protection (Waste Management) Regulation 2000*
- *Waste Reduction and Recycling Act 2011*
- *Waste Reduction and Recycling Regulation 2011*
- *Queensland's Waste Reduction and Recycling Strategy 2010–2020* (DERM, 2010)
- *Guideline ERA 60 Waste Disposal: Landfill Siting, Design, Operation and Rehabilitation* (DEHP, 2012).

Environmental Protection Act 1994

The *Environmental Protection Act 1994* (EP Act) is the primary legislation that controls the management of waste in Queensland. The EP Act deals primarily with protecting the environment and managing the pollution impacts of activities, including managing the impacts of waste after it has been generated. The aim of the EP Act is to protect Queensland's environment following the principle of ecologically sustainable development that is, allowing for development that improves the total quality of life in a way that maintains the ecological processes on which life depends.

Section 319 of the EP Act establishes a duty for a person to take all reasonable and practicable measures for protecting the environment from harm when carrying out an activity that causes, or is likely to cause, environmental harm. The general environmental duty places a clear onus on operators of industrial sites to develop and implement measures for preventing environmental harm.

Section 147 of the EP Act defines a Mining Activity as an activity under the *Mineral Resources Act 1989* (MR Act) that is authorised to take place on land to which a mining tenement relates or land authorised under the MR Act for access to that land.

Environmental Protection Regulation 2008

The objective of the *Environmental Protection Regulation 2008* (EP Regulation) is to provide the basis for effective and efficient administration and enforcement of the EP Act. A number of Environmental Relevant Activities (ERAs) will be conducted on the Project, which would otherwise be as per Schedule 2 of the EP Regulation.

- ERA 8 – Chemical Storage
- ERA 15 – Fuel Burning
- ERA 16 – Extractive and Screening Activities

- ERA 17 – Abrasive Blasting
- ERA 18 – Boiler making or engineering
- ERA 21 – Motor Vehicle Workshop Operation
- ERA 31 – Mineral Processing
- ERA 38 – Surface Coating
- ERA 43 – Concrete Batching
- ERA 50 – Bulk Material Handling
- ERA 56 – Regulated Waste Storage
- ERA 63 – Sewage Treatment
- ERA 65 – Water Treatment
- ERA 60 – Waste disposal

Environmental Protection (Waste Management) Regulation 2000

The *Environmental Protection (Waste Management) Regulation 2000* (EPR Waste Management) Regulation) aims to protect the environmental objectives and to minimise the impact of waste on the environment and establish an integrated framework for minimising and managing waste under the principles of ecologically sustainable development.

The regulation includes management requirements for specific waste, regulated waste tracking and local government administration of waste management activities within their local government area. The regulation identifies certain waste management activities as ERA's. These include landfills, regulated waste storage and treatment and transfer stations. The regulation supports the EIS process.

Waste Reduction and Recycling Act 2011 (WRR Act)

The primary objective of the *Waste Reduction and Recycling Act 2011* (WRR Act) is to create new legislation in respect to waste management and resource recovery in Queensland. The WRR Act encourages the proper use of resources by improving ways of reducing and dealing with waste, to repeal the *Environmental Protection (Waste Management) Policy 2000* and to amend the EP Act, and EPR (Waste Management).

At the core of the WRR Act is the waste and resource management hierarchy. The waste and resource management hierarchy is the following precepts, listed in the preferred order in which waste and resource management options should be considered:

- AVOID unnecessary resource consumption;
- REDUCE waste generation and disposal;
- RE-USE waste resources without further manufacturing;
- RECYCLE waste resources to make the same or different products;
- RECOVER waste resources, including the recovery of energy;
- TREAT waste before disposal, including reducing the hazardous nature of waste;
- DISPOSE of waste only if there is no viable alternative.

The waste management hierarchy will underpin been considered in the development of the Project (Mine) waste management strategy.

Key requirements of the WRR Act relevant to the Project (Mine) are:

- A requirement to prepare waste management plans;
- Product stewardship arrangements for any waste products that are identified as a growing problem for landfill in the future; and
- Strengthened litter and illegal dumping offences, including public reporting of vehicle related littering offences.

Waste Reduction and Recycling Regulation 2011

The Waste Reduction and Recycling Regulation 2011 sits under the *Waste Reduction and Recycling Act 2011* and provides much of the detail of the new legislative framework. The key provisions of the Regulation include:

- Waste levy rates for different waste streams;
- How to calculate the waste levy;
- Criteria for assessing application for exemption from the waste levy;
- Local government area in the waste levy zone;
- Weight measurement criteria for levyable waste disposal sites without weighbridges;
- Fees for applications under the Waste Reduction and Recycling Act 2011.

It is however important to note that the Industry Waste Levy has been repealed by the Queensland Government effective 30 June 2012.

Queensland Waste Reduction and Recycling Strategy 2010–2020

The Queensland Waste Reduction and Recycling Strategy (WRR Strategy) provides a framework for a sustainable waste management in Queensland. The aims of the strategy are to:

- Reduce waste
- Optimise recovery and recycling
- Develop sustainable waste industries and jobs.

Through adoption of the waste and resource management hierarchy the Project (Mine) waste management strategy will seek to align the Waste Reduction and Recycling Strategy to the extent practicable..

10.1.3 Existing Local Government Operated Services and Facilities

10.1.3.1 Local Government Operated Services and Facilities

The Project (Mine) is located within the Isaac Regional Council (IRC) Local Government Area (LGA). IRC operates Resource Recovery Centres (RCC) at nine sites, including Carmila, Clermont, Dysart, Glenden, Greenhill, Middlemount, Moranbah, Nebo and St Lawrence.

The Moranbah RRC is the largest facility and is the closest to the Project (Mine) site, however it is still greater than 150 km away. The centre can accept commercial waste for a fee, including green waste, concrete materials, e-waste, general solid loose and compacted waste, and asbestos materials.

Waste management facilities provided by other neighbouring local government authorities include:

- Central Highland Regional Council

  18 waste transfer or landfill sites, the closest of which is the Emerald transfer station and landfill which is greater than 250 km from the Project (Mine) site. The facility accepts commercial waste for a fee, including green waste, concrete materials and general solid waste.

- Charters Towers Regional Council

  Four landfills, located in Charters Towers including Stubley Street, Ravenswood, Pentland and Greenvale. The Council manages its own fleet of garbage trucks for collections within the region with the exception of Hervey's Range.

- Mackay Regional Council

  A range of waste disposal facilities including:

  - One active disposal site
  - Nine transfer stations
  - One resource recovery site
  - Four planned transfer stations

  Due to the operation of a landfill gas recovery system, Mackay Regional Council prefers not to accept construction and demolition waste. Mackay Regional Council currently charges for overburden material disposed at the landfill.

- Whitsunday Regional Council

  - Three active landfills
  - Four transfer stations

The distance (minimum 150 km) to these existing local government facilities together with the likely quantum of the waste stream from the Project (Mine) is considered to make regular long term use prohibitive both from a cost and resource efficiency point of view.

10.1.3.2 Private Waste Management Facilities and Services

Private waste companies service mine sites throughout Queensland, providing a range of waste management services to the industry depending on the particular requirements of individual sites.

Contractors who service the central and western Queensland area, and particularly mine sites area for collection and disposal of a broad range of wastes include Transpacific Industries, JJ Richards & Sons Pty Ltd and Veolia. Sterihealth is a Mackay-Based company who will service the Moranbah area for some clinical wastes.

Adani will take responsibility for the waste generated through various stages of the project and has made a conscious decision not to solely rely on private contractors for the provision of waste management services, however these will be utilised as and when required. Further details of the overall waste management strategy for the Project (Mine) are provided in Section 10.1.5.

10.1.4 Waste Generation

This section describes solid and liquid non mine waste sources, types and estimated volumes for the construction, operational and decommissioning phases of the Project (Mine), Gaseous/atmospheric emissions including exhaust and fugitive emissions associated with the Project (Mine) are discussed in Volume 2 Section 7 Air Quality and Volume 2 Section 8 Greenhouse Gas Emissions.

The waste stream identification and characterisation is based on the concept design of the Project (Mine) (Runge 2011) during the construction, operation and decommissioning phases. A full description of these project components and associated processes are outlined in Volume 2 Section 2 Project Description.

A full waste inventory included waste management strategies for individual waste streams is provided in Table 10-1 and Table 10-2 after this introductory section, which includes estimates of waste volumes.

10.1.4.1 Construction Phase

Wastes generated during the construction phase will be from a range of activities typically including vegetation clearing, civil earthworks and construction of mine infrastructure and buildings.

The construction program for the Project (Mine) defines a number of stages and activities which will take approximately nine years (refer to Volume 2 Section 2 Description of the Project), until full target production of 60 Mtpa product coal in 2022. This means that there is some overlap between the construction and operational phase of the project. For the purposes of the waste characterisation, construction phase wastes are limited to those wastes specifically associated with construction activities only, and not the operational activities associated with the mine infrastructure.

Wastes likely to be generated during the construction phase include:

- Green waste generated through site clearing
- Spoil generated through civil earthworks
- Building and construction waste generated through the construction of the workers accommodation village, mine infrastructure (including CHPP) and offsite infrastructure including timber, concrete, metals, and other excess building materials and packaging.
- General domestic waste generated by the construction workforce including kitchen and food scraps, recyclable materials such as paper, cardboard, plastics, glass, aluminium cans and packaging.
- Plant and equipment waste generated by the vehicles, plant and equipment used to undertake earthworks, building and construction activities such as transport, excavations, haulage, grading and material compaction. Typical wastes include tyres, batteries, oil filters and other hydrocarbon contaminated waste (such as spill clean up kits).
- Oily wastes, solvents, lubricants, paints and other hydrocarbon contaminated wastes from maintenance of vehicles, plant and equipment used to undertake earthworks, building and construction activities.
- Sewage and wastewater generated by the construction workforce via package wastewater treatment plants
- Sludge/biosolids from package wastewater treatments plants

- Clinical and related waste associated with onsite treatment of medical injuries.
- Electrical and electronic wastes, including batteries
- Drums and packaging
- Wastewater from concrete washout pits

Table 10-1 provides a summary of waste type and volume and management strategies.

Table 10-1 Construction Wastes

Activity	Waste generated	Approximate Quantity	Management Strategy
Vegetation Clearing	Green waste	Waste accrued from approximately 3,000 ha of clearing trees, shrubs and grasslands for initial mining and MIA Then progressively in line with mine development schedules	**Avoid/Minimise:** Minimise clearing requirements where practicable (eg around infrastructure areas). There will be a staged clearing of vegetation. **Reuse:** Larger vegetation including hollow logs and parts of hollow bearing trees will be reused onsite for fauna habitat. **Recycle:** Other native vegetation will be chipped, mulched and reused during rehabilitation and revegetation. **Dispose:** Weed species will be destroyed and disposed to the onsite landfill or offsite landfill by licenced contractor until the onsite landfill is operational.
Building Construction	Timbers – offcuts, packaging materials.	Currently unknown – to be determined following confirmation of design	**Avoid/Minimise:** Where practicable, avoid over-ordering and delivery of excess materials through thorough procurement process (including producer take back of timber pallets). **Reuse**: Stockpile for reuse on site if suitable. **Recycle:** Stockpile for chipping and mulching if suitable or removal from site by licences contractor for recycling if viable. **Dispose:** If no higher order options are viable (due to material type or lack of available services) disposal to onsite landfill or offsite landfill via licenced contractor until onsite landfill is operational.

Activity	Waste generated	Approximate Quantity	Management Strategy
	Metals including steel	Currently unknown – to be determined following confirmation of design	**Avoid/Minimise:** Where practicable, avoid over-ordering and delivery of excess materials through thorough procurement process. **Reuse**: Stockpile for reuse on site if suitable. **Recycle:** Stockpile for offsite reprocessing, reuse or recycling by licenced contractor. **Dispose:** If no higher order options are viable (due to material type or lack of available services) disposal to onsite landfill or offsite landfill via licenced contractor until onsite landfill is operational.
	Concrete	Currently unknown, likely to be minor quantities only – to be determined following confirmation of design	**Avoid/Minimise:** Where practicable, avoid over-ordering and delivery of excess materials through thorough procurement process. **Reuse**: Stockpile for reuse on site if suitable. Reuse in the form of concrete blocks on site. **Recycle:** Stockpile for onsite or offsite reprocessing, reuse or recycling. **Dispose:** If no higher order options are viable disposal to onsite landfill or offsite landfill by licenced contractor until onsite landfill is operational.
	Residual paints, sealants, solvents, resins	Minor quantities, likely to be less than 1 tonne per annum	**Avoid/Minimise:** Where practicable, avoid over-ordering and delivery of excess materials through thorough procurement process **Reuse:** Where suitable quantities permit, stockpile in a designated area for reuse onsite. **Dispose:** Store liquid wastes in a designated storage area for offsite disposal by a licenced contractor. Solid wastes such as resins and sealants may be disposed of in the onsite landfill or offsite by licenced contractor until onsite landfill is operational.

Activity	Waste generated	Approximate Quantity	Management Strategy
	Plastics – excess packaging	Minor quantities, likely to be less than 1 tonne per annum	**Avoid/Minimise:** Where practicable, avoid over-ordering and delivery of excess materials through thorough procurement process (including producer take back of plastic pallets). **Recycle:** Store in a designated area for recycling by licenced contractor if viable. **Dispose:** If no higher order options are viable (due to material type or lack of available services) disposal to onsite landfill or offsite landfill via licenced contractor until onsite landfill is operational.
	Electrical waste and electronic equipment	Minor quantities, likely to be less than 2 tpa	**Avoid/Minimise:** Where practicable, avoid over-ordering and delivery of excess materials through thorough procurement process. Consider leasing electronic equipment with lessor takeback of redundant/expired equipment **Recycle:** Store in a designated area and establish a recycling/collection service with licenced Waste electrical and electronic equipment (WEEE) contractor. Consider donation of old or unused electronic equipment to community organisations. **Dispose:** If recycling is not viable disposal to offsite landfill by licenced contractor.
Worker Accommodation Village	Putrescible wastes including food scraps, domestic waste	Approximately 260 tpa	**Avoid/Minimise:** Procurement and purchasing procedures will consider likely workforce numbers at any given time to minimise oversupply of these materials, however opportunities to minimise or avoid are likely to be limited. **Recycle:** Adani will consider a trial composting project for kitchen food scraps. **Dispose:** Disposal to onsite landfill or offsite landfill by licenced contractor until onsite landfill is operational.

Activity	Waste generated	Approximate Quantity	Management Strategy
	Recyclables including paper, cardboard, glass, aluminium cans	Approximately 130 tpa	**Avoid/Minimise:** Procurement and purchasing procedures will consider likely workforce requirements to minimise oversupply of these materials, however opportunities to minimise or avoid paper, cardboard, glass, aluminium cans etc. are likely to be limited. **Reuse:** Investigate options for reuse as fillers for composting trials associated with rehabilitation areas. **Recycle:** Store in a designated area for recycling by licenced contractor if viable. **Dispose**: If recycling is not viable, disposal to onsite landfill or offsite landfill by licenced contractor until onsite landfill is operational.
	Batteries – mobile phones, radio etc	Expect minor quantities less than 1 tpa	**Recycle:** Store in a designated area for recycling by licenced contractor. **Dispose:** If no viable recycling options, store in designated area for offsite disposal by licenced contractor.
	Grease trap wastes	Dependent on accommodation numbers, expect minor quantities less than 5 tpa	**Recycle:** Store in a designated area for recycling by licenced contractor if viable. **Dispose**: If recycling is not viable, disposal to offsite landfill by licenced contractor.
	Clinical waste from medical facilities	Expect minor quantities less than 1 tpa	**Dispose:** Store in secure containers in designated area for offsite disposal by licenced contractor.
	Sewage effluent	Approximately 153 ML pa	**Recycle/Dispose:** Package treatment plants will be utilised to treat sewage, with effluent being treated to Class A standard prior to being reused for irrigation or disposal back into the mine water system (subject to modelling of quality and quantity during detail design) for dust suppression..
	Sewage sludge	Dependent on treatment package adopted, expect in the order of 50 tpa	**Treat/Recycle:** Adani will consider trialling the use of sewage sludge/biosolids as a soil conditioner if quantities and characteristics permit. **Dispose:** Sludge produced by sewage treatment will be stockpiled in a designated area prior to disposal to onsite landfill, or offsite landfill by licenced contractor until onsite landfill is operational.

Activity	Waste generated	Approximate Quantity	Management Strategy
Operation and maintenance of plant and machinery	Waste oil and oily/hydrocarbon wastes	Up to approximately 440,000 L pa	**Recycle:** Store in a designated area (bunded and covered) for recycling by licenced contractor if viable. **Energy Recovery:** Adani will consider the installation of a small generator to harness energy from thermal treatment of waste oil if quantities produced prove viable. **Dispose:** If recycling and energy recovery are not viable, waste oil will be stored in a designated area (covered and bunded) for collection and offsite disposal by a licenced contractor.
	Tyres	Approximately 550 pa	**Recycle**: Store in a designated area for recycling by licenced contractor if viable. **Dispose:** Stockpile in designated area prior to onsite disposal in accordance with the *EHP Operational Policy for Disposal and Storage of Scrap Tyres on Mine Sites.*
	Batteries – vehicles, phones, radios and other equipment.	Less than 2 tpa	**Recycle:** Store in a designated area for recycling by licenced contractor. Note that separate storage of wet cell and dry cell batteries will be required.
	Drums – storage of grease, oils and other hydrocarbons or chemicals	Unknown at present	**Reuse:** Where possible, store in a designated area (bunded and covered) for reuse onsite. **Recycle:** Store in a designated area (bunded and covered) for collection by licenced contractor for reuse or recycling. **Dispose:** If no higher order options are viable dispose to onsite landfill or offsite by licenced contractor.
	Electrical waste and electronic equipment	Minor quantities, likely to be less than 2 tpa	**Avoid/Minimise:** Where practicable, avoid over-ordering and delivery of excess materials through thorough procurement process. **Recycle:** Store in a designated area and establish a recycling/collection service with licenced Waste electrical and electronic equipment (WEEE) contractor. Consider donation of old or unused electronic equipment to community organisations. **Dispose:** If recycling is not viable **d**isposal to offsite landfill by licenced contractor.

10.1.4.2 Operational Phase

Operational phase wastes include that generated as a result of mining, accommodation and business activities. Activities associated with the operational phase are detailed in Volume 2 Section 2 Description of the Project. The operational phase of the Project (Mine) will continue until approximately 2102.

The solid waste generated during the operational phase includes:

- Green waste generated through clearing required for general maintenance of the Project (Mine) on the mine lease area and mine infrastructure area
- Plant and equipment waste generated by the vehicles, plant and equipment used to for mining operations and offsite facilities, including tyres, drums, and other regulated wastes.
- Waste oils, fuels, lubricants and hydraulic fluids from maintenance of plant, equipment and vehicles used during Project (Mine) operations.
- Wastes contaminated with explosives residues including detonator boxes, pallets and cardboard packaging
- Waste generated through the ongoing repairs or redevelopment of on mine and offsite infrastructure including roads, levees, buildings etc, such as concrete, timber, scrap metals, packaging materials, electrical, paints etc.
- Putrescible wastes and recyclable materials generated by the operational workforce on the mine lease area and the workers accommodation village.
- Waste generated from activities associated with business and administration typically comprising waste stationery, paper and packaging, cartridges, printers, electronic equipment, batteries and office equipment, possibly including minor quantities of radioactive waste from componentry in processing plants.
- Sewage, wastewater and sludge/biosolids generated by package wastewater treatment plants
- Clinical and related waste associated with onsite medical facilities and first aid treatment

Table 10-2 provides a summary of wastes and estimated volumes along with management strategies.

Table 10-2 Operational Wastes

Activity	Waste generated	Quantity	Management Strategy
Vegetation Clearing	Green waste from site maintenance and clearance for pre-strip	In line with mining plan 1,200 ha in the first year varying with requirements until steady state of approximately 250 ha/year	**Avoid/Minimise:** Minimise clearing requirements where practicable (e.g. around infrastructure areas). **Reuse:** Larger vegetation including hollow logs and parts of hollow bearing trees will be reused onsite for fauna habitat. **Recycle:** Other native vegetation will be chipped and mulched and reused for during rehabilitation and revegetation. **Dispose:** Weed species will be destroyed and disposed of to the onsite landfill.

Activity	Waste generated	Quantity	Management Strategy
Workers Accommodation Village	Putrescible wastes including food scraps, domestic waste	Approximately 1, 300 tpa	**Avoid/Minimise:** Procurement and purchasing procedures will consider likely workforce numbers at any given time to minimise oversupply of these materials, however opportunities to minimise or avoid are likely to be limited. **Recycle:** Adani will consider a trial composting project for kitchen food scraps. **Dispose:** If recycling is not viable, disposal to onsite landfill.
	Recyclables including paper, cardboard, glass, aluminium cans	Approximately 700 tpa	**Avoid/Minimise:** Procurement and purchasing procedures will consider likely workforce requirements to minimise oversupply of these materials, however opportunities to minimise or avoid paper, cardboard, glass, aluminium cans etc. are likely to be limited. **Reuse:** Investigate options for reuse of cardboards as fillers for composting trials associated with rehabilitation areas. **Recycle:** Store in a designated area for recycling by licenced contractor if viable. **Dispose**: If recycling is not viable, disposal to onsite landfill.
	Batteries – mobile phones	Expect minor quantities less than 1 tpa	**Recycle:** Store in a designated area for recycling by licenced contractor.
	Grease trap waste	Dependent on accommodation numbers, expect minor quantities less than 5 tpa	**Recycle:** Store in a designated area for recycling by licenced contractor if viable. **Dispose**: If recycling is not viable, offsite disposal via licenced contractor.
	Clinical waste from medical facilities	Expect minor quantities less than 1 tpa	**Dispose:** Store in secure containers in designated area for offsite disposal by licenced contractor.
	Sewage effluent	Operations – approximately 229 ML pa	**Recycle/Dispose:** Package treatment plants will be utilised to treat sewage, with effluent being treated to Class A+ standard prior to being reused for irrigation or disposal back into the mine water system (subject to modelling of quality and quantity during detail design).

Activity	Waste generated	Quantity	Management Strategy
	Sewage sludge	Dependent on treatment package adopted, expect in the order of 75 tpa	**Recycle/Treat:** Adani will consider trialling the use of sewage sludge/biosolids as a soil conditioner if quantities and characteristics permit.. **Dispose:** If soil conditioner trial is unsuccessful sludge will be stockpiled in a designated area prior to disposal to onsite landfill.
Operation and maintenance of plant and machinery	Waste oil and oily wastes/hydrocarbon wastes	Approximately 440,000 L pa	**Recycle/Treatment:** Store in a designated area (bunded and covered) for recycling by licenced contractor if viable. **Energy Recovery:** Adani will consider the installation of a small generator to harness energy from thermal treatment of waste oil if quantities produced prove viable. **Dispose:** If recycling and energy recovery are not viable, waste oil will be stored in a designated area (bunded and covered) for collection and offsite disposal by a licenced contractor.
	Tyres	Approximately 550 pa	**Recycle**: Store in a designated area for recycling by licenced contractor if viable. **Dispose:** Stockpile in designated area prior to onsite disposal in accordance with the *EHP Operational Policy for Disposal and Storage of Scrap Tyres on Mine Sites.*
	Batteries – vehicles, phones, radios and other equipment	Unknown at present, approximately 30-40 tpa possible	**Recycle:** Store in a designated area for recycling by licenced contractor. Note that separate storage of wet cell and dry cell batteries will be required.
	Drums -storage of grease, oils and other hydrocarbons or chemicals	Unknown at present	**Reuse:** Where possible, store in a designated area (bunded and covered) for reuse onsite. **Recycle:** Store in a designated area (bunded and covered) for collection by licenced contractor for reuse or recycling. **Dispose:** If no higher order options are viable, dispose offsite by licenced contractor.

Activity	Waste generated	Quantity	Management Strategy
	Other regulated wastes	Unknown at present	**Avoid/Minimise:** Where practicable, avoid over-ordering and delivery of excess materials through thorough procurement process. **Recycle:** Store in a designated area (secure, bunded and covered) for collection by licenced contractor for reuse or recycling. **Dispose:** If recycling is not viable, treat and dispose to onsite landfill with relevant authorisation, or offsite by licenced contractor.
	Electrical waste and electronic equipment	Unknown at present, possibly between 1 and 5 tpa	**Avoid/Minimise:** Where practicable, avoid over-ordering and delivery of excess materials through thorough procurement process. Consider leasing electronic equipment with lessor takeback of redundant/expired equipment **Recycle:** Store in a designated area and establish a recycling/collection service with licenced Waste electrical and electronic equipment (WEEE) contractor. Consider donation of old or unused electronic equipment to community organisations.. **Dispose:** If recycling is not viable **d**isposal to offsite landfill by licenced contractor.
	Explosive wastes from packaging and excess or defective explosives	Dependent on blast design, and site specific geology, to be determined.	**Avoid/Minimise:** Where practicable, avoid over-ordering and delivery of excess materials through thorough procurement process. Negotiate with suppliers to takeback defective product and packaging. **Dispose:** Explosives cannot be disposed to landfill. Materials (including packaging) may require to be burnt or detonated by authorised personnel. Cardboard packaging contaminated with residual explosives cannot be recycled. NOTE: Explosive materials and packaging will be managed in accordance with *AS2187.2-2006 Explosives Storage, Transport and Use.*

Activity	Waste generated	Quantity	Management Strategy
Site and building maintenance and upgrades	Timbers – offcuts, packaging materials.	Currently unknown – to be determined following confirmation of design	**Avoid/Minimise:** Where practicable, avoid over-ordering and delivery of excess materials through thorough procurement process (including producer take back of timber pallets). **Reuse**: Stockpile for reuse on site if suitable. **Recycle:** Stockpile for chipping and mulching if suitable or removal from site by licences contractor for recycling if viable. **Dispose:** If no higher order options are viable (due to material type or lack of available services) disposal to onsite landfill.
	Metals including steel	Currently unknown – to be determined following confirmation of design	**Avoid/Minimise:** Where practicable, avoid over-ordering and delivery of excess materials through thorough procurement process. **Reuse**: Stockpile for reuse on site if suitable. **Recycle:** Stockpile for offsite reprocessing, reuse or recycling by licenced contractor. **Dispose:** If no higher order options are viable (due to material type or lack of available services) disposal to onsite landfill.
	Concrete	Currently unknown, likely to be minor quantities only – to be determined following confirmation of design	**Avoid/Minimise:** Where practicable, avoid over-ordering and delivery of excess materials through thorough procurement process. **Reuse**: Stockpile for reuse on site if suitable. Reuse in the form of concrete blocks on site. **Recycle:** Stockpile for onsite or offsite reprocessing, reuse or recycling. **Dispose:** If no higher order options are viable, disposal to onsite landfill.
	Residual paints, sealants, solvents, resins	Minor quantities, likely to be less than 1 tpa	**Avoid/Minimise:** Where practicable, avoid over-ordering and delivery of excess materials through thorough procurement process **Reuse:** Where suitable quantities permit, stockpile in a designated area for reuse onsite. **Dispose:** Store liquid wastes in a designated storage area for offsite disposal by a licenced contractor. Solid wastes such as resins and sealants may be disposed of in the onsite landfill.

Activity	Waste generated	Quantity	Management Strategy
	Plastics – excess packaging	Minor quantities, likely to be less than 1 tpa	**Avoid/Minimise:** Where practicable, avoid over-ordering and delivery of excess materials through thorough procurement process (including producer take back of plastic pallets). **Recycle:** Store in a designated area for recycling by licenced contractor if viable. **Dispose:** If recycling is not viable (due to material type or lack of available services) disposal to onsite landfill..
	Electrical waste and electronic equipment	Minor quantities, likely to be less than 1 tpa	**Avoid/Minimise:** Where practicable, avoid over-ordering and delivery of excess materials through thorough procurement process. Consider leasing electronic equipment with lessor takeback of redundant/expired equipment **Recycle:** Store in a designated area and establish a recycling/collection service with licenced Waste electrical and electronic equipment (WEEE) contractor. Consider donation of old or unused electronic equipment to community organisations.. **Dispose:** If recycling is not viable **d**isposal to offsite landfill by licenced contractor.
	Asphalt		**Recycle:** Store in a designated area for collection and recycling by a licenced contractor **Dispose:** Disposal to onsite landfill.
Processing Plant and Office Based Activities	Recyclables including paper, cardboard, glass, aluminium cans	Approximately 50 tpa	**Avoid/Minimise:** Procurement and purchasing procedures will consider likely workforce to minimise oversupply of these materials, however opportunities to minimise or avoid paper, cardboard, glass, aluminium cans etc. are likely to be limited. **Reuse:** Investigate options for reuse of cardboards as fillers for composting trials associated with rehabilitation areas. **Recycle:** Store in a designated area for recycling by licenced contractor if viable. **Dispose**: If recycling is not viable, disposal to onsite landfill or offsite landfill by licenced contractor until onsite landfill is operational.

Activity	Waste generated	Quantity	Management Strategy
	Batteries – mobile phones, radio etc.	Expect minor quantities less than 1 tpa	**Recycle:** Store in a designated area for recycling by licenced contractor. **Dispose:** If no viable recycling options, store in designated area for offsite disposal by licenced contractor.
	Clinical waste from medical facilities	Expect minor quantities less than 1 tpa	**Dispose:** Store in secure containers in designated area for offsite disposal by licenced contractor.
	Putrescible wastes including food scraps, domestic waste	Approximately 100 tpa	**Avoid/Minimise:** Procurement and purchasing procedures will consider likely workforce numbers at any given time to minimise oversupply of these materials, however opportunities to minimise or avoid are likely to be limited. **Recycle:** Adani will consider a trial composting project for kitchen food scraps. **Dispose:** If recycling is not viable, disposal to onsite landfill.
	Radioactive Wastes	Minor quantities expected less than 1 tpa associated with processing plant instrumentation	**Dispose:** Store in a secure, designated area for collection and disposal offsite by licenced contractor.
	Electrical waste and electronic equipment	Minor quantities, likely to be less than 1 tpa	**Avoid/Minimise:** Where practicable, avoid over-ordering and delivery of excess materials through thorough procurement process. Consider leasing electronic equipment with lessor takeback of redundant/expired equipment **Recycle:** Store in a designated area and establish a recycling/collection service with licenced Waste electrical and electronic equipment (WEEE) contractor. Consider donation of old or unused electronic equipment to community organisations.. **Dispose:** If recycling is not viable disposal to offsite landfill by licenced contractor.

Activity	Waste generated	Quantity	Management Strategy
	Printer cartridges	Expected minor quantities less than 1 tpa	**Avoid/Minimise:** Encourage printing of documents only when necessary. Default printer setting two sided black and white printing. **Recycle:** Store in a designated area for collection by licenced contractor for recycling. **Dispose:** If recycling is not viable, disposal to onsite landfill.

10.1.4.3 Decommissioning Phase

The Project (Mine) will be in operation until 2102 (Runge Macro Conceptual Plan) with completion of rehabilitation scheduled in 2110. Due to the timeframe until decommissioning, a detailed quantity of wastes likely to be generated during decommissioning and demolition of mining and building infrastructure is uncertain. Decommissioning will involve demolition and removal of mine, offsite infrastructure and buildings and is likely to generate similar wastes to the construction phase.

The mine voids would be progressively rehabilitated over the life of the mine using overburden and excavated materials and rehabilitated to a standard consistent with the best available technologies and techniques of the day.

In planning for decommissioning, a waste management plan would be developed at the appropriate time which would confirm the waste sources, types, quantities and management measures.

10.1.5 Waste Management Strategy

The proponent's overarching goal for the management of wastes associated with the Project (Mine) is to minimise impacts associated with waste materials on the receiving environment as well as the community and mine site workforce.

The main strategies that will be adopted for the Project (Mine) include waste minimisation (including waste segregation for re-use or recycling), cleaner production, and ensuring wastes are disposed of safely at appropriate facilities.

As noted in the waste inventories in the previous section, the proponent will preferentially adopt waste management strategies according to the waste hierarchy where practical and viable. It is noted however that local government provided waste management services are limited and unlikely to be a viable option, and whilst private contractors operate in the area, due to the remote location of the project some disposal of general wastes to landfill will be required. The proponent is willing to accept responsibility for the development of a landfill within the mine infrastructure area for those general wastes in accordance with EHP Guideline *Landfill siting, design, operation and rehabilitation*. Operation of the landfill would require application for a development permit for ERA 60 Waste Disposal. As the project progresses and more clarity on the viability of contractor provided waste services is obtained the proponent may also consider the following:

- Trialling of onsite composting or green and organic wastes;
- Reuse of sewage sludge (biosolids) in a soil conditioner trial.

This section outlines the key strategies for waste minimisation, cleaner production and waste handling, storage, treatment and disposal for the Project (Mine).

10.1.5.1 Waste Minimisation

The principal means by which the proponents seeks to minimise waste generation is through the adoption of cleaner production principles throughout the design, efficient use of available resources and service, and through the effective implementation of procurement and purchasing policies supporting resource efficiency through construction, operation and decommissioning of the Project (Mine).

Waste management plans for the construction, operation and decommissioning will provide specific details and procedures for individual waste streams including where relevant source separation, segregation, arrangements for transport, recycling and/or disposal via licenced contractors and onsite disposal procedures for the proposed landfill

10.1.5.2 Cleaner Production

The EIS Terms of Reference require that cleaner production be considered in determining how waste is managed. Cleaner production principles generally seek to use less energy, water and other inputs, generate less waste and waste that is less harmful to the environment. Table 10-3 demonstrates the application of cleaner production principles to the Project (Mine).

Table 10-3 Cleaner Production Principles and Adaptation

Cleaner Production Principle	Application to Project
Input substitution	This concept may be adopted for the Project through the assessment and possible use of less polluting raw materials
Production process modification	A Project specific procurement strategy will avoid the purchase of excess materials which may otherwise be disposed. To ensure the procurement process avoids excessive potential waste products, a procurement strategy should be adopted which outlines Project specific procurement requirements.
	The application of technical efficiencies in plant and equipment as, and once available, would provide more efficiency in operations. Due to the long life of the mining operations, regular equipment replacement may be subject to an appropriate business case review. To be effective in improving operations at the mine, an appropriate business case would identify equipment options to be considered, including any new technologies available. Consideration would also be given to embedded energy and material in existing plant and equipment prior to taking a decision on replacement and upgrade.
Technology change	Due to the long life of the mining operations, technology changes are inevitable. Changes and new technology will be considered where they support operational efficiencies and waste minimisation goals particular in terms of the CHPP, coal handling equipment and associated infrastructure.

Cleaner Production Principle	Application to Project
Improved operation and maintenance	The most efficient process equipment and plant will be used for the Project, including coal handling equipment and plan. The selection of the dragline has been based on minimising the number of excavation movements. This selection process by default ensures the most efficient plant and equipment is selected for the Project.
	The current mine plan is based on a large haulage fleet to transport waste from the mine face to the dumping site. The opportunity to reduce truck numbers by scaling up truck size is limited by the geometry of the coal and interburden. The opportunity exists to use continuous conveyor based mining systems to haul waste rather than run haulage trucks. This option is being evaluated and could possibly reduce overall emissions.
Reuse of resources that are otherwise wastes	The coal preparation plant requires significant quantities of process water for washing and wash downs. The liquid waste from this process will be collected and treated on- site for reuse in coal washing. An alternative for dry processing of coal is being investigated to reduce the overall CHPP raw water requirement
	Treated wastewater from the sewage treatment plant will be recycled and used for dust suppression or returned into the mine water system.
	Excavated overburden material will be considered in sourcing suitable materials for the construction of levee banks to separate the Carmichael River and the mining lease area.
Closed loop recycling	The reuse of wastewater from coal handling operations and returning it to the same operational processes demonstrates the closed loop recycling concept.

10.1.5.3 Waste Storage, Handling, Transport and Disposal

Waste storage, handling, transport and disposal requirements for the Carmichael Coal Mine have been incorporated into the Environmental Management Plan (EM Plan) for the mine, and waste management requirements for the off-site infrastructure facilities have been incorporated into the environmental management plan for the off-site facilities.

Requirements included in the EM Plan include:

- Maintenance of a waste register which tracks the types and quantities of wastes generated and the management approach for each waste
- Regular review of the waste register to:
  - Identify trends in waste generation, particularly increases in waste types
  - Identify opportunities for wastes to be avoided, reused, recycled or otherwise minimised
- Procedures for the identification of regulated wastes and utilisation of the EHP waste tracking system for regulated waste movement

- Waste removal and transport from site by authorised contractors with disposal only to authorised waste processing or disposal facilities
- Measures to ensure wastes do not attract or propagate pests, disease vectors or vermin
- Monitoring of waste streams and auditing against the relevant waste management plan and procedures with measures for continuous improvement
- Training of personnel on procedures concerning waste minimisation, handling, storage, reuse, segregation, collection and disposal
- Procedures for handling, stockpiling/storage, and reuse of suitable materials
- Process for identification of an appropriate site for a landfill in the mine infrastructure area
- Procedures for meeting legislative requirements for transport of waste

Waste disposal and recycling facilities will be provided onsite in a designated area, by either licenced contractors or the proponent. Arrangements for any waste to be disposed at an offsite landfills prior to the establishment of the onsite landfill will be negotiated with the licensed operator.

Any waste transportation will take place in accordance with the legislated waste tracking system to ensure waste reaches the appropriate destination. Only licensed contractors and drivers will be utilised. Any transporters will be expected to meet legislative requirements for spill control and be equipped with emergency equipment.

Details of the Environmental Management Plan are provided in Volume 2 Section 13 Mine Environmental Management Plan and Section 14 Offsite Environmental Management Plan.

Procedures for dealing with accidents, spills and other incidents that may impact on waste management are covered in the land contamination sections of the EMPs.

10.1.5.4 Onsite Waste Disposal

Whilst there are private contractors that supply some waste management services to mine sites throughout Queensland, a landfill will be required in the mine infrastructure area (onsite and offsite) for general wastes which are not able to reused or recycled. Wastes that cannot be recycled or reused onsite will be disposed of to the onsite landfill in a manner which seeks to minimise environmental harm. It is anticipated that the landfill will accept the following wastes:

- Food/kitchen wastes from the accommodation village and amenities at the mine infrastructure area,
- Other solid wastes from the village and amenities areas,
- Packaging/recyclables if these cannot be taken away by a contractor for recycling,
- Possibly sludge from water and wastewater treatment if these cannot be reused as soil conditioners (trials will be constructed to establish suitability)

Regulated wastes will not be disposed of in the onsite landfill.

Development and operation of the onsite landfill will be guided by the EHP Guideline *Landfill siting, design, operation and rehabilitation.* Onsite disposal and transport of waste are considered to be environmentally relevant activities (ERA) and require development approval under the *Sustainable Planning Act 2009*.

An appropriate site within the mine infrastructure area will be sought for the landfill. Siting criteria specified in the EHP Guideline will be applied to develop a short list of sites that will be the subject of further investigation to arrive at a preferred landfill site. The siting criteria include:

- Consideration of the type of landfilling method required;
- Buffer distances to adjacent land uses :
  - 100 m from surface waters and the '100 year flood plain'
  - 500 m from a noise, dust or odour sensitive place
  - 100 m from an unstable area
  - 1,500 m from an aerodrome for piston-engined propeller-driven aircraft
  - 3,000 m from an aerodrome for jet aircraft
- Proximity to groundwater resources
  - Impacts on water quality objectives of local and regional groundwater must not be compromised
  - Preference that the site that provides a natural unsaturated attenuation layer beneath the liner for contaminants that may leach through the liner to the aquifer
  - A minimum of a 2 m attenuation zones in relation to the highest seasonal watertable below the landfill
- Surface Water
  - Landfilling should not occur in protected wetlands or water supply catchments
- Biodiversity
  - An assessment of the impacts to local biodiversity is required, and landfilling should avoid areas protected under State and Commonwealth legislation in relation to biodiversity values
- External Infrastructure
  - Consideration of external infrastructure including transport links, roads, and utilities should be factored into the landfill siting
- Geological Setting
  - Landfills should be constructed in geologically stable areas to ensure the long-term integrity of the landfill capping and liner systems over the life and post-closure care period

As part of the design process at the preferred site, a detailed and specific environmental assessment will be conducted to develop an understanding of the receiving environment, such that appropriate mitigation and management measures can in turn be developed for implementation through construction, operation and rehabilitation.

As a minimum the design of the onsite landfill will include the following:

- Consideration of the anticipated waste generation rates for specified waste streams throughout the life of the Project (Mine)
- Cell layout and staging that considers ease of operation and minimisation of environmental impacts
- Engineered liner and capping system

- Assessment of the need for a landfill gas collection system and associated management and monitoring requirements
- Measures to manage leachate, sediment laden stormwater, clean stormwater and groundwater
- Development of a groundwater monitoring network (and if required surface water, landfill gas and air quality)
- Details of proposed methods of waste acceptance, placement, compaction and coverage, including separation and storage of prohibited materials for waste disposal
- Measures for managing air quality, odour, pests, vermin, litter, security, fire prevention
- Staged capping and rehabilitation of cells throughout the life of the landfill

10.1.5.5 Waste Management Plans

Detailed waste management plans will be developed for construction, operation and decommissioning phases of the Project (Mine). These plans will provide guidance to implement site-specific waste management procedures and practices. An outline of the requirements for the construction and operational phase is provided in this section. Requirements for decommissioning will be defined closer to the time they are required.

Construction Phase

- Identification of waste streams
- Consideration of the waste management hierarchy when selecting waste management strategies, with emphasis on minimising waste generation
- Identification of segregation, storage, reuse, collection, storage and or disposal strategies
- Personnel training requirements relevant to the plan
- Concept design of the proposed landfill in the mine infrastructure area for disposal of general waste, including putrescible, non-regulated wastes and those materials for which a viable recycling option is not available
- Arrangements for waste streams unsuitable for disposal in the onsite landfill, to be removed and transported from site by appropriately licensed contractors with disposal to licensed recyclers or waste disposal facilities
- Legislative compliance requirements for transport of any regulated wastes, waste tracking requirements
- Monitoring and auditing requirements to track implementation of plan and performance against overall objectives

Operational Phase

- Identification of waste streams and initial quantification
- Emphasis on waste minimisation where practical and consideration of the waste hierarchy in adopting specific waste management strategies
- Segregation, storage, handling and disposal of hazardous and related waste that are regulated under the *Environment Protection (Waste Management) Regulation (QLD) 2000* and or the *Waste Reduction and Recycling Regulation (QLD) 2011*. Regulated waste includes clinical (chemical,

cytotoxic, human body parts, pharmaceutical), radioactive and explosive materials, as well as any waste that has come into contact with a regulated material

- Personnel training requirements relevant to the plan
- Requirements and regulation for operation of onsite landfill
- Requirements for removal and transport offsite for those wastes not able to be managed onsite, including the use of licensed contractors
- Waste tracking requirements for any trackable wastes
- Monitoring and auditing requirements to track implementation of plan and performance against overall objectives

Table 10-4 summarises strategies to reduce, re-use, recycle, store, treat and dispose of the waste generated over the lifetime of the Project.

Table 10-4 Waste Management Strategies

Activity	Waste Generated	Management Option
Excavation works	Excess materials/spoil	◗ Reuse on site as backfill or to widen embankments wherever practicable. ◗ Reuse at another site. ◗ Transport any surplus soil that cannot be reused off – site to an approved landfill site where it can be used beneficially (e.g. landfill cap material or to backfill borrow pits). The material would be tested in accordance with relevant legislation prior to disposal. ◗ Locate material and stockpiling areas for spoil within the construction area until its ultimate destination is determined. ◗ Project specific procurement plan which outlines specific requirements in order to avoid purchasing of excess materials and subsequent waste. ◗ Ensure detailed designs and specifications minimise the generation of waste during construction.
Excavation works	Contaminated materials	◗ Classification by an appropriately qualified engineer. ◗ Onsite treatment if possible or disposal.
Construction works	General construction packaging material	◗ Separate recyclable material including glass, aluminium, plastic and paper will then be taken offsite for recycling at regional recycling facility. ◗ Non-recyclable material sent to licenced landfill facility. ◗ Project specific procurement plan which outlines specific requirements in order to avoid purchasing of excess materials and subsequent waste. ◗ Ensure detailed designs and specifications minimise the generation of waste during construction.

Activity	Waste Generated	Management Option
Operation of plant equipment and machinery	Used oils, fuels etc.	◗ Waste oils and liquids will be stored in designated containers and appropriately disposed of at a licensed facility or recycled where possible. ◗ All chemicals, fuels and oils will be stored in appropriately bunded areas in accordance with Australian Standards to minimise potential for any spills. ◗ Paints and solvent use will be minimised by using pre-painted products where practicable. ◗ Used or waste paints and solvents will be recycled or sent for disposal by an appropriately licensed facility.

10.1.6 Summary

Waste will be generated during the construction, operation and decommissioning phases of the Project (Mine). The waste management hierarchy for the Project (Mine) follows a framework for prioritising waste management practices to achieve the best environmental outcomes possible. This waste management hierarchy follows a strategy of:

- Avoid unnecessary resource consumption
- Reduce waste generation and disposal
- Re-use waste resources without further manufacturing
- Recycle waste resources to make the same or different products
- Recover waste resources, including the recovery of energy
- Treat waste before disposal, including reducing the hazardous nature of waste
- Dispose of waste only if there is no viable alternative

The characterisation of waste streams for the Project (Mine) is based on its concept design during the construction and operational phases and is generally defined as either construction or demolition waste, or commercial and industrial waste under the WRR Act. The waste management measures associated with waste streams is as follows:

- Vegetation removal will be carefully managed to minimise green waste, and where required will be reused for rehabilitation and habitat.
- Spoil will be reduced through the design of earthworks to maximise a balance of cut to fill, thereby minimising excess spoil. Where excess spoil is generated, it will be utilised within the Project (Mine) area as general fill, and fill for the construction of road and bund areas. Bund areas may include that required for water management and works required to protect the Carmichael River.
- Overburden will be managed through the implementation of a policy of in-pit disposal of overburden materials and/or use in rehabilitation, bund construction or other onsite management activities. Where in-pit disposal cannot be achieved out-of-pit disposal will be required.

- Domestic waste will be recycled or composted where possible, with as little waste going to land fill as possible.
- Commercial materials will be purchased through a considered procurement process, reducing excess material and associated waste. Materials such as paper, computer and printer waste and equipment will be recycled where possible.
- Plant and equipment waste will be recycled where possible, and stored and disposed of in accordance with regulatory requirements.
- Wastewater will be treated and reused where possible, or disposed of in accordance with regulatory requirements.

Based on the management measures proposed for the Project (Mine), it is unlikely that the waste generated during the construction and operational phases of the Project (Mine) will have a significant impact.

10.2 Mine Waste

10.2.1 Existing Environment

10.2.1.1 Introduction

Adani is proposing to develop a 60 million tonne (product) per annum (Mtpa) thermal coal mine in the north Galilee Basin approximately 160 kilometres (km) north-west of the town of Clermont, Central Queensland. The Project (Mine): a greenfield coal mine over EPC1690 and the eastern portion of EPC1080 (refer Volume 2; Figure 4-1), includes both open cut and underground mining, in addition to coal processing facilities. Refer to Volume 2, Chapter 2 for a full description of the mine project, including mine site layout and mine staging.

The Galilee Basin is a Late Carboniferous to Mid-Triassic depositional terrestrial basin of predominantly fluvial sediment infill. This has implications with respect to the potential for generation of acid and metalliferous drainage (AMD) as will be discussed. The targeted coal seams (AB, D1-3, E and F) are hosted within the Late Permian Colinlea Sandstone and overlying Late Permian Bandanna Formation, which sub-crop beneath a cover of Triassic Rewan Formation (refer Figure 2-3). The Rewan Formation is in turn, obscured beneath a variable cover of unconsolidated to poorly consolidated Tertiary sediments. The average limit of oxidation across the site is approximately 50 m deep, which also has implications for AMD potential.

The coal deposit underlies almost 100 per cent of EPC1690. The coal seams strike approximately north-south through the mine, with a regional dip of two to six degrees to the west. Therefore, the target seams are shallower along the eastern side of EPC1690, becoming deeper towards the western side of the same lease. Mine development economics therefore determined that the coal be removed in open cut pits along approximately the eastern half of the lease, and by underground methods along the western half. The implications of this mining method include significant surface disturbance along the eastern side of the lease where the open cut pits will progress. Refer to Volume 2, Chapter 2 for additional detail on mining method.

The project is located within a relatively benign area both for igneous intrusives and geological structures. To date, no igneous intrusive material has been encountered during drilling, and magnetics do not indicate any dykes or igneous plugs within the project area. This suggests the potential for pyrite formation from igneous sources is likely to be limited; again, with implications on AMD potential.

The product coal will be washed on site through a coal handling and preparation plant (CHPP). The CHPP facilities are designed for a peak annual capacity of 80 Mtpa run-of-mine (ROM) coal, to allow for overall annual production of 60 Mtpa product coal. The operation will therefore generate CHPP wastes in the form of coarse rejects and coal wash; otherwise known as fine tailings.

10.2.1.2 Mine Wastes and AMD Implications

Based on the project introduction above, there will be three key mine waste streams generated at Carmichael; being:

- Over / interburden from the open cut pits
- Coarse rejects from initial screening and the CHPP
- Fine tailings from the CHPP

Presently, Adani plans long term on site storage of the over and interburden initially in out of pit waste rock structures on EPC1080 and on the eastern side of the coal sub-crop on EPC 1690. The tertiary overburden will be beneficially utilised on the upper sections of the dump profile as a cap over the underlying Permian materials. Approximately 2.7 billion BCM of over and interburden material will be stored in this manner. Subsequently, the balance of the 22.9 billion BCM of over and inter-burden will be backfilled within mined out pit voids as the mine progresses. Any material that has demonstrated the chemical potentially to form acid, saline, and/or metalliferous drainage would be appropriately managed through either subaerial or subaqueous storage within the mine voids. Management strategies are further discussed later in this chapter.

Coarse rejects from the CHPP will be stored on site long term by blending them with over and interburden, and subsequently deposited into out of pit structures then within mine voids as the mine schedule progresses. Fine tailings from the CHPP will initially be stored in a purpose built surface structure that will be closed and capped once the mine progresses and mine voids within Pits J and G become available for longer term tailings wet deposition and storage.

Any potential for acid, saline, and/or metalliferous drainage formation is ultimately a function of a number of inputs; primarily the geology, the mining method, the climate, and the handling and storage of any mine wastes on site.

The geology at Carmichael, being a terrestrially formed, sedimentary environment, is lower risk for the formation of acid, saline, and/or metalliferous drainage than say, a marine palaeo-environment. The availability of sulphur in a freshwater environment is much less than that of sea water due to the much lower concentrations of dissolved sulphates. As a result, during deposition, net formation of pyrite within a freshwater or fluvial environment is often much less than that of marine environments. Furthermore, a greater percentage of sulphur in freshwater environments has a tendency to be bound up organically within coal, rather than as free sedimentary pyrite, thereby reducing the potential for AMD in the mine waste itself. The average total sulphur concentrations in the coal seams at Carmichael of 0.42 per cent is consistent with regional coal total sulphur contents including Alpha (0.57per cent), Kevin’s Corner (0.51 per cent) and the China First Project (0.45 per cent), demonstrating an overall low risk of AMD generation. This compares to the Collinsville coal measures which are a marine deposited geological units, which can have coal total sulphur concentrations of up to 21 per cent.

Pyrite is the key mineral that generates acid, saline, and/or metalliferous drainage once it oxidises with air or water; a natural process often accelerated during the mining process. The overall process of pyrite oxidation may be shown as:

$$FeS_2 + 3.75\ O_2 + 3.5\ H_2O \rightarrow 2SO_4^{2-} + Fe(OH)_3 + 4H^+$$

(pyrite) + (oxygen) + (water) → (sulphate) + (iron hydroxide) + (hydrogen ions)

It is the reaction product of sulphate that can lead to saline drainage, while the combination of sulphate and hydrogen ions form sulphuric acid. The sulphuric acid lowers solution pH values, making metals more soluble, thereby degrading water quality. This is known as acid and metalliferous drainage.

Similarly, a lack of structural alteration in the form of igneous dyke intrusion and/or fault formation; geological processes that can facilitate pyrite formation, also indicated a low risk of AMD at Carmichael. A limit of oxidation of approximately 50 m would also suggest that over and/or interburden removed along the eastern side of EPC 1690 during open cut mining would have a low risk of AMD generation, as any pyrite present would likely have oxidised naturally over the years.

10.2.1.3 Mine Waste Study: Preamble

To assess the geochemistry of the mine waste material, GHD commissioned SRK Consulting to undertake a *Mine Waste Acid and Metalliferous Drainage and Dispersive Materials Assessment* (refer Volume 4, Appendix V). Due to the timing and progress of exploration drilling at Carmichael, and the subsequent availability of geological core for geochemical sampling and analysis, a staged approach was adopted for the mine waste study. The study included a desktop assessment, reporting of initial laboratory results, and a final report which incorporated all laboratory results commissioned for the mine waste study.

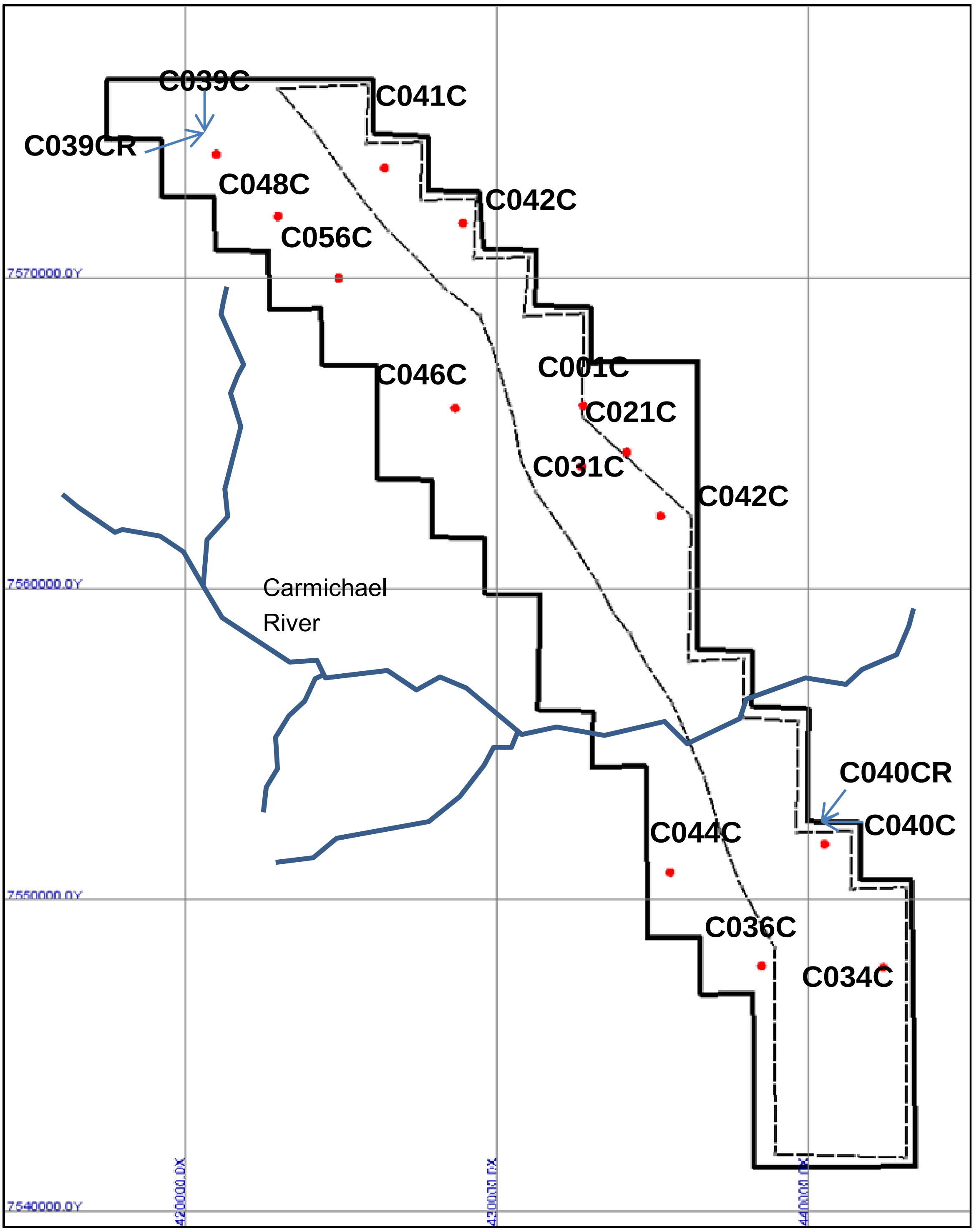
10.2.1.4 Mine Waste Study: Methods

In December 2011, SRK Consulting undertook a supervised site visit to Carmichael to collect geochemical samples from 16 of the 19 geological exploration (7 partially cored, 12 fully cored) holes that had been completed at that time. Sample selection was based on:

- the lithological units present;
- available drill core (all core had previously been sampled for coal quality and geotechnical testing; subsequently, not all core was available for geochemical sampling);
- distribution of drill holes across the project; and
- the need to obtain a set of samples that would be used in a geo-statistical assessment of the distribution of geochemical characteristics.

Figure 10-1 shows the location of the 16 exploration holes sampled for geochemical analysis.

Figure 10-1 Location of the 16 Exploration Holes Sampled for Geochemical Analysis



At this stage, it is important to recognise the limitations on data generation for the mine waste study. A critical component of assessing the AMD potential is generating a statistically representative data set for each geological unit planned for disturbance at Carmichael. The mine waste study was therefore limited due to the lack of a sufficient spatial distribution of geological holes at the time of sampling. This fact has been recognised, and as the drilling subsequent to progression of the drilling program throughout 2012, Adani has commissioned additional work. In late 2012, an additional 370 samples will be collected from the 2012 drill holes to increase statistical confidence on the geochemical data set. The data will be interpreted and results used to refine the mine waste management approach.

The cumulative total of 5,388 m for the 16 drill holes sampled for this study were summed to determine the vertical distribution of geological units (Table 10-5).

Table 10-5 Vertical distribution of geological units

Lithological group	Sum of length (m)	% of drillhole length	No. of samples
Carbonaceous	190	3.5	15
Clay and soil	442	8.2	12
Coal	403	7.5	2
Potential AN[1]	12	0.2	0
Rem[2]	4,259	79.0	71
Sand and gravel	82	1.5	0
Total	**5,388**	**100.0**	**100**

1: Potential AN = (acid neutralising) lithological units that thought to contain excess carbonate minerals.

2: Rem is a group of remaining lithological units not expected to have significant acid forming potential, or would be considered barren with respect to acid neutralisation capacity. Sandstone and siltstone made up the majority of this group.

Samples were selected from each drill hole such that they were approximately representative of the vertical presence of each geological unit (Table 10-6). This was with the exception of carbonaceous materials, which are highly represented in the collected samples because the experience at other coal sites is that these materials can have relatively high sulphide content (particularly adjacent to coal seams). Coal is under represented in the sampling because most of the coal core had been taken previously for coal quality analysis.

In total, 58 different lithological units and sub categories were logged from drill core. Since some of the lithological units were expected to have similar geochemical behaviour they were grouped together for the purposes of statistical and geochemical assessment, as shown in Table 10-5.

Table 10-6 Geochemical sample by drill hole

Drillhole	No. of samples	Drillhole	No. of samples	Drillhole	No. of samples
C001C	5	C039C	3	C044C	2
C0021C	4	C039CR	4	C046C	6
C024C	5	C040C	3	C048C	29
C031C	9	C040CR	2	C056C	7
C034C	5	C041C	6	-	-
C036C	7	C042C	3	Total	100

The ten samples collected from immediately above or below the coal seams are identified as roof and floor materials. These are important as they often represent coarse reject material from the CHPP resulting from underground mining. Additionally, two samples were taken from within coal seams and the remaining 88 samples were collected from overburden and interburden not immediately adjacent to coal seams. At the time of sample collection, material representing the fine tailings from the CHPP was not available; thus the two coal samples as a surrogate. Whilst material sourced from the weathered zone is generally a lower risk of AMD as noted above, 29 of the 100 samples were collected from weathered material non-the-less to document that risk.

Table 10-7 provides a summary of the geochemical analysis completed on the mine waste samples. ALS Environmental, Brisbane, conducted and coordinated all geochemical analytical testing.

Table 10-7 Geochemical analysis summary

Geochemical analyte[1]	Samples analysed
Paste pH and electrical conductivity (AMIRA, 2002) (solid:water ratio 1:2)	100
Total sulphur content (Leco)	100
Acid neutralising capacity (AMIRA, 2002)	100
Dispersivity testing: Cation exchange capacity (CEC) and exchangeable sodium percentage (ESP) Emerson aggregate test	28
Electrical conductivity (solid:water ratio 1:5)	14
Carbon speciation: total inorganic carbon (TIC), total organic carbon (TOC), total carbon (TC)	32
Single addition net acid generation (NAG) test (AMIRA, 2002)	12
Modified NAG test with extended boil (EGi, 2008)	23
Sequential NAG test.	2
Sulphur speciation (sulphate sulphur and chromium reducible sulphur content)	35

Geochemical analyte[1]	Samples analysed
Simple leach tests on solid (solid to de-ionised water ratio of 1:3) and multi element scan of the extract plus dissolved cations and anions (Price, 1997)	20
Acid buffering characteristics curve (AMIRA, 2002)	18

1: Refer to Volume 4, Appendix V for analytical references.

10.2.1.5 Mine Waste Study: Results and Discussion

For ease of reference, the results and discussion section has been divided into the following sub-sections:

- Analyte description and rationale. This section provides a simple overview of the analytical method and why it was conducted for Carmichael;
- Roof, floor and coal samples (12 samples). As noted above, the 10 roof and floor samples represent geological materials often with a higher AMD risk which are sometimes removed during underground mining and disposed of on-site as coarse reject output from the CHPP. The 2 coal samples were assessed herein as surrogates for fine tailings from the CHPP. The fine tailings are essentially a concentration of wash products from the coal seam itself; and
- Over and interburden material. There are significant quantities of over and interburden material being disturbed by open cut mining along the eastern section of EPC 1690 which therefore require geochemical assessment to assess the risk of AMD and/or saline drainage. In addition, geochemical assessment determines the suitability of the material for beneficial on-site reuse in mine rehabilitation.

Each of the three sub-sections are presented below for each geochemical analyte.

Paste pH and Electrical Conductivity (EC)

Paste parameters provide an indication of the acidity (paste pH) and salinity (paste EC) of a sample at the time of testing. ‘Paste’ is a term used for a slurry comprising one part ground geological sample and two parts water on a weight percentage basis. The degree of weathering the material has experienced, in addition to the availability of readily soluble salts, can be inferred from the paste pH and paste EC parameters respectively.

Generally, paste pH ($pH_{1:2}$) values less than pH 5 indicate the presence of stored acidity; which is the result of stored oxidation products), potentially leading to acid generating conditions. On the other hand, high paste pH values can suggest the presence of reactive neutralising minerals. Paste electrical conductivity ($EC_{1:2}$) provides an indication of the soluble salt loading associated with the sample. Where the sample originates from a naturally saline environment, an elevated paste $EC_{1:2}$ may simply indicate salinity. However, where natural salinity is low (such as that expected at Carmichael), a high paste EC would indicate salt loading from the oxidation of sulphide minerals. This information can then be used to infer the degree of weathering of the material.

Low paste pH or elevated paste EC values may be indicative of the immediate potential of a sample to impact the quality of water contacting the waste; i.e. rainfall. It is therefore a useful ‘first pass’ indicator of risk.

Roof, Floor and Coal Samples

The 10 roof and floor samples selected are from the Carbonaceous group and the remaining lithologies (Rem) group; being claystone, sandstone or siltstone (refer Volume 4 Appendix V – App B). In addition, the 2 coal samples are reported herein. Summary statistics for $EC_{1:2}$ of the samples are summarised in Table 10-8

Paste $pH_{1:2}$ and $EC_{1:2}$ data for the roof, floor and coal samples as a function of total sulphur are presented in Figure 10-2 and Figure 10-3, while Figure 10-4 presents paste EC as a function of paste pH.

Table 10-8: Roof and Floor Material $EC_{1:2}$ Summary Statistics

Statistic	$EC_{1:2}$ µS/cm
no. of samples	12
Minimum	37
Mean	578
Median	515
Maximum	1,620

The paste EC values ranged between 37 and 1620 µS/cm with the results for all but one sample the being less than 1,000 µS/cm, and only one sample falling below 300 µS/cm (i.e. most samples were within the EC range of 300 to 1,000 uS/cm).

The results suggest that most roof, floor and coal materials would not be expected to be an immediate source of salinity; however, some portion could be a source of salinity.

The paste pH of the samples ranged from a slightly acid minimum value of 5.5 to an alkaline 9.3, with the majority of samples (88 per cent) having a paste pH greater than 7. The absence of samples with a paste pH less than 5 indicates that none of the samples that may be potentially acid forming had progressed to acidic conditions at the time of testing. Since the majority of samples had a paste pH result of greater than 7, it indicates the presence of reactive neutralising minerals. Therefore, the roof, floor and coal materials should not be a source of acid following disturbance immediately after mining. It is not possible at this stage to determine longer term risk as that risk is determined using longer term, kinetic leaching column tests. Kinetic leach column tests are scheduled for completion on samples being collected in late November 2012; and results would be used to refine the approach to mine waste management.

There was no apparent correlation between the paste EC and paste pH (Figure 10-4).

Figure 10-2 Paste pH as a Function of Total Sulphur Content (Roof, Floor and Coal)

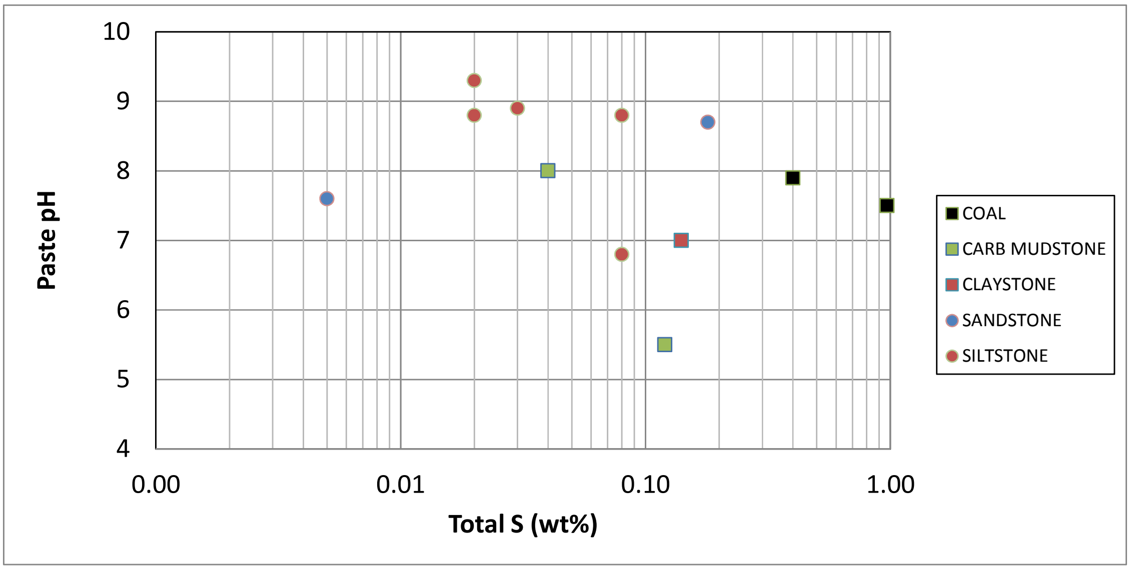


Figure 10-3 Paste EC as a Function of Total Sulphur Content (Roof, Floor and Coal)

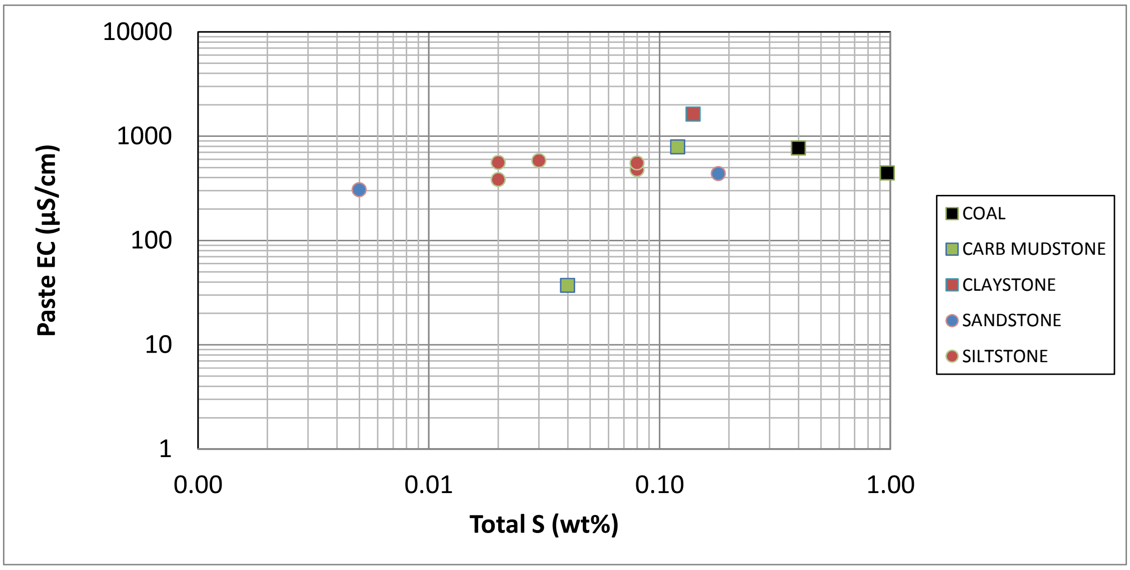
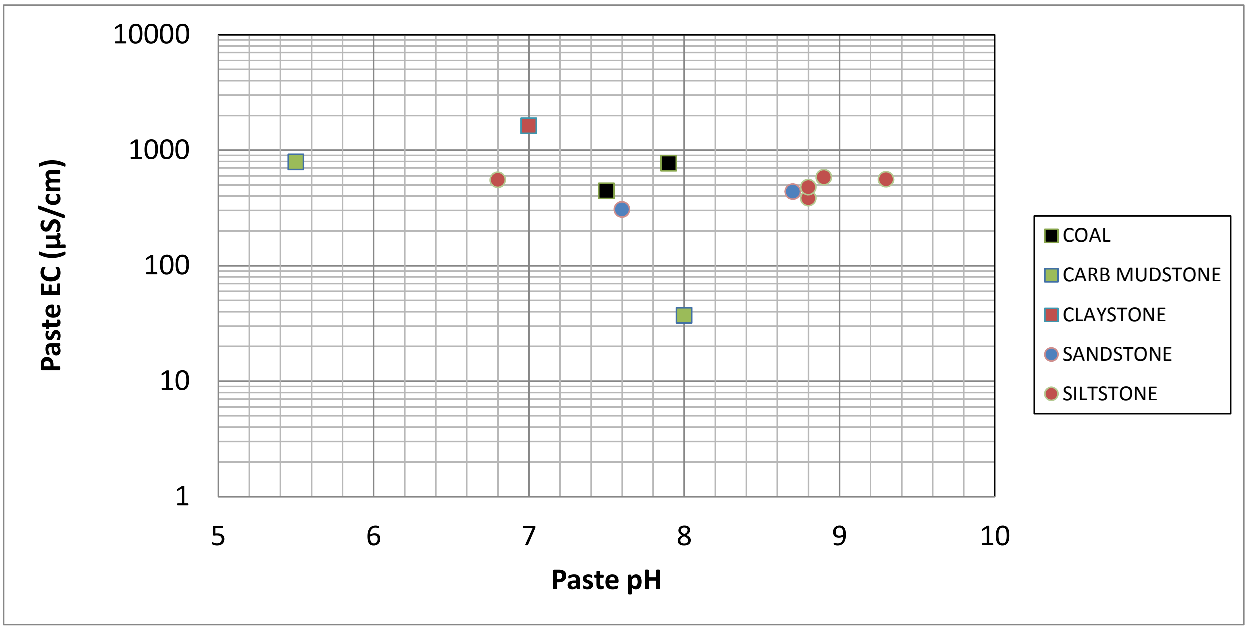


Figure 10-4 Paste EC as a Function of Paste pH (Roof, Floor and Coal)



Overburden and Interburden

A total of 88 overburden and interburden samples were tested and the summary statistics of the samples are provided in Table 10-9. Paste pH and EC data as a function of total sulphur are presented in Figure 10-5 and Figure 10-6, while Figure 10-7 presents the results of paste pH as a function of paste EC for the overburden and interburden samples.

Table 10-9 Overburden and Interburden Material $pH_{1:2}$ and $EC_{1:2}$ Summary Statistics

Statistic	$pH_{1:2}$ pH units	$EC_{1:2}$ µS/cm
no. of samples	88	88
Minimum	5.3	68
Mean	8.2	697
Median	8.3	383
Maximum	9.7	6,200

The paste pH characteristics of the overburden and interburden were broadly similar to those of the roof, floor and coal samples. That is, the paste pH of the samples ranged from slightly acid to alkaline (5.3 to 9.7). The majority of samples (91 per cent) had a paste pH of greater than 7.

The absence of samples with a paste pH less than 5 indicates that no stored oxidation products were likely to be present in the samples characterised. The majority of samples had a paste pH of greater than 7 suggesting that there may be reactive neutralising minerals present. Therefore, the overburden and interburden may not be a source of acid immediately after mining. Again, long term risk has not been determined at this stage. As for the roof and floor materials, this does not exclude the potential for acid release if sulphides are present and oxidise during and/or after mining.

The median paste EC of the overburden and interburden (383 µS/cm) was less than that of the roof, floor and coal samples, whilst the average was larger. The average value was strongly influence by the clay materials, which had an average paste $EC_{1:2}$ for the twelve samples of 2,490 µS/cm compared with the average for all other overburden and interburden samples of 415 µS/cm.

The vast majority of overburden and interburden not located immediately adjacent to the coal seams is therefore unlikely to be a significant source of salinity. However, the results indicate that the clay material could have a markedly higher potential to leach salts into water than all other tested materials from overburden, interburden, roof, floor and coal (Figure 10-7). It is therefore unlikely that the clay material is suitable for beneficial reuse in mine site rehabilitation and may need to be appropriately managed.

Like the roof, floor and coal materials, there were generally no significant correlations between the paste EC and paste pH values (Figure 10-7). Clay, however, produced paste EC values greater than 1,000 µS/cm with corresponding paste pH values between 7.4 and 8.4. For paste pH values outside this range the paste EC was less than 1,000 µS/cm. Only four clay samples lay outside of this paste pH range, so testing of additional samples would be required to confirm this observation.

Figure 10-5 Paste pH as a Function of Total Sulphur Content (Overburden and Interburden)

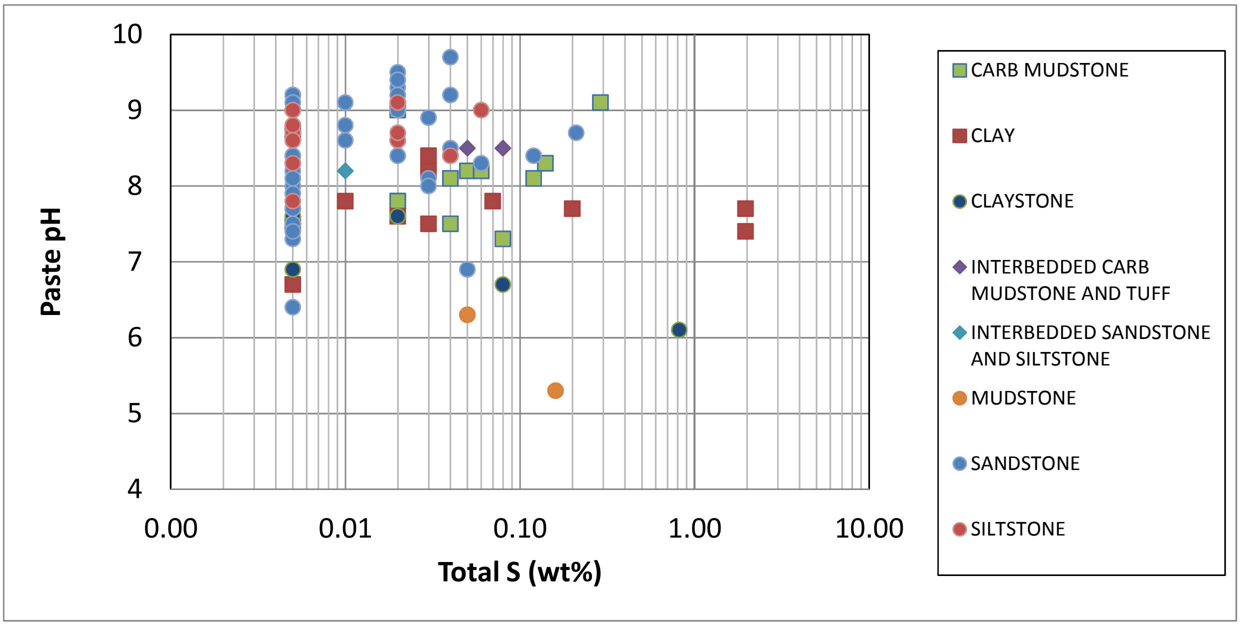


Figure 10-6 Paste EC as a Function of Total Sulphur Content (Overburden and Interburden)

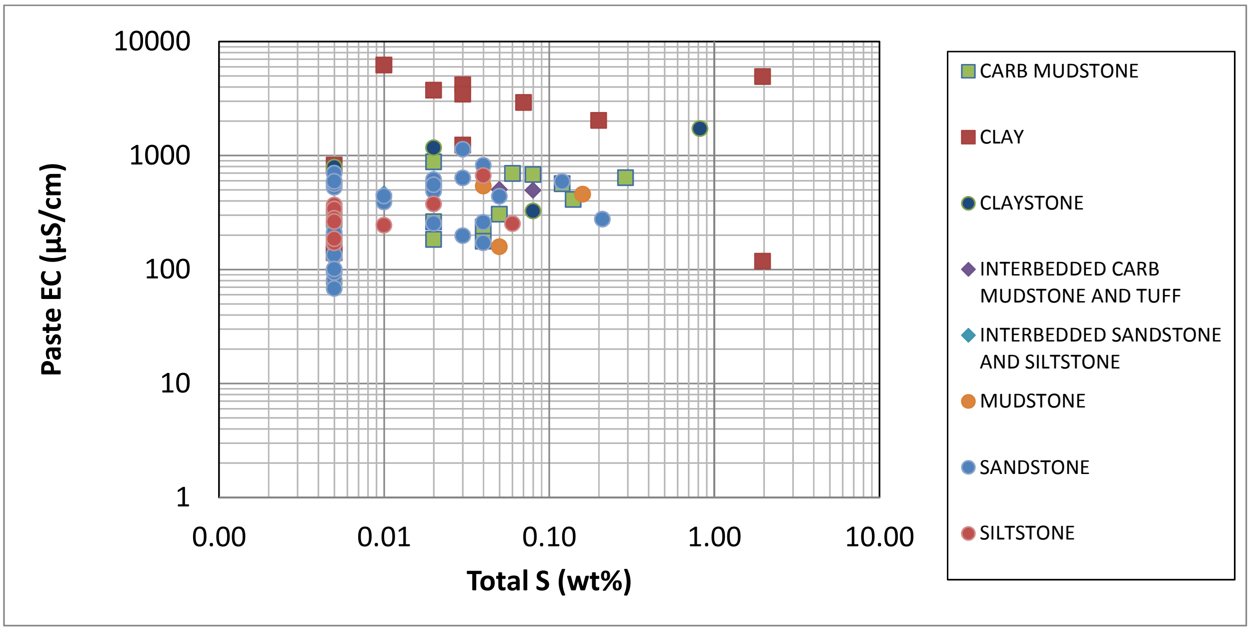
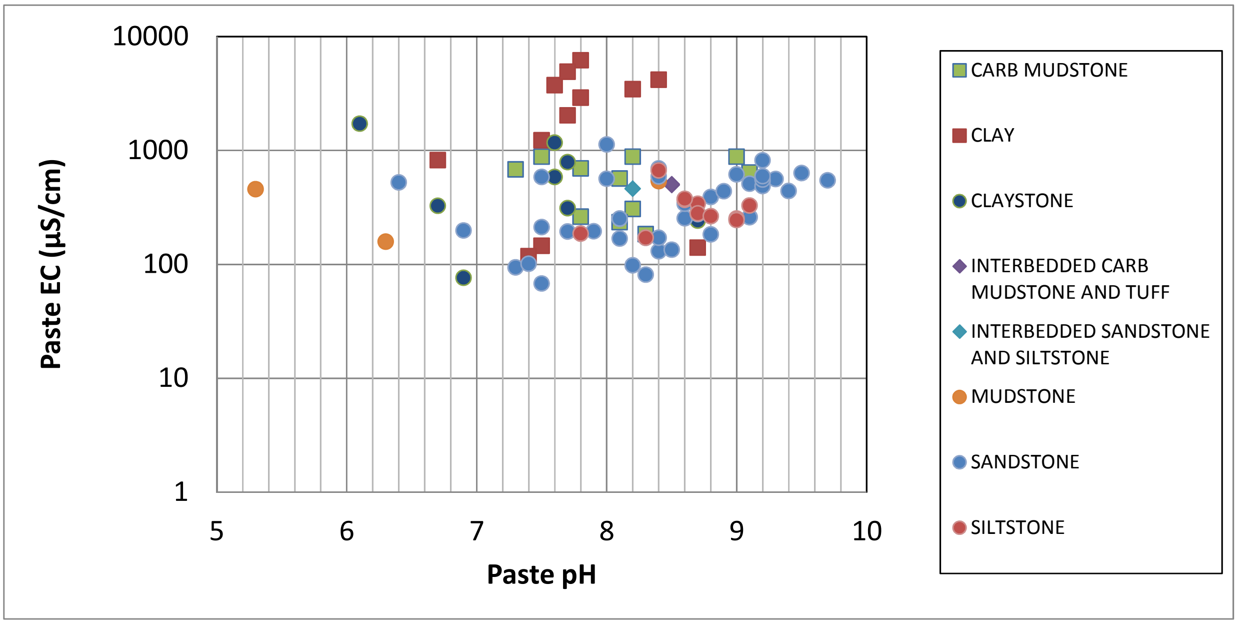


Figure 10-7 Paste EC as a Function of Paste pH (Overburden and Interburden)



Acid Base Accounting

Acid base accounting is a generic term for a series of geochemical tests that determine the AMD risk of a sample by adding and subtracting various analytical results to determine a net risk. Acid base accounting is generally reported as 'the net acid producing potential' (NAPP) of a geochemical sample, being the theoretical balance between the capacity of the sample to generate acid due to the oxidation of sulphides, and its capacity to neutralise any acid formed (i.e. its acid neutralising capacity, or ANC).

The maximum potential acidity (MPA) of a sample in acid base accounting is an estimate of how much acid a sample can produce, calculated from the total sulphur content. It is a conservative assessment as it assumes that all sulphur is present as reactive pyrite. This assumption generally overestimates the amount of acid potential since sulphur may exist in other forms that are not acid generating (e.g. as sulphate).

When sample results were borderline for classification purposes, additional analytical methods were undertaken to improve the accuracy of measuring MPA by determining discrete sulphur species. In that regard, in addition to all 100 samples being analysed for total sulphur, a subset of 35 samples were analysed for sulphate and / or chromium reducible sulphur.

The ANC of a sample in acid base accounting may comprise alkalinity generated from both carbonate and/or silicate minerals. Laboratory titration methods determine which minerals are likely represented in the neutralising ability of the sample. The ANC measurement sometimes overestimates the neutralisation capacity of a sample as the laboratory method as solution pH values may not be the same as laboratory pH values in nature; thereby dissolving silicate minerals that would otherwise not be dissolved, releasing additional neutralising capacity.

When sample results were borderline for classification purposes, additional analytical methods were undertaken to improve the accuracy of measuring acid neutralising capacity. In that regard, in addition to all 100 samples having ANC determined on them, 18 samples had acid buffering characteristics curve (ABCC) tests completed to determine which species of carbonate is likely present, and what percentage of the sample is available for neutralising acid.

The NAPP of a sample is therefore calculated as follows:

$$\text{NAPP (kg } H_2SO_4\text{/t)} = \text{MPA (kg } H_2SO_4\text{/t)} – \text{ANC (kg } H_2SO_4\text{/t)}$$

(Where MPA = 30.6 x Total S% and the sulphur content is expressed as weight per cent (wt%).

The additional sulphur speciation and ABCC tests are utilised to fine-tune the MPA and ANC values in the above equation respectively.

Additionally, single addition net acid generating tests (NAG), modified NAG tests, and sequential NAG tests were undertaken to further fine-tune the NAPP of the samples. NAG tests are undertaken by adding hydrogen peroxide to a sample and leaving it to complete its oxidation reactions. Once the reactions are complete, the solution pH value is taken (NAG pH). A standardised volume of the solution is then titrated using sodium hydroxide and a NAG result calculated in kg H_2SO_4/t. Modified (or kinetic) and sequential NAG tests are undertaken for very reactive, or high sulphur, samples whereby a single addition of hydrogen peroxide may be consumed prior to all oxidation and neutralising reactions being completed. Temperature is recorded in kinetic NAG tests to assess oxidation rates.

Once the NAPP of the Carmichael samples was determined, the samples were classified using the following two methods:

1. By plotting the NAPP and final pH value (as measured at the end of the NAG test); and
2. Using the net potential ratio (NPR), which is defined as the ratio of ANC to MPA i.e. how many times the acid neutralising potential exceeds the maximum ability of the sample to generate acid.

Acid Base Accounting Results – Maximum Potential Acidity

The combined MPA summary statistics for:

- the roof, floor and coal; and
- the overburden and interburden material

are presented in Table 10-10. Median MPA values for the12 roof, floor and coal, and the 88 overburden and interburden materials, are 2.4 and 0.6 kgH_2SO_4/t respectively. The maximum MPA values for the roof, floor and coal samples was 18.7 kgH_2SO_4/t, compared with the much larger value of 324.4 kgH_2SO_4/t for the overburden and interburden samples.

These results suggest that the roof, floor and coal waste may have less potential to produce acid and that there may a small fraction of overburden and interburden with a larger potential to produce acid.

The MPA values reported Table 10-10 may be an overestimate of the actual potential acidity. This is because, as described above, the MPA is determined from the total sulphur content; which is assumed to all be present as reactive (or pyritic or sulphide) sulphur – available to produce acid. Where a significant portion of sulphur is present as non-reactive sulphate, a more appropriate measure of the potential for acid generation is the acid potential (AP) of the material. The AP of a sample is calculated based on the sulphide content. The sulphide content may be estimated by subtracting the sulphate-sulphur content from the total sulphur content.

Alternatively, the chromium reducible sulphur (CRS) test is a supplemental test applicable to coal material developed to differentiate between oxidisable sulphides and other forms of sulphur, which may not be acid forming.

Table 10-10 Maximum Potential Acidity Summary statistics

Statistic	Roof, floor & coal	Overburden and interburden
	kg(H_2SO_4)/t	
no. of samples	12	88
Minimum	0.15	0.15
Mean	5.3	5.7
Median	2.4	0.6
Maximum	18.7	324.4
no. MPA>3	5	11
% MPA>3	41.7	12.5

Note: minimum values correspond to half the limit of detection for total sulphur (0.01 wt%).

As noted in Table 10-7, a subset of 35 samples was submitted for sulphate sulphur and CRS measurement. All samples to be subjected to CRS testing were also submitted for sulphate sulphur analysis.

Roof, Floor and Coal MPA

Sulphide S (non-sulphate sulphur) as a function of total sulphur are plotted in Figure 10-8. CRS and sulphide S are plotted in Figure 10-9, and CRS and total S are plotted in Figure 10-10. The ratios in all three graphs indicate that not all total sulphur is available as reactive, or pyritic sulphur. For example, Figure 10-10 shows that in 4 out of 7 samples, approximately half or less of the total sulphur is present as oxidisable, or acid generating sulphur. The relationships shown in Figures 10-8 to 10-10 inclusive, suggest that the MPA has been overestimated in these samples when calculated using only total sulphur values. However, it is recognised that the number of samples (eight) is small, and more samples from across the site are needed to increase the statistical confidence.

Figure 10-8 Sulphide sulphur vs total sulphur for roof, floor and coal samples

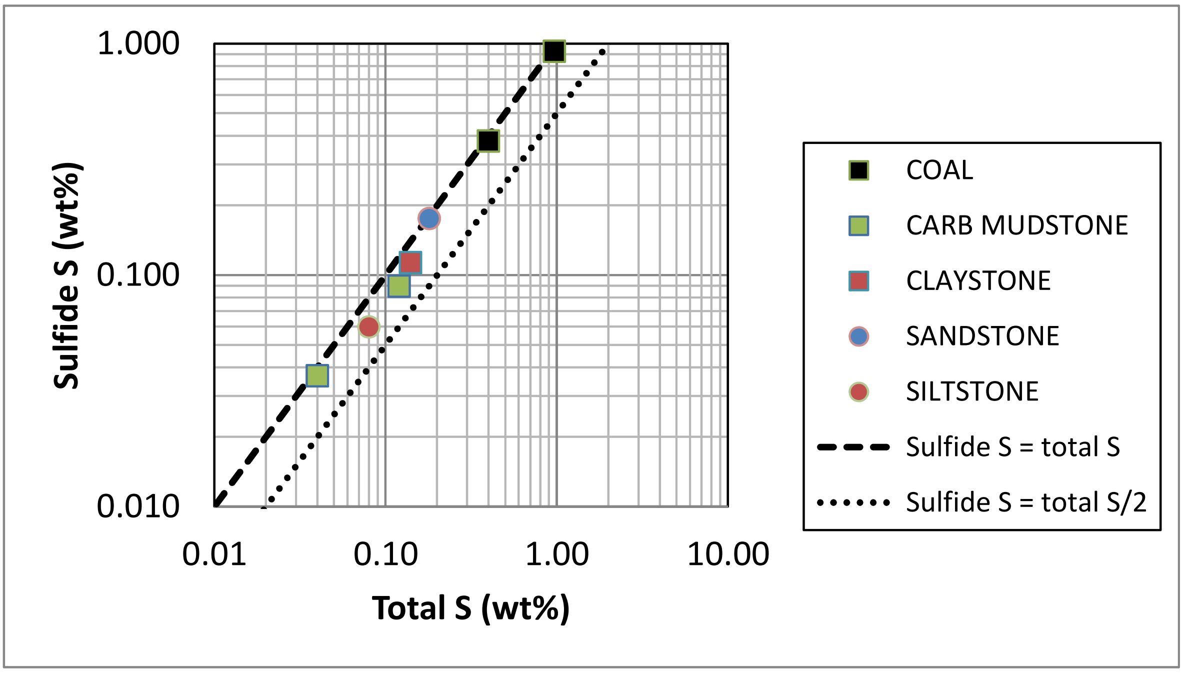


Figure 10-9 Chromium reducible sulphur vs sulphide sulphur for roof, floor and coal samples

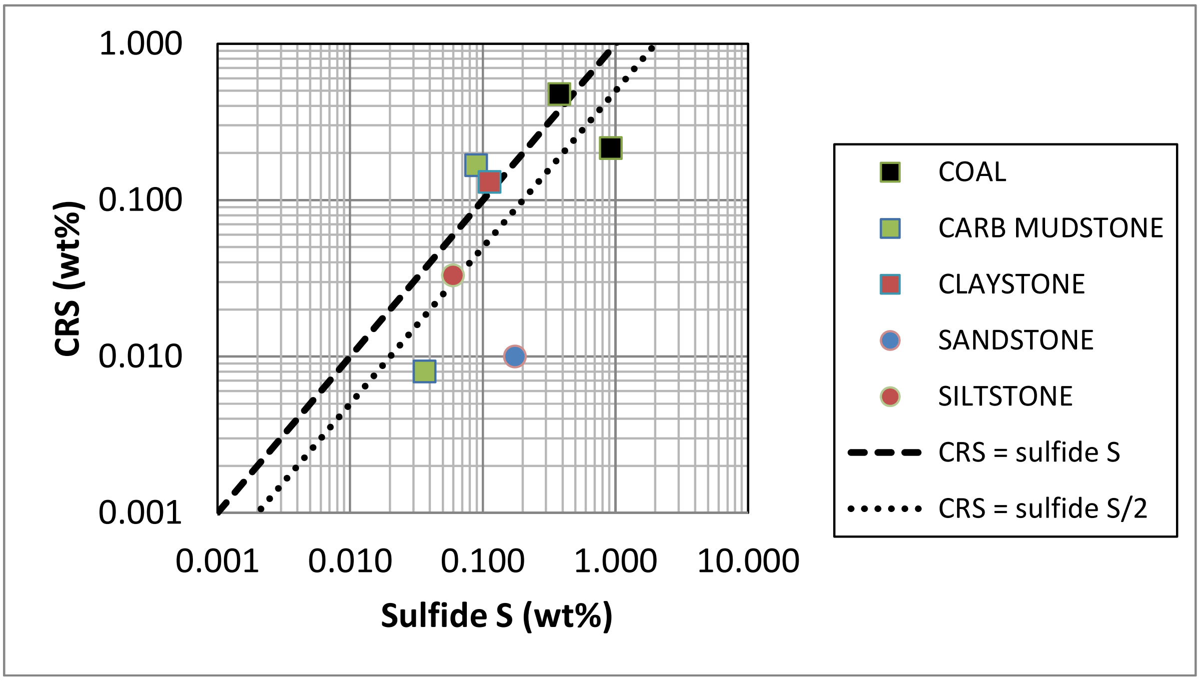
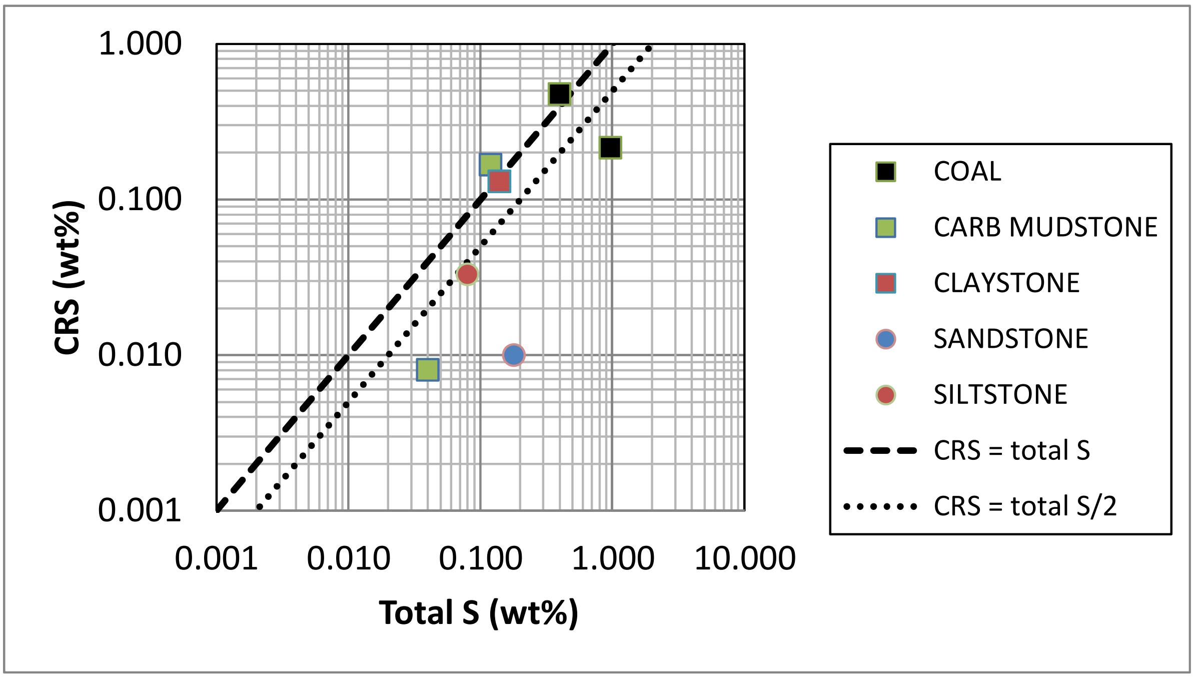


Figure 10-10 Chromium reducible sulphur vs total sulphur for roof, floor and coal samples

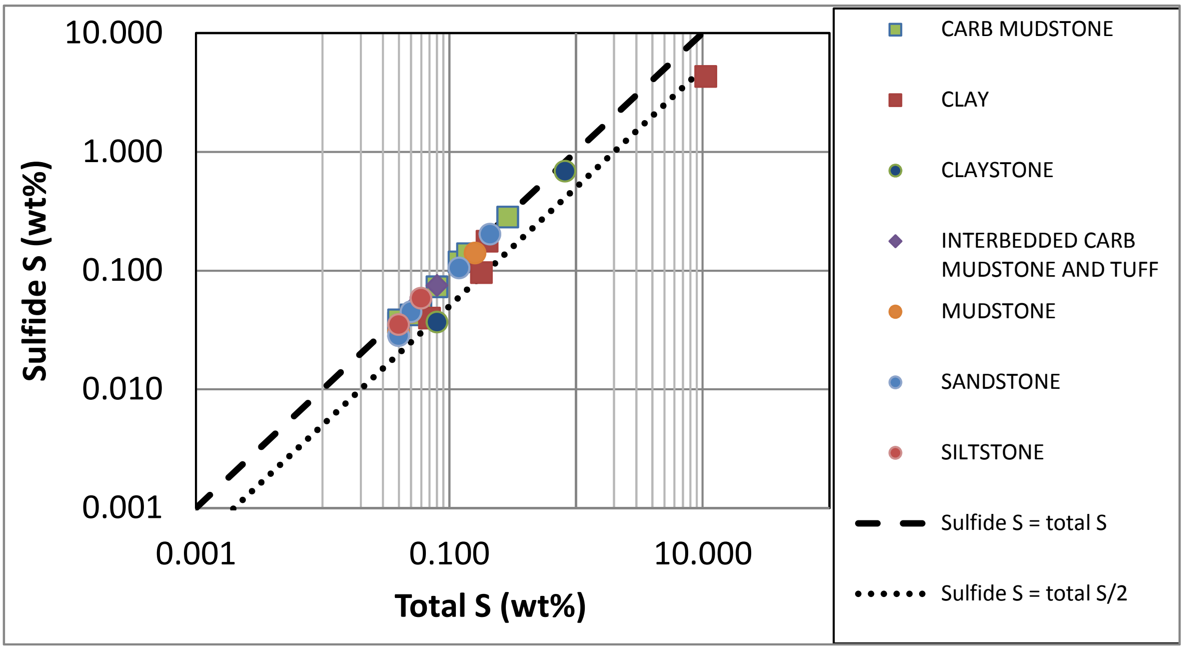


Over and Interburden MPA

A plot of sulphide sulphur (total sulphur minus sulphate sulphur) as a function of total sulphur for the overburden and interburden samples is presented in Figure 10-11. The dashed line represents a line of equivalence, where the sulphide sulphur and total sulphur are equal. The dotted line is where the sulphide sulphur content is half the total sulphur content.

The maximum sulphate sulphur content of 33 of the 35 samples is 0.13 wt%. However, two samples were reported to have sulphate sulphur contents of 6.3 and 6.87 per cent. The majority of the samples saw the sulphate sulphur content being a small fraction of the total S content, meaning that most of the total sulphur is reactive, or pyritic sulphur available to produce acid. However, there were still several samples where the sulphate S content was about 50 per cent of the total sulphur, ensuring that only around half of the total sulphur is available to produce acid.

Figure 10-11 Sulphide Sulphur vs Total Sulphur for Over and Interburden Samples



In 16 of the 35 samples the chromium reducible sulphur was less than 50 per cent of the sulphide sulphur (Figure 10-12) suggesting that some of the sulphide sulphur may not be in oxidisable form, and therefore unable to produce acid. This indicates that potentially species including alunite, barite or other insoluble sulphate minerals (compounds not soluble in HCl) may be present.

A plot of the CRS is shown as a function of the total sulphur in Figure 10-13. The CRS was less than 50 per cent of the total sulphur for 20 of the 35 samples (74 per cent) implying that only around half of the sulphur is available to produce acid. For the clay and claystone samples, the CRS contents approached zero indicating that these lithological units may not contain sulphide minerals. Oxidisable (or pyritic) sulphur was the largest fraction of the total S for the sandstone and mudstone samples.

Figure 10-12 Chromium reducible sulphur vs sulphide sulphur for over and interburden samples

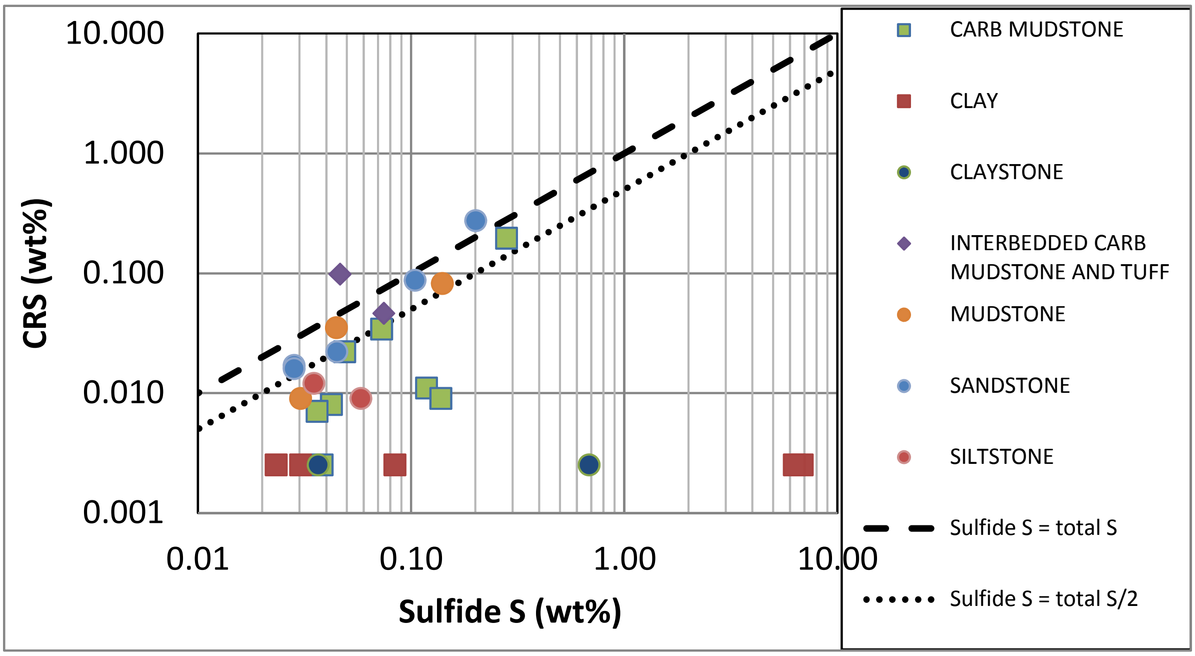
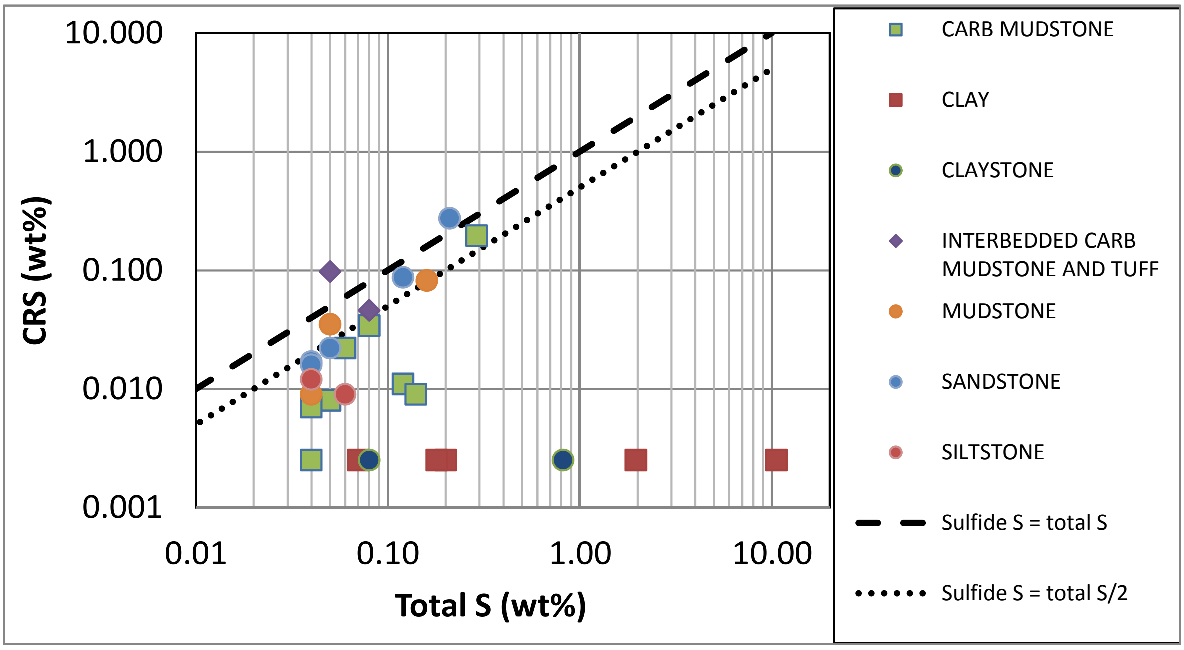


Figure 10-13 Chromium reducible sulphur vs total sulphur for over and interburden samples



Acid Base Accounting Results – Acid Neutralising Capacity

The combined acid neutralising capacity (ANC) summary statistics for the 12 roof, floor and coal and the 88 overburden and interburden are presented in Table 10-11. The median ANC values for the roof, floor and coal and the overburden and interburden materials was 6.8 and 14.2 kgH_2SO_4/t respectively. However, in each case, there are samples with ANC greater than 300 kgH_2SO_4/t.

Table 10-11 Acid Neutralising Capacity Summary Statistics

Statistic	Roof, floor & coal	Overburden and interburden
	ANC	
	kg(H_2SO_4)/t	
no. of samples	12	88
Minimum	0.7	0.3
Mean	72.0	26.9
Median	6.8	14.2
Maximum	381.0	315.0

As for sulphur speciation above to fine-tune the MPA of a sample, so too, the ANC of a sample can be fine-tuned. It is the calcium and magnesium carbonates including for example calcite ($CaCO_3$) and dolomite ($CaMg(CO_3)_2$) that are of greatest importance in terms of neutralising acid, as they react rapidly and buffer acid in the near neutral pH range (7.0).

To better define the reactive carbonate content available for acid neutralisation, the total inorganic carbon (TIC) content can be subtracted from the total carbon value to infer the reactive carbonate content. The net value is termed the carbonate neutralization potential (CarbNP). The CarbNP of a subset of 32 samples was measured and the summary statistics are presented in Table 10-12.

Table 10-12 Carbonate neutralising potential summary statistics

Statistic	Roof, floor & coal	Overburden and interburden
	CarbNP	
	kg(H_2SO_4)/t	
no. of samples	6	26
Minimum	0.001	0.001
Mean	98.1	10.8
Median	12.7	4.1
Maximum	359.2	44.1

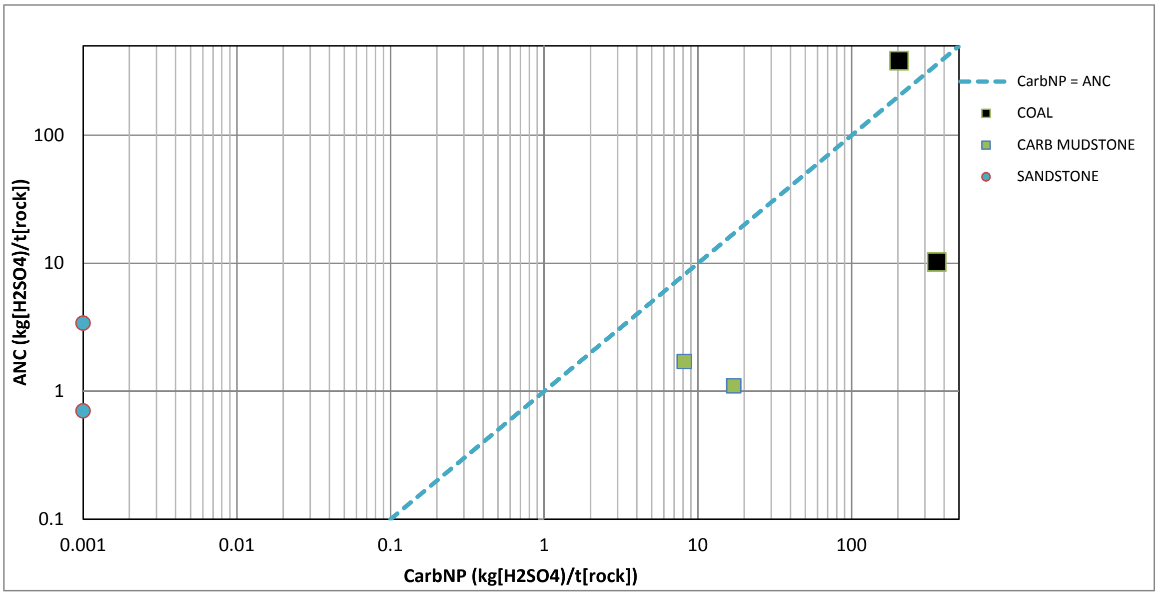
The ANC is plotted as a function of CarbNP in Figure 10-14 (6 roof, floor and coal samples) and Figure 10-15 (26 over and interburden samples). A line of equivalence is also shown on each plot (dotted diagonal line), which indicates where the ANC equals the CarbNP. Where the CarbNP equals or exceeds the ANC (below the line of equivalence) it may be assumed that a portion of the carbonate minerals present, do not contribute to acid neutralisation (e.g. siderite ($FeCO_3$)). Where the ANC exceeds the CarbNP (above the line) it may be assumed that slow reacting silicate minerals contribute to the ANC.

Roof, Floor and Coal ANC

Of the roof, floor and coal samples, 3 of the 6 samples had an ANC/CarbNP ratio that is less than 1.0; thereby suggesting that some carbonate present does not contribute to the ANC (Figure 10-14).

For the other three samples with the ANC/CarbNP great than 1.0, a portion of ANC is attributed to slow reacting silicate minerals. It is therefore expected that the ANC readily available to neutralise acidity for these samples is less than that indicated by the ANC test as it is unlikely solution pH values on site would be low enough to liberate this neutralising capacity.

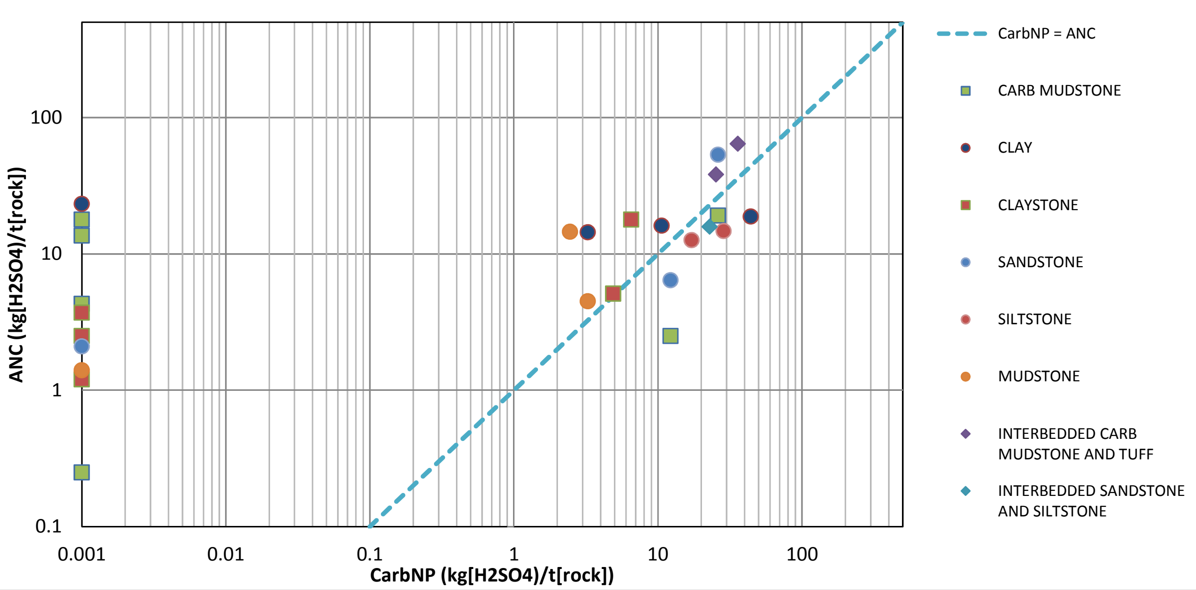
Figure 10-14 Acid Neutralising Capacity Plotted as a Function of Carbnp (Roof, Floor and Coal)



Overburden and Interburden

Approximately 65 per cent of the overburden and interburden samples had at least 30 per cent of the ANC not present as carbonate, and therefore, it may be attributed to the presence of slow reacting aluminosilicate minerals (Figure 10-15). The presence of non-neutralising carbonates in the waste is consistent with the records of siderite in the drill logs.

Figure 10-15 ANC plotted as a function of CarbNP (overburden and interburden)



Acid Base Accounting Results – Acid Base Characteristic Curve (ABCC)

In addition to fine-tuning carbonate availability as an acid neutralising agent as demonstrated above, the utilisation of acid base characteristic curves (ABCC) are an additional check to infer the availability of carbonate neutralisation potential. The test involves the slow titration of a sample with hydrochloric acid, whilst continuously monitoring pH values. The ABCC results may be used to infer the availability of the neutralisation potential by calculating the equivalent ANC to pH 6. The ANC measured above pH 6 is indicative of buffering by calcium and magnesium carbonate minerals, such as calcite and dolomite; and therefore implies that it is available for acid neutralisation.

A total of 18 samples with a broad range of initial ANC values were selected for ABCC testing. To assess the variance between methods, the results of the ABCC tests were compared with the ANC and CarbNP in Table 10-13.

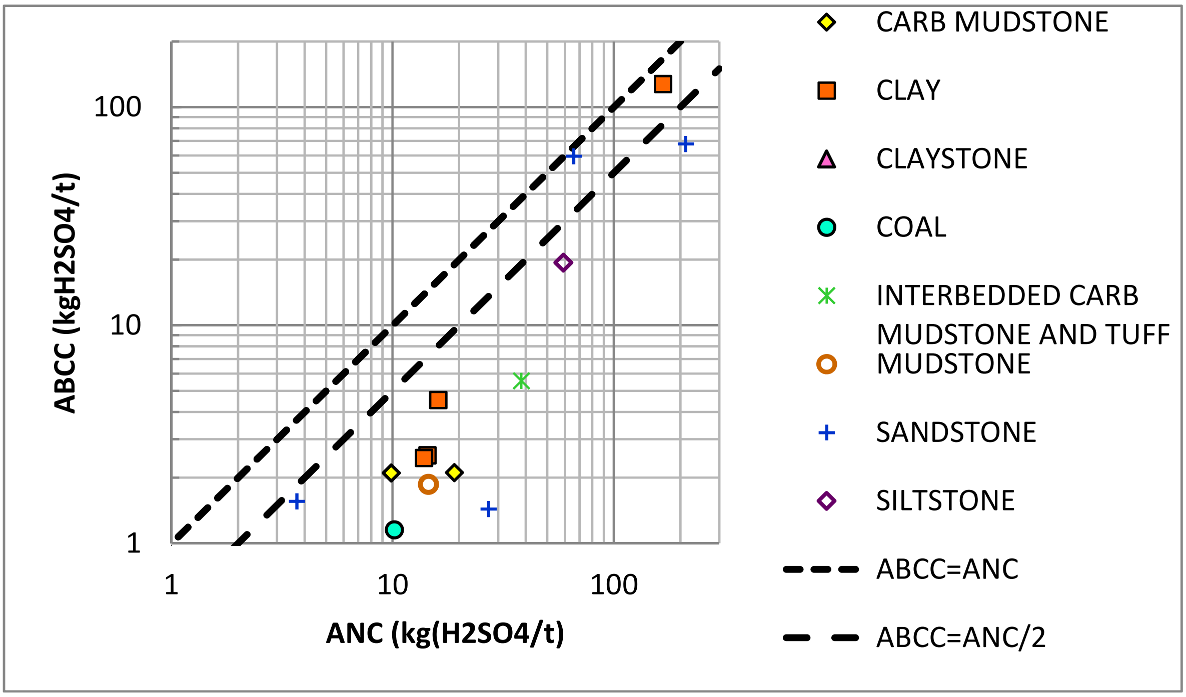
Further, Figure 10-16 presents a plot of ANC versus available ANC determined from the ABCC test results. The results in both Table 10-13 and Figure 10-16 show that the ABCC neutralisation potentials to pH 6 are significantly lower than those indicated by the CarbNP and ANC methods. As a group the sandstone samples tend to have the largest portion of available ANC, however, again the number of samples characterised is small and more samples will be tested to confirm this result from the samples collected in late November 2012.

The neutralising capacity available to buffer above pH 6.0 ranges between <1 to 127 kgH_2SO_4/t and the fraction of ANC available ranges between 4 and 90 per cent of the ANC, suggesting the balance of neutralising capacity as measured by the ANC method may be due to reactions with aluminosilicates at low pH values. Hence, the ANC and the CarbNP may overestimate the neutralisation potential that is available immediately to buffer the pH to above 6 (i.e. to prevent the onset of acid generating conditions).

Table 10-13 Summary of neutralising capacity derived from ANC, CarbNP and ABCC tests

Client sample ID	Lithological unit	ANC	CarbNP	ABCC (to pH 6)	ABCC (to pH 4.5)	Available ANC (to pH 6)
		kgH_2SO_4/t				%
81381	CARB MUDSTONE	19.1	26.12	2.1	3.7	11
81392	CARB MUDSTONE	11.2	-	0.5	1.1	4
81415	CARB MUDSTONE	9.9	-	2.1	2.8	21
81445	CARB MUDSTONE	2.5	12.24	0.3	0.9	13
81356	CLAY	14.4	3.27	2.5	4.8	18
81374	CLAY	167	-	127.2	136.9	76
81376	CLAY	13.9	-	2.5	4.5	18
81394	CLAY	16.1	10.61	4.5	6.8	28
81362	CLAYSTONE	3.7	0.82	0.4	1.0	10
81382	COAL	10.2	359.17	1.2	2.2	11
81439	INTERBEDDED CARB MUDSTONE AND TUFF	38.3	25.31	5.6	13.3	15
81403	MUDSTONE	14.5	2.45	1.9	3.1	13
81368	SANDSTONE	27.2	-	1.4	2.8	5
81380	SANDSTONE	65.9	-	59.6	78.0	90
81384	SANDSTONE	3.7	-	1.6	5.3	42
81391	SANDSTONE	212	-	67.8	134.4	32
81405	SANDSTONE	3.4	0.82	0.5	1.0	14
81371	SILTSTONE	59.3	-	19.4	23.4	33

Figure 10-16 ANC vs ABCC to pH 6



Acid Base Accounting Results – Sample Classification

As noted above, once the NAPP of the Carmichael samples was determined, considering fine-tuning of sulphur and carbonate species, the samples were classified using the following two methods:

1. By plotting the NAPP and final pH value (as measured at the end of the NAG test) (AMIRA 2002); and
2. Using the net potential ratio (NPR), which is defined as the ratio of ANC to MPA i.e. how many times the acid neutralising potential exceeds the maximum ability of the sample to generate acid.

In order to classify the geological units by AMD risk using the AMIRA (2002) method, use of the NAG test was required.

NAG Testing

The AMIRA (2002) described the single addition NAG test method used to classify the samples according to their potential to be acid forming. The scheme takes account of both the NAGpH and the NAPP of the sample, and was designed to be used for samples with low carbon contents. The samples were classified according to the scheme shown in Table 10-14. Actual NAG results and the sample classifications are presented in Volume 4, Appendix V Acid Mine Drainage Report.

Table 10-14 Acid base accounting classification

Class	Sub-class	Description
NAF	NAF	Samples with a negative NAPP value and a NAG pH of ≥4.5
	NAF-Barren	As above, and also a low ANC (≤5 kgH_2SO_4/t). Such samples have little value with respect to mitigating the effects of acid production in other mine waste materials
PAF	PAF	Samples with a positive NAPP value and a NAG pH of <4.5
	PAF-LC	PAF materials associated with low NAG acidities (NAGpH4.5 < 5 kgH_2SO_4/t)
Uncertain	UC(PAF)	Samples with negative NAPP but giving NAG pH values <4.5 or NAPP ≥0 but giving NAG pH values ≥4.5 and total S > 1%S.
	UC(NAF)	Samples with NAPP ≥0 but giving NAG pH values ≥4.5 and total S ≤ 1%S. Possibly in these samples some of the sulphur present is in non-pyritic forms

Notes: ANC=acid neutralisation capacity; NAPP=net acid producing potential; NAG pH=pH measured during net acid generation test.

The classification results for roof, floor and coal material in addition to over and interburden material, are plotted in Figure 10-17 and Figure 10-18 respectively.

Figure 10-17 AMIRA (2002) classification of roof, floor and coal samples

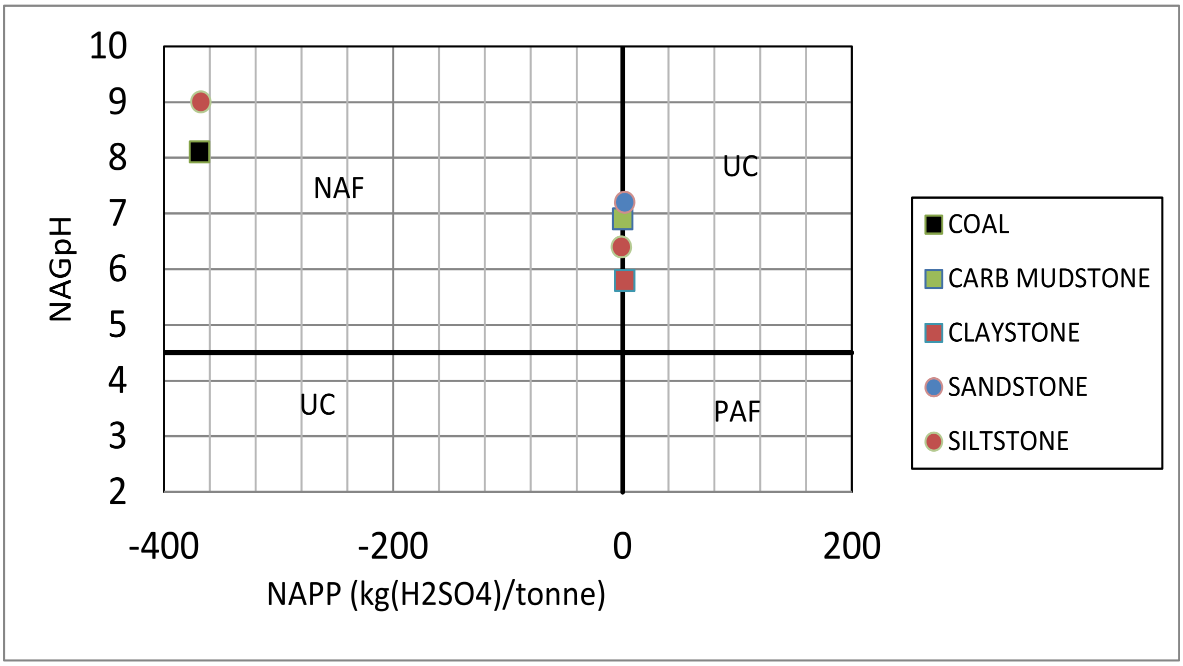
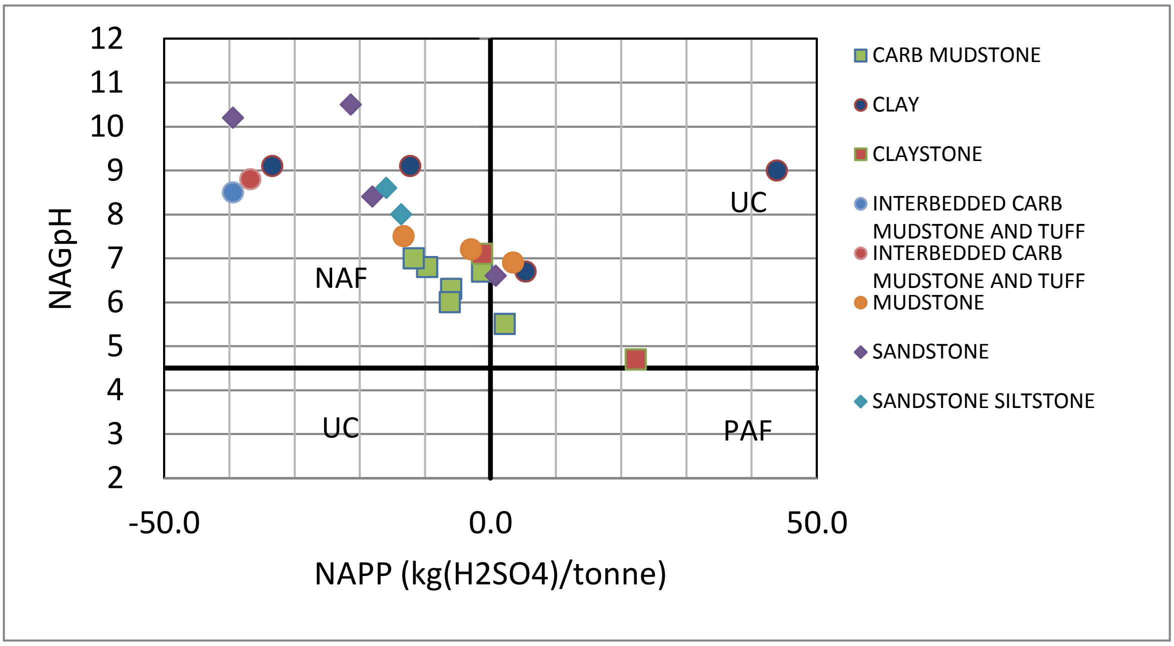


Figure 10-18 AMIRA (2002) classification of over and interburden samples



In addition to the 6 single addition NAG tests undertaken on roof, floor and coal samples shown in Figure 10-17, one sample of coal and one of carbonaceous mudstone were subjected to the modified, or extended boil, NAG tests. The latter two samples are not plotted on Figure 10-17 as they have undergone a different analytical method. It is noted that the number of samples from any lithological unit is very small and the geochemical characteristics of the set therefore may not accurately represent the distribution of characteristics present in the waste at the site. Therefore, additional NAG testing is scheduled for the samples collected in late November 2012.

Results indicate that all 6 samples plotted on Figure 10-17 are either NAF or uncertain. Samples plotting in the upper right UC quadrant are often representative of the presence of non-reactive sulphur forms, whereby gypsum or sulphate have been included in the NAPP value. That fact notwithstanding, and as noted above, further testing of roof, floor and coal material will be undertaken as part of the geochemical sampling/testing programme in late November 2012. Additional sampling and analysis will assist with understanding the distribution of geochemical characteristics for the various roof, floor and coal wastes.

Table 10-15 presents the sample classification results using the AMIRA (2002) and extended boil methods.

Table 10-15 Combined standard and extended boil NAG classification for roof, floor and coal samples

Carmichael Sample ID	Lithological Unit	AMIRA/NAG Classification [1]
81355	CARB MUDSTONE	UC(NAF)
81400	CARB MUDSTONE	**PAF**
81358	CLAYSTONE	UC(NAF)
81370	COAL	NAF
81382	COAL	**PAF**
81405	SANDSTONE	UC(NAF)
81372	SILTSTONE	NAF
81373	SILTSTONE	NAF-Barren

1: Refer Table 10-14

Twenty seven of the over and interburden samples were also subjected to either single addition or extended boil NAG tests. The full results are presented in Volume 4, Appendix V Acid Mine Drainage Report. AMIRA (2002) classification of the single addition NAG tests on the over and interburden samples is plotted on Figure 10-18. Results indicate that all samples are either NAF or UC. One claystone sample plots just above the PAF boundary in the upper right UC quadrant.

In addition to the single addition NAG samples presented in Figure 10-18, two carbonaceous mudstone and one sandstone sample were subjected to extended boil NAG tests. The carbonaceous mudstone samples were subsequently classified as NAF, while the sandstone sample was classified as PAF (not plotted due to different analytical methodology); refer Volume 2, Appendix V – Appendix C.

Table 10-16 provides the breakdown of over and interburden samples by rock type and AMD risk classification. Nineteen of twenty seven samples were classed as either NAF or NAF-Barren, with a further seven samples being classified as uncertain.   One sample was classified as PAF.

The number of samples is again small; however, the results indicate that some PAF material may be present in the over and interburden waste rock. Characterisation of additional samples will be undertaken to determine the distribution of PAF material across the site from the samples collected in late November 2012.

Table 10-16 Combined AMIRA (2002) and extended boil classification (over and interburden)

	NAF-Barren	NAF	UC (NAF)	UC (PAF)	PAF	Total
CARB MUDSTONE	1	6	1	0	0	8
CLAY	0	2	1	2	0	5
CLAYSTONE	1	0	1	0	0	2
INTERBEDDED CARB MUDSTONE AND TUFF	0	1	0	0	0	1
INTERBEDDED SANDSTONE AND SILTSTONE	0	1	0	0	0	1
MUDSTONE	1	1	1	0	0	3
SANDSTONE	0	3	1	0	1	5
SILTSTONE	0	2	0	0	0	2
Subtotal	**3**	**16**	**5**	**2**	**1**	**27**
Per cent	11	59	19	7	4	100

The second classification method noted above is the neutralisation (or net) potential ratio, or NPR. The NPR classification scheme is based on the ability for an excess of neutralising capacity (ANC) inherent in the sample to exceed the maximum acid potential (MPA) of the sample; and includes a contingency margin.

For waste rock, a sample may be classified using the NPR as follows:

- NPR < 1 – potentially acid forming (PAF)
- 1 < NPR < 3 – uncertain (UC)
- NPR > 3 – non-acid forming (NAF)
- Total S < 0.1 wt% – non-acid forming as net acid production is low (< 3 kg(H_2SO_4)/t))

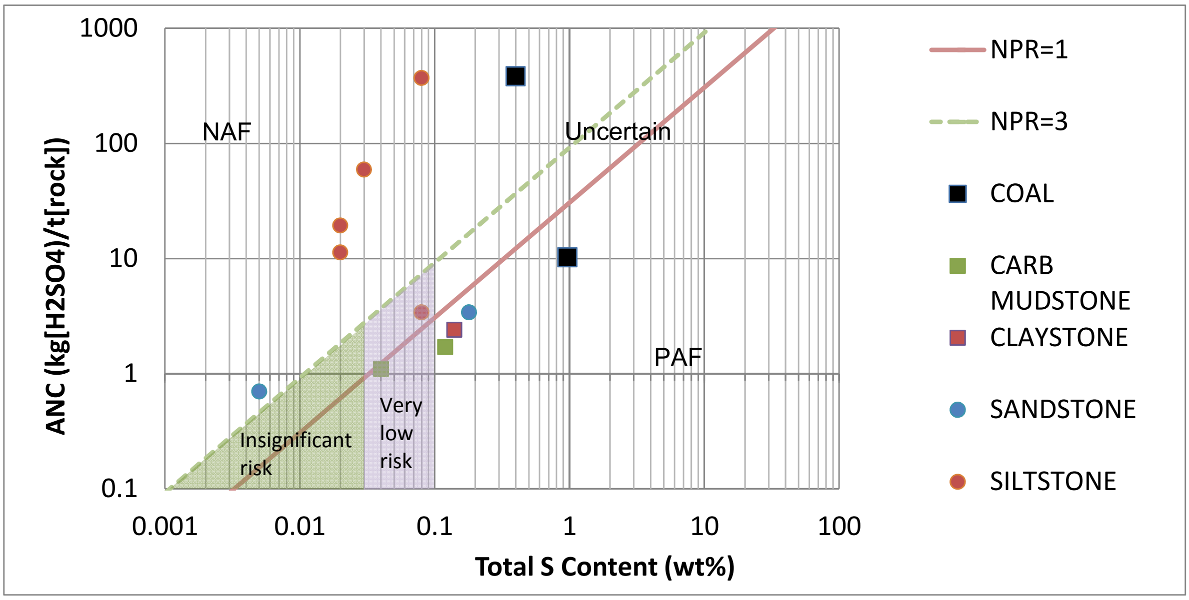
Note the last criterion involving total sulphur is not a part of the standard NPR method. It is adopted herein because samples with potential acid loads of less than 3 kg(H_2SO_4)/t are considered of low risk.

The NPR classification scheme becomes more accurate by replacing the MPA with the AP based on estimates of the sulphide sulphur content rather than the total sulphur, in addition to estimates of the neutralising capacity based on ABCC results. However, as AP and ABCC were not undertaken on all samples, standard ANC and MPA results (using weight per cent total sulphur) were used in the NPR classification.

Figure 10-19 presents the total sulphur and ANC results for the 2 samples of coal and 10 samples of roof and floor material. The green dashed line in the plot differentiates samples with characteristics that are NAF (NPR>3) from those that are UC (1 < NPR < 3). The solid pink line differentiates the samples with PAF (NPR<1) characteristics from those that are UC. The samples below the solid pink line also have a positive NAPP. The calculated NAPP and NPR values and the sample classifications based on the NPR are shown in Table 10-17.

The results in Figure 10-19 indicate that a proportion of the coal would be expected to be acid generating. As much of this coal is saleable product rather than waste, it would be stockpiled on site only for a short period of time. Given that there would be appropriate runon and runoff controls in place, any potential for AMD generation would be greatly reduced. The results also indicate that a portion of the roof and floor material would also be expected to be potentially acid forming.

Figure 10-19 NPR plot of roof, floor and coal samples



The raw coal samples would also potentially be representative of uneconomic coal that would be left in the pit. A portion of the roof and floor material, which may comprise non-coal material immediately above and below the coal seams, would also remain in the pit.

Table 10-17 Roof, Floor and Coal Sample Classification (NPR Method)

	No. of samples				Percentage of samples		
	NAF	UC	PAF	Totals	NAF	UC	PAF
Coal	1	0	1	2	50.0	0.0	50.0
Roof and Floor	7	0	3	10	70.0	0.0	30.0
Totals	8	0	4	12	66.7	0.0	33.3

In addition, the coal material may act as a surrogate for any fine tailings that may be generated by coal washing in the CHPP. In this regard, and in lieu of any tailings samples, it is implied that any tailings may have an AMD risk.

As the number of samples that have been tested at this stage is small the inferences drawn from the measurement results must be considered as interim results. These inferences would be reviewed subsequent to the analysis of additional samples scheduled for collection in late November 2012. Additionally, actual coal tailings samples would be analysed once generated under a pilot plant or

similar. Such testing is proposed in parallel with geochemical analysis of samples collected in late November 2012.

Figure 10-20 shows the NPR classification of all 88 overburden and interburden samples. Classification criteria are the same as for the roof, floor and coal material shown above. A summary of the over and interburden samples' NPR classification by geological group is shown in Table 10-18. The results plotted in Figure 10-20 indicate that 4 samples plot as PAF.

Figure 10-20 NPR plot of over and interburden samples

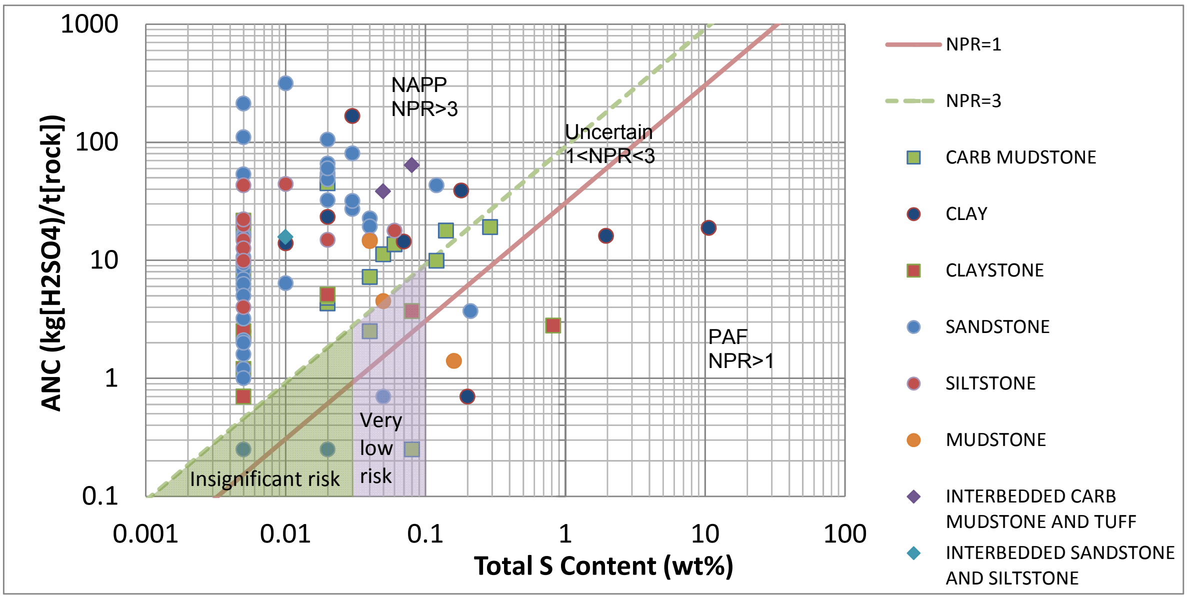


Table 10-18 Overburden and Interburden Sample Classification (NPR method)

Lithology	No. of samples				Percentage of samples		
	NAF	UC	PAF	Total	NAF	UC	PAF
Carbonaceous mudstone	9	2	0	11	81.8	18.2	0.0
Clay	9	0	3	12	75.0	0.0	25.0
Claystone	8	0	1	9	88.9	0.0	11.1
Interbedded mudstone and tuff	2	0	0	2	100.0	0.0	0.0
Interbedded sandstone and siltstone	1	0	0	1	100.0	0.0	0.0
Mudstone	2	0	1	6	33.3	33.3	33.3
Sandstone	38	0	1	39	97.4	0.0	2.6
Siltstone	11	0	0	11	100.0	0.0	0.0
Totals	80	2	6	88			

The results presented in Table 10-18 indicate that:

- The mudstone samples were equally divided amongst NAF, UC and PAF classes.
- The lithologies with the largest percentage classed as PAF or UC were carbonaceous mudstone, clay, claystone, and mudstone. Materials from these lithologies may require management to control the development of AMD.
- All siltstone and the large majority of sandstone samples were classed NAF, thus some sandstone and siltstone materials may be suitable for use in management strategies designed for the control of AMD generation in UC and PAF materials.

Again it is recognised that the number of over and interburden samples tested at this stage is relatively small for a project the size of Carmichael. Thus, as for the roof, floor and coal samples, inferences drawn from the measurement results for over and interburden must be considered as interim results. These inferences would be reviewed subsequent to the planned analysis of additional geochemical samples scheduled for collection in late November 2012.

Elemental Abundance

A direct comparison of the measured elemental abundance in the 100 solid samples was made and compared against average global abundance of elements in sediments using appropriate references. This was undertaken to determine what, if any, elements are present in samples higher than global average, and therefore, which elements may be present in leachate in higher concentrations once the material has been disturbed.

As the abundance of elements varies many-fold, a log base 2 index is used to simplify comparison of measured abundances with average global abundances. The index is called the ‘global abundance index’ (GAI), and is calculated by:

$$\text{GAI} = Int\left(\log_2\left(\frac{\text{Measured Concentration}}{1.5\times\text{Average Abundance}}\right)\right)$$

The GAI classification scheme is shown in Table 10-19. In the table *n* is the ratio of the measured abundance in the sample to the reference material abundance. Zero or positive GAI values indicate enrichment of the element in the sample when compared to average global abundances. As a general rule, a GAI of 3 or higher signifies enrichment that warrants further evaluation. The GAI values all presented in Volume 4, Appendix V.

Table 10-19 GAI classification scheme

n range	GAI
$1.5 < n < 3$	0
$3 \leq n < 6$	1
$6 \leq n < 12$	2
$12 \leq n < 24$	3
$24 \leq n < 48$	4
$48 \leq n < 96$	5
$96 \leq n < 192$	6

Of the 100 samples submitted for whole rock elemental analysis; the elements that were identified as enriched using GAI in more than 1 or more samples were sulphur (2 samples), silver (18), rhenium (1) and tellurium (35). As these elements are enriched, further evaluation of their leachability is required, which will be undertaken on a selection of the 370 samples being analysed in late November 2012 using the Australian Standard Leaching Procedure (ASLP) methodology, or similar.

Solute Leachability

In addition to the leaching tests noted above as identified for further assessment, 29 simple leach tests were undertaken using a 1:3 solid:water ratio over a period of 24 hours. The tests provide an indication of the soluble elements and salts that are already present in the samples and form a basis for an initial assessment of the potential for any negative impacts to drainage water quality as a result of rainfall contact with the waste.

Since the physical and chemical conditions of the leach test will not be the same as those expected in the 'as placed' environment (e.g. solubility constraints, liquid to solid ratio and particle size may be different), the leach composition is not expected to be representative of that which may develop in the field. The results cannot be directly extrapolated to predict the leachate quality expected to seep from a dump of the material, but are useful to provide an indication of the leachable elements that may be present.

Selected parameter values are presented in Table 10-20 with full results presented in Volume 4, Appendix V – Appendix E. The results have therefore been compared to Stock Water Quality Guidelines (AGWQMR, 2000) only to identify solutes that potentially may be of significance.

The pH values of all leachates were circum-neutral. The electrical conductivities, alkalinity, acidity and sulphate concentration were generally low. The largest EC value (2,120 µS/cm) was more than 4 times the next largest value and was observed for a clay sample (81394). The clay sample also exhibited the largest SO_4 concentration. These results indicate that the quality of water contacting some clay materials could be adversely impacted.

Concentrations of metals were generally low and did not exceed guideline values for livestock drinking water.

Table 10-20 Selected parameters for static leach test water quality

Sample ID		pH Value	Electrical Conductivity @ 25°C	SO_4	Aluminium	Arsenic	Cadmium	Chloride	Calcium	Iron
	Units	pH Unit	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
	AGWQMR (2000) Stock water guideline value					0.5	0.01		1000	
	LOR	0.01	1	1	0.01	0.001	0.0001	1	1	0.05
	Lithological Unit									
81351	SANDSTONE	7.44	113	4	1.72	0.006	<0.0001	5	2	0.75
81355	CARB MUDSTONE	6.51	103	2	2.06	0.004	0.0001	<1	1	0.5
81356	CLAY	6.64	274	8	2.27	0.002	0.0002	48	2	1.13
81370	COAL	7.48	176	22	0.23	0.002	<0.0001	4	5	0.09
81382	COAL	7.46	363	169	0.28	0.003	0.0006	10	112	0.28
81388	SANDSTONE	6.41	26	26	0.2	0.002	<0.0001	<1	1	0.08
81394	CLAY	6.59	2120	995	0.02	0.001	0.0004	101	269	0.06
81397	CLAYSTONE	6.54	240	15	1.4	0.002	<0.0001	43	2	0.32
81400	CARB MUDSTONE	6.21	82	20	0.55	0.023	<0.0001	2	2	<0.05
81403	MUDSTONE	7.05	95	10	1.31	0.003	<0.0001	2	2	0.68
81406	CARB MUDSTONE	6.89	207	6	0.65	0.001	<0.0001	34	3	0.13
81417	SILTSTONE	7.41	104	5	1.8	0.003	<0.0001	1	1	1.18
81420	CARB MUDSTONE	6.82	57	7	0.59	0.007	<0.0001	<1	1	0.16
81426	SANDSTONE	6.68	30	2	0.74	0.009	<0.0001	<1	<1	0.46
81433	INTERBEDDED SANDSTONE AND SILTSTONE	7.36	97	4	1.16	0.014	<0.0001	<1	2	0.66
81438	INTERBEDDED CARB MUDSTONE AND TUFF	6.62	48	6	0.99	0.011	<0.0001	2	1	0.36

Sample ID		pH Value	Electrical Conductivity @ 25°C	SO_4	Aluminium	Arsenic	Cadmium	Chloride	Calcium	Iron
	Units	pH Unit	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
	AGWQMR (2000) Stock water guideline value					0.5	0.01		1000	
	LOR	0.01	1	1	0.01	0.001	0.0001	1	1	0.05
	Lithological Unit									
81439	INTERBEDDED SANDSTONE AND SILTSTONE	6.4	20	2	1.14	0.003	<0.0001	<1	<1	0.32
81445	CARB MUDSTONE	6.81	70	8	1.46	0.001	0.0001	1	2	0.11
81450	CLAYSTONE	6.35	36	<1	0.06	<0.001	<0.0001	3	1	<0.05
81455	CARB MUDSTONE	6.71	40	<1	1.51	0.002	0.0001	<1	1	0.74

Mine Waste Dispersivity Assessment

In addition to the static geochemical tests reported above, dispersivity assessments were undertaken on a selected range of samples. Dispersivity testing is used to determine the sodicity of soils, which is essentially a cationic balance. If there is a high proportion of exchangeable sodium in the soil, the soils has the propensity to erode through tunnel erosion and gullying on the surface of the waste rock dumps, which can affect their long term stability and sustainability. In addition to having a high susceptibility to gully erosion, sodic materials can also display severe surface crusting, causing low infiltration, further hindering rehabilitation. A dispersivity assessment, therefore, provides information regarding the material that may be suitable for beneficial reuse in mine site rehabilitation.

Dispersivity can be assessed by means of chemical tests to ascertain potential causes of dispersion, or by physical tests to observe the effect of dispersion. Accordingly, four tests were conducted to determine the dispersion potential for the materials; being:

- Exchangeable sodium percentage (ESP) and cation exchange capacity (CEC);
- Emerson aggregate test; and
- Simple accelerated weathering testing on four rock samples.

For soil materials, an ESP greater than 6 per cent may indicate dispersive properties, and greater than 15 per cent indicates highly dispersive properties. The Emerson aggregate test (also called the crumb test) is a simple test in which a block of soil (about 2 cm in diameter) is placed in still water and the reaction between soil and water (slaking or dispersion) noted. If no reaction occurs, the sample is remoulded, then shaken and the reaction observed, and the sample also tested for gypsum.

Twenty eight samples were selected for the Emerson aggregate test and 14 samples for chemical testing. The samples were selected to cover all major material types and weathering grades, but with emphasis on materials more likely to show dispersive behaviour. In addition, four samples were selected for accelerated weathering testing (AWT) in which the deterioration of submerged samples was visually observed. A summary of sample selection for the dispersivity assessment is provided in Table 10-21.

Table 10-21 Number of Samples – Dispersivity assessment and weathering test

Lithological Group	Rock type	Number of Samples		
		Emerson Testing	Chemical Testing	AWT
Coal	Coal	2	1	
Clay and Soil	Clay (weathered layers)	2	1	1
Sand and Gravel	Sandstone	2	1	
Carbonaceous	Carb. Mudstone	7	2	1
Remaining	Claystone	4	3	
	Siltstone	4	3	1
	Sandstone	4	1	1
	Clay (potentially AN)	3	2	

Test results are summarised in Volume 4, Appendix V, with an interpretation of the dispersivity of each sample provided below in Table 10-22. An overall classification of dispersive, marginally dispersive and non-dispersive was assessed for each lithological group, according to results of the individual tests.

Table 10-22 Interpretation of dispersivity results

Sample ID	Lithology Group	Rock Type	Weathering	Emerson Test	CEC and ESP	Assessed Dispersivity for Group
81356	Clay And Soil	Clay	EW	D	D	Dispersive
81362	Clay And Soil	Claystone	HW	D		
81394	Potential An	Clay	EW	N	N	Dispersive
81450	Remaining	Claystone	EW	N		
81365	Remaining	Clay	HW	D	D	
81396	Potential An	Clay	HW	N		
81357	Remaining	Claystone	HW	D	D	
81400	Carbonaceous	Carb Mudstone	SW	D		
81367	Remaining	Siltstone	SW	N	M	Marginally dispersive
81351	Sand And Gravel	Sandstone	MW	N		Non-dispersive
81363	Remaining	Sandstone	MW	N	N	
81382	Coal Group	C5 Coal	FR	N	N	Non-dispersive
81370	Coal Group	Coal	FR	N		
81355	Carbonaceous	Carb Mudstone	FR	N	N	Non-dispersive, very occasionally marginal
81406	Carbonaceous	Carb Mudstone	FR	N		
81455	Carbonaceous	Carb Mudstone	FR	N		
81453	Remaining	Claystone	FR	N	M	
81438	Carbonaceous	Interbedded Carb Mst And Tuff	FR	N		
81401	Carbonaceous	Mudstone	FR	N	N	
81403	Carbonaceous	Mudstone	FR	N		Non-dispersive
81404	Remaining	Sandstone	FR	N		
81405	Sand And Gravel	Sandstone	FR	N	ND	

Sample ID	Lithology Group	Rock Type	Weathering	Emerson Test	CEC and ESP	Assessed Dispersivity for Group
81410	Remaining	Sandstone	FR	N		
81436	Remaining	Sandstone	FR	N		
81371	Remaining	Siltstone	FR	M	M	Marginal or non-dispersive
81379	Remaining	Siltstone	FR	M		
81418	Remaining	Siltstone	FR	N	N	

Where: D = dispersive, M = marginally dispersive and N = non-dispersive

Paste testing, and results from leach testing, suggest that the rock samples contained little salinity; paste electroconductivity (EC) ranged from 37 to 584 µS/cm for fresh rock and 525 to 1,170 µS/cm for weathered rock. The clay samples showed high salinity, with EC ranging from 2,030 to 3,740 µS/cm. The exchangeable sodium percentage (ESP) values ranged from 3.8 to 56.7 per cent. While these values classify the samples as sodic to strongly sodic the results should be viewed in the context of low cation exchange capacities of less than 10 meq/100g.

Overall, the clay and soil group and weathered mudstone, claystone, carbonaceous mudstone and siltstone generally showed dispersive behaviour. Slightly weathered siltstone and fresh mudstones may show very slight potential for dispersivity. The weathered sandstone did not show any indication of dispersive behaviour. The fresh rocks generally tested non-dispersive, although some claystones and siltstones showing a very low potential for dispersion. There was variability in dispersion results within each group. This indicates that not all materials within a group show the same degree of dispersivity.

The AWT showed that the weathered rock, siltstone and sandstone showed potential for deterioration and breakdown after exposure to water. The siltstone showed moderate deterioration, and sandstone slow deterioration. This may indicate that although the fresh rock units are not dispersive, they are not durable, and with time may degrade. The degraded material may be more prone to physical erosion than the original fresh rock.

This dispersivity assessment should be read in conjunction with the soils chapter, and the Soils, Pre Mining Land Suitability and Stripping Recommendations for the Carmichael Mine (Volume 2, Section 4 Land).

10.2.1.6 Summary

One hundred samples of potential mine wastes and coal materials were taken from drill core and assessed for their potential to produce acid and metalliferous drainage (AMD). Eighty eight samples were of overburden and interburden, 12 samples were roof, floor or coal materials. No coal reject samples were available for characterisation. Standard static geochemical tests were conducted to characterise the samples. Net potential ratio (NPR) and AMIRA (2002) methods were used to classify the materials into acid generating or non-acid forming categories.

Twenty four samples were tested to determine their potential to be dispersive.

Based on the available results the majority of the overburden and interburden materials (not immediately adjacent to the coal seams) and roof and floor wastes are not likely to be a source of acid immediately after mining. Nor would most of these materials be expected to an immediate source of salinity; however, some portion could be a source of salinity. The clay materials of the overburden and interburden could have a markedly higher potential to release salts and metals to contact water even though the pH may remain alkaline. Typically however, the concentrations of metals in water contacting the waste would be expected to be low while waters remain circum-neutral.

A portion of the carbonaceous mudstone, claystone and sandstone roof and floor and coal materials could be expected to be potentially acid forming in the longer term. The majority of the overburden and interburden waste from all lithological groups is likely to be non-acid forming in the longer term. Some clay, claystone, mudstone and sandstone components of the overburden and interburden may be acid forming in the long term and there may be a requirement to manage these materials prevent or limit the longer-term development of AMD.

All siltstone overburden and interburden samples were classed non-acid forming (NAF).

There was variability in dispersion results within each lithological group. The fresh rocks were typically non-dispersive, however, there was a very low potential for dispersion for some lithological groups.

The clays, weathered mudstone, claystone, carbonaceous mudstone and siltstone generally may exhibit dispersive behaviour. Slightly weathered siltstone and fresh mudstones may show a very slight potential for dispersivity. The weathered sandstone did not show any indication of dispersive behaviour.

Weathered rock (all lithological units), fresh siltstone and fresh sandstone showed potential for deterioration and breakdown after exposure to water. The fresh siltstone showed a moderate rate of deterioration, and the fresh sandstone showed slow deterioration. This may indicate that although the fresh rock units are not dispersive, they are not durable, and with time may degrade to sand, silt or clay. The degraded material may be more prone to physical erosion than the original fresh rock.

Further sampling and testing is required to estimate average values of AMD parameters for the significant lithological units, and to characterise the spatial variability of AMD related parameters for all lithological units. To that end, an additional sampling and static geochemical analytical program of 370 samples are being selected for testing in late November 2012, along with 12 kinetic leach columns being commissioned to determine longer term AMD and saline drainage risk.

10.2.2 Potential Impacts and Mitigation Measures

10.2.2.1 Over and Interburden

Potential Impacts

Approximately 22.9 billion bank cubic metres (bcm) of over and interburden will be generated from the open cut section of the Carmichael mine during the mine life. Of this material, for the first 5 years of operation, some 2.7 billion bcm of the total 22.9 billion bcm will initially be stored in out of pit waste rock structures on EPC1080 and on the eastern side of the coal sub-crop on EPC 1690. Following this, the balance of the material will be placed into mined out voids as these become available. The material will include weathered Tertiary material, in addition to fresh and weathered soils and rock from the Triassic and late Permian units that must be removed in order to access the coal seams.

Potential impacts from the excavated mine over and interburden includes acid and metalliferous (AMD) and/or saline drainage from higher risk materials. The geochemical test work reported in this chapter suggests that some proportion of the Carbonaceous Group, which included carbonaceous claystones, carbonaceous mudstones, shales and carbonaceous siltstone, in addition to the uneconomic C coal seam may be potentially acid forming. The approximate maximum volume of Carbonaceous Group material within fresh interburden required for removal as determined within the limitations of this study was calculated as 1 billion bcm, or approximately 5.5 per cent of total waste. The approximate maximum volume of the C seam in pits and therefore required to be removed is 0.8 billion bcm, which represents approximately 3.5 per cent of the total mine waste. Therefore, based on the limitations of the mine waste geochemistry assessment, a total of 1.8 billion bcm, or around 8 to 9 per cent of the total volume of mine waste may require the application of dedicated AMD management strategies.

In addition, there remains the potential for dispersive or sodic mine waste units to erode and negatively impact drainage water quality and rehabilitation success if not identified and selectively managed. A limited dispersivity assessment conducted as part of the mine waste geochemical assessment indicated that the clay geological units were likely to be the highest risk with respect to generating saline runoff in addition to being the most prone to being dispersive. The weathered clay and soil group, along with weathered mudstone, claystone, carbonaceous mudstone and siltstone generally showed dispersive behaviour. Slightly weathered siltstone and fresh mudstones may also show very slight potential for dispersivity.

Failure to appropriately manage the higher risk materials may result in negative impacts to drainage water quality, including acidic pH values, and elevated salinity and dissolved metal concentrations. Impacts may also include accelerated erosion and failure of engineered out-of-pit rehabilitation structures should the potentially dispersive material be beneficially reused in the capping of waste rock dumps for example. Such erosion may lead to sedimentation of waterways and negative impacts to aquatic species.

Mitigation and Management

The geochemical static testing conducted to date, being 100 samples, indicated that the Carbonaceous Group, along with the coal, is the most likely to be potentially acid forming (PAF). In addition some materials have been classed as uncertain (UC) in regard to their potential to be net acid forming. These UC samples were from a range of lithological units including mudstone, clay, claystone and sandstone.

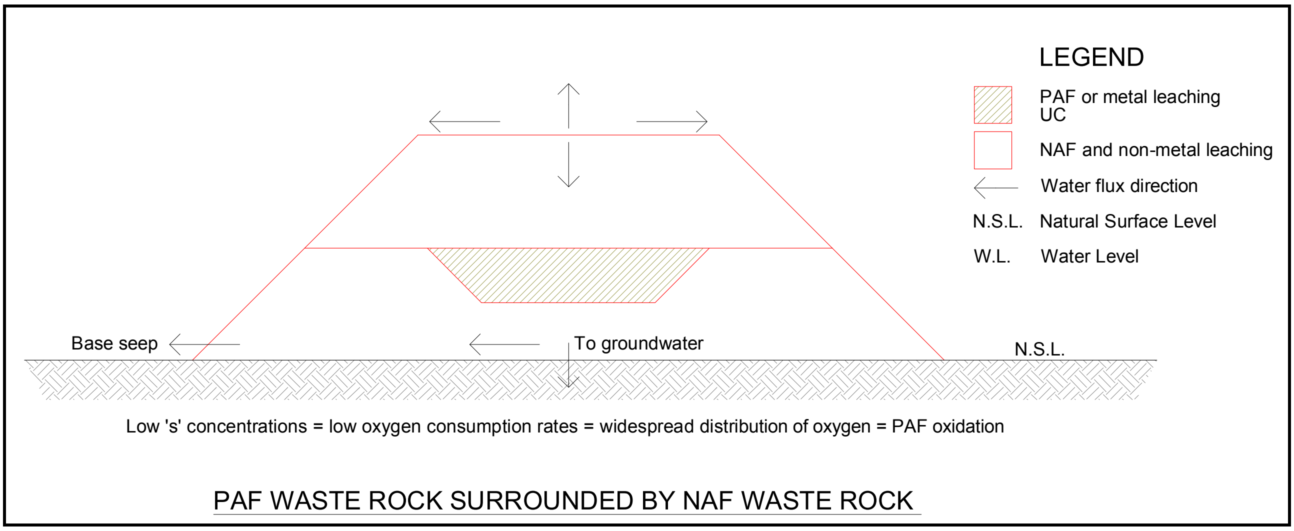
Generally, the results indicate that the majority of units within the over and interburden are likely to be non-acid forming (NAF); however, additional testing in the form of another 370 static geochemical tests and 12 kinetic leach columns is planned to increase statistical confidence in the dataset. Following assessment and reporting of these additional samples, more definitive management strategies can be determined.

Based on the estimated volumes of PAF material as described above, and considering the additional work planned to further define the AMD risk on site, some preliminary design controls considered include:

i) Covering or isolating the PAF waste with NAF materials subaerially to reduce the quantity of water making direct contact with the PAF waste, thereby reducing pyrite oxidation rates. A conceptual arrangement is shown in Figure 10-21. Compaction of the batters further reduces pyrite oxidation by reducing oxygen diffusion through the engineered structure.

ii) Co-mingling or blending the PAF waste with acid consuming waste that has excess neutralisation capacity. However, based on the geochemical assessment completed at Carmichael, there are currently no indications that such acid consuming materials will be available in suitable quantities.

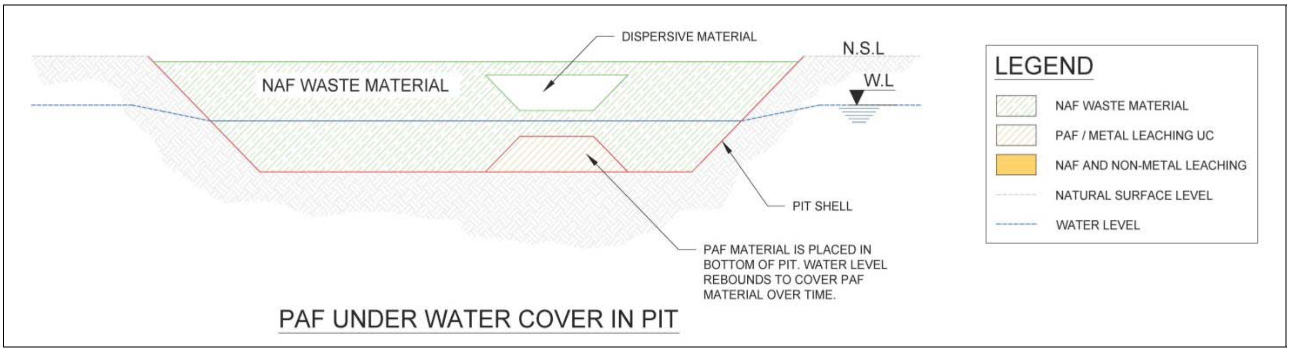
Figure 10-21 PAF mine waste encapsulated by NAF mine waste



iii) A variation of option ii) is the addition of limestone ($CaCO_3$) during deposition of PAF waste. This has been demonstrated at some sites to extend the lag time to acidification; thereby reducing the short to medium impact if balanced stoichiometrically. The benefits include improvements in surface and pore water quality prior to implementing other longer term management strategies potentially including active or passive water treatment through dosing or wetlands respectively for example.

iv) Segregating and placing the PAF waste where acid generation can easily be controlled or prevented through reduction of the rate of atmospheric and/or aqueous oxygen supply. Other than subaerially as shown in (i), this may be achieved by placing the PAF waste in the open pit below the long term groundwater table. This is shown schematically in Figure 10-22.

Figure 10-22 PAF waste rock under water cover in pit with groundwater rebound



For option (i) NAF material would be placed at the base of the out of pit waste rock dump to reduce contact between PAF waste and the water that flows at the interface of the waste (base of the dump) and the original ground surface. PAF material would then be covered with NAF material, graded to an appropriate batter slope commensurate with the soil used for rehabilitation to enhance runoff and compacted to limit infiltration. This would reduce the contact between infiltrating rainwater and PAF waste. Depending on the properties of the NAF material (e.g. thickness of layer, sulphide mineral content, particle size distribution, weathering properties etc.), it may also serve to reduce the availability of oxygen to the PAF material thus further reducing the rate of oxidation. This management strategy may be used during mining when the pit is being constructed and PAF material must be removed from the pit for efficient mining.

A further design control when considering option (i) are the sediment basins sized and designed to incorporate sufficient potentially contaminated runoff to a minimum storm event recurrence interval such that any contaminated runoff from engineered structures is suitably contained and can be treated before release. Further discussion on water management from spoil disposal areas is described in Volume 2 Section 2 Project Description and water resources section of this EIS; being Volume 2, Chapter 6, and to the Hydrology and Mine Water Quality technical reports in Volume 4, Appendices P1 and Q respectively.

For options (ii) and (iii) PAF material would be blended with material containing excess neutralisation capacity and would require tight controls on blending ratios. This process is operationally complex to implement. Success has been limited in the past due to the fact that it is not always possible to achieve well mixed conditions during placement and maintain contact between the acid produced and neutralising materials in the longer term. It is further constrained by the simultaneous availability of the neutralising materials during mining, and may require rehandling of materials. Based on current information, options (ii) and/or (iii) are not recommended.

For option (iv), reducing the rate of oxygen transfer to PAF waste would reduce the rate of sulphide oxidation and thus acid and sulphate production.

A reduction in oxygen transfer rates can potentially be achieved by covering the PAF wastes within NAF material (low sulphate production rate) that has low intrinsic permeability and a low oxygen diffusion coefficient. Some materials, such as clay, can be suitable for reducing oxygen transport if compacted and maintained at a high degree of saturation (say, greater than 0.85). The success of this approach would depend on the characteristics of the materials available and the amount and frequency of rainfall at the site. The suitability of dispersive materials for use as a subaerial cover would need to be further investigated given that only 28 samples were assessed for dispersivity, and 14 of those for chemical dispersivity. Early indications suggest that the clay unit is not a suitable waste rock capping material due to its propensity to disperse and leach slightly saline drainage.

Alternatively, the in-pit disposal could limit oxygen and oxidation rates of sulphides to very low levels if the PAF waste is placed below the long term steady water level in the pit. To ensure that solute release is limited when the PAF waste is inundated post mining, the material can either be amended with limestone or covered with NAF material to limit oxygen entry. Amendment with limestone will not, however, prevent oxidation of sulphides and the production of sulphates. Thus, sulphates may be mobilised when the waste is inundated.

The long term benefit of in-pit disposal is that once the wastes are inundated, oxidation is effectively controlled and no further maintenance or control is required. Waste placed at the base of the pit would potentially be inundated after the long term recovery of the water table, thereby reducing the diffusive supply of oxygen to the waste by about four orders of magnitude or more. This would subsequently greatly slow the rate of oxidation. Initial calculations suggest an excess mine void space relative to the volume of potentially PAF material identified. Ongoing groundwater modelling is being undertaken in order to determine sustainable long term groundwater recovery levels, to assist with best determining which mine voids to store and inundated the PAF material.

Because of the demonstrated performance on controlling oxidation and acid generation, placement of PAF materials below the water table within the open pit is considered to be the most effective long term option for managing PAF waste materials. This method is also preferred where there is limited non-dispersive material available for capping, as may be the case with the Carmichael Coal Mine. In addition, land based disposal in waste rock dumps requires inter-generational, and ongoing, cover monitoring and management to ensure long term performance.

A limiting factor of the effectiveness of in-pit disposal method could be the time taken for the groundwater table to recover and saturate the waste. The PAF material placed within pits would require burial with NAF as mine voids became available to limit the oxygen supply until long term groundwater recharge was realised to submerse the material. This option should be considered in conjunction with the groundwater section of this EIS, and in particular, Volume 4, Appendix R.

Considering the above, of the four options considered for managing the PAF wastes identified above, in-pit disposal where the PAF waste is placed below NAF material and inundated below the long term, sustainable groundwater level in the mine voids would be considered the most appropriate.

As a general recommendation, suitable precautions should be taken to prevent water contact with dispersive materials. Storage of the soil and clays and weathered mudstone, claystone and siltstones which show a high potential for dispersion within the core of the overburden storage areas is also recommended (Figure 10-22). Further testing on both dispersivity of soil-like and weathered rock, and time dependant slake potential of the unweathered units is being undertaken on samples scheduled for collection and analysis in late November 2012.

Operational level management and mitigation strategies include construction of runon diversion banks to minimise dirty water catchment areas, in addition to the development of a detailed testing and management program for mineral wastes. This management program should clearly define mine waste validation sampling, analysis and reporting throughout the life of mine and provide for forward planning of management of mine waste as the mine progresses. Such data would validate the initial mine waste geochemical characterisation reported herein, plus the additional 370 static samples, and 12 kinetic column tests to be undertaken commencing in late November 2012. The Mine EM Plan (and mineral waste management plan) will identify roles and responsibilities, and procedures for identifying, handling, placing and monitoring any PAF material on site.

A risk based approach has been adopted to determine operational level mine waste validation monitoring requirements, as per leading practice industry guideline documents including INAP (2009) and Commonwealth Government - Department of Industry, Tourism and Resources (2007); in addition to Queensland Government guidelines (Queensland Department of Mines and Energy 1995). Whilst the Commonwealth Government - Department of Industry, Tourism and Resources (2007) document suggests daily operational level sampling rates; a more risk-defined rate of sampling will become more apparent following analysis and interpretation of the additional 370 geochemical samples scheduled for collection in late November 2012. The subsequent increase in the size of the data set will help define the higher risk geological units; and therefore, assist with apportioning sample volume by unit. This information would then be prescribed in the mineral waste management plan for implementation.

With respect to operational validation sampling, the Queensland Government guidelines (Queensland Department of Mines and Energy 1995) state that "a detailed inventory of all waste or exposed materials should be maintained. These AMD/ARD records should include the rock type, acid/base accounting data, NAG data, metal content, storage location, and date of emplacement." Accordingly, the mineral waste management plan would incorporate, at minimum, the requirements of the Queensland Government guidelines (Queensland Department of Mines and Energy 1995), whilst also giving consideration to other leading practice documents (Commonwealth Government - Department of Industry, Tourism and Resources 2007, and INAP 2009 for example).

10.2.2.2 CHPP Coarse Rejects and Tailings

Potential Impact

In addition to the over and interburden, the coarse rejects and CHPP tailings can pose environmental risks if incorrectly managed. The risks are similar to those of the over and interburden, in that, should any potentially acid generating material be incorrectly managed, there remains the potential to adversely impact receiving water quality. This would be realised through lowered (acidic) pH values, and elevated sulphate (salinity) and metal concentrations.

Coarse rejects are likely to comprise roof and floor material from the underground mine, identified in the chapter above as being potentially one of the higher risk geological units at Carmichael. The geoechemical assessment indicated that salinities generally ranged between 100 and 1,000 µS/cm for roof and floor material, posing a risk for slightly saline drainage. Additionally, the carbonaceous mudstone, claystone and a sandstone sample indicated that these geological units may be potentially acid forming.

Furthermore, in lieu of having available CHPP tailings samples available for assessment, coal itself was geochemically analysed as a surrogate. One of two coal samples indicated that it was potentially acid forming. In lieu of an actual CHPP tailings sample for assessment, this implies that the CHPP fine tailings may require active management to mitigate AMD risk.

Mitigation and Management

Adani has proposed the following coal handling, beneficiation and waste disposal for the Carmichael Mine.

Run of mine (ROM) coal receival areas will be provided for each of the three underground mines and for the northern, central and southern open cut areas, with the central open cut receival areas located at the main MIA. From the hoppers, coal will pass through a series of crushers that will progressively reduce coal lumps to a nominal size of 50 mm or less. Oversize coal material will be rejected and returned to the crushers for resizing. Any material that is rejected from crushing will be disposed of by placement in overburden disposal areas.

It is anticipated that coal from the underground mine will not require further processing and will be placed directly in product coal stockpiles while a proportion of coal from the open cut will also be placed directly in product coal stockpiles, and a portion directed to raw coal stockpiles for further processing. A proportion of coal from the open cut mine is expected to be further processed in a coal handling and preparation plant (CHPP) to remove ash and fine particles.

There will be three processing streams within the CHPP:

- A coarse circuit for coal sizes greater than 2 mm
- A fines circuit for coal sizes between 0.25 mm and 2 mm
- An ultra-fines circuit for coal sizes smaller than 0.25 mm. If this material is high ash, it will be rejected as tailings as the particle size creates significant issues in relation to coal handling.

For the coarse and fines circuits, a range of processing approaches are available, however fundamentally, each process involves physical agitation and washing with water to remove ash and ultrafine particles and then a recovery process where water and ultrafine material is separated from the coarse and fine materials.

It is the ultrafine tailings that can may be high risk as if present, the process concentrates sedimentary pyrite for disposal.

Ultrafine material will then be partially thickened to reduce water content. For the first 10-12 years of mining tailings will be placed in an above ground tailings storage facility east of the mine infrastructure area. Once sufficient space is available in-pit, tailings will then be placed in dedicated areas. It is anticipated that between 3 and 5 Mtpa (dry) of tailings will be produced.

The above ground tailings storage facility used prior to in pit disposal will be an engineered structure with hydraulic capacity as required by the *Manual for Assessing Hazard Categories and Hydraulic Performance of Dams* (Queensland DERM 2012).

A preliminary assessment of this facility indicates that it is likely to fall into the significant hazard category and hence is required to:

- Provide for a design storage allowance equivalent to a 1:20 year annual exceedence probability (AEP) event
- Have a mandatory reporting level set at the 1:10 year AEP (72 hour duration) storm level
- Provide spillway capacity for 1:100 to 1:1000 AEP event
- Have embankment crests set at the 1:100 AEP level plus 500 mm freeboard.

The above ground tailing storage facility will also be lined with a very low permeability liner.

The above initiatives are design mitigation strategies to reduce potential impacts from unmanaged, potentially acid forming, tailings.

In the longer term once void space becomes available, Adani proposes to blend the coarse rejects from the CHPP back into overburden spoil dumps, and then, in pit.

To further define the geochemical risk of AMD and/or saline drainage, additional coal samples will be analysed from the late November 2012 sampling and assessment program. Additionally, mine tailings will undergo geochemical assessment as they become available and this will inform ongoing management.

10.2.3 Additional Geochemical Work Commissioned

Statistical analysis on the data set reported in this chapter showed that the selection of samples was large enough to draw conclusions about average values of the total sulphur content, the ANC and the NAPP across the site for several lithological units. The average NAPP and the upper 95 per cent confidence interval for the average NAPP was less than 0 kg(H_2SO_4/t) for carbonaceous mudstone, clay, claystone, sandstone and siltstone.

The upper 95 per cent confidence limit was above 0 kg(H_2SO_4/t) for mudstone. The average NAPP could not be determined for coal or incidental samples (primarily clay and containing calcite and unusually large total sulphur contents of 2 and 10 wt%) because there were too few samples of these types.

The fraction of samples representing each lithological group was proportional to the fraction of the waste in that lithological group with the exception of the carbonaceous group which was intentionally oversampled.

The number of samples was however, insufficient to make assessments about the spatial variability of the total S content, ANC and NAPP.

Of the lithological units with more than two samples, only the carbonaceous mudstone and mudstone lithological units require better definition with regard to their global mean values based on total S. The carbonaceous mudstone and mudstone lithological units belong to the fresh carbonaceous grouping which is typically contained in the fresh interburden.

The C-seam inferior coal that will not be processed, and therefore will be mined as waste, requires sampling as it has not been sampled.

The spatial density of sampling was inadequate to characterise the spatial distribution of total S, ANC and NAPP. Further sampling from drill holes spaced between 1000 m and 3000 m apart is required to further investigate the spatial variability. Samples of each significant lithological unit would be required from these holes. A schematic of the additional holes required is presented in Figure 10-23.

To achieve the statistical representation described above, an additional sampling and analysis program is scheduled for late November 2012, with the additional sampling to collect approximately 370 samples for static geochemical analysis.

In addition to the analysis of an additional 370 samples for static geochemical analysis, kinetic geochemical column leach testing will be undertaken on 12 representative geological units to determine the longer term risk of AMD and/or saline drainage from the Carmichael lithologies.

Figure 10-23 Additional drill holes required for geochemical sampling