3. Land Resources

3.1 Existing Environment

3.1.1 Tenure

The background land parcels for MLs 1884 and 1904 are either Freehold or Leasehold tenures held by the Proponent, with smaller areas covered by a Stock Trucking Reserve and road reserve.

ML 1884 and ML 1904 were both granted in 1983. ML 1884 is for the purposes of mining and ML 1904 is currently for the purposes of mine infrastructure.

It is proposed that much of ML 1904 will be conditionally surrendered, and an application made for a new ML over the surrendered area for mining purposes. This will enable the use of the resource to be maximised and the location of mine facilities to be optimised. The south-east part of ML 1904 covered by a Stock Trucking Reserve would initially remain. If extraction of coal from the Stock Trucking Reserve is required, then Native Title interests would need to be resolved and a new ML for mining purposes granted before any extraction of coal could commence.

The background land description for the Clermont MLs are Lot/Plan 33/10387, 24/L4113, 1/CP805053 and 82/CLM514. Land parcels along the conveyor route are Lot/Plan 83/CLM806555, 84/CP901140 and 18/CLM628. Background land parcels for the proposed infrastructure mining lease for the conveyor corridor, between the existing Clermont and Blair Athol mining leases, include Lands Lease tenures (not held by the Proponent) and road reserve tenures.

Background land parcels for the Cement Hill MLs (MLs 1787, 1788, 1985 and 2355) are Camping and Water Reserve tenures and Lands Lease tenures (not held by the Proponent). The Cement Hill MLs were granted in 1975, 1988 and 1992 and are held by the Proponent.

3.1.2 Existing Land Use

Land use on the Clermont MLs currently includes cropping, grazing and minor timber production. Rainfed cropping and grazing represent the only agricultural pursuits that are viable in the area in the long term (Carroll, 1997; Shields and Williams, 1991). Removal of rosewood for fence posts is an occasional use of the western portion of ML 1904.

Small areas of minor mining excavations are scattered in the western sections of ML 1904. These works have not been rehabilitated and contain some unfenced shafts. Surface soils have also been removed for earthworks over some areas which have also not been rehabilitated.

There is currently a residence and other associated buildings located in the north east section of ML 1884. This residence will not be inhabited during the life of the mine.

Surrounding land uses include grazing, cropping, coal mining, forestry, an airport (south of the mining leases), and a rifle range.

The Cement Hill MLs cover former gold mining operations, including a final mining void and small areas used for gravel extraction. The Cement Hill MLs have been partially rehabilitated and are fenced off to prevent public access. Areas within the Cement Hill MLs are sub-leased for grazing to an adjacent landholder. Water in the void at Cement Hill is also used by the adjacent landholder for irrigation.

The current land uses for the area of the infrastructure mining lease for the conveyor corridor include grain farming, grazing and roads.

3.1.3 Land Use and Planning Provisions

The Project has been declared a "significant project" under Section 26 of the *State Development and Public Works Organisation Act 1971* (SDPWO Act). An EIS is required for a significant project. The ToR requires that the EIS address the land use planning implications for the Project.

3.1.3.1 Integrated Planning Act and IDAS Related Matters

The *Integrated Planning Act 1997* (IPA) establishes the framework for planning and development assessment in Queensland. IPA also establishes IDAS, the Integrated Development Assessment System, that calls up other related environmental and natural resource management legislation as appropriate.

Schedule 8 of IPA exempts ‘material change of use’ and ‘operational work’ applications for authorised activities under the *Mineral Resources Act 1989*.

The Project is located within Belyando Shire. Development applications for any relevant activities off mining leases will be made to Belyando Shire Council.

The Belyando Shire Council must then make a decision to approve, refuse or approve subject to conditions the development application. The EIS may be used to support any such Development Application.

Regardless of the exemptions of the mining activities from IPA, an assessment of the Project has been undertaken against the State Planning Polices, the Whitsunday Hinterland and Mackay (WHAM) Regional Plan, as well as the Shire of Belyando – Town of Clermont and Environs Planning Scheme 1990. An assessment of the project against the provisions of these policies and plans ensures that a full land use planning analysis is completed, and relevant land use planning issues identified.

3.1.3.2 State Planning Policies

State Planning Policies (SPP) are statutory planning instruments that relate to matters of State interest. These policies must be considered in the assessment of development applications lodged under IPA. They are addressed in **Table 3-1**.

State Planning Policy 1/03 – Mitigating the Adverse Impacts of Flood, Bushfire and Landslide

SPP 1/03 – Mitigating the Adverse Impacts of Flood, Bushfire and Landslide seeks to minimise the potential adverse impacts of these natural hazards on people, property, economic activity and the environment.

Under this policy, Belyando Shire is not identified as an applicable local government area for landslide or bushfire natural hazards. The hazards identified under the policy are not applicable to the Project.

The natural hazard management area for a flood hazard is dependent on a local government identifying the affected area in a planning scheme. The current transitional planning scheme for the Shire of Belyando identifies Special Flooding zones. These zones do not cover the Project area and the provisions in relation to flood hazard in the policy are not applicable.

Discussions with Belyando Shire Council and the consultants preparing their new IPA planning scheme have indicated that the new planning scheme will not include identification of flood hazard zones (Higginson *pers comm*; Goldworthy *pers comm*).

State Planning Policy 1/02 – Development in the Vicinity of Certain Airports and Aviation Facilities

SPP 1/02 seeks to protect identified airports and aviation facilities from development that could undermine their safety or operational efficiency (DLGP, QT, 2002).

The Clermont Airport is located in relatively close proximity to the Project area, approximately 1.2 km to the south of the Mining Lease boundaries. The Clermont Aviation Facilities are listed in Appendix 2 of the SPP 1/02 Guidelines. Therefore, they are subject to the SPP.

SPP 1/02 lists seven development outcomes that are important to the protection of airports / aviation facilities. Development assessed against the SPP must have regard to Outcomes 1 to 4. Outcomes 5 to 7 relate to making and amending a planning scheme and are not relevant to this proposal. Outcomes 1 to 4 and the impacts of the Project on these outcomes are discussed in **Table 3-2**.

The Shire of Belyando - Town of Clermont and Environs Planning Scheme 1990 has special provisions for development in the vicinity of the Airport. The Project is outside the area to which the provisions apply. However, as the Project is consistent with SPP 1/02, it conforms with the planning provisions in the Planning Scheme.

Table 3-1 State Planning Policies

State Planning Policy	Response
SPP 1/03 Guideline: Mitigating the Adverse Impacts of Flood, Bushfire and Landslide	This SPP aims to minimise the potential adverse impacts of flood, bushfire and landslide on people, property, economic activity and the environment. The implications of this SPP are addressed further in this EIS.
SPP 1/02 Development in the Vicinity of Certain Airports and Aviation Facilities	This SPP sets out broad principles for protecting airports and aviation facilities considered essential for the State's transport infrastructure or the national defence system. The Clermont Airport is located in relatively close proximity to the Project area, approximately 1.2 km to the south of the Mining Lease boundaries. The Clermont Aviation Facilities are subject to the State Planning Policy 1/02 Planning for Aerodromes and Other Aeronautical Facilities as they are listed in Appendix 2 of SPP 1/02 Guidelines. The implications of this SPP are addressed further in this EIS.
SPP 1/00 Planning and Management of Coastal Development Involving Acid Sulfate Soils	This SPP applies to coastal areas of Queensland below 5 m AHD. As the land involved in the Project is not coastal land this SPP will not apply.
SPP 1/97 Conservation of Koalas in the Koala Coast	This SPP concerns the conservation of koalas in a defined area of south-east Queensland. This SPP does not relate to the subject site.
SPP 1/92 Development and the conservation of Good Quality Agricultural Land	This SPP seeks to protect good quality agricultural land from subdivision into uneconomic units and to minimise the potential for land use conflicts between agricultural and non-agricultural land uses. A provision for 'over-riding need in terms of public benefit' exists within the policy and is applicable for the proposed development. The project will maintain employment in the region as the nearby BAM winds down production. The project will also generate a large amount of employment (3000 + jobs). The coal produced from the mine will also potentially generate $400 to $500 M/a to Queensland's export earnings. This EIS addresses the potential impact of the Project on the protection of good quality agricultural land.

Table 3-2 Development Outcomes Under SPP 1/02

Development Outcomes	Potential Impacts
Outcome 1 When undertaking development to which this SPP applies, adverse effects on the safety and operational efficiency of operation airspace and the functioning of aviation facilities are avoided by: either not including the actions and activities listed in Annex 2; or including appropriate site planning and management plans that avoid the potential adverse effects of such activities.	The sensitive area for the Airport Facility in Clermont is the area 500 m in radius from the runway. Thus in terms of protecting the sensitive area there are no development constraints outside a radius of 500 m from the runway. The mining lease is well outside of this boundary, so will not impact on the sensitive area. The Proponent has been advised by the Civil Aviation Safety Authority that the licensed aerodrome operator (Belyando Shire Council) is required to assess the potential for obstruction of aviation activities by waste rock dumps (see section 1.8.12). The mining development will not cause a high velocity gaseous plume or a transient intrusion, nor is it likely to attract wildlife into operational airspace. It is also not likely that the lighting from the mining operations or any generation of particulate matter would affect aircraft operations.
Outcome 2 Within areas defined by the 20 Australian Noise Exposure Forecast (ANEF) contour around airports to which this SPP applies, material changes of use are compatible with forecast levels of aircraft noise except where the proposed development is a development commitment or there is an overriding need for the development in the public interest, and no other site is suitable and reasonably available for the proposal.	The mining operations are not affected by the 20 ANEF contour. Temporary housing of workers is also located outside of the 20 ANEF contour.
Outcome 3 Within particular ANEF contours around airports to which this SPP applies, certain developments must include noise attenuation measures.	Not Applicable – no developments planned within this area. Attenuation is required at the mine to limit noise at other surrounding sensitive receivers.
Outcome 4 Except where the proposed development is a development commitment, development within the public safety areas at the ends of airport runways avoids: significant increases in people living, working or congregation in those areas, and the use or storage of hazardous materials.	The dimensions for public safety areas at the Clermont Airport are a trapezoidal shape with a perpendicular length of 1000 m. The mining leases boundary is outside this area.

3.1.3.3 Regional Planning Provisions

WHAM 2015 Regional Plan

The Whitsunday Hinterland and Mackay (WHAM) Regional Plan was released in draft form in May 2002. The region covers the local government areas of Bowen, Whitsunday, Mackay, Sarina, Mirani, Nebo, Broadsound and Belyando. The implementation of the plan is coordinated by the WHAM Regional Planning Advisory Committee (RPAC). The WHAM RPAC was established under IPA in June 2000. When a final plan is released it is required to be endorsed by the Queensland Government and the WHAM Regional Organisation of Councils.

The plan is a non-statutory strategic planning document that relies on voluntary implementation and co-operation of local government. It sets out overarching policy and planning frameworks and a regional vision to guide the long-term management and development of the region. It lists regional issues, goals and strategies and contains a regional structure plan.

The vision for the region is "In the year 2015, Whitsunday, Hinterland and Mackay is distinguished as a unique and vibrant region in its own right, blessed with beauty and natural wealth that provides the greatest possible long term social, economic and environmental benefit for residents, visitors and future generations." The key regional issues, goals and strategies seek to contribute toward achieving the desired vision. They relate to:

- regional identity,
- leadership and management;
- environment and natural resources;
- economy;
- people,
- communities and culture;
- urban development; and
- infrastructure and transport.

Table 3-3 addresses the relevant WHAM Goals and provides a response in relation to the Project.

The WHAM Regional Plan establishes a structure plan that identifies the preferred physical and spatial arrangements for the region. In general the structure plan supports the concept of a new mining project near Clermont.

It identifies coal mining as a major economic activity in the Bowen Basin, stating that accessibility to the region's coal reserves should be maintained. Clermont is also identified as a district centre. The employment generated from the Project would help consolidate this role for Clermont.

The plan also states that the region's agricultural land needs to be protected. Dry land agriculture is identified as a major industry within the Clermont area. The proposed development will result in the loss of land for agriculture. However the impact of this on the intent of the WHAM Regional Plan is considered minor, given the relatively small area affected by the Project, compared with the area of good quality agricultural land in the region.

3.1.3.4 Belyando Shire Planning Scheme

The Belyando Shire Planning Scheme does not apply to the mining leases. The Planning Scheme will apply to new developments off the mining leases, for example, the proposed Township Village. The Shire of Belyando – Town of Clermont and Environs Planning Scheme 1990 is a transitional planning scheme under IPA. Under IPA the Belyando Shire Council is required to prepare a new IPA planning scheme. This new planning scheme is currently under preparation, and expected to be released in draft form for public comment and final adoption in late 2004.

The current Planning Scheme contains planning provisions (including zoning maps) which provide for the administration, guidance and implementation of land use and development and a strategic plan. The strategic plan seeks to guide future growth within the Scheme Area.

Table 3-3 WHAM Goals and Responses

WHAM Goal	Response
Regional Identity, Leadership and Management.	
This goal relates to establishing a recognisable regional identity, improving collaborative decision making processes, building capacity, facilitating funding and co-ordinating disaster planning and recovery.	Most of these requirements are unaffected by the proposed development. Hazard and risk assessment is an important consideration for the Project and includes emergency response. This is addressed in **Section 15**.
Environment and Natural Resources	
This goal encompasses conserving biodiversity, preserving scenic beauty, sustainable natural resource use, sustainable land and mineral use, water and floodplain management.	The impacts on flora and fauna are assessed in **Section 5**. The visual impacts are assessed in **Section 9**. The flooding impacts are assessed in **Section 4**. An environmental management plan (in the form of an EMOS) has been prepared for the development and is included in **Section 16**. Rehabilitation at the end of the mine's life will return the site to a native vegetated environment.
Economy	
The economic goals seek to achieve a diverse, sustainable regional economy supported by adequate infrastructure with integrated marketing, promotion and economic development.	The proposed development will help strengthen the economic value of the existing mining industry and help maintain employment and investment in the area. This will be important as the BAM winds down production.
People, Communities and Culture	
Included in these social goals is a desire for social impact assessment, promoting and facilitating the development of diverse cultures, recognising and protecting indigenous and non-indigenous cultural heritage, and Native Tittle.	Social impacts of the proposal are discussed in **Section 13**. Indigenous and non-indigenous cultural heritage management is discussed in **Section 8**. Native Title is addressed in **Section 3.1.4**.
Urban Development These goals relate to the quality of the urban environment. Relevant is the goal of 'rural community revitalisation'. This seeks to improve employment opportunities, services and community lifestyle values in rural urban centres.	The proposed development will help maintain employment in the region, especially in the township of Clermont.
Infrastructure and Transport These goals cover a wide area including coordinated infrastructure provision and integrating transport networks.	The Project will utilise existing transport infrastructure on the Peak Downs Highway, Gregory Highway and Gregory Development Road. Coal from the mine will be transported via an overland conveyor to the BAM prior to dispatch to the DBCT using existing rail facilities. This provides efficient use of existing infrastructure.

3.1.3.5 Stock Routes

Stock routes in Queensland are governed by the *Land Protection Act 2002*. Gregory Developmental Road (S406) is classified as a Secondary Route, and Peak Downs Highway (M404) is classified as a Minor Route. The Clermont area is a collection point for a number of minor routes joining together before continuing to Emerald. The routes are used infrequently, two to three times a year.

Currently there are two watering points in the vicinity of the mining leases. The first is at the Black Ridge camping reserve. The second is an excavated earth tank at the Stock Trucking Reserve near the intersection of the Peak Downs Highway and Gregory Development Road. The watering points will be unaffected by the Project.

Following consultation with the DNRME and Belyando Shire Council, it is proposed to deviate the Minor Stock Route that follows the Peak Downs Highway to the east of the mining leases and maintain the Gregory Developmental Road / Gregory Highway Secondary Stock Route along the realigned section of these roads **(Figure 3-1)**. The Minor Stock route will be 60-200 m wide and will join the Stock Trucking Reserve. The Secondary Stock Route will be 90 m wide and will rejoin with the Peak Downs Highway south of the mining leases.

3.1.4 Native Title

The Proponent has entered into discussion with the Gurang Land Council, the registered Native Title Representative Body relevant to the Project. The Gurang Land Council assisted a group of Aboriginal people to prepare and register a Native Title claim for the area. This claim was lodged on behalf of the Wangan and Jagalingou people and was recently registered by the National Native Title Tribunal (National Native Tribunal file number: QC0416).

The Proponent attended the authorisation meeting for the claim and met with the claimant group. Preliminary discussions centred on a general introduction between the parties, introductory briefing on the Project, discussion on requirement and process for cultural heritage assessment, and processes for engagement between the parties. The Proponent also attended two subsequent working group meetings to provide a briefing on the Project, explain the cultural heritage process for the EIS, and discuss Native Title claim issues.

To ensure inclusion of all Native Title claimants with relevant interests in the Project, formal engagement with Aboriginal parties on Native Title interests was deferred until the Native Title claim lodged with the National Native Title Tribunal had completed the registration process. The Native Title claim was only recently registered.

The Proponent accepts that in the long term there are Native Title interests to be addressed in relation to this Project. Specifically, Native Title interests would need to be resolved before any extraction of coal took place on the Stock Trucking Reserve (note, infrastructure is able to be built on the Stock Trucking Reserve without invoking the Native Title Act). If extraction of coal from the Stock Trucking Reserve is required, it will occur late in the mine life.

The Proponent commits to developing processes whereby matters surrounding the question of Native Title can be effectively negotiated. It is accepted that some resources will need to be provided by the Proponent to enable the relevant group to negotiate with the Proponent in an equitable fashion, and the Proponent commits to providing such resources within reasonable limits.

The Proponent will need to initiate processes related to cultural heritage. The Proponent is taking steps so that the claim group are fully briefed prior to the cultural heritage notification being made, and understand that the need to make the necessary notifications is a statutory requirement.

It is the intention of the Proponent to ensure that the cultural heritage and social impact studies are suitably broad so as to cover the issues raised within section 39 of the *Native Title Act 1993*. The purpose of this is to make certain that, in the event of Native Title negotiations not reaching an agreed outcome, the Native Title claimants have a reasonable opportunity to present a case to an independent arbitrator as to their Native Title interests and the impact of the proposed development on those interests.

3.1.5 Sensitive Environmental Areas

The vegetation communities within the mine site, the conveyor route and the Cement Hill leases have all been affected by grazing, timber harvesting, small-scale mining and road and track construction to varying levels. The levels of disturbance vary across these areas. In most cases, the understorey typically has experienced the greatest level of disturbance. The overstorey remains relatively intact in the western areas.

Of the nine regional ecosystems identified within the project site, three are listed as Threatened ecological communities under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. Five of the communities are classified as Endangered or Of Concern under the Queensland *Vegetation Management Act 1999*.

Most of the eastern section of the mining area has been cleared for cropping and the improvement of pastures for grazing. This has resulted in very little remnant vegetation remaining in this area.

Aspley State Forest is located directly west of ML 1904. There are no National Parks or other protected areas within the vicinity of the Project.

Sensitive environmental areas are discussed in more detail in **Section 5**.

3.1.6 Topography

The Clermont MLs contain a broad range of distinct topographic units but are generally of low relief. The western side of the project area is composed of rolling to undulating low hills with slopes from 20-25% (**See Figure 2-1**). These hills merge into low undulating rises (slopes < 5%) and plains that dominate the western third of the leases. Prospect Hill is a low conical hill that emerges from these rises west of Gowrie Creek.

Gowrie Creek drains most of the Clermont mining leases, with gently sloping drainage lines, floodways and braided channel systems extending into basalt dominated areas to the north and sedimentary and metamorphic dominated areas to the west. A narrow, level to gently undulating alluvial plain is associated with Gowrie Creek.

A basaltic plateau is a prominent feature in the north-east of ML 1884. This plateau blends into undulating basaltic rises along the eastern boundary. These rises merge with level alluvium associated with Gowrie Creek and Wolfang Creek.

A broad alluvial floodplain with braided channels, low levees and undulating interfluves dominates the south east corner of the lease. This alluvial plain is associated with the Gowrie and Wolfang Creeks and drains to the south.

The conveyor route and pipeline route are dominated by undulating rises and colluvial material derived from basalt, metamorphic and sedimentary geologies. The slopes are generally less than 5%, although some sections of the metamorphics may reach 10%.

3.1.7 Climate

The Commonwealth Bureau of Meteorology has maintained a weather station at Clermont Post Office since 1870. A summary of long-term meteorological monitoring data for Clermont is provided in **Table 3-4**. Clermont has a sub-tropical continental climate. In general winter days are warm and sunny and nights are cool. During summer days tend to be hot and nights warm. Summer weather is influenced by a semi-permanent trough that lies roughly north-south through the interior of the state.

The trough is normally the boundary between relatively moist air to the east and dry air to the west. It is best developed during spring and summer months when it triggers convection with showers and thunderstorms on its eastern side (BoM, 2004).

3.1.7.1 Temperature

Average maximum temperatures are 23-25^{o}C during winter and 34-35^{o}C during summer. A highest maximum temperature of 45^{o}C has been recorded (BoM, 2004). Minimum overnight temperatures are 21-22^{o}C during the summer months and 6-8^{o}C during winter. A lowest minimum temperature of -2.6^{o}C has been recorded in July.

3.1.7.2 Humidity

Relative humidity is fairly constant throughout the year, ranging from 70% in the summer to 28% in the winter (**Table 3-4**), and is generally highest during the early morning hours.

3.1.7.3 Rainfall

Rainfall at Clermont is seasonal, highly variable and unreliable, with the majority falling during the summer months. The average monthly rainfall varies from around 8 mm/month in winter months to over 115 mm/month during summer months. Annual Median rainfall is approximately 634 mm, falling on an average of 56 rain days. The mean annual evaporation in the Clermont area is 2054.2 mm.

Table 3-4 Climate Averages, Clermont Post Office (BoM 2004)

Month	Temperature (°C)		Relative Humidity (%)		Evaporation (mm)	Wind speed (km/h)	Rainfall (mm)		
	Average Min	Average Max	9am	3pm	Monthly	3pm	Median	Highest Daily	Highest Monthly
Jan	21.5	34.4	65	40	235.6	10.9	93.3	171.5	516.0
Feb	21.0	33.0	70	45	190.4	11.4	85.1	137.7	428.0
Mar	19.4	32.0	69	42	198.4	11.2	47.6	148.7	403.4
Apr	15.7	29.5	66	40	150	11.0	30.0	113.6	274.2
May	11.5	26.0	68	43	111.6	10.4	23.1	110.8	234.4
Jun	8.1	23.1	68	40	90	10.3	20.5	99.1	307.2
Jul	6.7	23.0	65	36	99.2	10.5	10.3	96.5	192.5
Aug	8.2	25.2	60	32	127.1	11.2	8.7	93.6	171.2
Sep	12.0	28.7	54	28	171	11.7	6.5	97.8	184.9
Oct	16.2	31.9	54	29	207.7	11.9	27.3	125.4	154.2
Nov	19.0	34.0	55	32	219	11.1	44.0	130.1	263.9
Dec	20.8	34.9	60	36	254.2	11.2	71.1	419.1	670.7
Annual Average	**15.0**	**29.6**	**63**	**37**	**2054.2**	**11.1**	**633.9**		

3.1.7.4 Flood, Drought and Climatic Extremes

The Bowen Basin area within which Clermont is located has experienced relatively few cyclones in the past 100 years. The most intense cyclone, which occurred in January 1918, was classified as a Category 2 cyclone.

The cyclone caused most damage on the coast near Mackay, although severe damage was also reported in the northern Bowen Basin. No other Category 2 cyclones have occurred in the past 100 years but some Category 1 cyclones have been reported. Category 1 cyclones are the weakest cyclones with wind speeds of between 63 km/hr and 125 km/hr.

Heavy rain and flooding associated with cyclonic low pressure systems has caused flooding damage in the area downstream from the junction of Sandy Creek with Wolfang Creek. The highest daily rainfall recorded at Clermont was 419 mm, however, such rainfall is exceptional.

Given the location of the Project, there is a very low risk of impact from cyclonic winds. Potential impacts from flooding and heavy rains have been assessed in **Section 4**.

Clermont is periodically subject to drought. The potential impacts of unreliable rainfall on water supply to the Project have been assessed in **Section 4**.

3.1.7.5 Wind Speed and Direction

Strong winds are rare in the Clermont area and are normally associated with thunderstorms during late spring or summer. Wind roses are provided in **Appendix L2**.

During the summer months night-time and early morning winds are predominantly from the north to north-north-east. Winds during the afternoon are predominantly from the east when strongest wind speeds tend to occur. Lowest speeds generally occur at night. Westerly winds are rare.

In the winter months the predominant wind during the nocturnal hours is from the south-south-east. Winds during the afternoon are predominantly from the south-east to east and highest speeds typically occur during the day with winds from the south-east.

3.1.8 Geology

The Project is located in the Wolfang Coal Basin, north of the Clermont town. The central and eastern part of the Wolfang Basin is a broad gently undulating basalt plain with surface elevation generally between RL 280 m in the northern part and RL 260 m in the southern part. The geology units of the Project area are shown in **Figure 3-2**.

The western side of the basin is gently undulating to low hilly terrain where the ground surface ranges from RL 280 m to RL 300 m. The Wolfang Coal Basin geology is represented by the following geological units, which are listed in descending stratigraphic order:

- Quaternary Alluvium;
- Tertiary Basalt;
- Undifferentiated Tertiary Sediments;
- Permian Sediments; and
- Pre-Devonian Anakie Metamorphics.

Four major coal seams have been identified within the coal sequence. These are discussed in **Section 2**, and presented in **Figure 2-3** and **Figure 2-4**. Geology in relation to groundwater, is discussed in more detail in **Section 4**.

The competent basalt that will be mined is generally suitable as road building material.

3.1.9 Soils

3.1.9.1 Survey Methodology

The land resource information presented here is based on three surveys. The first was conducted by Hollingsworth (1983) as part of an earlier EIS. Additional survey work was undertaken by Sinclair Knight Merz in 2002 to refine the scale of mapping, comply with contemporary guidelines and provide estimates of topsoil resources. A further survey was undertaken in 2004 to map soils along the proposed conveyor route between the Clermont mining leases and the BAM and to make an assessment of potential land contamination.

The Hollingsworth (1983) report included 19 soil profile descriptions and 10 profiles of chemistry and Emmerson Aggregate Dispersion tests. The 2002 survey contained over 170 observation points with 109 detailed profile descriptions to a maximum depth of 4 m. Profiles at 22 points were analysed for organic carbon, nitrogen, phosphorus, potassium, exchangeable cations, pH and electrical conductivity. Field measurements of pH and Electrical Conductivity (1:5) were performed on 220 samples. Chemical analyses are presented in **Appendix G1**. The profile logs are contained in **Appendix G1**.

The 2004 survey described ten profiles along the conveyor route and conducted laboratory analysis on three profiles that were not adequately characterised by previous surveys. These profiles are described as Sites 1-10 in **Appendix G1**. Surface (0-10 cm) samples were collected from sites identified as potentially containing contaminants.

The Clermont MLs have a combined area of 3220 ha. The combined soils surveys give an intensity of sampling of one observation every 17 hectares which allows soils mapping at a scale of 1:10 000. Mining Industry guidelines (DME 1995) regards this as sufficient for planning of a mining operation. This sampling is also consistent with the Planning Guidelines: The Identification of Good Quality Agricultural Land (DLGP and DPI 1993) for the survey extent and degree of soil complexity.

Sampling and profile inspection points were spread across the entire Project area to characterise all landform elements and geological units (**Figure 3-3**). Soil types were characterised to allow them to be related to QDPI type profiles contained in Bourne and Tuck (1993) and Shields and Williams (1991). This allowed additional chemical and physical characteristics to be inferred for some profiles. Particle size analysis and moisture retention measurements were used from these sources to determine plant available water capacity for the soil types encountered.

The survey was designed to provide sufficient information on land resources to allow the determination of land suitability, soil erosion, rehabilitation potential and storm water runoff quality consistent with the methods set out by the Queensland DPI (1990), Shields and Williams (1991) and DME (1995). Advice on local production systems, land suitability and flood levels was obtained from local DNRME staff and the primary producer managing the leases. Local DNRME staff confirmed prior to fieldwork in 2002 that the methodology would be adequate to determine land suitability and soil characteristics. DNRME staff attended some of the fieldwork.

Profile descriptions were consistent with the Australian Soil and Land Survey Field Handbook (MacDonald *et al* 1998), the Australian Soil Classification (Isbell, 1996) and Munsell soil colour charts. Profiles were sampled using drilling flights, hand augers and a backhoe. Slope, landform, vegetation and geology were also assessed at inspection points.

Sampling and observation points were recorded using a global positioning system. Soil units were mapped using the most recent stereo aerial photography at 1:25 000. Soil unit boundaries were digitised and spatial analysis conducted using a MapInfo Geographic Information System.

3.1.9.2 Soil Characteristics

Topsoil was examined using soil and chemical properties including pH, electrical conductivity (EC1:5), phosphorus and exchangeable sodium percentage (ESP). Physical properties such as permeability and drainage characteristics were inferred from profile morphological characteristics such as concretions, depth to rock, observed root depth, colour and mottling.

Typical depths of primary and secondary topsoil were determined using DME (1995) guidelines, site data and experience with similar soil types used in rehabilitation at the BAM. Primary topsoil is the uppermost layer of soil used in site rehabilitation. It is salvaged from the surface horizons of areas to be disturbed, is relatively stable, contains seeds and micro-organisms and is relatively fertile. Secondary topsoil (if used) is placed directly in contact with waste rock and may be obtained from subsurface soil horizons, including weathered rock.

The Project area is included in four Land Resource Areas (LRAs) determined by Bourne and Tuck (1993) (**Table 3-5**). These LRAs represent a repeated pattern of soils, vegetation and geology and were mapped at 1:500 000.

The dominant profiles listed for the LRAs are consistent with the most common soils found on site. Many of the soil types found on the Project area match those described by Shields and Williams (1991) on similar geology in the adjacent Kilcummin area.

Table 3-5 Land Resource Areas of Bourne and Tuck (1993) contained in the Project Area

Land Resource Area	Land Form	Soils	Vegetation	Land use
Alluvial Plains	Level plains on Quaternary alluvium	Cracking clays, non-cracking clays and solodics	Eucalyptus woodlands with coolibah and poplar box	Rainfed and irrigated cropping; grazing on native and sown pastures
Undulating scrub plains	Undulating plains and rises developed on sedimentary rocks, tertiary basalts and unconsolidated sediments	Cracking clays, solodics, redbrown earths, non-cracking clays and structured earths	Brigalow and gidgee scrubs, minor communities of poplar box, belah and Dawson gum	Rainfed cropping, grazing on sown pastures, minor irrigated cropping
Undulating Downs	Gently undulating plains formed on basalts, Permian shales sandstone and unconsolidated sediments	Black, brown and grey cracking clays; frequent stony phases	Bluegrass, Mitchell grass, minor elements of mountain coolibah open woodland, bloodwoods and silver leaved ironbark	Rainfed cropping and grazing on native pastures: minor irrigated cropping
Ranges	Undulating to very steep hills formed on sedimentary rocks, metamorphics	Stony lithosols, hallow loams, minor red and yellow earths, non-calcic brown s soils and solodic soils	Woodlands of narrow leaved ironbark, silver leaved ironbark, ghost gum, bendee, lancewood or cypress pine	Grazing on native pastures

Ten soil types occur on the Project area and conveyor corridor. These soil types are related to geology, landform and past land use of the area (**Table 3-6**).

Table 3-6 Relationship Between Landscape Elements and Soil Types of the mining leases

Landscape Element	Major Soil Characteristics	DNR Soil Type	Australian Soil Classification **	Geotech. Class. +	Soil Area (ha)	Soil types and Soil Mapping Code
Alluvial Plains derived principally from basalt	Self-mulching alkaline clays over 2m deep, high PAWC, may be saline and sodic	Moramana *#	Black vertosol	CH	954	Very deep cracking clays on Alluvium (VDCA)
Undulating Downs on Basalt	Self-mulching alkaline clays 1.2-2m deep, high PAWC, non-sodic and non-saline	Orion *	Black vertosol	CH	895	Deep cracking clays on basalt (DCB)
Undulating downs and lower slopes on basalt hills	Self-mulching alkaline clays 0.6-1.2m deep, high to moderate PAWC, non-sodic and non-saline	Jimbaroo *	Black vertosol	CH	279	Shallow cracking clays on basalt (SCB)
Upper slopes and plateaus on basalt hills	Self-mulching alkaline clays <0.6m deep low PAWC, non-sodic and non-saline	Cheeseboro	Black vertosol	CH	43	Very shallow cracking clays on basalt (VSC)
Alluvium and colluvium on lower slopes and undulating plains	Cracking brown clays with low to moderate PAWC, may be sodic and saline, neutral to alkaline	Diamond footslope variant	Brown Vertosol	CH	74	Brown cracking clays (BCC) and red cracking clays (RCC)
Alluvium and colluvium on lower slopes and undulating plains	Clay loam to sandy clay loam over +/- sodic and saline medium clay	Good Glengallan	Brown Sodosol	SC-CL over CH	295	Duplex on clay sheets (RDC)
Colluvial lower slopes	Clay loam to sandy clay loam over medium clay over weathered basalt	Glen Idol *	Brown Chromosol	CL over CH	43	Duplex on basalt (RDB)
Crests and upperslopes on metamorphics	Lithosols and shallow duplex, Low to very low PAWC, Sodic or rocky subsoils	Highlands* Violet #, Glengallan *	Rusosols and Brown Tenosols	GM-GC	428	Lithosols (LITH) and sodic duplex (RDM)
Crests and upperslopes	Gravel, Very low PAWC,	None suitable	Rudosols	GM	42	Stripped lithosols (SL)
Undulating rises on conveyor and pipeline routes	Sodic duplex, low PAWC	None Suitable	Sodosol	SC over CL	NA	Duplex on Sedimentary rocks (DS)

*Bourne (1993), #Shields and Williams (1991), **Isbell, (1996), +Hollingsworth (1983), PAWC = Plant available water capacity

Note: Geotech Class – CH = Inorganic clays of high plasticity, SC = Clayey Sands, poorly graded sand-clay mixtures-Inorganic clays of low to medium plasticity, GM = Silty gravels, poorly graded gravel-sand-silt mixtures, GC = Clayey gravels poorly graded gravel sand clay mixtures

3.1.9.3 Soil Mapping Units

The soil mapping units are shown in **Figure 3-3** for the Clermont MLs and **Figure 3-4** for the conveyor corridor.

Most of the area to be disturbed contains black cracking clays of varying depth which have developed on basalt and alluvium. Duplex soils have also developed on older basalt in the western areas. Brown and red cracking clays, lithosols and duplex soils have developed on various sedimentary and metamorphic geologies in the western half of the lease.

The dominant soil types identified in this study are consistent with the Hollingsworth (1983) report, however additional soil types have been identified and soil boundaries altered due to the smaller mapping scale.

The black cracking clays derived from alluvium and basalts can be mapped with a high degree of confidence. The duplex soil mapping units may contain small areas of brown cracking clays and brown cracking clay units may contain small areas of duplex soil.

Similarly, the lithosols and duplex soils derived from metamorphics will contain small areas of mixed soils. For this reason reference soil types are defined below in **Section 3.1.9.4**.

These soil types are typical for each soil mapping unit and can be used to estimate depth of topsoil for the various soil types. Surface texture, size of aggregates and colour are simple methods for differentiating between soil types.

3.1.9.4 Soil Descriptions

A description of each soil follows, with photographs of soil profiles and a description of the soil horizons.

Very Deep Cracking Clay on Alluvium >2m (VDCA) (Plate 3-1)

General -This soil type occupies a large proportion of the mining leases. It occurs on 1-2% slopes, is susceptible to flooding and supports coolibah woodland, black tea-tree and pasture on the mining lease. Black tea-tree areas commonly have rooting depth restricted by salinity within 1m of the surface. Phosphorus levels are high, nitrogen levels are low. Surface pH is typically >8, subsoils commonly have pH over 9. This soil type is suitable for dryland and irrigated crops where it is not inundated by flooding. Flood prone areas are suited to grazing.

Physical characteristics – The surface structure is fine and granular, typically less than 1 cm diameter. The high clay content allows it to retain water making it susceptible to compaction. It dries to very strong material, making moisture content a critical aspect for operational works. Trafficability is poor when wet. Cracking during dry periods can relieve compaction. It is imperfectly drained and may waterlog after rain and flooding.

Management – Moderate water erosion hazard, suitable for broad-based contour banks. Reactive, so requires geo-technical analysis for foundations and large earth structures. Suitable for use in dams, diversion banks, contour banks, and waterways at low slopes. Sown pastures needed if fresh topsoil is not used as native pastures are slow to regenerate unassisted on cultivated land. Nitrogen required to accelerate vegetation establishment. Only strip, cultivate or traffic topsoil when it is drier than the plastic limit. The top 30 cm should be stripped for topsoil.

Distinguishing features – occupies low landscape positions, very low slopes, fine surface structure, greater than 2 m soil depth, supports coolibah/black tea-tree on current floodplain. Large, shiny surfaces develop in subsoils. These slickensides or “slippery backs” are generated by rubbing during swelling and shrinking.

Chemical Characteristics

Depth (m)	pH	EC	N	P	K	OM	ESP	Dispersion
0-0.2	7-8.5	L	L -M	H-VH	VH	Low	L	L
0.2-1.0	7.5-8.5	L-H	L	H	H	VL	L-M	L
1.0-2.0	8-9	M-VH	L	H	H	VL	L-H	L-M
2.0-4.0+	8.0-9.5	M-VH	L	H	H	VL	L-H	L-H

VL = Very Low, L = Low, M = Medium, H = High, VH = Very High

Limiting factors could be pH, ESP and dispersion (for the higher values, at depth in the profile). Otherwise, chemical characteristics are good.

Moderately Deep Cracking Clay Soils on Basalt (1.2-2 m deep) (Plate 3-2)

General - Formed from basalt and occur on gently undulating lower slopes and raised areas surrounded by flat alluvium. They are alkaline to strongly alkaline and are generally non-saline and non-sodic. This soil unit represents the majority of the area to be disturbed by the mine pit. Most of the area has been cleared for rain fed cropping. Shallow linear gilgai (corrugations) of 30 cm depth may occur on lower slopes.

Physical characteristics - These soils have high to very high plant available water capacity. The surface structure is fine and granular, typically less than 1 cm diameter. The high clay content allows it to retain water, making it susceptible to compaction. The soil cracks as it dries so it can repair compaction. It is very soft when wet but dries to very strong material.

Management - Soil will remain wet for long periods if plants are not present to extract water. Moisture content critical for effective stripping and spreading. Nitrogen phosphorus and potassium required to accelerate establishment of vegetation. The top 30 cm can be stockpiled for use as topsoil. These soils can be used for broad-based contour banks, diversion banks and grassed waterways.

Distinguishing features – These cracking clays occur over basalt on lower slopes, are non-sodic or slightly sodic and free of significant salt.

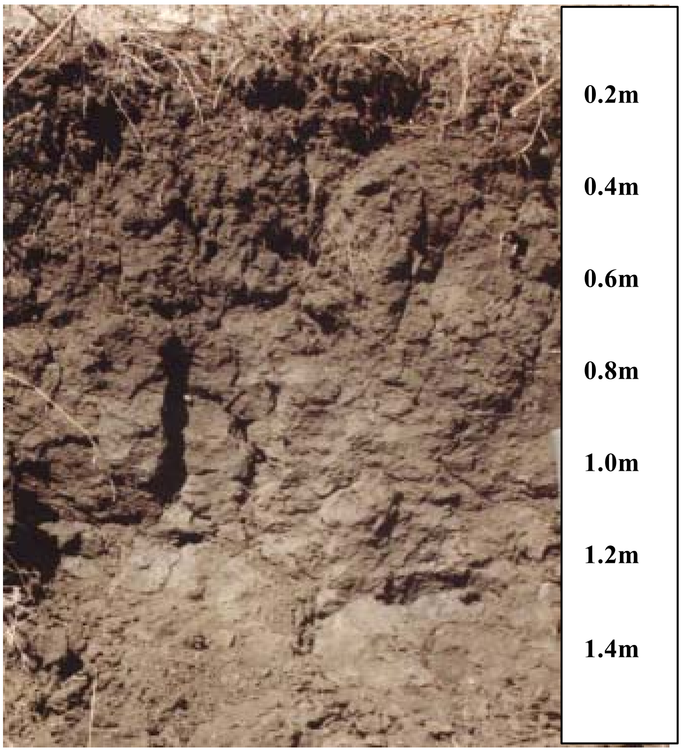
Chemical Characteristics

Depth (m)	pH	EC	N	P	K	OM	ESP	Dispersion
0-0.02	H	L	VL	L	L	VL	L	L
0.02-0.7	H	L	VL	L	L	VL	L-M	L
0.7-1.2	H	L-M	VL	L	L	VL	L-M	L
1.2-2.0	H-VH	L-M	VL	L	L	VL	L-M	L

VL = Very Low, L = Low, M = Medium, H = High, VH = Very High

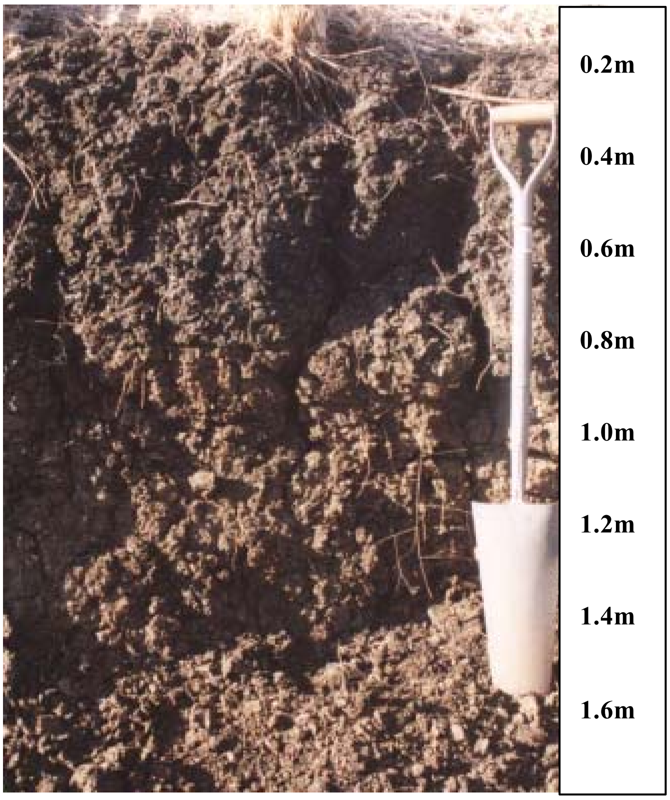
Limiting factors could be pH at the higher end of the range at depth in the profile, otherwise most chemical factors are good.

Plate 3-1 Very Deep Cracking Clay on Alluvium >2 m (VDCA)



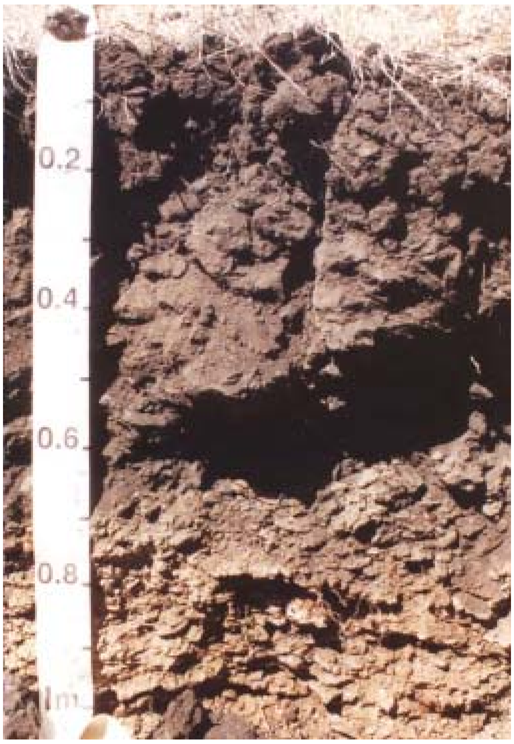
Horizon	Depth	Description
A	0-0.02 m	Medium clay, very dark grey, strong granular surface mulch.
B21	0.02 – 0.8 m	Medium clay very dark grey, strong blocky structure +/- calcium carbonate concretions
B22	0.80-1.20 m	Medium to medium heavy clay, very dark grey to greyish brown, strong lenticular structure, +/- calcium carbonate concretions, brown or red mottles
B23	1.20 m+	Medium to heavy clay, dark greyish brown to grey brown, strong, large lenticular units with shiny surfaces.

Plate 3-2 Moderately Deep Cracking Clay Soils on Basalt (1.2-2 m deep)



Horizon	Depth	Description
A	0-0.02 m	Medium clay, very dark grey, strong granular surface mulch.
B21	0.02 – 0.7 m	medium clay very dark grey, strong blocky structure +/- calcium carbonate concretions
B22	0.70-1.20 m	Medium to medium heavy clay, very dark grey to greyish brown, strong lenticular structure, +/- calcium carbonate concretions, brown or red mottles
B23	1.20 m+	Medium to heavy clay, dark greyish brown to grey brown, strong, large lenticular units with shiny surfaces

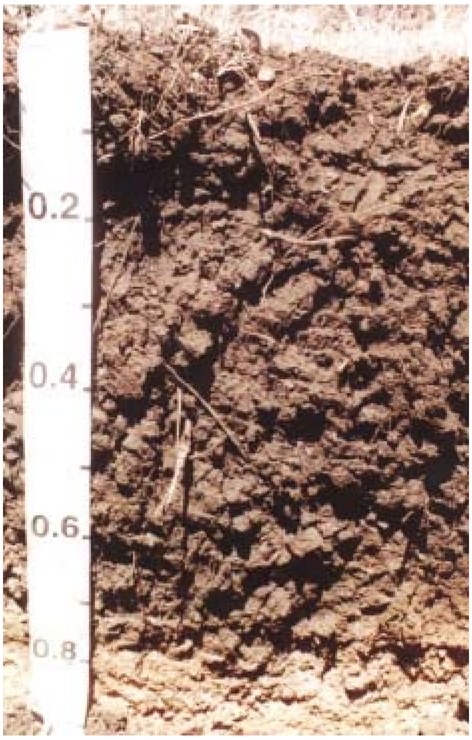
Plate 3-3 Shallow Cracking Clay Soil over Basalt (0.6-1.2 m deep)



0.2m
0.4m
0.6m
0.8m
1.0m
1.2m
1.4m
1.6m

Horizon	Depth	Description
A	0-0.02 m	Medium clay, very dark grey, strong granular surface mulch.
B21	0.02 – 0.7 m	Medium clay very dark grey, strong blocky structure +/- calcium carbonate concretions
B22	0.70-1.20 m	Medium to medium heavy clay, very dark grey to greyish brown, strong lenticular structure, +/- calcium carbonate concretions, brown or red mottles
B23	1.20 m+	Medium to heavy clay, dark greyish brown to grey brown, strong, large lenticular units with shiny surfaces Photo: Gully line exposure

Plate 3-4 Brown and Red Cracking Clays



0.2m
0.4m
0.6m
0.8m
1.0m
1.2m
1.4m
1.6m

Horizon	Depth	Description
A	0-0.02 m	Medium clay, very dark grey, strong granular surface mulch.
B21	0.02 – 0.7 m	Medium clay very dark grey, strong blocky structure +/- calcium carbonate concretions
B22	0.70-1.20 m	Medium to medium heavy clay, very dark grey to greyish brown, strong lenticular structure, +/- calcium carbonate concretions, brown or red mottles
B23	1.20 m+	Medium to heavy clay, dark greyish brown to grey brown, strong, large lenticular units with shiny surfaces Photo: Gully line exposure

Shallow Cracking Clay Soil over Basalt (0.6-1.2m deep) (Plate 3-3)

General – These soils occupy the midslopes and undulating areas overlying basalt with mountain coolibah and bloodwood. Some areas have been cleared for forage and grain cropping. They are non-sodic and non-saline. Structure is strong and a granular surface mulch is present. Some basalt cobbles may be present on the surface and in the profile.

Physical characteristics - Plant available water capacity is medium to high. Depth to weathered basalt ranges from 0.4 m to 1.2 m to. Plant available water capacity is limited by depth to weathered basalt and horizons containing over 30% gravel.

Management - High clay content makes this soil difficult to work as it has high strength when dry and is easily compacted when moist. Only strip, cultivate and traffic soil when it is drier than the plastic limit. Erosion hazard in these soils is high due to the high clay content and moderate slopes. These soils have a mildly alkaline surface over strongly alkaline subsoil. The upper 20 cm can be stripped.

Distinguishing features – Lower slope position, cobbles, depth of profile.

Chemical Characteristics

Depth (m)	pH	EC	N	P	K	OM	ESP	Dispersion
0-0.02	M-H	L	L-M	VL -M	VL-H	L	L	L
0.02-0.7	M-H	L	L		VL	VL	L	L
0.7-1.2	M-H	L	L		VL	VL	L-M	L
1.2-2.0	M-H	L	L		VL	VL	L-M	L

VL = Very Low, L = Low, M = Medium, H = High, VH = Very High

There are no limiting factors. The soil is considered to have good chemical characteristics.

Very Shallow Cracking Clay Soils on Basalt (<0.6m) (no Plate)

General -These soils occupy the scree slopes and crests of basalt hills and plateaux. They are alkaline to strongly alkaline. Land suitability is limited by steep slopes, rockiness and low plant available water capacity.

Horizon	Depth	Description
A	0-0.02 m	Medium clay, very dark grey, strong granular surface mulch; stones, cobbles and gravel 10-50%
B21	0.02 –0.4 m	Medium clay very dark grey, strong prismatic to subangular blocky structure. Stones and cobbles 10- 20%
B22	0.40-0.6 m	Strong lenticular structure, medium clay, dark greyish brown to brown +/- weathered basalt with gravel 40-60%, +/- calcium carbonate.
C	0.6m+	Basalt

Physical characteristics - Erosion hazard in these soils is high due to the high clay content and steep slopes. These soils have a mildly alkaline surface over strongly alkaline subsoil.

Management - High clay content makes this soil difficult to work as it has high strength when dry and is easily compacted when moist. Only strip, cultivate and traffic soil when it is drier than the plastic limit. These soils are generally unsuitable as topsoil due to large amounts of surface stone.

Distinguishing features – occur on crests, have abundant surface stone, shallow soil profile.

Chemical Characteristics

Depth (m)	pH	EC	N	P	K	OM	ESP	Dispersion
0-0.02	H	L	L	L-M	H	M	L	L
0.02-0.4	H	L	L	L-M	H	L	L	L
0.4-0.6	H	L	VL	L-M	M	L	L	L

VL = Very Low, L = Low, M = Medium, H = High, VH = Very High

There are no chemical limiting factors, but the soils are generally unsuitable for topsoil due to large amounts of surface stone.

Brown and Red Cracking Clays (Plate 3-4)

General – Clay soils derived from unconsolidated sediments, usually on lower slopes and drainage lines. Supports brigalow, Dawson River blackbutt and bauhinia. Neutral to mildly alkaline surface to strongly alkaline subsoil, +/- salinity, subsoil sodic. Linear gilgai to 30 cm deep may occur with mounds covered in white quartz pebbles. Profile may be over 2 m deep.

Physical characteristics – Plant available water capacity is low to moderate depending on the depth to saline or highly sodic layers.

Management – Erosion hazard in these soils is high due to the high clay content and high sodium levels. Soils are susceptible to compaction when moist and have low ability to repair structure through cracking. The top 20 cm can be stripped for topsoil.

Distinguishing features – the clay content of surface soils, cracking and colour distinguish these soils from the duplex soils they are associated with.

Chemical Characteristics - Very low potassium, moderate phosphorus, and moderate organic mater. High to very high levels of salt may occur at approximately 60 cm to 2 m. Erosion hazard in these soils is high due to the high clay content.

Depth (m)	pH	EC	N	P	K	OM	ESP	Dispersion
0-0.02	M	L	L-M	M	VL	M-H	M	L
0.02-0.6	M-H	L-H	L-M	M	VL	L	H	M
0.6-0.8	M-H	L-H	L-M	L	VL	VL	VH	VH
0.8-1.1+	M-H	M-VH	L-M	L	VL	VL	VH	VH

VL = Very Low, L = Low, M = Medium, H = High, VH = Very High

Limiting factors could be EC, ESP and dispersion for some components of the soil at depth, otherwise the soils have good chemical characteristics.

Duplex Soils on Basalt (Plate 3-5)

General- Non saline, non-sodic duplex soil formed on basalt and colluvium on lower slopes in undulating rises. Silver leaved ironbark, Dawson River blackbutt, beefwood and brigalow predominant.

Physical characteristics –This soil has a medium erosion hazard. Bourne and Tuck (1993) considered it had limited suitability for winter forage and crops and that long-term suitability for cropping was doubtful. It supports low productivity pasture uncleared but highly productive pasture when cleared and sown with buffel grass, Rhodes grass, stylo and green panic. Surface susceptible to wind erosion when disturbed. Plant available water capacity is low to medium.

Management – Nitrogen levels are very low. Avoid stripping topsoil too dry, as this will pulverise structure and generate dust. If large quantities of dust are generated the soil is too dry. This soil is suitable for dams diversion banks, waterways, narrow based contour banks. The top 20 cm can be stripped and retained as topsoil. The surface soil is a useful source of loam.

Distinguishing features – Neutral clay loam surface over strongly structured reddish brown subsoil.

Chemical Characteristics

Depth (m)	pH	EC	N	P	K	OM	ESP	Dispersion
0-0.15	M	L	VL	M	H	L	L	L
0.15-0.5	M	L	VL	M	H	VL	L	L
0.5-0.65	H	M	VL	L	M	VL	M	M
0.65-1.1	H	M	VL	L	L	VL		M

VL = Very Low, L = Low, M = Medium, H = High, VH = Very High

Duplex soils on basalt may have EC and ESP limitations at depth.

Duplex on Clay Sediments (Plate 3-6)

General – Sandy loam surfaced duplex soils on undulating rises. These soils support brigalow, silver leaved ironbark and Dawson River blackbutt. They are weathered from clay sheets and are mixed with brown and red clay units.

Physical characteristics – Surface soil is very prone to wind erosion and dust generation. Subsoil is highly dispersive and should not be left bare or have run-off concentrated on it. Drains should be pushed up from down slope to avoid exposing subsoil in drain bottoms. This soil has low to very low PAWC. It is suitable for cleared and improved pasture.

Management – These soils are highly susceptible to gully and rill erosion. Tunnel erosion is common in gully lines indicating the subsoils are highly dispersive. The top 20 cm can be stripped for topsoil.

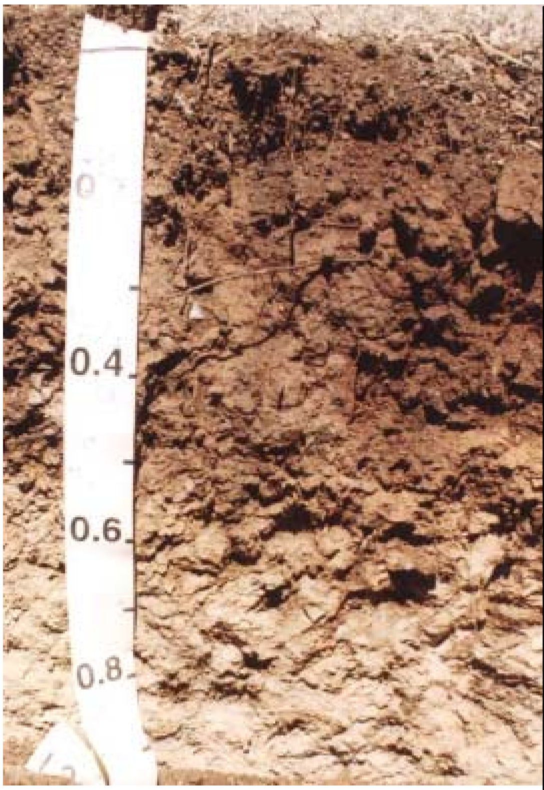
Distinguishing features – Lighter surface texture and no subsoil red hues compared with duplexes.

Chemical Characteristics

Depth (m)	pH	EC	N	P	K	OM	ESP	Dispersion
0-0.02	M	L	L	L	M	M	M	L
0.02-0.7	H	M-H	VL	VL	M	VL	H	H
0.7-1.2	VH	H-VH	VL	VL	L	VL	VH	VH

VL = Very Low, L = Low, M = Medium, H = High, VH = Very High. pH, EC, ESP and dispersion could all be limiting factors for the deeper layers of the profile.

Plate 3-5 Duplex Soils on Basalt



0.2m
0.4m
0.6m
0.8m
1.0m
1.2m
1.4m
1.6m

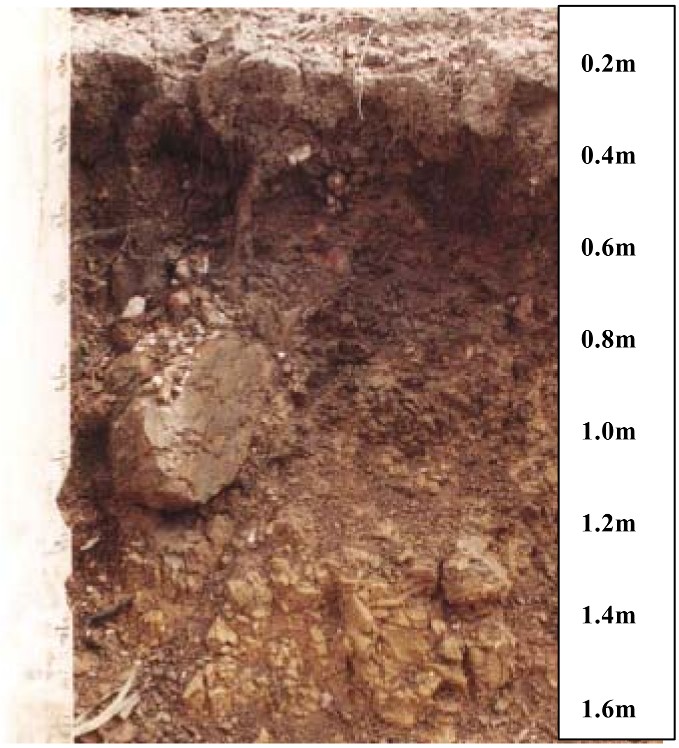
Horizon	Depth	Description
A	0-0.02 m	Medium clay, very dark grey, strong granular surface mulch.
B21	0.02 – 0.7 m	Medium clay very dark grey, strong blocky structure +/- calcium carbonate concretions
B22	0.70-1.20 m	Medium to medium heavy clay, very dark grey to greyish brown, strong lenticular structure, +/- calcium carbonate concretions, brown or red mottles
B23	1.20 m+	Medium to heavy clay, dark greyish brown to grey brown, strong, large lenticular units with shiny surfaces Photo: Gully line exposure

Plate 3-6 Duplex on Clay Sediments

0.2m
0.4m
0.6m
0.8m
1.0m
1.2m
1.4m
1.6m

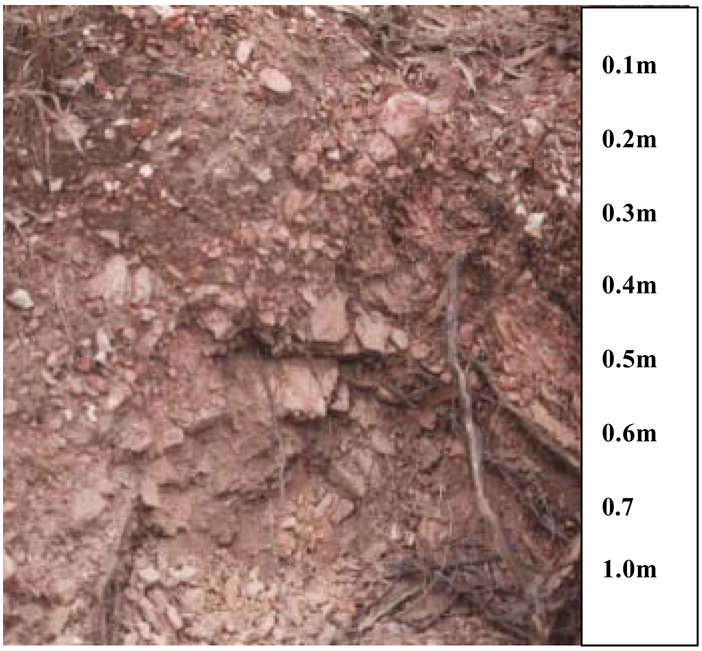
Horizon	Depth	Description
A	0-0.02 m	Medium clay, very dark grey, strong granular surface mulch.
B21	0.02 – 0.7 m	Medium clay very dark grey, strong blocky structure +/- calcium carbonate concretions
B22	0.70-1.20 m	Medium to medium heavy clay, very dark grey to greyish brown, strong lenticular structure, +/- calcium carbonate concretions, brown or red mottles
B23	1.20 m+	Medium to heavy clay, dark greyish brown to grey brown, strong, large lenticular units with shiny surfaces Photo: Gully line exposure

Plate 3-7 Duplex on Metamorphics



Horizon	Depth	Description
A	0-0.02 m	Medium clay, very dark grey, strong granular surface mulch.
B21	0.02 – 0.7 m	Medium clay very dark grey, strong blocky structure +/- calcium carbonate concretions
B22	0.70- 1.20 m	Medium to medium heavy clay, very dark grey to greyish brown, strong lenticular structure, +/- calcium carbonate concretions, brown or red mottles
B23	1.20 m+	Medium to heavy clay, dark greyish brown to grey brown, strong, large lenticular units with shiny surfaces Photo: Gully line exposure

Plate 3-8 Lithosols and Stripped Lithosols



Horizon	Depth	Description
A	0-0.02 m	Medium clay, very dark grey, strong granular surface mulch.
B21	0.02 – 0.7 m	Medium clay very dark grey, strong blocky structure +/- calcium carbonate concretions
B22	0.70- 1.20 m	Medium to medium heavy clay, very dark grey to greyish brown, strong lenticular structure, +/- calcium carbonate concretions, brown or red mottles
B23	1.20 m+	Medium to heavy clay, dark greyish brown to grey brown, strong, large lenticular units with shiny surfaces Photo: Gully line exposure

Duplex on Metamorphics (Plate 3-7)

General – A widespread duplex soil on moderate to steep slopes on rolling low hills in the western third of the lease. Surface is hard-setting. Vegetation includes ironbark, rosewood and Dawson River blackbutt.

Physical characteristics – The soil has very low plant available water capacity and is suitable for grazing with careful thinning of native vegetation. Gully erosion was observed in disturbed areas. Surface soil is very prone to wind erosion and dust generation. Subsoil is highly dispersive and should not be left bare or have run-off concentrated on it. Drains should be pushed up from down slope to avoid exposing subsoil in drain bottoms.

Management – Retain vegetative cover. The top 20 cm can be retained for topsoil.

Distinguishing features – Soil occurs throughout moderate to steep slopes on metamorphic rocks.

Chemical Characteristics

Depth (m)	pH	EC	N	P	K	OM	ESP	Dispersion
0-0.2	L	L	L-VL	VL	VL	M	L	L
0.2-0.5	M-H	M	VL	VL	VL	L	H	VH
0.5-0.7	M-H	M-H	VL	VL	VL	VL	VH	VH
0.7-1.0	M-H	M	VL	VL	VL	VL	VH	VH

VL = Very Low, L = Low, M = Medium, H = High, VH = Very High

ESP and dispersion may be limiting factors for some of the soil at depth, otherwise most chemical characteristics are good.

Duplex on Sedimentary (no Plate)

Duplex soils developed on sedimentary rocks are located on the conveyor route and at the Cement leases. These soils are sodosols with similar properties to the Duplex on metamorphics. They will not be significantly disturbed by the development and will not be used for topsoil extraction.

Lithosols and Stripped Lithosols (Plate 3-8)

General – Lithosols cover a large areas of the waste rock dump areas as shallow soils on crests and ridgelines on metamorphic rocks. Poorly developed profiles consisting of clay loam over weathered and unweathered rock. Supports ironbark and rosewood. Very low nutrient levels.

Physical characteristics – Very low plant available water capacity. The A horizon has weak structure that will be lost following stripping and spreading.

Management – Retain vegetative cover. Areas of previously stripped lithosol may be rehabilitated using bunds and diversion banks. They offer no significant topsoil but may be used for gravel extraction. Regeneration of acacia and eucalypt species is occurring on these gravel areas. Areas that have been previously stripped may yield useful, soft weathered rock. The top 20 cm or soft material can be taken for topsoil.

Distinguishing features – Occur on crests and upper slopes as shallow profiles (lithosols) or areas of bare gravel (stripped lithosols).

Chemical Characteristics

Depth (m)	pH	EC	N	P	K	OM	ESP	Dispersion
0-0.1	L	L	VL	VL	VL	VL-M	L	L
0.1m+	L	L	VL	VL	VL	VL	L	L

VL = Very Low, L = Low, M = Medium, H = High, VH = Very High

Stripped lithosols and lithosols may have excessive rock fragments, but otherwise the soil is considered to have good chemical characteristics.

3.2 Land Suitability

Land suitability classification is based on specific land uses assessed using the following classes (based on Shields and Williams, 1991 and DME, 1995):

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

Suitability for beef cattle grazing and dryland cropping were determined as these are the dominant land uses in the district. The methodology used to identify the limitations and their impacts on land suitability follow DPI (1990), DME (1995) and the local work of Shields and Williams (1991) and DPI internet resources. The land suitability classification identifies limitations of the different soil types present on the leases and identifies suitable uses.

3.2.1 Limitations for Rainfed Cropping

This classification evaluates the broad acre potential for growing non-irrigated sorghum, wheat, safflower, cotton and chickpeas. The suitability of each soil type for rainfed cropping is shown in **Figure 3-5**.

Eleven limitations were identified that significantly affect rainfed cropping in the area of the mining leases. These were (using the DPI nomenclature in brackets):

- plant available water capacity (m);
- nutrient deficiency (n);
- soil physical factors (p);
- soil workability (k);
- salinity (s);
- rockiness (r);
- microrelief (g-gilgai);
- wetness (w);
- water erosion (e);
- flooding (f); and
- topography (t).

3.2.1.1 Plant Available Water Capacity (PAWC)

Plant available water is a significant soil property in this locality as cropping is based on fallow storage of moisture in the soil profile. PAWC is the moisture stored in the soil profile that is available to the plant and is classically defined as the moisture present between field capacity and permanent wilting point (15 bar).

All land suitable for rainfed cropping has a moisture availability limitation (m2-3) that reduces the maximum cropping success to a maximum of 75% (i.e. 1 in 4 crops will fail due to insufficient moisture) (Shields and Williams, 1991).

PAWC was assessed using site specific chemistry, guidelines in Bourne and Tuck (1991), Shields and Williams (1991), QDPI internet resources (2001), DME (1995) and profile data and information from local publications **Table 3-7**.

The QDPI model PAWCer was used to verify these general guidelines were suitable for soil types on the mining lease. Particle size analysis and moisture retention characteristics were taken from Bourne and Tuck (1993) and Shields and Williams (1991) for PAWC modelling. Particle size analyses were corrected to sum to 100%, typically by reducing clay percentage.

Table 3-7 Criteria for assessing cropping limitations due to PAWC

Limitation Level	PAWC (mm)	Depth of Black Cracking Clay	Predicted Cropping Success
2	>130	900 mm	70-75%
3	100-130	600 mm	40-70%
4	75-100	400 mm	<40%
5	<75	<400mm	<<40%

Modelling results confirmed that the black cracking clays hold significant water that can be effectively used for cropping in a fallow storage system. Lithosols and sodic duplexes typically had less than 75mm PAWC.

Soil texture and barriers to root growth such as high sodium, poor soil structure, high electrical conductivity and chloride limit PAWC. Observed rooting depths were used as a check of simulated profiles.

3.2.1.2 Soil Physical Factors (p)

The clay soils present on site will have a narrow moisture content suitable for cultivation as they are susceptible to compaction and smearing when wetter than the plastic limit. Trafficability is also limited by high clay content and moisture retention on the clay soils.

The black clay soils compact readily. Controlled traffic farming is one method of increasing application on these soils that reduces compaction. Compaction and structure decline does not preclude production on the clay soils. It does limit production on the duplex soils.

Handling of soils when in a plastic state must be avoided during topsoil stripping to prevent compaction of this material.

3.2.1.3 Rockiness (r)

Rockiness refers to the amount of rock out crop and coarse fragments greater than 6 cm in diameter. Plough zones 30 cm depth with 10% or less rock was considered to be r1. r2 was 10-20%, r3 was 20-30%, r4 30-40% and r5 50% or greater. Soils with significant rock included minor areas of shallow cracking clays, very shallow cracking clays and lithosols.

3.2.1.4 Flooding (f)

Flooding limits cropping opportunities due to the high risk of erosion of cultivated soil. Strip cropping is not considered to be a viable management option by DNRME in the area due to the unreliable winter cropping and large areas of bare soil left in forage crops during summer. The highest erosion risk occurs in summer with the majority of rainfall coming in intense storms.

Flooding risk also increases the risk of crop and pasture improvement failure due to water logging, particularly during establishment. The very deep cracking clays on alluvium are subject to flooding and these areas are currently not cropped due to the high erosion and financial risk.

3.2.1.5 Topography (t)

Topography is assessed in terms of slope and micro-relief.

Slopes (ts) refers to slope at the local scale in terms of rise over run. Slope may limit the effective and safe use of machinery and contribute to erosion hazard.

Microrelief (tg) – refers to regular surface undulations due to gullies, gilgai and debbil-debbil. Gilgai are present in the shallow cracking clays on basalt and the brown cracking clays. They are not severe enough to prevent the use of machinery in routine cultivation. Creek lines associated with Wolfang and Gowrie creek are deeply dissected and unsuitable for cultivation. More severe linear gilgai are present in the brown clays. These gilgai have scalded mounds with substantial quartz gravel and would not be suitable for cultivation.

3.2.2 Limitations for Beef Cattle Grazing

The regional land types used by Lambert and Graham (1996) indicate that most of the mining lease is suitable for at least one species of improved pasture (**Table 3-8**).

Table 3-8 Regional Land Types

Land Type#	Soil equivalent	Improved Pasture Type Buffel	Bambatsi	Sorghum	Rhodes	Purple pidgeon
Softwood scrub	RDM, BCC	S	S	S	S	S
Blackbutt duplex	RDM	S	LS	S	LS	LS
Grassland black clay	VDCC, DCC	NS	S	S	NS	S
Coolibah Clay	VDCC, DCC	NS	S	S*	NS	S*
Box/Ironbark duplex		LS		NS	LS	NS
Woodland shallow clays	SCB	NS	LS	LS	NS	LS
Melonhole clays	BCC, RCC	LS	S	S	LS	S

S- Suitable, NS- will grow but difficult to establish or persistence poor, U – Unsuited, *Except where flooded. # from Lambert and Graham, 1996.

Twelve limitations to grazing improved pasture were considered in relation to the lands of the mining leases. These limitations are the same as those for rainfed cropping with the addition of regrowth (rg) (Shields and Williams, 1991). Species considered included buffel grass (*Cenchus ciliaris*), Rhodes grass (*Chloris gayana cv. Katambora*), forage sorghum, purple pidgeon grass (*Setaria incrassata*) and bambatsi panic.

These species have been researched by Queensland DPI and their suitability for use on the land types matching those on the mining leases has been documented (Lambert and Graham, 1996). Criteria were adapted from DME 1995. The suitability of each soil type for improved pastures is shown in **Figure 3-6**.

3.2.2.1 Plant Available Water Capacity

The mechanisms of water supply to pastures are the same as for dryland cropping (see **Section 3.2.1**). Pasture production occurs in a shallower root zone than cropping systems and 60 cm of rooting depth in clay soils is considered to be adequate for pastures to achieve maximum production (Shields and Williams, 1991). Other limitations (m2-m5) were interpolated based on PAWC (**Table 3-9**), depth to salinity and sodicity and soil texture.

Table 3-9 Land Suitability for Cattle Grazing – Effects of PAWC

	Land suitability class				
	1	**2**	**3**	**4**	**5**
Moisture (M)	PAWC>125mm	PAWC 100-125mm	PAWC 75-100mm	PAWC 50-75mm	PAWC<50mm

3.2.2.2 Nutrient deficiency (n)

This was determined from levels of N and P determined from sampled profiles in the Hollingsworth (1993) and the SKM surveys. These were rated using DME 1995 and checked for consistency with the land types of Lambert and Graham (1996).

3.2.2.3 Soil Physical Factors

These limit pasture establishment and spread. They are typically related to size of surface aggregates, hardsetting or cracking. Small seeded species such as buffel and Rhodes grass are difficult to establish on cracking clays as they are lost down large airspaces or rapidly dry out after germination in the porous soil.

Spread of most species is restricted on hardsetting surface soils such as sandy loam to clay loam textures. Larger seeded species such as sorghum and bambatsi are more suited to the clay surface textures (Lambert and Graham 1996).

The hardsetting gilgai mounds of the brown clays and duplex soils were still suitable for establishment of species tolerant of wetness is the depressions.

Rockiness (r)

Rockiness refers to rock outcrop and coarse fragments that may impede cultivation. Cultivation is occasionally necessary to rejuvenate pastures. The very shallow cracking clays (r5), lithosols (r4-5) and stripped lithosols (r5) were the only soil types restricted by rockiness.

Microrelief (g)

Microrelief limits the effectiveness of cultivation and reduce trafficability. These limitations are limited to the brown and red cracking clays where they are a minor limitation (g2).

Wetness (w)

Wetness can affect persistence of some species and trafficability of machinery. The gilgai soils were considered to have a wetness limitation of w2 as were the drainage channels. Wetness limitations were not considered to significantly affect other soil types.

Water Erosion (e)

Water erosion is related to soil physical and chemical properties and landform (especially slope). Slope limits were based on DME 1995 (**Table 3-10**).

Table 3-10 Land Suitability for Cattle Grazing – Effects of Slopes

	Limitation rating				
	1	2	3	4	5
Cracking clays	<3% slope	Slopes 3-6%	Slopes 6-9%	Slopes 9-15%	>15%
Sodic rigid soils	<1% slope	Slopes 1-3%	Slopes3-6%	Slopes 6-12%	>12%

3.2.2.4 Flooding (f)

Flooding was considered to limit the suitability of low lying alluvial areas associated with Gowrie Creek and adjacent stream channels. Flooding was considered to make the cultivation for improved pastures too limiting.

Only a limited number of improved species persist in areas subject to frequent or extended inundation (eg bambatsi). This was considered to be a moderate limitation only (f2) in some stream channel areas.

3.2.2.5 Vegetation regrowth (v)

Regrowth can be a serious limitation to establishment and persistence of improved pastures in eucalyptus woodlands with wattle understoreys such as the Ironbark/Rosewood communities that occupy large areas of the metamorphic hills.

Brigalow areas with melonholes (such as the brown cracking clays) were rated v2 with the duplex on metasediments with ironbark and rosewood were considered v4. All other areas had a regrowth rating of v1. The only vegetation to have a moderate to severe rating is the ironbark with rosewood/lancewood.

3.2.3 Pre-Mine Land Suitability

The land suitability of the proposed Project area is shown in **Table 3-11**.

3.2.4 Post Mine Land Use Suitability

Factors influencing changes in land suitability include changed physical, chemical and biological properties of soil, changes in slope and slope length and changes in soil depth. The suitability of the waste rock dumps for cropping and grazing is constrained by slope angle, the nature of soil cover, and altered moisture profile. These constraints would increase the risk of erosion significantly if cropping or grazing were undertaken.

The plateau of the final waste dump landforms is not considered suitable for rainfed cropping as it would require the replacement of a black cracking clay profile of approximately 900 mm depth and the installation of suitable soil conservation works, and that is not practical. The erosional stability of the waste dump plateau may also be compromised by grazing. It is also isolated from other pastures and suitable watering points and so was not considered suitable for sustained grazing.

3.2.4.1 Rainfed Cropping

The pre and post mine areas of land suitability for rainfed cropping is shown in **Table 3-12**. Maps of pre and post mine suitability for rainfed cropping are shown in **Figure 3-5** and **Figure 3-7** respectively.

Approximately 35% of the pre-mined area is suitability class 2 or 3, and is suitable for rainfed cropping (**Table 3-12**). This is consistent with existing land use although some potential cropping land currently supports native pastures. The post mining landscape has 16% of the area suitable for rainfed cropping, a decrease of approximately 610 ha.

Table 3-11 Land Suitability Classes – Pre-Mining

Soil Unit	Limitation	Major Limitations (suitability)	Suitable Landuse	Cropping Suitability	Grazing Suitability	SPP1/92 Agricultural Land Classification
Very Deep Cracking Clays on Alluvium > 2.0 m deep	Flooding, Erosion, Workability, Salinity, Frost	f4-5,e3,w4,k2, s2,t2-5	Flooding limits cropping Grazing of native and improved pastures	4-5	3	C1-D
Deep cracking clays on basalt 1.2 m to 2.0 m	Erosion, fertility, surface structure, surface sealing, surface stone, workability	e2,n2,p2,m2,r2	Irrigated and rainfed cropping Grazing of native and improved pastures	2	2	A
Shallow cracking clay soils between 0.45 and 1.2 m	Erosion, fertility, surface structure, surface sealing, surface stone, workability variability of depth and PAWC	e3,m3,p2,k2,g2,n2	Irrigated and rainfed cropping Grazing of native and improved pastures	3	2	B-C1
Very Shallow Cracking Clay	Erosion, rockiness, fertility, surface structure, surface sealing, workability shallow rooting depth and low to moderate PAWC	e4, m5,r4,n2,t5	Grazing of Native pastures, stone limits effective cultivation for improved pastures	5	3	C2
Brown Cracking Clay	Erosion, fertility, surface structure, surface sealing, salinity workability shallow depth and low PAWC	e3,m4-5, g3,p3,n3,s2-5	Grazing of native pastures, Cultivation of improved pastures	4	2-3	C1-D
Red Cracking Clay	Erosion, fertility, surface structure, surface sealing, workability, shallow depth and low to moderate PAWC	e3, m4, p3	Grazing of native pastures, Cultivation of improved pastures	4	2-3	C1
Red Duplex on Basalt	Erosion, fertility, surface structure, surface sealing, surface stone, workability shallow depth and low to moderate PAWC	e4, m4, n3, p4	Grazing of native pastures, Cultivation of improved pastures, very occasional cropping	4	3	C1
Red Duplex on Metamorphics	Erosion, fertility, surface structure, surface sealing, workability, shallow depth and low PAWC	e4-5, m5	Grazing of native pastures with careful clearing	5	3-4	D
Red Duplex on Clay Sheet	Erosion, fertility, surface structure, surface sealing, workability, shallow depth and low PAWC	e4-5, m5	Grazing of native pastures with careful clearing	5	3-4	C2 D

Soil Unit	Limitation	Major Limitations (suitability)	Suitable Landuse	Cropping Suitability	Grazing Suitability	SPP1/92 Agricultural Land Classification
Lithosols on Metamorphics	Erosion, fertility, surface structure, surface sealing, slope, regeneration and very low PAWC	e4-5, m5	Grazing of native pastures with thinning of vegetation	5	5	D
Stripped Lithosols	Erosion, fertility, shallow soil, depth and low PAWC	e5,m5,n4	Regeneration of native vegetation occurring	5	5	D

Table 3-12 Pre and Post Mine Land Suitability – Rainfed Cropping

Land Suitability Class	Area within Mining lease (ha)		% of Total Mining Lease Area		Area within Disturbance Footprint (ha)[1]		% of Total Disturbance Area	
	Pre-mining	Post-Mining	Pre-mining	Post-Mining	Pre-mining	Post-Mining	Pre-mining	Post-Mining
2	902	455	28	14	482	55	31	4
3	226	64	7	2	166	0	11	0
4	129	73	4	2	47	0	3	0
5	1963	2628	61	82	840	1480	55	96
Total	**3220**	**3220**	**100**	**100**	**1535**	**1535**	**100**	**100**

[1] Footprint excludes conveyor and highways.

3.2.4.2 Cattle Grazing

The pre and post areas of land suitability for cattle grazing is shown in **Table 3-13**. Maps of pre and post mine beef cattle suitabilities are shown in **Figure 3-6** and **Figure 3-8** respectively.

Limitations for beef cattle grazing are similar to those for rainfed cropping, with the addition of regrowth (rg) (Shields and Williams, 1991). Regrowth can be a serious limitation in Eucalyptus woodlands with wattle understoreys such as the ironbark/rosewood communities that occupy large areas of the metamorphic hills. The slopes of the waste rock dump were considered have an unacceptable erosion risk if used for grazing.

The largest changes occur in Class 5 which increases from 2% to 46% post mining. Areas downgraded are mainly Class 1 and Class 2.

Table 3-13 Pre and Post Mine Land Suitability – Cattle Grazing

Land Suitability Class	Area within Mining lease (ha)		% of Total Mining Lease Area		Area within Disturbance Footprint (ha)[1]		% of Total Disturbance Area	
	Pre-mining	Post-Mining	Pre-mining	Post-Mining	Pre-mining	Post-Mining	Pre-mining	Post-Mining
1	837	374	26	12	476	0	31	0
2	998	604	31	19	428	55	28	4
3	869	516	27	16	356	0	23	0
4	451	223	14	7	231	0	15	0
5	65	1503	2	46	44	1480	3	96
Total	**3220**	**3220**	**100**	**100**	**1535**	**1535**	**100**	**100**

[1] Footprint excludes conveyor and highways

3.3 Good Quality Agricultural Land

The Planning Guidelines: The Identification of Good Quality Agricultural Land (DLGP and DPI, 1993) indicate that crop land (Class A), marginal crop land (Class B) and land suitable for improved pastures (Class C1) are good quality agricultural land (GQAL) in Belyando Shire.

Land considered to be good quality agricultural land is shown in **Table 3-11** and

Figure 3-9. The Project will remove some areas of GQAL – 648 ha Class A land, 46 ha of Class B land and 1260 ha of Class C1 land. The Class C1 land includes the Class A and Class B land.

SPP 1/92 provides a framework for development to be assessed that considers the value of GQAL. The policy acknowledges that there will be developments that can legitimately alienate GQAL because they represent an overriding benefit to the community.

The Project is considered to provide the following overriding community benefits:

- it allows the utilisation of the coal resources of the State;
- it provides substantial employment within Belyando Shire and elsewhere in Queensland;
- it allows the continuation and expansion of a locally significant industry that provides substantial export income to the State;
- it allows the continued utilisation of infrastructure associated with the BAM; and
- there is no alternative location on land of lesser agricultural quality. The Project location is dictated by the position of the coal reserves.

3.4 Erosion Potential and Control

3.4.1 Erosion Hazard

The erosion sensitivities of the soil types found on site are presented in **Table 3-14**.

Table 3-14 Susceptibility of Soil Types to Erosion, Soil Erodibility Factor (K)

Soil type	Sheet	Rill	Gully	Wind	Soil Erodibility Factor K*
Very Deep Cracking Clay	M	L	L	L	0.05
Deep Cracking Clay	M	M	L	L	0.05
Shallow Cracking Clay	M	M	M	L	0.05
Very Shallow Cracking Clay	M	H	H	L	0.05
Brown and Red Cracking Clay	M	H	H	L	0.05
Duplex on Basalt	L	H	VH	L	0.02- 0.03 A horizon
					0.05 B horizon
Duplex on Clay	M	VH	VH	M	0.02-0.03 A horizon
Duplex on Metamorphics	H	VH	H	M	0.02-0.03 A horizon
Lithosols	H	H	H	M	0.025- 0.03
Stripped Lithosols	VH	VH	H	M	0.02

Source: Bourne and Tuck (1993), Broadscale Tree Clearing Policy for State Lands, 2000. *assumes 60% surface cover and rainfall erosivity between 2000-3000.

Erosion hazard was based on exchangeable sodium percentage, Ca:Mg, particle size distribution, Emmerson Aggregate Stability Index and profile morphology and observed erosion problems. This is consistent with the soil conservation handbook (Macdonald et al 1998), mining industry guidelines (DME, 1995) and DNRME/DPI guidelines (Shields and Williams, 1991; DPI, 1990).

Generally the duplex soils had the greatest erosion hazard due to dispersion induced by sodium domination of the exchange complex. Soils that had a hard-setting surface due to chemistry and particle size distribution are also prone to soil erosion on steeper slopes if left bare. Erosion hazard must consider how the soil would perform on modified landforms such as batter slopes.

The potential for erosion of disturbed areas varies with soil type throughout the site. The duplex and lithosols are particularly prone to erosion and are actively gullying under the current grazing/forestry land use. The most significant risks are due to raindrop impact, sheet erosion, rills and gullies and tunnelling.

Bourne and Tuck (1993) consider October to April to be the period of highest rain erosivity at Clermont and soil should not be left bare at these times if possible.

Wind erosion is also possible, particularly following mechanical disturbance of soil by stripping and stockpiling.

Currently, erosion potential varies markedly across the site due to soil type, vegetation cover and topography. The deep cracking clays of the alluvial plains have low erosion hazard under vegetation while lithosols and sodic duplex soils have readily generated gullies due to stock tracks and vehicle tracks concentrating overland flow.

The Project would give rise to the potential for erosion due to the land disturbance required for construction of mine infrastructure (buildings, roads, dams), development of the pit and development of out-of-pit waste rock dumps. There is also a risk of erosion on areas that have been rehabilitated.

3.4.2 Erosion Control

Disturbed areas will be stabilised as quickly as practical to limit erosion. Progressive revegetation will be undertaken. Erosion and sediment control measures will be employed, which are consistent with the practices described in the 'Technical Guidelines for Environmental Management for Exploration and Mining in Queensland' (DME, 1995).

The design parameters for the construction of erosion control work such as rock armoured or grass lined waterways will be in accordance with sound engineering and soil conservation earthworks principles. A number of variables are included such as time of concentration, rainfall intensity, erosivity, gradient, scour velocities and flow estimations.

The erosion control measures to be employed throughout the life of the Project are summarised in **Table 3-15**.

Table 3-15 Erosion Causes and Control – Mining Activities

Area	Control Measure
Cleared Land	▪ restrict clearing to areas essential for the works ▪ windrow vegetation debris along the contour ▪ minimise length of time soil is exposed ▪ divert run-off from undisturbed areas away from the works ▪ direct run-off from cleared areas to sediment dam
Exposed Subsoils	▪ minimise length of time subsoil is exposed ▪ direct run-off from exposed areas to sediment dam
Active Pit	▪ divert run-off from undisturbed areas away from pit ▪ pump rainfall run-off from pit only to the Pit Water Dam
Active Waste Rock dump	▪ direct all run-off from dumps to sediment dams ▪ avoid placement of sodic waste material on final external batters ▪ control surface drainage to minimise the formation of active gullies
Rehabilitation	▪ recontour waste rock dumps progressively to landform criteria specified in **Section 3.7.2** ▪ install drainage control works (refer **Section 3.7.2**) ▪ replace topsoil, rip on the contour and seed ▪ direct run-off from rehabilitated areas to sediment dams
Infrastructure	▪ provide protection in drains (e.g. rip rap, grass) where water velocity may cause scouring ▪ confine traffic to maintained tracks and roads ▪ install sediment traps, silt fences, hay bales where necessary to control sediment ▪ rehabilitate disturbed areas around construction sites promptly

3.5 Contaminated Land

3.5.1 Potential for Contamination

The proposed mine site has been used for sheep and cattle grazing, small-scale mining and cropping. Contamination may have occurred from agricultural chemicals such as dips, drenches and herbicides. Sites selected for assessment of potential contamination targeted areas likely to have been sites of spillage or disposal of chemicals or leachate from historical mine wastes.

3.5.2 Sampling, Analysis & Results

Surface samples (0-10cm) were taken from the following four locations (see **Figure 3-3**):

- the Wolfang residence refuse dump, which has been used for over 100 years and contained intact and broken remains of domestic and agricultural chemical containers;
- the old shearing shed, which no longer stands. However, a concrete slab and rusted metal remain. The sheep drench BAN (Bluestone Arsenic and Nicotine) was widely used during the period of the sheds operation;
- the old gold mine shaft which contains a number of slumped spoil heaps and the posts of a hut. The mining may have occurred during the depression. The spoil had not revegetated since abandonment; and

- the main yards on Wolfang which have been used since about the 1950s for the application of insecticides to cattle and possibly the mixing of chemicals. The current occupier of the Clermont Mining leases knew of no dip at the site.

The results of the analysis are shown in **Table 3-16**. Samples exceeding investigation thresholds are bolded.

Table 3-16 Contaminated Land Assessment – Analytical Results

Site	Concentrations mg/kg							
	Arsenic	**Cadmium**	**Chromium**	**Copper**	**Nickel**	**Lead**	**Zinc**	**Mercury**
Refuse Dump	2	<1	**107**	57	**99**	257	**512**	**1.5**
Old Shearing Shed	5	<1	92	45	85	293	161	0.2
Gold Shaft Heap	12	<1	34	59	**80**	10	43	0.2
Wolfang Yards	<1	<1	**70**	33	**66**	3	93	0.4
Environmental threshold (DoE 1998)	20	3	50	60	60	300	200	1
Health threshold (industrial) (DEH 1998)	500	100	500	1500	3000	7500	35000	75
Background levels (DoE 1998) mg/kg	0.2-30	0.04-2	0.5-110	1-190	2-400	<2-200	2-190	0.001-0.1

The refuse dump, old mining shaft and main yards on Wolfang exhibited levels of some contaminants above the environmental investigation threshold. However, the concentrations were within the range of published background levels and are consistent with the prior use of each site for small-scale activities.

Under the proposed mine plan, none of the sites sampled will be disturbed by mining activities. None of the sites showed any metals above the health investigation threshold for industrial sites.

The sites present a negligible risk to the environment. If these areas are required to be disturbed in the future for mine-related purposes, the surface soil horizon will be stripped and buried in the waste rock dump.

A search was also conducted on the Queensland Environmental Management Register and the Contaminated Land Register. There were no sites on the properties relating to the Project that are included on either register.

3.5.3 Contamination Prevention and Control

The principle risks of land contamination arise from hydrocarbon spills and from the potential for acid rock drainage (ARD). The management of mine waste for ARD control is discussed in **Section 3.6.2**.

The mine workshop and fuel storage areas are recognised as having the potential to generate contaminated land through hydrocarbon spills. All fuel and chemical storage areas within the industrial area will be bunded, and contaminants from the workshop and truck wash-down areas will be directed to a sump or drain where they can be contained for subsequent treatment or proper disposal.

Potential for land contamination from the spilling of hydrocarbons will be minimised through the development and implementation of standard operating procedures for transport, handling and storage of hydrocarbons. Other measures such as bunding around storage areas, emergency spill response planning and employee training will be employed. Correct handling procedures will be followed at all times. Any land contamination that occurs will be recorded on a register and remediated.

3.6 Overburden and Coal Rejects Characterisation and Management

3.6.1 Geochemistry and Acid Rock Drainage (ARD) Characterisation of Mine Waste

Environmental Geochemistry International Pty Ltd (EGi) undertook a geochemical assessment to identify any potential ARD, salinity, sodicity and metal leaching issues that may be associated with waste rock dumps, disposal areas for coal washery waste (coarse rejects and fine rejects/tailings) or exposed pit wall/floor resulting from development of the Project.

An exploration drilling program was undertaken by the Proponent in 2002. A total of 157 non-coal samples were collected from seven exploration drill holes to represent waste rock (overburden, interburden and coal seam roof and floor materials) expected to result from development of the Clermont deposit.

Material resulting from laboratory coal washing analyses were collected and recombined to produce material representative of the combined coarse and fine rejects expected to be deposited in the coal Washery Waste Disposal Area. A total of 20 samples were selected to represent coal washery waste materials from all of the four main coal seams to be mined, as well as the Wolfang Lower Seam. The feasibility of mining the Wolfang Lower Seam is still being investigated by the Proponent. The number of samples selected to represent each coal seam were based on the expected proportions of coal washery waste from each seam.

The following tests were carried out on all 157 waste rock samples and all 20 washery waste samples:

- determination of pH and electrical conductivity (EC) on 1:2 sample/deionised water extracts. (These tests are described in this report as $pH_{1:2}$ and $EC_{1:2}$);
- total Sulfur (S) analysis;
- acid neutralising capacity (ANC); and
- net acid producing potential (NAPP) calculation (from total S and ANC).

Tests carried out on selected waste rock samples include:

- net acid generation (NAG) tests;
- acid buffering characteristic curve (ABCC) tests;
- soluble and exchangeable cations, dispersion test, texture and colour; and
- multi-element scans of solids and water extracts.

Tests carried out on selected coal washery waste samples include:

- NAG tests; and
- multi-element scans of solids and water extracts.

A general description of standard ARD test methods used is provided in **Appendix G2**.

3.6.1.1 Waste Rock Geochemistry

Acid Forming Characteristics

Results of $pH_{1:2}$ and $EC_{1:2}$, Total S, ANC and NAG tests, and NAPP values, as well as a brief lithological description for the 157 waste rock samples are presented in **Table G2-1** in **Appendix G2**. A summary of results is shown in **Table 3-17**.

Table 3-17 Summary of acid forming characteristic test results for waste rock material

	$pH_{1:2}$	$EC_{1:2}$	Total S (%)	ANC ($kg\ H_2SO_4/t$)	NAPP ($kg\ H_2SO_4/t$)	NAGpH
Minimum	2.5	0.08	<0.01	0	-171	2
Maximum	9.7	3.27	3.78	171	115	8.6
Median	7.9	0.17	0.06	4	-2	3.7

The $pH_{1:2}$ and $EC_{1:2}$ give an indication of the inherent acidity and salinity of the waste material when initially exposed in a waste emplacement area. The $pH_{1:2}$ values range from 2.5 to 9.7, indicating significant existing acidity in some of the waste rock samples. Most of the low $pH_{1:2}$ values are associated with the Permian sediments. The $EC_{1:2}$ values ranged from non saline (<0.4 dS/m) to saline (>1.6 dS/m). The median $EC_{1:2}$ for most lithologies is within the non-saline range, with only a small percentage in the moderately saline and saline ranges. Most of the higher $EC_{1:2}$ values are associated with the Permian sediments.

Comparison of pH, EC and total S results indicate that in general the higher EC values are associated with lower pH and elevated total S. This suggests that the main salinity issue associated with these materials is directly related to oxidation of pyrite, rather than due to the occurrence of stored soluble salts from ground water or other sources. Management of ARD issues will therefore also address salinity issues.

Total S values range from very low (<0.1 %S) to high (>2 %S). Most samples (59%) have very low total S concentrations of less than 0.1%, and only 6% of samples had total S values greater than 1%S. Some samples from the Permian sediments and Tertiary sediments have elevated Total S values of greater than 0.5%, however, most samples from the Permian and Tertiary sediments have total S values less than 0.5%. The Quaternary and basalt units generally have low S values of less than 0.2%.

Kinetic NAG tests provide an indication of the kinetics of sulphide oxidation and acid generation for a sample. Kinetic NAG testing was carried out 5 selected waste rock samples with high S (>1%S) and NAG pH<4.5. Overall the kinetic NAG results indicate that the high S waste rock materials with NAG pH<4.5 are pyritic, highly reactive and will have negligible lag prior to acid production, if exposed to oxidating conditions.

ANC values are highly variable, ranging up to 171 kg H_2SO_4/t, but most samples (70%) have a low ANC of less than 10 kg H_2SO_4/t. ANC is highest (>50 kg H_2SO_4/t) in the Quaternary, weathered basalt and fresh basalt units. The Tertiary sediments show a broad range of ANC, and ANC in the Permian sediments is generally low (<10 kg H_2SO_4/t), with occasional spot highs.

Acid buffering characteristic curve (ABCC) tests provide an indication of the relative reactivity of the ANC measured and can be used as an estimate of the proportion of readily available ANC. ABCC tests were carried out on eight selected waste rock samples, and the results indicate that the availability of the ANC in the Clermont waste rock materials may be significantly less than the total ANC measured, particularly for the Permian lithologies. Hence ANC test results are not a reliable guide to the effective acid buffering in these samples. Leach column testing would be required to confirm the relative rates of acid generation and acid buffering in these materials.

Comparison of Total S and ANC results indicates that those lithologies with the highest total S (and thus most pyritic) have low ANC, and those lithologies with the lowest total S have higher ANC. Acid buffering characteristic curve (ABCC) testing also shows that much of the neutralising component measured by the standard ANC method is poorly available, whereas the acid producing component is highly reactive. This implies that exposure of PAF waste rock to atmospheric conditions could result in rapid production of acid with little or no lag time (days to weeks).

The NAPP value is an acid-base account calculation using measured total S and ANC values. It represents the balance between the maximum potential acidity (MPA) and ANC. A negative NAPP value indicates that the sample may have sufficient ANC to prevent acid generation. Conversely, a positive NAPP value indicates that the material may be acid generating. Most of the NAPP positive values were associated with Permian siltstone, sandstone and carbonaceous mudstone and (to a lesser extent) conglomerate samples. For samples with an ANC greater than or equal to 20 kg H_2SO_4/t, the NAPP negative samples are associated with Tertiary sediments and basalt, but also some Permian sediments.

NAG tests were carried out on all waste rock samples with total S greater than or equal to 0.1% and selected samples with total S less than 0.1% S. A NAGpH<4.5 indicates the sample is acid producing. NAGpH values range from 2.0 to 8.6, and a total of 52 of the 87 samples tested had a NAGpH less than 4.5. Most of the low NAGpH values are associated with the Permian sediments.

Geochemical classifications for all tested waste rock samples are provided in **Table G2-1** in **Appendix G2**. Samples were classified as Non-Acid Forming (NAF), Uncertain – NAF [UC(NAF)], and Potentially Acid Forming (PAF). PAF samples that have only low acid generating capacity were further classified as Potentially Acid Forming-Lower Capacity (PAF-LC). PAF-LC materials may be amenable to blending with acid consuming waste rock materials or treatment by incorporation of agricultural lime to reduce or eliminate the potential for acid production.

Classification of waste rock into NAF, UC(NAF), PAF-LC and PAF was carried out on the following basis:

- samples with a NAPP = 0 H_2SO_4/t and NAGpH = 4.5 were classified NAF;
- samples with total S = 0.05% were classified NAF regardless of NAPP or NAG results due to the very low risk of significant acid formation from these samples;
- uncertain samples with a NAPP = 0 H_2SO_4/t and NAGpH < 4.5 had low S <0.2% and were classified UC(NAF). These samples represent very low risk due to low S, and it is expected that NAG results for these samples were affected by organic acids;
- uncertain samples with a NAPP > 0 H_2SO_4/t and NAGpH = 4.5 were also classified UC(NAF). The NAG test for these samples suggest most of the S measured is in non-pyrite forms;
- samples with a positive NAPP and NAGpH < 4.5 were classified PAF; and
- those PAF samples with either NAPP values = 5kg H_2SO_4/t or NAG acidities to pH 4.5 = 5kg H_2SO_4/t were classified PAF-Low Capacity (or PAF-LC). Many of these samples had much higher NAG test values than NAPP values due to organic acid effects, and in these cases it was expected that the NAPP results were more representative of the potential acid generating capacity.

The sample geochemical classifications were used to calculate a weighted distribution (based on sample intervals) of sample geochemical types within each of the major lithological units, i.e. quaternary clay/weathered basalt, fresh basalt, Tertiary sediments and Permian sediments. For convenience, UC(NAF) classifications were assumed to be NAF. The expected volumes of materials to be placed in waste rock dumps for each of these major lithologies were determined from mine planning modelling.

The overall expected weighted distribution of PAF, PAF-LC and NAF materials in waste rock was calculated, based the expected volumes of materials to be placed in waste rock dumps for each of these major lithologies. The resulting expected distribution of geochemical types for major lithological units, and total waste rock is shown in **Table 3-18**.

The results presented in **Table 3-18** indicate that overall 87% of waste rock to be mined is likely to be NAF, 8% is likely to be PAF-LC, and 5% is likely to be PAF. All of the material representative of Quaternary and Tertiary basalt lithologies was NAF, therefore Quaternary and Tertiary basalt may be confidently assumed to be NAF and acid consuming. However, PAF materials were identified within Tertiary and Permian sediments, with most of the PAF material occurring within the Permian sediments. The mean NAPP of the PAF and PAF-LC Permian samples is 18 kg H_2SO_4/t and the mean NAPP of the PAF and PAF-LC Tertiary sediment samples is 10 kg H_2SO_4/t.

An evaluation of the distribution of geochemical characteristics with stratigraphic distribution in the Permian and tertiary lithologies suggest that PAF horizons associated with the Gowrie Seam, Wolfang Lower floor and Wolfang Upper roof may be reasonably continuous. The distribution of PAF/PAF-LC horizons in the remaining Permian sequence appears to be more sporadic.

Table 3-18 Distribution of geochemical types for major lithological units.

Lithological Unit	% Distribution Of Geochemical Types			Volume of Each Lithological Unit Mbcm (%volume)	Volume of Geochemical Types (Mbcm)		
	NAF	PAF-LC	PAF		NAF	PAF-LC	PAF
Quaternary Clay/Weathered Basalt	100	0	0	123 (17%)	123	0	0
Tertiary Basalt (Fresh)	100	0	0	189 (27%)	189	0	0
Tertiary Sediments	85	12	3	62 (9%)	53	7	2
Permian Sediments	76	15	9	334 (47%)	254	50	30
Overall % Weighted Distribution of ARD Types For All Waste Rock					**87%**	**8%**	**5%**

The occurrence of PAF and PAF-LC materials in the Tertiary sediments appears to be minor and laterally discontinuous. More detailed sampling and testing is required to define the continuity of PAF/PAF-LC horizons in the Tertiary and Permian.

Elemental Enrichment and Solubilities

A total of 10 waste rock samples were selected for multi-element testing of solids and water extracts to obtain more information on the relative elemental enrichment and solubilities of materials with a range of ARD potential. Note that the sample set was biased towards PAF samples, to obtain more information on the relative elemental enrichment and solubilities of pyritic materials. Results of multi-element scans for the 10 selected solids were compared to the median soil abundance to highlight enriched elements. The extent of enrichment is reported as the Geochemical Abundance Index (GAI), where a GAI of 0 indicates the element is present at a concentration similar to, or less than, average crustal abundance; and a GAI of 6 indicates approximately a 100-fold enrichment above average crustal abundance.

As a general rule, a GAI of 3 or greater signifies enrichment that warrants further examination. Results of multi-element analysis of waste rock sample solids and the corresponding GA1 values are presented in **Table G2-2** in **Appendix G2**. Results show that in addition to S, slight enrichment of Be, Hg and Tl is indicated for some of the Permian sediment samples. Although slightly enriched, the Be, Hg and Tl concentrations are within typical soil values. Except for S, the results indicate only low concentrations of environmentally important elements in the waste rock samples.

The same 10 waste rock sample solids were subjected to water extraction at a solids:liquor ratio of 1:2. These water extraction tests provide an indication of which elements are readily soluble in a given sample. The compositions of the 10 water extractions are given in **Table G2-3** in **Appendix G2**. The pH of the Tertiary basalt and Tertiary sediments sample extracts were above pH 8, show low EC, and have low concentrations of environmentally important elements.

The remaining samples are Permian sediments and generally have low pH (<5) and high EC values (>1 dS/m) due to partial oxidation of pyrite after sampling. The low pH Permian samples show correspondingly elevated concentrations (relative to typical values from benign waste rock) of soluble Al, Co, Cu, Fe, Mn, Ni, SO_4 and Zn.

The elevated elements of environmental importance in water extracts are the result of sulphide oxidation and acid generation. Results indicate that exposure of pyritic waste rock materials to atmospheric oxidation will result in generation of acid and release of elevated quantities of Al, Co, Cu, Fe, Mn, Ni, SO_4 and Zn, and possibly As. The solubility of these elements will largely be determined by pH and therefore control of acid generation will effectively control metal leaching.

Sodicity and Dispersion

Soluble and exchangeable cations and Emerson aggregate tests were carried out on 66 waste rock samples to provide a preliminary indication of any sodicity and dispersion issues associated with waste rock materials. Results are presented in **Table G2-4** in **Appendix G2**. Sodic materials tend to form low permeability soil horizons, accelerating erosion and inhibiting plant growth.

Sodic soils are also dispersive and should not be used as construction materials since they are prone to tunnelling and collapse. The exchangeable sodium percentage (ESP) is a measure of exchangeable Na as a percentage of the total effective cation exchange capacity (ECEC). The ESP can be used to classify samples according to sodicity as follows:

- ESP < 6% - Non-Sodic
- ESP 6-15% - Sodic
- ESP 15-30% - Strongly Sodic
- ESP >30% - Very Strongly Sodic

ESP's varied from non-sodic (<6%) to sodic (6-15%), with a maximum value of 14%. None of the samples tested were strongly sodic (>15%). Most of the samples tested (59 of the 67 total) had non-sodic ESP values. There were eight samples with a sodic ESP, comprising Permian conglomerate (1 sample), Quaternary clay (3 samples), Tertiary basalt (2 samples) and Tertiary sediments (2 samples).

The Permian sediment sample had a sodic ESP of 9%, but a very low ECEC (<1 meq%), and therefore has a low risk of developing physical problems. The low ECEC of the Permian sediments also indicates poor nutrient holding capacity. By contrast, the ECEC of the Quaternary clays, basalts and weathered basalt clays are relatively high, indicating good nutrient holding capacity.

The dispersive properties of materials was also assessed by using the Emerson aggregate test (EAT). This test assigns classes to samples according to dispersive behaviour of sample aggregates in water. The samples are divided into eight main classes, and in general samples classified as Class 1 or 2 indicates dispersion potential, and associated risk of tunnelling, surface crusting and erosion.

EAT classes ranged from very low dispersion (classes 6, 7 and 8) to high dispersion (sub-class 2(2)). Most of the samples tested (85%) had EAT classes indicating low to very low dispersion risk. The remaining 15% of samples consisted of two Tertiary sediment samples that had EAT classes indicating moderate dispersion, and seven Tertiary sediment samples and one Upper Permian sediment sample that had EAT classes indicating high dispersion.

A comparison of ESP and EAT values with lithology indicate a possible risk of dispersion and consequent issues in relation to tunnelling, and hard-pan formation for units within the Quaternary clays, Tertiary basalt, and Tertiary sediments.

3.6.1.2 Coal Washery Waste Geochemistry

Acid Forming Characteristics

Results of coal washery waste geochemical characterisation, comprising $pH_{1:2}$, $EC_{1:2}$, total S, ANC, NAPP and NAG, are presented in **Table G2-5** in **Appendix G**. The $pH_{1:2}$ values ranged from highly acidic at 1.2 to slightly acidic at 5.9, and $EC_{1:2}$ values ranged from non saline (<0.4 dS/m) to very highly saline (>40 dS/m). The two coal washery waste samples from the Gowrie seam have the lowest pH values of 1.2 and 1.4, and the Prospect Seam sample has the next lowest pH of 2.5. EC follows a similar trend, with the highest EC corresponding to the Gowrie Seam samples, and the next highest EC corresponding to the Prospect Seam sample. The general association of higher $EC_{1:2}$ values (>1 dS/m) with low $pH_{1:2}$ values indicates that much of the salinity detected in the coal washery waste samples is associated with partial oxidation of acid generating sulphides during processing and sample storage.

Coal quality test work was carried out by ACIRL on 533 coal, parting/interburden, seam roof and seam floor materials from each of the main coal seams, and included analysis of Total S concentrations. **Table G2-6** in **Appendix G** presents summary statistics for total S according to seam name and coal/non-coal material types. Results show that the highest S content in coal and non-coal materials is associated with the Gowrie Seam, with a S content in non-coal materials of around 1%S. Non-coal materials associated with the Prospect Seam have a moderate S content of 0.3-0.5%S. Lower S contents of around 0.2%S are indicated for non-coal materials associated with the other seams.

Total S values determined by EGi ranged from very low at 0.06%S to very high at 32%S. Two very high S contents of 27.5%S and 32%S were returned from the Gowrie Seam washery waste samples. These total S concentrations are anomalously high when compared to results of total S analyses carried out on Gowrie seam coal material by ACIRL and therefore cannot be relied on. The high S values may reflect issues with original preparation of the samples. Total S values of >1%S were measured in samples from the Gowrie, Prospect and Wolfang seams.

ANC values were very low for all samples, reaching a maximum of 3 kg H_2SO_4/t, indicating that these washery waste materials will rapidly produce acid under oxidising conditions, with no appreciable lag. NAPP values for each of the samples was calculated and are presented in **Table G2-6** in **Appendix G2**.

Standard NAG test results confirmed that high S samples (>1%S), were acid forming, but were not a reliable guide to acid producing capacity for samples with S <1%, due to the potential interference by organic acids. Modified NAG tests were carried out on selected samples to provide a guide to the relative contribution of pyritic and organic acid to the standard NAG test result.

The modified NAG test involved the application of an extended boiling step to check for evidence of organic acid destruction, and assay of the NAG solution to calculate the proportion of pyritic and organic acid released. Results of modified NAG testing indicate that the NAG solutions from coal washery waste is likely to contain a mixture of pyritic and organic acidity. The calculated NAG value from the modified NAG test is based on the concentration of dissolved S assumed to be derived from pyrite, and the concentration of cations indicative of acid neutralising reactions. The resulting calculated NAG acidity corresponds very closely to the NAPP values, confirming the validity of using the NAPP value as reliable measure of acid forming capacity for these samples rather than standard NAG test results.

The geochemical classification of the coal washery waste samples was based on NAPP values because the results of the standard NAG test are not considered to be reliable. The criteria for geochemical classification of coal washery wastes is as follows:

- Samples with a NAPP = 0 H_2SO_4/t were classified NAF.
- Samples with a NAPP > 0 and = 5kg H_2SO_4/t were classified PAF-LC.
- Samples with a NAPP > 5kg H_2SO_4/t were classified PAF.

The expected total produced tonnage of each of the coal seam washery waste materials was estimated from mine planning modelling, allowing calculation of the overall expected weighted distribution of PAF, PAF-LC and NAF in washery wastes. The distribution of geochemical types for each of the seam washery wastes was firstly calculated by assuming each sample had equal weighting for a particular seam washery waste.

The relative tonnage of each seam washery waste was then used to calculate the total tonnes of geochemical types from each seam washery waste, allowing calculation of the overall distribution of geochemical types for all washery waste. The resulting expected distribution of geochemical types for each seam washery waste, and total washery waste is shown in **Table 3-19**.

The results in **Table 3-19** indicate that 51% of coal washery waste produced at Clermont is likely to be PAF-LC, 44% is likely to be PAF, and 5% is likely to be NAF. Note that this distribution should treated as a guide only, since the total number of washery samples produced for some seams was limited (particularly for Gowrie, Prospect and Wolfang Upper seam). Results in **Table 3-19** indicate that washery wastes from coal processing at Clermont are likely to be acid forming, with the Gowrie coal washery wastes likely to have the highest acid potential. Overall the coal washery wastes are likely to be mainly PAF-LC, with a high proportion of PAF, and only minor NAF.

Table 3-19 Distribution of geochemical types by coal seam

Coal Seam	% Distribution Of Geochemical Types			Washery Waste, kilotonnes (%)	Volume of Geochemical Types (kilotonnes)		
	NAF	PAF-LC	PAF		NAF	PAF-LC	PAF
Gowrie	0	0	100	135 (1%)	0	0	135
Prospect	0	0	100	396 (4%)	0	0	396
Wolfang Upper	0	0	100	406 (4%)	0	0	406
Wolfang	0	58	42	7195 (70%)	0	4197	2998
Wolfang Lower	25	50	25	2092 (20%)	523	1046	523
Overall % Weighted Distribution of ARD Types For All Coal Washery Waste					**5%**	**51%**	**44%**

Four selected coal washery waste samples with total S values >0.8% were subjected to kinetic NAG testing to provide an indication of the reactivity of the pyrite present. The kinetic NAG results for the coal washery wastes indicate that the high S materials are pyritic, highly reactive and will have negligible lag, i.e. likely to produce acid almost immediately (days) after exposure.

Elemental Enrichment and Solubilities

Four coal washery waste samples were selected for multi-element analysis to represent coal washery samples with elevated S (= 0.5%S) from four different seams. The testing was designed to obtain more information on the relative elemental enrichment and solubilities of pyritic washery materials.

Results of multi-element analysis of the four selected coal washery waste solids and the corresponding GAI values are presented in **Table G2-7** in **Appendix G2**. Results show that in addition to S, slight enrichment of Be, Co, Hg, Mo and Se is indicated for some of the samples. The same four coal washery waste sample solids were subjected to water extraction at a solids:liquor ratio of 1:2 to provide an indication of the extent of any readily soluble constituents and a guide to constituents likely to be initially elevated when these pyritic coal washery wastes are flushed.

The compositions of the four water extractions are given in **Table G2-8** in **Appendix G2**. All samples have a low pH (<5) and high EC values (>1 dS/m) due to partial oxidation of pyrite after sampling. The elevated elements of environmental importance in water extracts are the result of sulphide oxidation and acid generation. Results indicate that exposure of high S coal washery waste materials to atmospheric oxidation is likely to release significant quantities of Al, As, Co, Fe, Mn, Ni, SO_4 and Zn. Their solubility will largely be determined by pH and control of acid generation will control leaching.

3.6.2 Management of Waste Rock and Coal Washery Wastes

The results of these initial investigations have the following implications for materials management:

- approximately 5% of Clermont waste rock are likely to contain PAF materials and will require appropriate management to control ARD during operations and at closure;
- most coal washery wastes are likely to be PAF/PAF-LC materials and will require appropriate management to control ARD;
- coal roof and floor cleanings are likely to be PAF, and should be treated as such unless confidently characterised as otherwise;
- approximately 8% of Clermont waste rock are likely to contain PAF-LC materials and will also require appropriate management;

- selective placement and burial of PAF waste rock materials is likely to be an appropriate method to control ARD. Appropriate waste rock dump design and optimum depth of burial would require further investigation once run-of-mine waste materials are available, and the investigation undertaken would involve:
  - better definition of PAF/PAF-LC horizons to enable these materials to be identified, selectively mined and appropriately placed;
  - development of selective placement options (including specifications for NAF, PAF-LC and PAF waste rock types);
  - physical characterisation of available NAF materials for burying PAF materials;
  - physical characterisation of the PAF rock to be covered; and
  - modelling of water/oxygen flux;
- low capacity PAF (PAF-LC) waste rock may be amenable to blending with acid consuming materials (such as high ANC waste rock) and/or treatment with agricultural lime to reduce or eliminate its ARD potential. Blending and treatment has the potential to reduce the amount of PAF-LC material requiring selective placement and covering, and increase the amount of available benign material for near surface placement, potentially providing greater flexibility in waste rock and washery waste scheduling and management. Investigations into the feasibility of blending/treatment options would be required before implementation;
- Basalt and Quaternary materials contain little or no sulphide but commonly contain significant carbonate. These materials have potential as an acid consuming source for use in construction of dump foundation layers for additional security or co-disposed with PAF-LC material to decrease its ARD potential;
- Basalt and Quaternary materials would be suitable for construction of haul roads, if their physical properties were suitable;
- placement of sodic/dispersive materials at surface and within the plant root zone will be avoided due to their tendency form low permeability soil horizons, accelerating erosion and inhibiting plant growth. They should also not be used as construction materials (unless treated) since they are prone to tunnelling and collapse;
- appropriate management of the final Coal Washery Waste Disposal Area is likely to include construction of an earth material cover. Cover strategies to minimise release of oxidation products in leachate, and salt rise into the growth horizon would need to be investigated. Store and release and/or infiltration barriers are likely to be the most appropriate cover strategy. Once run-of-mine NAF waste rock and coal washery waste is available, the cover design investigation would be undertaken and would include:
  - physical characterisation of available NAF materials for burying PAF materials;
  - physical characterisation of the PAF material to be covered; and
  - modelling of water/oxygen flux.
- Given the surplus of NAF waste rock materials, appropriate NAF material for burial and construction of earth material covers is likely to be available.

3.7 Rehabilitation

3.7.1 Proposed Post Mining Land Use

The over riding principle for the rehabilitation program at the Project is that the land should be returned to a post-mine land use that will be stable, self-sustaining and require minimal maintenance. The post-mine land use for areas disturbed by mining at the Project will be a self sustaining vegetation community using appropriate native tree, shrub and grass species based on site-specific trials. The attainment of this land use will protect downstream water quality.

3.7.2 Post-Mine Landform

The Project will change the land use and land suitability of the site. The primary control strategies to reduce the impacts of these changes centre on:

- achieving stable rehabilitated landforms;
- using measurable standards to assess the success of rehabilitated landforms; and
- progressively rehabilitating over the life of mine.

The primary design objective is the creation of stable final landforms. The Proponent will use experience gained on other RTCA mines (including the BAM), specialist consultants and relevant research findings to meet this objective.

Stable landforms will be established following mining, using soils capable of supporting vegetation communities adapted to the local environment. The stability of the post-mine landform will be achieved by applying sound rehabilitation practices. The disturbed land will be rehabilitated to a condition that is self-sustaining, or to a condition where the maintenance requirements are consistent with the post-mining land use.

The proposed final landform consists of a main waste rock dump in the north-west, a second smaller out-of-pit dump located to the south-west of the pit and the Coal Washery Waste Disposal Area west of the pit. A final void will be left at the south end of the pit, with the remainder of the pit backfilled. The diversion of Gowrie Creek will remain after mining ceases.

A key objective for creating the post mine landform is to maximise in-pit dumping and minimise out of pit dumping. Approximately 500 Mm^3 of waste will be disposed of in-pit (below pit crest) and approximately 215 Mm^3 will be external to the pit. Complete backfilling of the pit is not an economically feasible alternative.

The post mine final landform will most likely be a terraced landform constructed by 10 m lifts on external dump faces, with a maximum working dump lift height of 30 m. The landform will be recontoured from angle of repose slopes to a maximum overall angle of 17% (or 9.6 degrees).

The coal washery waste area will be contoured to similar design criterion, covered with benign waste rock and revegetated.

Drainage benches will be retained between dump lifts after recontouring to control run-off. The drainage benches will be designed and constructed to control the run-off from a 1:20 year ARI 'time-of-concentration' flow from the catchment. Run-off will be conveyed along the benches to engineered designed rock-lined waterways, and then to sediment dams. Surface run-off from all disturbed areas will pass through sediment dams to reduce the levels of suspended solids. The sediment dams will discharge to nearby creeks.

The pit will be left in a geotechnically stable condition at the final batter angle. Bunds will be constructed along the crest of the pit to prevent vehicular access.

3.7.3 Mine Rehabilitation Strategies

Rehabilitation studies at the BAM have examined soils, landforms, the nature of waste materials, drainage and vegetation. These studies have demonstrated that conventional rehabilitation on a range of materials mined at the BAM is successful. The knowledge gained from the BAM will be adapted and used in rehabilitation programs for the Project.

The rehabilitation strategy will also consider the findings outlined in the 'Final Report Post Mining Landscape Parameters for Erosion and Water Quality Control' by the Australian Coal Association Research Program (ACARP). This report provided information for the prediction, prevention or minimisation of erosion from post-mining landscapes, recognising that optimal landscape design is best achieved using field experience. The design criteria adopted for the Project has considered the acceptable outcomes for rehabilitation at the BAM.

Rehabilitation strategies for the Project will include all areas of disturbance and will be reviewed on a regular basis in order to take into account any changes to mine operations, changes in legislative requirements and/or results of ongoing studies and monitoring.

The rehabilitation strategies have been developed after consideration of the Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland, DME (1995). In particular, the following guidelines have been considered:

- Land Suitability Assessment Techniques – which addresses the applicability and use of land suitability assessment techniques in determining pre-mining land capability and post-mining land use potential;
- Determination of Post-Mining Land Use - which describes the identification and selection of suitable post-mining land use options;
- Progressive Rehabilitation - which describes the advantages of and opportunities and strategies for progressive rehabilitation;
- Assessment and Management of Acid Drainage – which addresses the identification, evaluation and management of solid waste materials with potential to generate acid drainage and/or heavy metal toxicity;
- Open Pit Rehabilitation - discusses the criteria to be applied in the design and rehabilitation of open pits having regard to geophysical aspects, sealing of strata, water accumulation and safety issues;
- Erosion Control – which addresses the prediction, control and measurement of soil erosion on mining lease areas;
- Growth Media Management – which outlines the selection, handling, storage, treatment and replacement of soils and other media to be used for establishing and growing vegetation on land following mining;
- Minesite Decommissioning – which addresses the closure and decommissioning of areas, works and facilities used for mining, including tailings dams;
- Site Water Management – which discusses the management of water on mine sites so as to reduce the amount of contaminated water that may need to be handled; and
- Water Discharge Management – which addresses the management of water discharged from mine sites to ensure compliance with statutory requirements and protection of downstream uses.

The post mine landform will be as discussed in **Section 3.7.2**. Trials will be conducted to vary the slope angle used. In particular, the use of competent waste rock and soil will be trialed on slopes steeper than 17%.

The rehabilitation strategy at the Project consists of the following integrated measures:

- appropriate pre-disturbance preparation such as topsoil salvage and management plans;
- implementation of practical landform designs, to prevent erosion and establish final landform stability;
- identification of an appropriate post-mine land use consistent with local environmental constraints;
- on-going sampling and testing to define the continuity of PAF/PAF-LC horizons in the Tertiary and Permian waste rock and coal washery waste;
- selective placement and burial of PAF waste rock materials to control ARD. Appropriate waste rock dump design and optimum depth of burial will be further investigated from the results of characterisation and modelling;
- possible blending of low capacity PAF (PAF-LC) waste rock with acid consuming materials and/or treatment with agricultural lime to reduce or eliminate its ARD potential;
- possible use of the Basalt and Quaternary materials where appropriate as an acid consuming source in construction of dump foundation layers;
- avoiding the placement of sodic/dispersive materials near the surface of the dumps, or within the plant root zone; and
- appropriate management of the final coal washery waste, including construction of an earthen cover, most likely a store and release and/or infiltration barrier;

- revegetation trials, for selection of appropriate revegetation species and methodologies;
- progressive rehabilitation of disturbed areas, using rehabilitation procedures for appropriate to the type of disturbance;
- a rehabilitation monitoring program to assess the success of rehabilitation;
- a corrective action program to address areas of failed rehabilitation; and
- preparation of Final Rehabilitation Report (FRR) prior to surrender of the Mining Leases.

3.7.4 Progressive Rehabilitation

A progressive rehabilitation program will be implemented throughout the mine life.

The indicative rehabilitation schedule for the Project is shown in **Table 3-20**. The progressive rehabilitation of the mined areas is depicted in **Figure 2-7** to **Figure 2-10**. Out of the approximate disturbance footprint of 1535 ha, within ML 1904 and ML 1884, 1125 ha will be rehabilitated. Of the remaining disturbed area, 400 ha is the final void, and the balance is infrastructure left for the benefit of the background landholder.

Table 3-20 Indicative Rehabilitation Schedule

Production Year	Cumulative Area Rehabilitated (ha)
– 1 (Construction)	0
1	0
3	64
8	303
13	625
Final Year of Production	860
Prior to closure	1125

The indicative rehabilitation program for the Project includes:

- commencement of rehabilitation in Year 3 (of production) on the lower batters of the northern and western part of the North West Waste Dump;
- by Year 8, a large part of the North West Waste Dump and the lower batters of the South West Waste Dump will have been rehabilitated;
- rehabilitation of the South West Waste Dump will be completed by Year 13, and a substantial part of the North West Waste Dump would be rehabilitated – the northern and western areas of this dump by this time having established vegetation, and newer areas contoured, topsoiled and seeded;
- in the final year of production (Year 17), a small area on the south-western batters of the North West Waste Dump adjacent to the overland conveyor will remain to be rehabilitated, together with the areas disturbed by the CPP and Coal Washery Waste Disposal Area. These areas will be rehabilitated once the conveyor and CPP have been removed after mining ceases; and
- all buildings, plant and equipment will be removed, dams will be left for the background landowner (if agreed). The levees and Gowrie Creek diversion will remain. Rehabilitation of the diversion is discussed in **Section 4**.

3.7.5 Topsoil Management

Suitable topsoil will be stripped for use in the rehabilitation program. The topsoil will either be stockpiled until suitable re-contoured areas are available, or respread immediately across the area to be rehabilitated. The topsoil resources present are more than adequate for the rehabilitation of the waste rock dumps and other disturbed areas.

3.7.5.1 Topsoil Stripping Depth and Volumes

There is a sufficient volume of topsoil available for rehabilitation. The topsoil volume for salvage is equivalent to stripping a depth of 245 mm from all disturbed areas on the mining leases.

3.7.5.2 Topsoil Stockpiles

The peak volume of topsoil stockpiled at any one time will be about 2.9 Mm^3. The space available for storing large volumes of topsoil is very restricted. The main topsoil stockpile will be located north-east of the pit. The stockpile footprint will be approximately 50 ha and will not interfere with the Gowrie Creek floodplain. Due to the constrained area available, the stockpile will average 6 m in height.

Stockpiling of topsoil will be necessary initially as rehabilitation will not begin until the waste rock dumps are being constructed and in-pit backfilled spoil reaches pre-existing surface ground levels and is no longer required for dumping. As the pit expands, there will be more opportunity to strip topsoil and haul directly to re-contoured areas, thus avoiding topsoil stockpiling. Freshly stripped and placed topsoil retains more viable seed, micro-organisms, and nutrients than stockpiled soil. Vegetation establishment is generally improved by using fresh topsoil.

Stockpiles will be managed so that:

- soil types with significantly different properties will be stockpiled separately;
- locations are recorded using GPS and data recorded relating to the soil type and volume; and
- stockpile surfaces are ripped and seeded (if natural revegetation does not provide adequate cover).

3.7.6 Revegetation

The revegetation methods for all types of disturbed land at the Project will normally consist of the following:

- respreading stockpiled or freshly stripped topsoil;
- contour ripping;
- seeding with an appropriate seed mix; and
- application of appropriate fertiliser for plant establishment if required.

Where available, competent materials such as basalt will be placed on steeper slopes to aid stability. Contour ripping will be used as an erosion control measure immediately after surface preparation and before revegetation. A seed mix containing grass, native shrub and tree species will be used to establish a sustainable vegetation cover in a one-pass operation.

The revegetation of mined areas will normally occur prior to the commencement of the wet season (October- December) to maximise the benefits of subsequent rainfall. Local plant species will predominantly be used so as to restore elements of the pre-mining communities to the rehabilitation assemblages.

These species will be similar to those currently used at the BAM, supplemented by existing key dominants from the Clermont mining leases, including Dawson Gum Woodland (RE 11.4.8).

3.7.7 Rehabilitation Success Criteria

The site-specific criteria for achieving a self-sustaining vegetation community will be developed during the operation based on rehabilitation trials and the monitoring of progressive rehabilitation.

Criteria for successful rehabilitation may include the following parameters:

- tree and shrub density;
- tree and shrub species diversity;
- percentage ground cover;
- indicators for rill and gully erosion; and
- downstream water quality.

Rehabilitated areas will be monitored using the selected parameters and trends tracked to demonstrate progress towards a self-sustaining ecosystem.

The experience at the BAM has shown that native tree and shrub density on areas where black soil has been replaced is appreciably lower than on areas covered with more sandy loam soils. It is expected that a similar outcome will occur at the Clermont Mining Leases.

3.7.8 Rehabilitation Maintenance

Rehabilitated areas will be monitored in order to identify any areas in need of maintenance at an early stage. Rehabilitated areas that have not reached a sufficient growth density of vegetation will be reseeded.

Supplementary plantings or seeding may be used to increase species diversity. Maintenance work will be performed to repair any areas exhibiting excessive soil erosion. If problem areas occur, they will be investigated to determine the reason for substandard rehabilitation.

3.7.9 Rehabilitation Monitoring

Objective success criteria provides a means by which the success of rehabilitation can be gauged. The Project will be monitored for the following rehabilitation success criteria:

- canopy cover in native areas – this success criterion will be researched to determine an appropriate benchmark value and quantify its robustness as an indicator of post-mining sustainability of rehabilitated areas;
- the number of stems/ha of native trees and shrubs in rehabilitated areas;
- runoff water quality; and
- occurrence of active erosion gullies.

3.7.10 Decommissioning

The decommissioning and final rehabilitation of the Project will occur on a staged basis over several years. A contaminated site assessment will be carried out as part of the Final Rehabilitation Report.

On the completion of mining, infrastructure will be treated as follows:

- mine roads will be left behind for use as farm roads (or rehabilitated);
- water dams and levee banks will remain if required by the subsequent landowner and approved by regulators; otherwise, they will be breached;
- the levee banks will be retained and maintained by the subsequent landholder of the Project Area;
- buildings, plant and equipment will be removed and the surface rehabilitated. This will include the CPP, workshop, offices, storage tanks and coal handling facilities; and
- concrete pads will be covered with benign waste rock, topsoiled and revegetated.

The final void remaining at the end of the mine life will cover approximately 400 ha and will be on average 120 m deep, with a maximum depth of about 175 m. A bund and fence will be constructed around the crest of the pit to prevent access to the final void.

The void will collect water from groundwater ingress and direct rainfall. Void water quality is addressed in **Section 4**.