BENGALLA Mining Company

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Preliminary Hazards Analysis

CONTINUATION OF BENGALLA MINE ENVIRONMENTAL IMPACT STATEMENT

PRELIMINARY HAZARD ANALYSIS

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For

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PRELIMINARY HAZARD ANALYSIS

for
Bengalla Mining Company Pty Limited

1 OVERVIEW

1.1 INTRODUCTION

Hansen Bailey has been commissioned on behalf of Bengalla Mining Company (BMC), to undertake a Preliminary Hazard Analysis (PHA) for the Continuation of Bengalla Mine Project (the Project). This PHA will form part of the Environmental Impact Statement (EIS) supporting an application for Development Consent under Part 4, Division 4.1 of the *Environmental Planning and Assessment Act* 1979 (EP&A Act).

BMC operates the existing Bengalla Mine (Bengalla) in the Upper Hunter Valley of NSW. Bengalla is situated approximately 130 km north-west of Newcastle, and 4 km west of the township of Muswellbrook. It is generally bounded by Wybong Road to the north, Roxburgh Road to the west, Overton Road to the east, and the Bengalla Link Road and Muswellbrook-Ulan Rail Line to the south (see **Figure 1**).

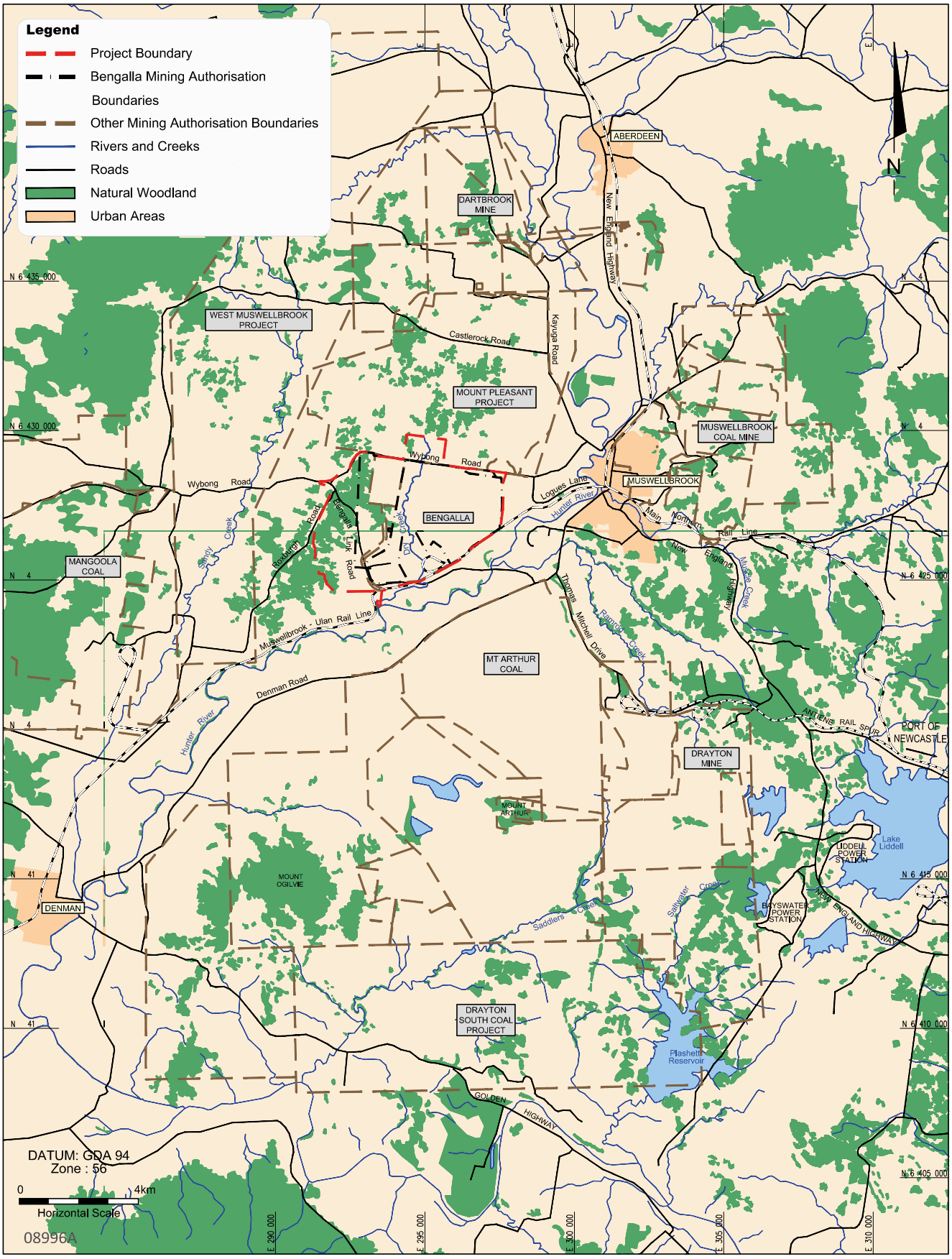
On 7 August 1995, BMC was granted Development Consent (DA 211/93) by the then Minister for Urban Affairs and Planning. This consent authorised the construction and operation of a surface coal mine, coal preparation plant, rail loop, loading facilities and associated facilities. There have since been four approved modifications to DA 211/13. Bengalla is now approved to produce up to 10.7 Mtpa of Run of Mine (ROM) coal. Approximately 6.7 Mtpa of ROM was extracted at Bengalla in 2010 (BMC 2011).

1.2 PROJECT DESCRIPTION

BMC is seeking Development Consent under Part 4, Division 4.1 of the EP&A Act to facilitate the continuation of open cut coal mining largely within current mining authorities within the Project Boundary. The mining will largely be conducted within current mining leases. The Project will enable the extraction of an additional 316 Mt of ROM coal from the Whittingham Coal Measures.

An indicative layout for the Project is provided in **Figure 2** and generally comprises the following:

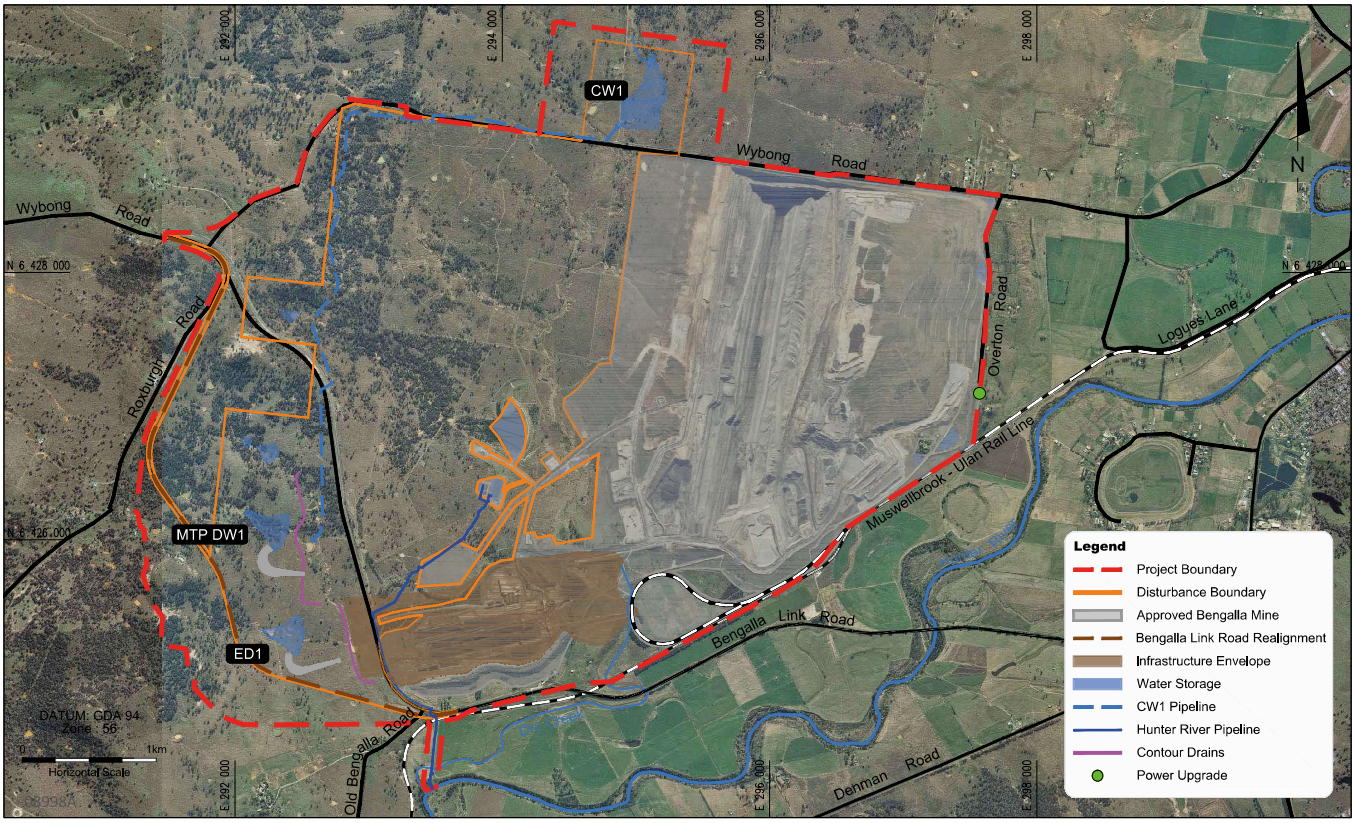
- Open cut mining towards the west at a rate of up to 15 Mtpa ROM coal for 24 years to a total of 316 Mt;
- Continued use of the existing dragline, truck fleet and excavator fleet (with progressive replacement or substitution with equivalent);



BENGALLA MINE

Regional Locality

FIGURE 1



BENGALLA MINE

Conceptual Project Layout

FIGURE 2

- An out of pit OEA to the west of Dry Creek which may be utilised for excess spoil material until it is intercepted by mining;
- Continued use, extension or relocation to existing infrastructure, including administration and parking facilities, in-pit facilities (including dragline shut down and erection pad), helipad, tyre laydown area, explosives and reload storage facility, core shed workshop, roads, reject bin, ROM Hopper, stockpiles, conveyors, water management infrastructure, bioremediation area, supporting power infrastructure and ancillary infrastructure;
- Construction and use of various items of new infrastructure (including radio tower, extensions to the MIA, Mount Pleasant Staged Discharge Dam and associated water reticulation infrastructure, additional Raw coal stockpile and upgrade to the ROM coal stockpile (along with associated conveyor network) generally as shown on the infrastructure plans;
- Processing, handling and transportation of coal via the (upgraded) CHPP and rail loop for export and domestic sale;
- Continued rejects and tailings co-disposal in the Main OEA and temporary in pit reject emplacement;
- Relocation of a 3 km section of Bengalla Link Road after Year 15 near the existing mine access road to facilitate coal extraction;
- The diversion of Dry Creek via dams and pipe work with a later permanent alignment of Dry Creek through rehabilitation areas when emplacement areas are suitably advanced;
- Relocation of water storage infrastructure as mining progresses through existing dams (including the Staged Discharge Dam and raw water dam); and
- A workforce of approximately 900 full time equivalent personnel (plus contractors) at peak production.

1.3 BACKGROUND

The results of Bengalla's environmental performance are published in the Annual Review (formerly the Annual Environmental Management Report). BMC currently maintains compliance with its 'Licence to Store' (formerly termed Dangerous Goods Licence) 07-100151-001 issued by Work Cover NSW. BMC also maintains compliance with its 'Licence to Store Explosives' XSTR100151 (the details of which are provided in **Section 3.2**) and Environmental Protection Licence (EPL) 6538.

BMC operates in accordance with the Rio Tinto Coal Australia Health, Safety, Environment and Quality (HSEQ) management system which provides a framework and reporting requirements for health, safety and environment standards and quality. This group-wide system ensures that all Rio Tinto Coal Australia operations work consistently within internationally recognised health, safety and environment frameworks and requirements.

The Bengalla Environmental Management System (EMS), accredited to the International Standards Organisation 14001 (ISO 14001), is designed in order that BMC can effectively manage its environmental issues, ensure compliance with regulatory requirements, continually improve its environmental performance and satisfy the expectations of stakeholders.

To drive the operation's performance, each BMC department has in place a documented Health, Safety and Environmental Action Plan, which outlines projects that will aid in achieving the mine's environmental objectives and targets. Existing management systems, standards, procedures and plans will be updated and continue to be implemented throughout the Project and will include:

- Rio Tinto Coal Australia HSEQ System – Management Standards;
- Rio Tinto Environmental Performance Standards;
- Current Coal and Allied EMS Procedures; and
- Current BMC management plans.

Due to the operation of the Project, some proposed changes will occur to the hazardous materials storage locations, and types and quantities of materials stored to that which is currently held on site. This includes:

- The relocation of the Explosives Magazine and Reload Facilities;
- An additional 880,000 L of diesel storage capacity, to be constructed adjacent to the existing diesel storage tanks in the workshop infrastructure area. Diesel will continue to be stored in above ground, self-bunded tanks constructed in accordance with relevant Australian Standards, including but not limited to *AS 1940, The Storage and Handling of Flammable and Combustible Liquids*;
- Construction of new light and heavy vehicle wash stations and associated solids removal system and hydrocarbon treatment; and
- Additional smaller volumes of other hazardous materials required for storage in the MIA workshop areas.

1.4 DOCUMENT PURPOSE

This PHA was undertaken in accordance with *SEPP 33 – Hazardous and Offensive Development Application Guidelines* (DUAP 1994) (SEPP 33 Guidelines). The Hazardous Industry Planning Advisory Papers (HIPAPs) developed under SEPP 33 were also considered throughout the assessment. HIPAPs of particular relevance to the Project PHA included:

- The *Hazardous Industry Planning Advisory Paper No 3 – Risk Assessment* (HIPAP No. 3);
- *The Hazardous Industry Planning Advisory Paper No 4 – Risk Criteria for Land Use Planning* (HIPAP No. 4); and
- *The Hazardous Industry Planning Advisory Paper No. 6 – Guidelines for Hazard Analysis* (HIPAP No 6).

The specific objectives of this PHA were to:

- Provide a clear hazard analysis which satisfies any relevant legislative requirements and existing BMC management procedures, standards and plans;
- Identify any additional hazards and risks including hazardous materials, storage areas, transportation and other activities that may relate to the Project;
- Analyse the significance of each hazard in terms of likelihood of occurrence and potential off-site consequences; and
- Quantify where appropriate and assess the off-site levels of risk due to the Project hazards and operations.

2 METHODOLOGY

The PHA requires the key components of the Project are reviewed against the threshold SEPP 33 Guidelines and HIPAP No. 6.

The methodology applied as per HIPAP Guidelines included:

1. Identification of potentially hazardous materials and events associated with the Project;
2. Examine the potential consequences of identified hazards;
3. Qualitatively estimate the likelihood of Project hazards occurring;
4. Examine any proposed mitigation measures;
5. Qualitatively assess the risks to the environment, safety of members of the public and their property arising from sudden and unexpected incidents and compare these to the applicable qualitative criteria;
6. Recommend any further risk mitigation, management or remedial measures as required for the Project in consideration of the relevance and adequacy of proposed safeguards; and
7. Determine the acceptability and level of risk associated with the Project to allow industry classification and the implementation of appropriate management procedures.

3 POTENTIAL HAZARD IDENTIFICATION

The PHA identified a number of Project related activities which may require the use of potentially hazardous materials. The Project will continue to require the transport and storage of diesel, materials for explosives and other substances, which may be considered potentially hazardous and are discussed further below. BMC will continue to improve and implement environmental management and remedial measures for any hazardous events including the handling, storage and transport of any hazardous substances.

3.1 POTENTIALLY HAZARDOUS MATERIALS

The key hazardous materials required for the Project include explosives, hydrocarbons and other hazardous chemicals. The key hazardous chemicals are predicted to include, although not limited to, fuels such as diesel and petrol, degreaser, kerosene, greases and explosives.

Potentially hazardous materials identified in this PHA are stored in a number of areas within the Project Boundary. A description of each of the bulk storage locations for existing operations and the Project is provided below location is shown on **Figure 3**.

3.1.1 Explosives

The Project will continue to require the continued use of explosives and other related materials. As noted in **Section 1.2**, the existing explosives storage facility will be required to be relocated and this work is anticipated to be completed during quarter 1 of Year 2 of the Project. The current and proposed locations for explosives storage at Bengalla are presented on **Figure 3**.

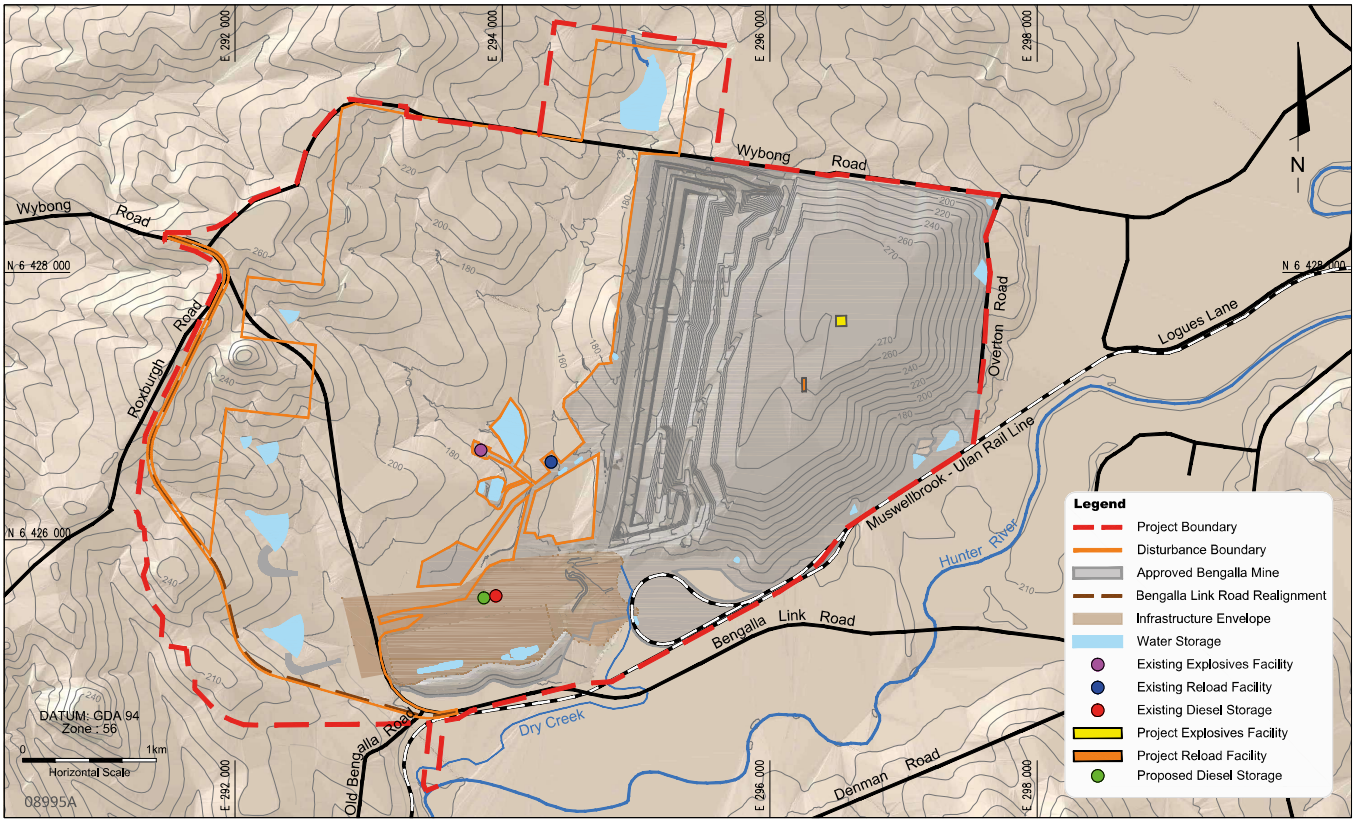
This new facility will be designed in accordance with the relevant Standards and Guidelines including *AS 2187.1 – 1998: Explosives – Storage, Transport and Use – Storage*, *AEISG Code of Practice – Precursors for Explosives* (1999) and the BMC relevant management plans and procedures.

The key potential hazards associated with explosives include the on-site storage facility, transportation of potentially hazardous materials, the proximity to fuel and workshop and possible explosions as a result of mixed materials.

3.1.2 Fuels

Diesel is a combustible liquid as classified by *AS 1940 – 2004: The Storage and Handling of Flammable and Combustible Liquids* (Class C1) for the purposes of storage and handling. However, this hazardous material is not classified as a dangerous good under the ADG Code.

Petrol is classified as a flammable liquid (Class 3) by AS 1940:2004 and as such is classified as a dangerous good by the criteria of the ADG Code. Only very small volumes of petrol will be required for Project-related activities, such as some site maintenance equipment (i.e. mowers) and in workshop areas.



BENGALLA MINE

Hazardous Materials Storage

FIGURE 3

Hansen Bailey

The key potential hazards associated with fuels required by the Project include diesel storage, spills and fires. Diesel has a flashpoint of approximately 61.5ºC and has the potential to result in a fire if ignited. Diesel can be damaging to the surrounding environment if a significant spill is experienced. If the spill leaves site, it has the potential to damage soils and/or aquatic environments.

3.1.3 Other Hazardous Materials

Some other hazardous materials will also be utilised and stored within the workshop areas. The Project will require the use of a number of hazardous chemicals, which will include however not limited to, the use of oil, degreaser and kerosene. Oil is classified as a combustible liquid (Class C2) by AS 1940:2004. All hazardous materials will continue to be managed in accordance with AS 1940:2004 and the relevant BMC management plans and procedures.

3.2 POTENTIALLY HAZARDOUS ACTIVITIES

This PHA includes a detailed assessment of any potentially hazardous activities as summarised below, and is provided in full in **Appendix A**. In order to identify and assess risks associated with the Project, activities were subdivided into the following areas:

- Storage of hazardous materials on-site;
- Transportation of materials including on-site and off-site handling;
- Spill, leakage or runoff causing land contamination;
- Project operations; and
- Natural events.

Potentially hazardous materials identified in this PHA are stored in a number of areas within the Project Boundary.

A description of each of the materials handling and bulk storage locations for existing operations and the Project is provided in the following sections. Key storage facilities for the Project include:

- Explosives and related materials storage facilities;
- Diesel storage facilities; and
- Other potentially hazardous materials storage.

Each location is shown on **Figure 3**.

3.2.1 Explosives Storage Facility

BMC currently holds two licences to store explosives and associated materials, being 07-100151-001 and XSTR100151 for the existing Bengalla explosive precursor storage facility and explosives storage facility respectively. These facilities were approved under DA 273/2006 granted by Muswellbrook Shire Council.

Under the existing 'Licence to Store' 07-100151-001, the precursor facilities are approved to store the following materials:

- 20,000 units of 11B.1B explosives;
- 100,000 kg of 11D1.1D explosives; and
- 1,000 kg of 0025.1 oxidizing substance.

Under the existing 'Licence to Store Explosives' XSTR100151, maximum volumes of the following materials are approved to be stored:

- 9,500 kg of boosters;
- 9,500 kg of detonating cord;
- 20,000 non-electric detonator assemblies;
- 20,000 electric detonators;
- 20,000 non-electric detonator assemblies;
- 20,000 electric detonators;
- 20,000 non-electric detonator assemblies;
- 60,000 kg of Ammonium Nitrate;
- 80,000 kg of Ammonium Nitrate Emulsion; and
- 80,000 kg of Ammonium Nitrate Emulsion.

The products stored at these facilities are stored and handled in accordance *AS 2187.2-2006 – Explosives – Storage, Transport and Use* and internal BMC management plans and procedures. Detonators are stored in a separate, earth-bunded compound, which is fully fenced and locked from general access.

The continuation of mining operations for the Project will require ongoing blasting to achieve suitable fracturing and fragmentation of hard rock overburden to enable efficient removal of these materials. A review of the material proposed to be mined has confirmed that the desired powder factor for blasting is likely to be approximately 0.57 kg of explosive per bcm of material.

Mine planning has predicted that approximately 4 blast events per day, or up to 11 blast events per week will be required for the Project. Blasting will continue to be undertaken during the hours 7:00 am to 5:00 pm Monday to Saturday, with a maximum of four blasts per day. Blasting will be limited to up to one blast per day, between 10:00 am and 3:00 pm on Sundays, when a scheduled blast is within 500 metres of infrastructure areas (including the approved but not yet constructed Mount Pleasant Project infrastructure area) in accordance with the Blast Management Plan, to be revised for the Project.

Initially, the storage of explosives and other related materials for the Project will continue to occur within the existing explosives storage facility. However, the explosives storage facility will be required to be relocated and it is anticipated that this work will be completed during quarter 1 of Year 2 of the Project. The new location for this facility will be on the eastern side of the Main OEA, as illustrated on **Figure 3**. This facility and will be designed in accordance with the relevant Standards and Guidelines (listed previously) and BMC will ensure the explosives storage facility is securely fenced and enclosed by an earthen safety bund.

All existing drill rigs at Bengalla have a contemporary High Precision GPS system installed to maintain accuracy of drill positioning and hole depth within the blasting pattern to minimise potential impacts. Computer modelling software will also continue to be utilised to simulate the blast patterns and reduce associated impacts.

Existing management plans will continue to be utilised and updated regularly to manage the operation of this facility for the Project, with only appropriately qualified and licensed contract personnel, familiar with site procedures to access the area and handle explosive materials and explosive precursors.

3.2.2 Fuel Storage Facilities

BMC holds an 'Acknowledgement of Notification of Dangerous Goods on Premises' 35/033746 for the diesel storage on-site. The existing Bengalla diesel storage facilities are shown on **Figure 3** and include:

- 3 x 110,000 L bunded diesel storage tanks in pit; and
- 2 x 110,000 L bunded diesel storage tanks adjacent to the store and workshop area.

Small volumes of petrol will also be required for some site maintenance equipment (i.e. mowers, etc.) and in workshop areas. Small volumes of diesel, fuels, oils, flammables and hydrocarbons are also stored in the CHPP workshop. Some volumes of petrols, fuels oils and hydrocarbons are also stored in a service trailer and self bunded Hazardous Substance Bins for maintenance purposes.

Additional fuel and lubricant storage facilities will be required for the Project, with a 550,000 L self-bunded storage facility proposed to be constructed in Year 2 adjacent to the existing diesel storage tanks in the workshop infrastructure area. In Year 3 of the Project, there will be a further upgrade to increase the additional diesel refuelling facilities required for the Project to a total maximum storage volume of 1,320,000 L.

The location of the additional fuel storages proposed is illustrated on **Figure 3**. The fuel storage areas will be constructed, with bunding, in accordance with the relevant Australian Standards including (however not limited to) NSW OH&S Regulations and AS1940-2004.

3.2.3 Storage of Other Hazardous Materials

Any hazardous materials required for the Project will be stored within infrastructure areas in accordance with relevant Australian Standards and Guidelines. Substances will continue to be stored on-site in above ground facilities in the Main Infrastructure Area (MIA), at a distance from any diesel or explosive storage areas to minimise any potential risks. These substances will be located in a bunded area in accordance with the NSW OH&S Regulations, which will minimise the risk and consequence should a fire or explosion occur and prevent any toxic contamination of the surrounding environment.

Activities undertaken in the CHPP require the use of Sodium Hypochlorite, which is classed as a red hazard material. BMC stores a maximum of 2,000 L on-site in a fully bunded storage facility at the waste water treatment plant as shown on **Figure 3**.

Approximately 135,000 L of undiluted anionic flocculent is also stored in three 45,000 L bunded tanks and 30,000 L of cationic flocculent stored in two 15,000 litre bunded tanks located to the east of the washery in the CHPP area. A total of approximately 100 t of magnetite is stored in two sumps located in the washery structure and the magnetite pit located to the east of the washery building.

Smaller quantities of other chemicals including paints, oils, solvents, glues and degreasers are required in the CHPP and for maintenance activities. These are predominantly stored in the hazardous chemicals storage cabinet in the CHPP Workshop area. No licence is required for the maximum storage volumes needed. The maximum storage capacity for storage tanks and cabinets within the CHPP workshop includes:

- 6,000 L of storage for waste coolant;
- 6,000 L for coolant;
- 2 x 10,000 L tanks for oil;
- 2 x 25,000 L tanks for oil;
- 2 x 15,000 L for coolant;
- 3 x 6,560 L hydrocarbon cabinets;
- 4 x 1,000 L gas cabinets;
- 7 x 250 L flammables cabinet; and
- 2,500 kg bulk grease.

3.2.4 Transport of Hazardous Materials

All bulk materials will continue to be transported to Project by a licensed contractor in accordance with the relevant contractor transport codes and standards and site operation procedures. Diesel will be delivered on a daily basis with up to six B-Double (50,000 L) trucks per day. The vehicles used for the transport of hazardous substances will continue to have appropriate signage displayed in accordance with the *Australian Code for the Transport of Dangerous Goods*, *Australian Code for the Transport of Explosives* and relevant NSW legislation.

3.2.5 Spills / Leakage and Contaminated Runoff

Any hazardous material releases will be managed in accordance with BMC emergency response procedures. These procedures implement techniques and handling requirements that assist in preventing spills and leakages from occurring and ensure prompt and effective clean-up practices are employed should any spills occur.

BMC will continue to implement an emergency spill response procedure, which will incorporate appropriate training, implementation of best practice procedures and the undertaking appropriate remediation measures.

Emergency Oil Spill Response Kits are readily available; particularly in areas where work involving activities that require the use of hydrocarbons. BMC also maintains a contaminated sites register in accordance with Bengalla Environmental Procedure EP13.1. The register will maintained for the Project and will record at a minimum:

- The locations on any areas used for the storage of hydrocarbons, chemicals, wastes and other potential contaminants;
- Any areas routinely used for vehicle and plant re-fuelling and servicing;
- The location of any contamination events and the remediation works that were undertaken;
- Type and quantities of the contaminating materials; and
- Recommended remediation works and performance criteria required to be undertaken.

Bengalla's oil / water separator is currently utilised to treat runoff from the MIA, specifically the administration building, vehicle wash bay and workshop areas prior to water being recycled through Bengalla's water management system. A new solids removal system and hydrocarbon treatment will be constructed adjacent to the new heavy and light vehicle wash bays to ensure any runoff continues to be captured and appropriately treated.

3.2.6 Natural Events

Natural events such as floods, bushfires and landslides can also create hazardous conditions. Consideration of these natural hazards and their management has been included as part of this assessment.

The potential risk of fires will continue to be managed in accordance with the existing Landscape Management Plan. A Bushfire Risk Assessment and associated review of the existing Landscape Management Plan will be undertaken for the Project.

It is possible that the Project and its associated activities may increase the risk of fires occurring and spreading to the surrounding environment.

The bushfire danger period in NSW runs from 1 October to 31 March (inclusive) of the following year depending upon the seasonal weather conditions. BMC will continue to monitor fuel supplies and climatic conditions to determine if there is a high risk of a fire occurring. Severe conditions may result from:

- Wet, late summer and autumn promoting heavy fuel accumulation;
- Dry and windy winters with heavy frosts;
- Dry springs and the early onset of summer conditions; or
- An extended drought period.

BMC will continue to implement control measures for the Project to minimise any potential hazards including:

- Grazing of pastures to minimise fuel build-up;
- Slashing grass around infrastructure;
- Maintaining fire breaks as required; and
- Ongoing communications with the NSW Rural Fire Service.

BMC has installed and maintained fire control infrastructure, with fire fighting equipment at key points, and an emergency response team.

The Project is located in an area with no recorded history of landslides and exhibits no evidence of instability. Slope angles and shapes are negligible across the development area. On this basis the geological and geomorphological conditions indicate very low risk of landslide occurrence.

All components of the Project are located outside the 1 in 100 year flood extent of the Hunter River and therefore the flood risks are considered low.

4 IMPACT ASSESSMENT

The potential hazards and risks identified during the hazard identification process for the Project were assessed according to qualitative risk assessment criteria. This was achieved through a consideration of the various levels of consequences of an event should it occur and the likelihood of such an event occurring. Predicted impact risk ratings associated with the Project are detailed in **Appendix A**, which details:

- A consequence analysis; and
- The estimated likelihood of a potential hazard occurring;
- The consequences, in particular to the surrounding environment should a potential hazard occur; and
- The subsequent risk rating for each potential hazard identified specific to the Project.

4.1 CONSEQUENCE ANALYSIS

The consequence criteria and descriptors were developed based on the Rio Tinto Health Safety and Environment Qualitative Risk Analysis Handout v 2.1 (September 2010). A qualitative scale of consequences for potential hazardous events is provided in **Table 1**.

The qualitative risk assessment criteria are based on the following principles:

- All 'avoidable' risks associated with the Project should be avoided. This may require the investigation of alternative locations and technologies;
- The level of risk from a significant hazard should be reduced wherever possible, irrespective of the level of cumulative risk from the Project as a whole; and
- The consequences of the more likely hazardous events should, wherever possible be contained within the Project Boundary.

Table 1
RTCA HSEQ Qualitative Consequence Descriptors

Consequence	Definition
Minor	Low level short term impact which is easily confined and promptly reversible. Low level or short term subjective inconvenience or symptoms typically only requiring first aid.
Medium	Near-source confirmed and short-term reversible impact (typically one week). Reversible injuries requiring treatment but does not lead to restricted duties.

Consequence	Definition
Serious	Near source confined and medium – term recovery impact. Reversible injury or moderate irreversible damage or impairment to one or more persons.
Major	Impact that is unconfined and requiring long-term recovery leaving residual damage (typically months to years). Single fatality and/or severe irreversible damage or severe impairment to one or more persons.
Catastrophic	Impact that is widespread, unconfined and requiring long-term recovery, leaving major residual damage. Multiple fatalities or permanent damage to multiple people.

4.2 LIKELIHOOD OF HAZARDOUS EVENTS OCCURRING

The likelihood and risk acceptability criterion for potential hazardous events was developed based on the Rio Tinto Health Safety and Environment Qualitative Risk Analysis Handout v 2.1 (September 2010). A qualitative scale of likelihood for potential hazardous events is provided below in **Table 2**.

Table 2
Qualitative Likelihood Scale

Descriptor	Definition
Almost Certain	Occurs more than twice per year. Recurring event during the lifetime of the Project.
Likely	Typically occurs once or twice per year. Event that may occur frequently during the lifetime of an operation/project.
Possible	Typically occurs once every 10 years. Event that may occur during the lifetime of an operation/project.
Unlikely	Typically occurs once every 100 years. Event that is very unlikely to occur during the lifetime of the Project.
Rare	Greater than 1:100 year event. Event is extremely unlikely to occur during the lifetime of the Project.

4.3 RISK ASSESSMENT CRITERIA

The level of risk for each hazardous activity identified was determined using the risk levels provided below by combining the consequence and likelihood of the event from **Table 1** and **Table 2** above and identifying the level of risk associated with potential hazards identified in **Section** 3. The final critical qualitative risk classification was determined using the Bengalla Risk Matrix as presented in **Table 3**.

The levels of risk presented below as rated by the Risk Matrix, may be described by the following:

- Low: Manage by routine procedures, implementing corrective action where practicable;
- Moderate: Manage by corrective action and specific monitoring or response mechanism, with management responsibilities specified;
- High: Senior management attention required. Action plans and responsibility required to eliminate or reduce risk to lower level through introduction of additional risk controls; and
- Critical: As per the High Risk ranking category; however immediate action to reduce risk level is required.

Table 3
Bengalla Risk Matrix

Likelihood	Consequence				
	Minor	Medium	Serious	Major	Catastrophic
Almost Certain	Moderate	High	Critical	Critical	Critical
Likely	Moderate	High	High	Critical	Critical
Possible	Low	Moderate	High	Critical	Critical
Unlikely	Low	Low	Moderate	High	Critical
Rare	Low	Low	Moderate	High	High

5 RISK ASSESSMENT ANALYSIS

The risk assessment presented in **Appendix A** presents a qualitative risk assessment of the hazards associated with the Project. These will continue to be managed in accordance with management measures and procedures in place for existing Bengalla operations.

The risk assessment identified a need for the following preventative measures:

- Personnel entering the explosive precursor and explosives storage facilities will be authorised to do so and trained in relevant procedures for the loading, transport and preparation of hazardous substances. Any visitors entering this area must be site inducted and will need to 'sign on';
- At no time will the use of unapproved substances be permitted within the Project site. All chemicals must be assessed according to their MSDS as supplied by the Manufacturer/Supplier and the National Occupational Health and Safety Commission (NOHSC) criteria prior to use. In addition, the chemicals are to be approved by the Department Manager, the Environmental Specialist and the Health & Safety Specialist, for use in a specific area;
- All storage facilities will satisfy the following requirements:
    - Facilities will be designed, constructed, inspected and maintained in accordance with the requirements of the Dangerous Goods Act and the relevant Australian Standards;
    - All facilities will be secure and protected from damage and theft;
    - Designs will ensure easy access for fire fighting should a fire occur;
    - Where possible any chemical containers and storage facilities will be designed to minimise any physical damage due to temperature extremes, moisture, corrosive mists or vapours and vehicles; and
    - All substances shall be stored in the areas or facilities provided.

BMC will update the relevant management plans in place for existing Bengalla operations to improve performance and manage any additional hazards and risks that may be associated with the Project.

Explosives will continue to be utilised in accordance with site procedures and the requirements of *AS/NZS 2187 – 1998: Explosives – Storage, Transport and Use* (Standards Australia, 1998), the *Explosive Act 2003*, the *Explosive Regulations 2005*, the *Coal Mines Health and Safety Act 2002* (CMH&S), the *CMH&S Regulations 2006* and other relevant codes.

6 CONCLUSION

The qualitative risk assessment presented in **Appendix A** identifies potential hazards associated with the Project and ensures that adequate risk mitigation and response measures will be implemented.

This risk assessment has confirmed that the Project will not impose an unacceptable level of risk, with appropriate management and is therefore not a hazardous or offensive development.

* * *

for
HANSEN BAILEY

Dorian Walsh
Environmental Scientist

Dianne Munro
Principal

7 REFERENCES

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- NSW DoP (2011b), *Hazardous Industry Planning Advisory Paper No. 6 – Hazard Analysis*.
- DUAP (1994), *SEPP 33 – Hazardous and Offensive Development Application Guidelines.*
- National Transport Commission (2011), *Australian Code for the Transport of Dangerous Goods by Road and Rail*. Seventh Edition.

APPENDIX A

Project Hazards and Risk Assessment Summary

Table A1
Project Hazards & Risk Assessment Summary

Operational Activity / Hazard	Incident Type	Scenario	Proposed Management Measures	Likelihood	Consequence	Risk
Transport to Site	Spill	Vehicle collision, poor maintenance, or human error leading to off-site impacts	• Approved contractors to transport and operate in accordance with Australian Codes & Standards; • Spill kit stored in transport vehicles; • Fire fighting equipment to be stored in vehicle; • Transport vehicles to have communication (e.g. mobile, radio etc.).	Likely	Medium	High
	Fire	Material ignited following spill		Unlikely	Serious	Moderate
	Explosion			Unlikely	Serious	Moderate
	Theft	Theft of dangerous goods during transport, leading to off-site impacts	• Transportation in accordance with the *Australian Code for Transport of Dangerous Goods and Explosives*; • Follow specified route to the Project.	Unlikely	Major	High
Delivery to Site (filling storages)	Spill	Vehicle collision, overfill of storages, leaking pipeline, human error, leaking storage container	• Storage facility, containers, bunding, drainage and pipelines designed in accordance with Australian Standard; • Approved contractors to fill storages following operating procedures; • Contractor 'sign-on' prior to entering site to fill storages;	Likely	Medium	High
	Fire	Material catching on fire, with possible spread to other		Unlikely	Medium	Low

Operational Activity / Hazard	Incident Type	Scenario	Proposed Management Measures	Likelihood	Consequence	Risk
		hazardous materials	• Regular inspections of storages and daily before delivery.			
	Explosion	Explosion as a result of mixed materials		Unlikely	Serious	Moderate
On-Site Storage (Explosives Facility, Fuel and Workshop Storages)	Leak/Spill	Failed storage tank / facility / pipeline	• Storage facility, containers, bunding, drainage and pipelines designed in accordance with Australian Standard; • Operating procedures followed; • Maintenance activities as required.	Possible	Medium	Moderate
	Theft	Unauthorised personnel removing product from facility, which could lead to off-site impact	• Explosives Facility designed for compliance with NSW legislation; • Explosives storages to be securely fenced.	Unlikely	Major	High
	Fire	Flammable or combustible materials ignited causing a fire which has potential to spread	• Storage facility, containers, bunding, drainage and pipelines designed in accordance with Australian Standard; • Regular inspections of storages; • Maintenance activities; • Fire fighting equipment available on site and at storage locations; • All spillage cleaned up following operating procedures; and • Emergency response procedure in place.	Unlikely	Serious	Moderate
	Explosion	Possible explosion if fire spreads		Unlikely	Serious	Moderate

Operational Activity / Hazard	Incident Type	Scenario	Proposed Management Measures	Likelihood	Consequence	Risk
General Project Operations	Spill	Vehicle collision, poor maintenance, procedures absent	• Storage facility, containers, bunding, drainage and pipelines designed in accordance with Australian Standard; • Daily inspections of facilities; • Maintenance when required; • Operating procedures followed for spill response.	Likely	Medium	High
	Fire	Flammable or combustible materials ignited causing a fire which has potential to spread	• Storage facility, containers, bunding, drainage and pipelines designed in accordance with Australian Standard; • Regular inspections of storages; • Maintenance activities as required; • Fire fighting equipment available on site; • All spillage cleaned up in accordance with response procedures; and • Emergency response procedure in place.	Unlikely	Serious	Moderate
	Explosion	Possible explosion if fire spreads		Unlikely	Major	High
Natural Events	Bushfire	Bushfire spreading to operational areas and wider area	• Bushfire Management Plan; • Grazing of pastures to minimise fuel build-up; • Slashing grass around storage areas; • Maintaining fire breaks as required; and • Ongoing communications with the NSW Rural Fire Service.	Unlikely	Serious	Moderate
	Flooding	Flooding of hazardous materials storage areas	• Storage facility design in accordance with Australian Standard; • Storage facility location outside of 1:100 year flood limit of Hunter River • Surface Water Management Plan.	Unlikely	Serious	Moderate

BENGALLA Mining Company

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Contamination Assessment

CONTINUATION OF BENGALLA MINE

PRELIMINARY CONTAMINATION ASSESSMENT

Prepared by:

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SINGLETON NSW 2330

July 2013

For:

BENGALLA MINING COMPANY PTY LIMITED
LMB 5
MUSWELLBROOK NSW 2333

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CONTINUATION OF BENGALLA MINE
PRELIMINARY CONTAMINATION ASSESSMENT

for
Bengalla Mining Company Pty Limited

1 BACKGROUND

Bengalla Mining Company Pty Limited (BMC) operates the Bengalla Mine (Bengalla) in the Upper Hunter Valley of NSW. Bengalla is situated approximately 130 km north-west of Newcastle and 4 km west of the township of Muswellbrook (see **Figure 1**).

On 7 August 1995, BMC was granted Development Consent (DA 211/93) by the then Minister for Urban Affairs and Planning. This consent authorised the construction and operation of a surface coal mine, coal preparation plant, rail loop, loading facilities and associated facilities. The application for development consent was supported by the *Environmental Impact Statement for Bengalla Coal Mine* (Bengalla EIS), dated November 1993 (Envirosciences, 1993). There have since been 4 approved modifications to DA 211/13. Bengalla is now approved to produce up to 10.7 Million tonnes per annum (Mtpa) of Run of Mine (ROM) coal.

1.1 THE PROJECT

BMC is seeking Development Consent under Division 4.1 of Part 4 of the *Environmental Planning & Assessment Act 1979* (EP&A Act) for the Project within the Project Boundary shown on **Figure 2**. The Project generally comprises:

- Open cut coal mining at up to 15 Mtpa ROM for 24 years continuing to utilise a dragline and truck / excavator fleet;
- Continue mining to the west of current operations;
- An additional Overburden Emplacement Area (OEA) to the west of Dry Creek which may be utilised for excess spoil material until it is intercepted by mining;
- Processing, handling and transportation of coal via the existing CHPP (to be upgraded) and rail loop for export and domestic sale;
- An additional CHPP stockpile and ROM coal stockpile;
- Continued use, expansion and upgrades to existing coal infrastructure;
- The construction of a radio tower;
- Relocation of the Explosives Magazine and Reload Facility;
- Relocation of a section of Bengalla Link Road near the existing mine access road to enable coal extraction;

- The re-diversion of Dry Creek via dams and pipe work with a later permanent re-alignment of Dry Creek through rehabilitation areas once stability is established;
- Relocation of water storage infrastructure as mining progresses through existing dams (including the staged discharge dam);
- The construction of raw water dams and a clean water dam;
- A workforce of approximately 900 full time equivalent personnel (plus contractors) at peak production; and
- Supporting power reticulation infrastructure.

1.2 DOCUMENT PURPOSE & OBJECTIVES

The purpose of this Preliminary Contamination Assessment (PCA) is to form part of the Environmental Impact Statement (EIS) being prepared by Hansen Bailey to support an application for Development Consent under Division 4.1 of Part 4 of the EP&A Act.

This PCA addresses the relevant Director-General's Environmental Assessment Requirements issued for the EIS by the NSW Department of Planning and Infrastructure (DP&I) on 13 March 2012 which states that the EIS must include:

> '*a detailed assessment of the potential impacts on soils and land capability (including salinization and contamination)'*.

Further, the Environment Protection Authority's (EPA's) submission to DP&I (Attachment 1 to the DGRs) for the Project statedthe following:

1. *"The EIS should include an assessment of the contaminated site that is conducted in accordance with the guidelines made or approved under section 105 of the Contaminated Land Management Act 1997, for example: Guidelines for Consultants Reporting on Contaminated Sites (EPA, 2000), Guidelines for the NSW Site Auditor Scheme – 2nd edition (EPA, 2006), Sampling Design Guidelines (EPA, 1995), National Environment Protection (Assessment of Site Contamination) Measure 1999 (or update).*
2. *The EIS should provide the details on how the site contamination will be remediated and/or managed so that the site is, or can be, made suitable for the proposed use.*
3. *All reports should be prepared in accordance with the Guidelines for Consultants Reporting on Contaminated Sites (EPA, 2000).*
4. *The EIS should specify whether or not a site auditor, accredited under the Contaminated Land Management Act 1997, has been or will be engaged to issue a site audit statement to certify on the suitability of the current or proposed uses."*

The specific objectives of this PCA were therefore to:

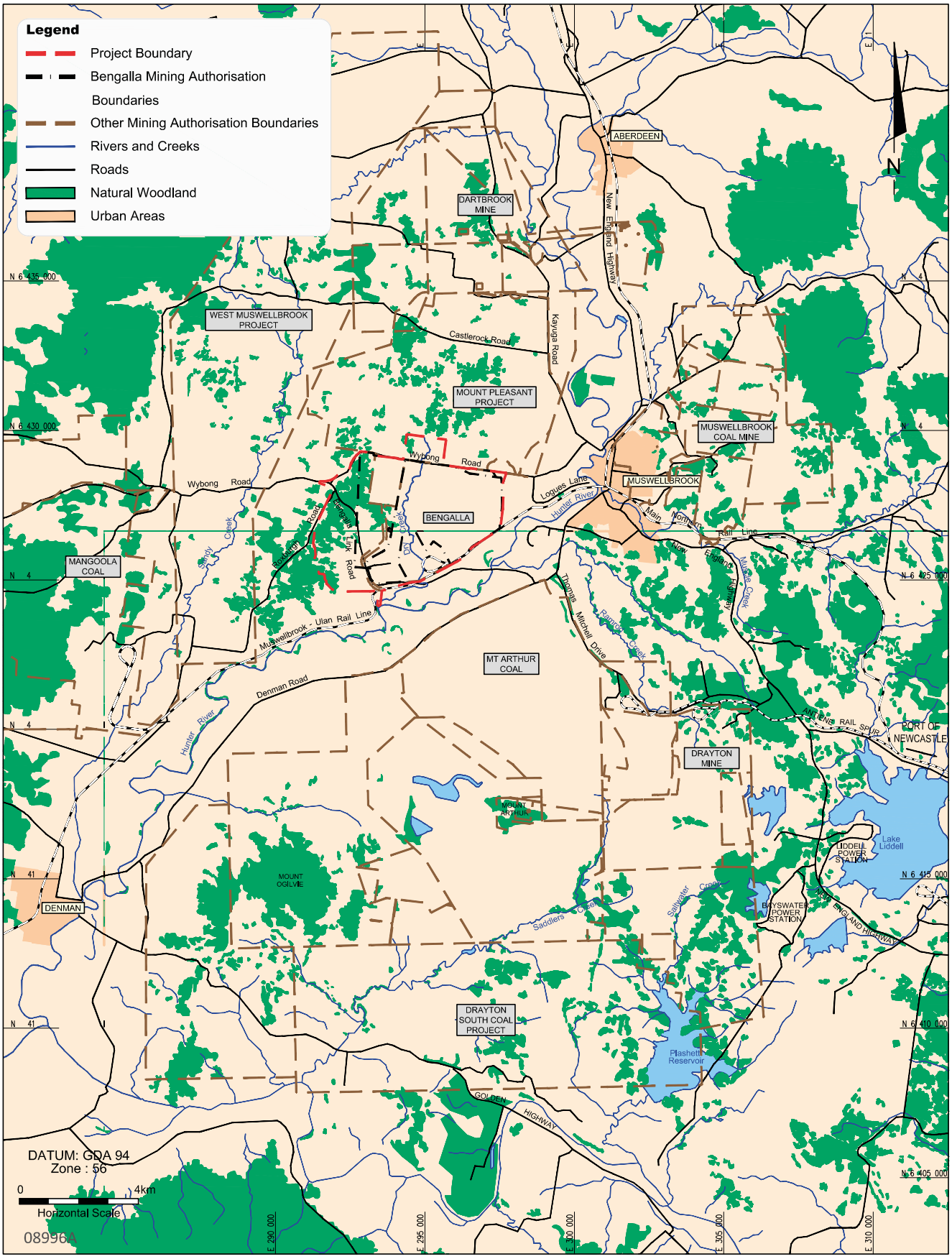
- Identify all past and present potentially soil contaminating activities within the Project Disturbance Boundary;
- Identify potential contamination types;
- Discuss the site condition;
- Provide a preliminary assessment of contamination within the Disturbance Boundary; and
- Assess the need for further investigations by a Site Auditor accredited under the *Contaminated Land Management Act 1997*.

1.3 DOCUMENT STRUCTURE

This report contains 10 sections. This section provides background information on the Project and a description of the purpose of this PCA.

The remainder of the report is structured as follows:

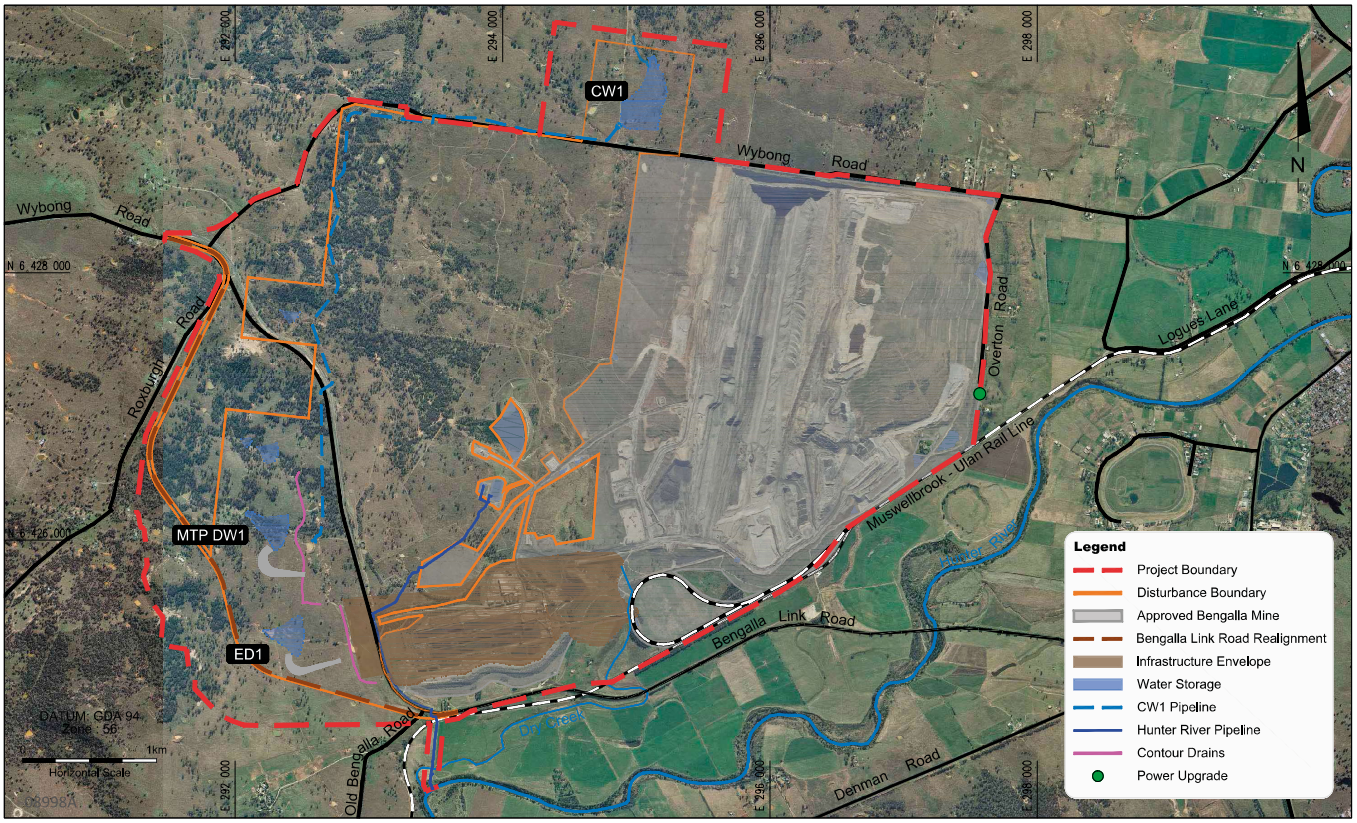
- **Section 2** outlines the regulatory framework applicable to this PCA;
- **Section 3** summarises the existing environment within the Project Boundary;
- **Section 4** describes the methodology used for this PCA;
- **Section 5** provides the results of a desktop study of available information;
- **Section 6** provides a review of the historical heritage impact assessment prepared as part of the EIS for the Project;
- **Section 7** summarises the potentially contaminated areas identified within the Disturbance Boundary;
- **Section 8** identifies mitigation and management measures based on the results of this PCA;
- **Section 9** outlines the limitations of this PCA; and
- **Section 10** lists references provided throughout the PCA.



BENGALLA MINE

Regional Locality

FIGURE 1



BENGALLA MINE

Conceptual Project Layout

FIGURE 2

2 REGULATORY FRAMEWORK

2.1 INTRODUCTION

This PCA has been prepared in accordance with the regulatory framework outlined below and with reference to the following guidelines:

- *Guidelines for Consultants Reporting on Contaminated Sites* (NSW Office of Environment and Heritage, 2011); and
- *Managing Land Contamination, Planning Guidelines, SEPP 55 – Remediation of Land* (NSW Department of Urban Affairs and Planning & NSW Environment Protection Authority (EPA), 1998).

2.2 ENVIRONMENTAL PLANNING AND ASSESSMENT ACT 1979

As noted in **Section 1**, BMC is seeking development consent for State Significant Development under Division 4.1 of Part 4 of the EP&A Act for the Project. The consent authority is the Minister for Planning & Infrastructure.

The EP&A Act provides an important role in the management of land contamination in NSW by incorporating mechanisms to ensure that:

- Planning authorities consider contamination issues when they are making rezoning and development decisions;
- Local councils provide information about land contamination on planning certificates that they issue under Section 149 of the EP&A Act; and
- Land remediation is facilitated and controlled through *State Environmental Planning Policy 55 – Remediation of Land* (SEPP 55).

2.3 CONTAMINATED LAND MANAGEMENT ACT 1997

The *Contaminated Land Management Act 1997* (CLM Act) regulates significantly contaminated sites in NSW. The general objective of the CLM Act is to establish a process for investigating and (where appropriate) remediating land that the NSW Environment Protection Authority (EPA) considers to be contaminated significantly enough to require regulation.

2.4 STATE ENVIRONMENTAL PLANNING POLICY 55

SEPP 55 – Remediation of Land (SEPP 55) was enacted to provide a state wide approach to the remediation of contaminated land for the purpose of minimising the risk of harm to the health of humans and the environment.

Managing Land Contamination, Planning Guidelines, SEPP 55 – Remediation of Land (the Guidelines) have been prepared to assist in managing land contamination in NSW in accordance with SEPP 55.

Specifically, the Guidelines provide:

- Information to assist in the investigation of contamination possibilities;
- A decision making process that responds to the information obtained from an investigation;
- Information on how planning and development control can cover the issues of contamination and remediation;
- A suggested policy approach for planning authorities;
- Discussion of information management systems and notification and notation schemes, including the use of section 149 planning certificate notations; and
- Approaches to prevent contamination and reduce the environmental impact from remediation activities.

3 EXISTING ENVIRONMENT

3.1 TOPOGRAPHY

The land within the Project Boundary is generally undulating and slopes downwards towards the Hunter River to the south. The Hunter River alluvial flats are situated within the eastern and southern extents of the Project Boundary.

In the eastern part of the Project Boundary, the Overton Ridge reaches an elevation of 188 m Australian Height Datum (AHD). To the south of the Overton Ridge are the lower hillslopes of the Hunter Valley, which range in elevation from 250 m AHD to 134 m AHD near the Hunter River (Envirosciences, 2003).

The area within the Project Boundary predominantly consists of gentle gradients (less than 5 degrees). The gullies in the lower reaches of ephemeral streams draining into the Hunter River generally have slopes of less than 2.5 degrees. Ridge tops also generally have a gradient of less than 2.5 degrees. The Hunter River alluvial floodplain generally has a gradient of less than 1 degree (Envirosciences, 2003).

A wide range of landscape features are present within the Project Boundary, including:

- Active mining areas within the approved Bengalla Mine;
- Completed mining areas that are awaiting or in the process of being rehabilitated;
- Rehabilitated areas;
- Bengalla Mine surface infrastructure; and
- Open paddock grazing land with limited stands of remnant forest and woodland.

3.2 LAND USE

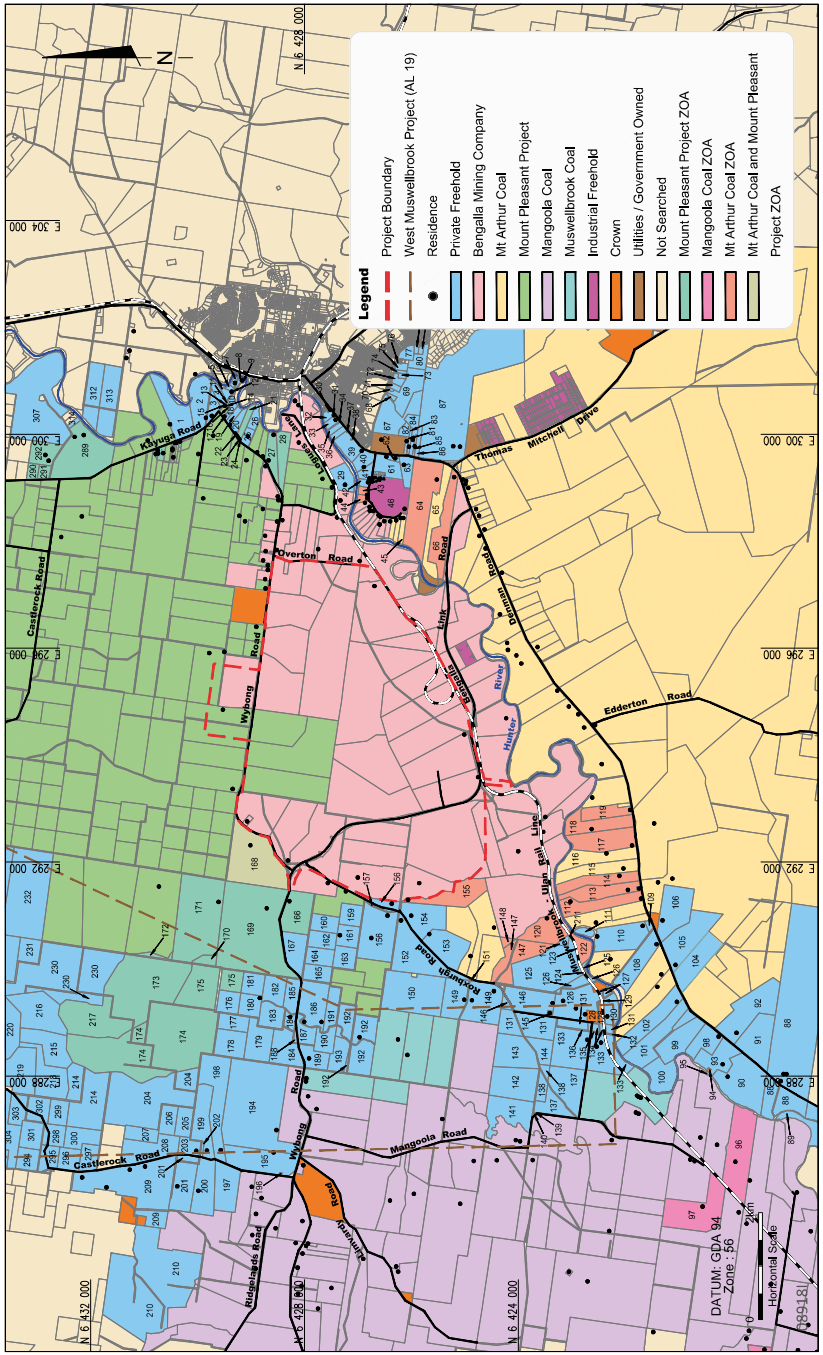
The Upper Hunter region has a long history of rural land use for a variety of agricultural and industrial activities, predominantly grazing and coal mining. The current dominant land uses within and adjacent to the Project Boundary include open cut coal mining and industrial activities, agriculture, rural residential and residential areas.

The Hunter River is located approximately 1 km south of the Project Boundary and plays an important role in the region's mining, power generation and agricultural enterprises.

3.3 LAND OWNERSHIP

Land ownership within and surrounding the Project Boundary is shown on **Figure 3**.

All of the land within the Project Boundary is owned by BMC, with the exception of three lots owned by Coal & Allied (for the Mount Pleasant Project). Coal & Allied also owns a large area of land to the north of Bengalla. The land to the south of the Project Boundary is held by BHP Billiton for the Mt Arthur Coal Complex.


N
Legend
Project Boundary
West Muswellbrook Project (AL 19)
Residence
Private Freehold
Bengalla Mining Company
Mt Arthur Coal
Mount Pleasant Project
Mangoola Coal
Muswellbrook Coal
Industrial Freehold
Crown
Utilities / Government Owned
Not Searched
Mount Pleasant Project ZOA
Mangoola Coal ZOA
Mt Arthur Coal ZOA
Mt Arthur Coal and Mount Pleasant
Project ZOA
N 6 428 000
N 6 424 000
N 6 432 000
E 304 000
E 300 000
E 296 000
E 292 000
E 288 000
Kayuga Road
Thomas Mitchell Drive
Overton Road
Castlerock Road
Wybong Road
Edderton Road
Hunter River
Main Northern Railway Line
Rixbush Road
Mangoola Road
Ridgelands Road
DATUM: GDA 94
Zone : 56
Horizontal Scale
0
2km
BENGALLA MINE
Land Ownership
FIGURE 3
Hansen Bailey
ENVIRONMENTAL CONSULTANTS
BENGALLA

4 METHODOLOGY

To assess the history and land use of the Project Boundary, a desktop study of the following available information was undertaken, including:

- Review of a soil landscape map and relevant impact assessments completed for the region;
- Review of land ownership information for the area to identify potential contaminated sites;
- Review of historical aerial photos to identify historical land use and potentially contaminating activities; and
- Search of the register of the NSW Contaminated Sites Notified to the EPA (EPA, 2012).

The findings of the desktop study are provided in **Section 5**.

The findings of the review of the Historical Heritage Report for the Project are presented in **Section 6**.

A summary of the areas of potential contamination identified by this PCA is provided in **Section 7**.

5 DESKTOP STUDY

5.1 REVIEW OF SOIL LANDSCAPE

The soil landscapes within the Project Boundary have been mapped during a number of previous assessments, which were reviewed for this PCA and include:

- Soil Landscapes of the Singleton 1:250,000 Sheet (Kovac and Lawrie, 1991);
- Soil Survey for the Proposed Bengalla Coal Mine (Envirosciences Pty Ltd, 1993);
- Bengalla Coal Mine Soil Survey Report (GSS, 2005);
- Soil and Land Capability Impact Assessment, Bengalla Development Consent Modification (GSSE, 2010); and
- Soil and Land Capability Impact Assessment, Continuation of Bengalla Mine (GSSE, 2013) prepared for the Project.

The soil landscapes mapped in these assessments were reviewed for this PCA to identify any areas within the Disturbance Boundary mapped as disturbed terrain. Soils mapped in such a way indicates areas where the natural soil profile in the area is known to have been disturbed by human activities and may have been backfilled with imported filling materials.

No areas of disturbed terrain were previously identified within the Disturbance Boundary in the above maps or assessments.

5.2 HISTORICAL AERIAL PHOTO REVIEW

Aerial photos for the years 1953, 1964, 1972, 1982, 1993, 1998 and 2007 were investigated to identify previous land use and potentially contaminating activities throughout the Disturbance Boundary.

The results of the historical aerial photo review indicate that the area within the Project Disturbance Boundary has generally been cleared since the first available aerial photos for the site were taken in 1953. Evidence of agricultural activity and infrastructure such as cropping, dairies, drainage structures and farm dams is present, with more intensive activities present in lands adjacent to the Hunter River. A number of rural residences, dairies and associated infrastructure and unsealed access roads are also present in the local area.

During the period since 1953, similar agricultural activities within the Project Disturbance Boundary were seen to continue. Disturbance of some additional patches of vegetation occurred during the period from 1953 – 1982, with the more intensive activities remaining in the alluvial areas adjacent to the Hunter River.

Mining activities associated with approved Bengalla Mine operations first become evident in the 1998 aerial image, with the open cut, coal stockpiles and mine infrastructure area well developed.

5.3 LANDOWNERSHIP INFORMATION REVIEW

To provide further information on potentially contaminated sites within the Disturbance Boundary, land ownership records and property information gathered by BMC during the preparation of the EIS for Bengalla Coal Mine (Environsciences, 1993) were also reviewed.

This review confirmed the location of residential sites and the status of agricultural activities occurring within the Disturbance Boundary.

5.4 SEARCH OF THE EPA CONTAMINATION REGISTER

A review of the NSW Contaminated Sites Notified to the EPA (EPA, 2012) indicated that the land within the Project Boundary has no statutory notices issued under the provisions of the CLM Act.

6 REVIEW OF HISTORICAL HERITAGE IMPACT ASSESSMENT

As part of the Historical Heritage Impact Assessment for the Project, AECOM (2013) conducted a field survey in November and December 2011 to identify sites of heritage significance within the Project Boundary.

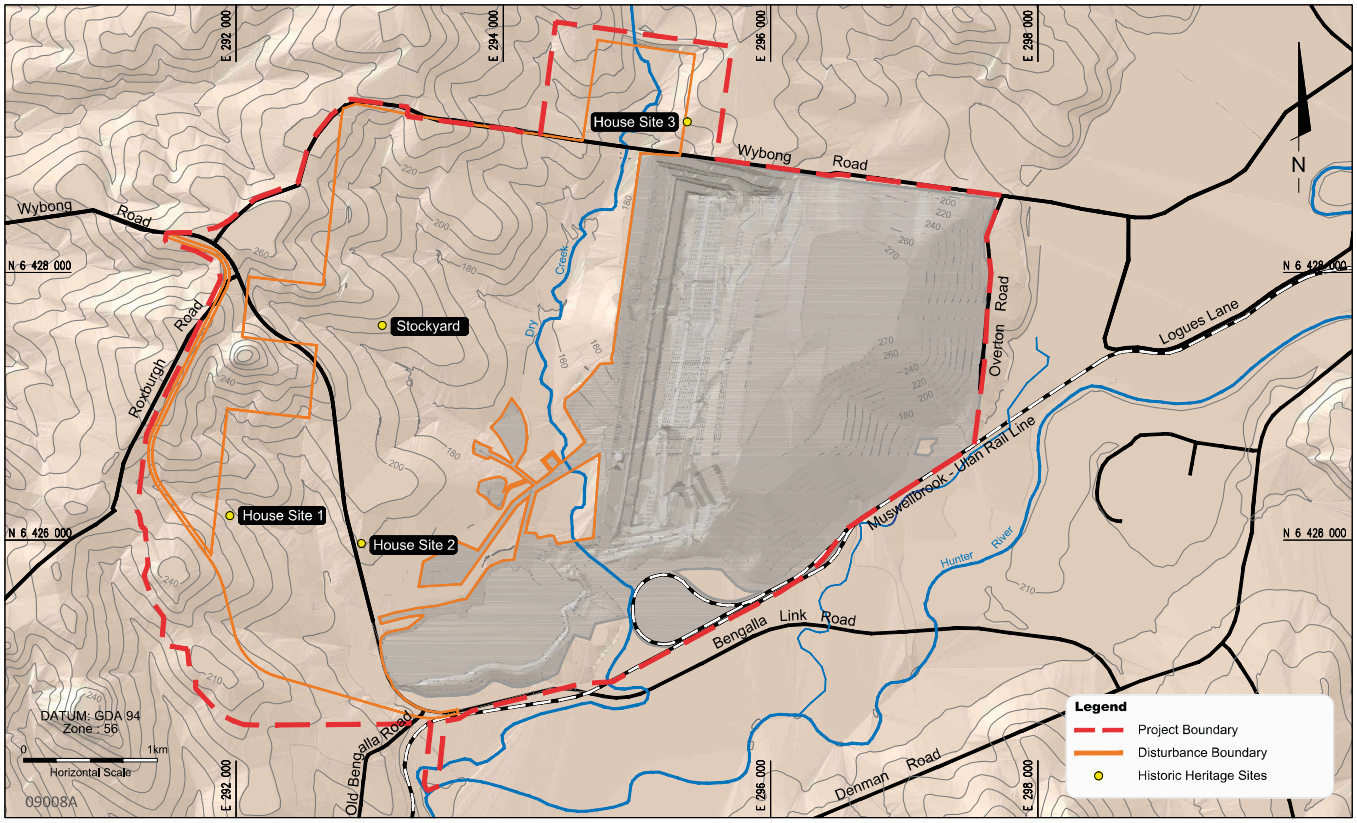
The Historical Heritage Impact Assessment was not primarily conducted to identify areas of potential contamination and the personnel undertaking the inspections were not qualified to undertake contamination assessments. However, the results of the inspections were reviewed in order to provide additional information on potential contamination for each site identified within and adjacent to the Disturbance Boundary (see **Table 1**). The locations of these sites are shown in **Figure 4**.

Table 1
Review of Historical Heritage Impact Assessment

Site Name	Potential Sources of Contamination
House Site 1	In-ground septic tank, above ground concrete tank and scatter of material to the north of the former house site
House Site 2	Former house site and waste material
House Site 3	Former house site (demolition rubble pile), dairy site, scatter of waste material to the north of the former house site
Stockyard	Chemical use for livestock management

7 IDENTIFIED POTENTIAL CONTAMINANT SOURCES

On the basis of the available site history and a review of observations presented in the Historical Heritage Impact Assessment, the principal sources of potential contamination are former residences within and adjacent to the Disturbance Boundary (see **Table 1** and **Figure 4**).



BENGALLA MINE

Historic Heritage Sites

FIGURE 4

8 MITIGATION AND MANAGEMENT

Although potential sources of contamination were identified within the Disturbance Boundary, these were associated with structures and activities likely to be identified on other properties with a history of agricultural land uses.

The results of this PCA identified the need for an additional investigation to be undertaken to assess the extent of contamination within the Disturbance Boundary.

It is recommended that a contamination investigation be undertaken by a licensed contractor to further assess the extent of contamination throughout the Disturbance Boundary. This investigation should be undertaken prior to the commencement of mining in potentially contaminated areas associated with the sites of current and former rural residences.

Following the detailed contamination investigation, a remedial action plan should be prepared for the Project to manage any identified contamination.

Bengalla operates a bioremediation facility where any soil contaminated with hydrocarbons is placed for remediation. The bioremediation facility consists of active cells where the bioremediation process occurs. The cells are (optionally) fitted with an automated irrigation system and soil moisture probes to ensure soil conditions are suitable for beneficial bacteria and microbes to aid the remediation process.

To reduce the duration of the bioremediation process, BMC adds a microbial powder to the soil to increase the hydrocarbon breakdown process and reduce the time required for treatment. Samples are regularly taken to confirm hydrocarbons levels, and when the soil meets specific land use criteria, it is appropriately placed in the Main OEA.

* * *

for
HANSEN BAILEY

Dorian Walsh
Senior Environmental Scientist

Dianne Munro
Principal

9 LIMITATIONS

This PCA was prepared by Hansen Bailey to provide a preliminary indication of contamination conditions within the Project Disturbance Boundary, based on the limited amount of available information at the time of the assessment and does not constitute a detailed site investigation undertaken by an accredited Site Auditor.

A detailed site investigation should be undertaken by an accredited Site Auditor to assess the extent of contamination within the Disturbance Boundary prior to the construction phase of the Project.

The information reviewed in the preparation of this report was not prepared for the purpose of a contamination assessment and therefore the observations made were not targeted towards the identification of potential contaminant sources.

10 REFERENCES

- AECOM Australia Pty Limited (2013). *Bengalla Mine Continuation Project Environmental Impact Statement, Historical Heritage Report*.
- Envirosciences (1993). *Environmental Impact Statement of Bengalla Open Cut Coal Mine*.
- GSS Environmental (2013). *Soils and Land Capability Impact Assessment, Continuation of Bengalla Mine*.
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- NSW Department of Urban Affairs and Planning & NSW Environment Protection Authority (1998). *Managing Land Contamination, Planning Guidelines, SEPP 55 – Remediation of Land*.
- NSW Environment Protection Authority (2012). *List of NSW Contaminated Sites,* http://www.environment.nsw.gov.au/clm/publiclist.htm, accessed 14 June 2012.
- NSW Office of Environment and Heritage (2011). *Guidelines for Consultants Reporting on Contaminated Sites*.

BENGALLA Mining Company

V

Soils and Land Capability Impact Assessment

Soil and Land Capability Impact Assessment

Continuation of Bengalla Mine

July 2013

HAN05-001

GSS ENVIRONMENTAL
Environmental, Land and Project Management Consultants

Prepared on behalf of Hansen Bailey for Bengalla Mining Company Pty Limited

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Date of Issue: 11 July 2013

GSSE Reference: HAN05-001

ISSUE AND AMENDMENT CONTROL HISTORY

Issue	Date	Description	Author	QA/QC
1	03/05/2012	Draft Report 1	JL/RW	CR/RM
2	20/07/2012	Draft Report 2	JL/RW	AC/RM
3	23/07/2012	Draft Report 2.1	JL/RW	AC/RM
4	14/08/2012	Draft Report 2.2	JL/RW	RM
5	07/11/2012	Draft Report for Client Review	JL/RW	RM
6	24/06/2013	Final Report	JL/RW	AC
7	11/07/2013	Final Report 2	JL/RW	AC

EXECUTIVE SUMMARY

GSS Environmental was commissioned by Hansen Bailey Pty Ltd on behalf of Bengalla Mining Company Pty Ltd to undertake a soil and land capability assessment for the Continuation of Bengalla Coal Mine, located approximately 4km west of Muswellbrook. This continuation of mining will see operations progress for a further 24 years at production rate of up to 15 Million tonnes per annum, the ongoing use and upgrade of existing infrastructure and the temporary diversion and reinstatement of Dry Creek.

The total area assessed was 1,370 ha and included the proposed disturbance area within the Project Boundary. The land within this area has been extensively cleared and its predominant land use is cattle grazing. Seven soil types and one variant were identified within the survey area; Red Chromosols occur on the upper slopes, and cover 13% of the area; Brown Chromosols are the dominant soil type present and cover 41.8% on the mid-slopes; Brown Vertosols occur on the low slopes and on the areas of gentle incline, covering 11.7% of the area. Red Sodosols occur on the mid to lower slopes and cover 5% of the area; a zone of Brown Kurosols draining into Dry Creek covers 1.4% of the area. A moderately deep Brown Sodosol covering 6.5% of the area is a variant of a deep Brown Sodosol, which is found in Dry Creek and covers 4.4% of the area. Rudosols are found on upper slopes and crests, predominately in the west and covers 16.1% of the area.

In terms of Rural Land Capability classification, the Brown Vertosols are a mix of Class II and Class IV land (comprising 11.7% of the survey area; suitable for regular cultivation and grazing respectively); the Red & Brown Chromosols and Red Sodosol are Class V land (comprising 59.8% of the area, suitable for grazing and occasional cultivation); the Brown Kurosol and Brown Sodosols are Class VI land (comprising 12.3% of the area, suitable for grazing only), while the Rudosols are Class VII land (comprising 16.1% of the area, which should be maintained under green timber). In terms of Agricultural Suitability, the land is assessed as being predominately moderate to marginal, with 67.6% of the area being Class 3 land (moderately productive, suited to grazing and occasional cropping) and 28.4% of the area being Class 4 land (marginal land, unsuited to cultivation, but suitable for low intensity grazing). A small area of Class 2 land (suitable for cultivation) comprises 4.1% of the area. All soils within the study area are assessed as having a moderate soil erosion risk and, therefore, require careful management, such as maintaining adequate ground cover, maintaining low stocking rates, using erosion control measures such as contour banks and ripping, and maintain riparian vegetation.

The assessment has shown that the capability of the soils subject to disturbance within the Project Boundary have a recommended topsoil stripping depths of 0 – 0.60 m varying between soil types. Brown Chromosols and Brown Kurosols can be stripped to 0.10 m; Red Chromosols to 0.15 m; Brown Vertosols and Red Sodosols to 0.20 m and Brown Sodosols to 0.60 m. Rudosols should not be stripped. Allowing for a 10% handling loss, approximately 1,549,800 m^3 of suitable topdressing material is available within the Disturbance Boundary. The recommended depths relate to soil that could be salvaged via the stripping process and re-used in progressive and post construction rehabilitation works. All subsoils are undesirable for topsoil use due to severe physical and/or chemical limitations.

Stripped soils should be carefully managed in accordance with established protocols and wherever possible, used in rehabilitation as soon as practicable after stripping to preserve native seed banks and soil microflora. Land disturbance should be minimised by clearing the smallest practical area of land ahead of construction. General vegetation clearing and soil stripping should not be undertaken until earthwork and construction operations are ready to commence. All proposed erosion and sediment control measures should be implemented in advance of, or in conjunction with, clearing activities.

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APPENDICES

1.0 INTRODUCTION

GSS Environmental (GSSE) was commissioned by Hansen Bailey Pty Ltd (Hansen Bailey) on behalf of Bengalla Mining Company Pty Limited (BMC) to undertake a soil and land capability impact assessment for the Continuation of Bengalla Mine Project (the Project). This assessment will form part of the Environmental Impact Statement (EIS) supporting an application for Development Consent under Part 4, Division 4.1 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). The Project involves the continuation of mining to the west of the existing extraction limit at a rate of up to 15 Mtpa for 24 years. The mining will largely be conducted within current mining leases. The Project will enable the extraction of an additional 316 Mt of ROM coal from the Whittingham Coal Measures.

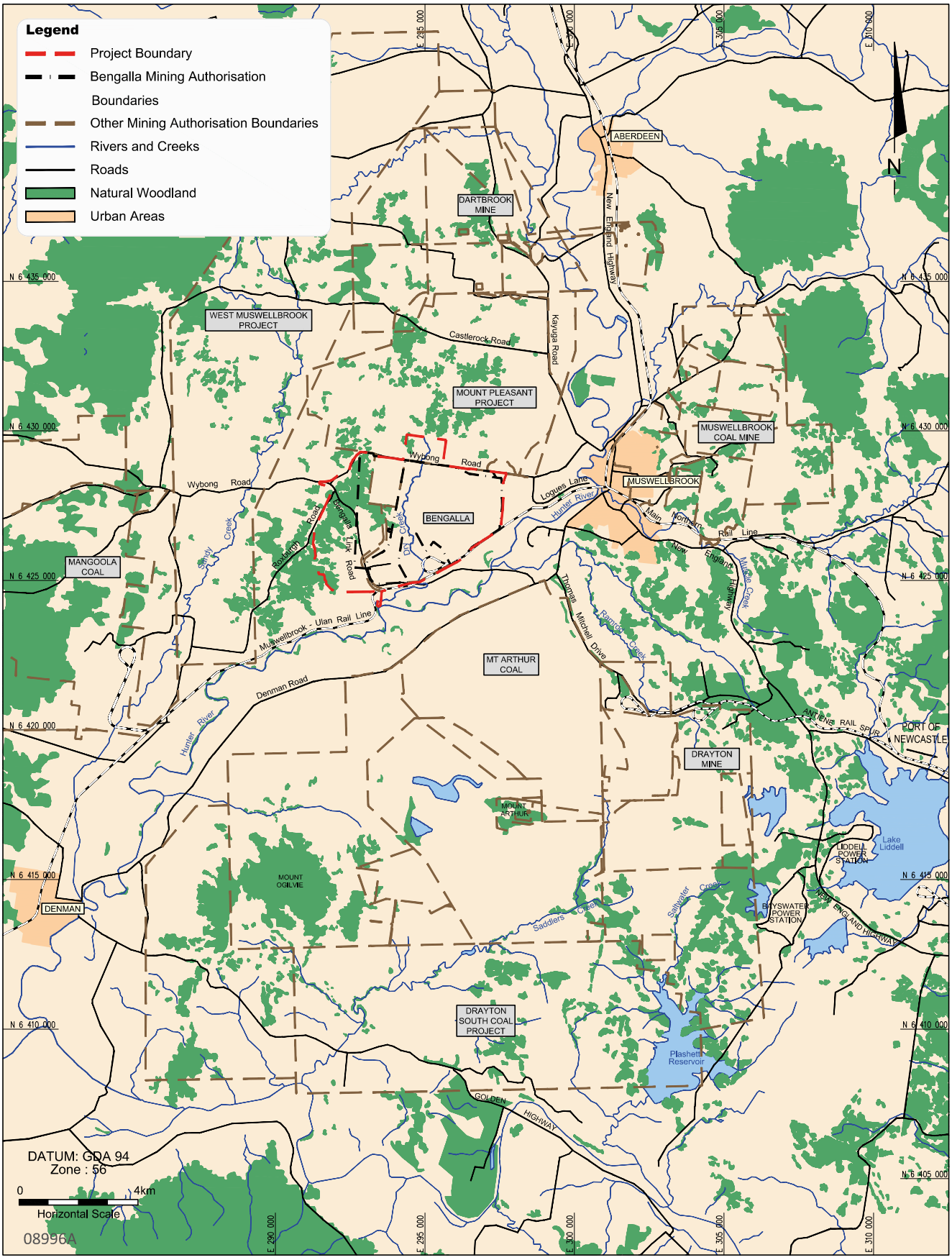
The Project consists of the following characteristics:

- Open cut mining towards the west at a rate of up to 15 Mtpa ROM coal for 24 years;
- Continued use of the existing dragline, truck fleet and excavator fleet (with progressive replacement);
- An out of pit Overburden Emplacement Area (OEA) to the west of Dry Creek which may be utilised for excess spoil material until it is intercepted by mining;
- Continued use, extension or relocation to existing infrastructure, including administration and parking facilities, in-pit facilities (including dragline shut down and erection pad), helipad, tyre laydown area, explosives and reload storage facility, core shed workshop and administration buildings, roads, reject bin, ROM Hopper, water management infrastructure, supporting power infrastructure, and ancillary infrastructure;
- Construction and use of various items of new infrastructure (including radio tower, extensions to Main Infrastructure Area (MIA), MTP Staged Discharge Dam and associated water reticulation infrastructure, additional ROM coal stockpile and upgrade to the emergency ROM coal stockpile along with associated conveyor network);
- Processing, handling and transportation of coal via the (upgraded) CHPP and rail loop for export and domestic sale;
- Continued rejects and tailings co-disposal in the Eastern OEA and temporary in pit reject emplacement;
- Relocation of a 3 km section of Bengalla Link Road around Year 13 near the existing mine access road to facilitate coal extraction;
- The diversion of Dry Creek via dams and pipe work with a later permanent alignment of Dry Creek through rehabilitation areas when emplacement areas are suitably advanced;
- Relocation of water storage infrastructure as mining progresses through existing dams (including the Staged Discharge Dam, raw water dam); and
- A workforce of approximately 900 full time equivalent personnel (plus contractors) at peak production.

1.1 Project Description and Project Boundary

Bengalla is located in the Upper Hunter Valley of NSW, approximately 130 km north-west of Newcastle and 4 km west of the township of Muswellbrook (**Figure 1**). Bengalla is a strip mining, open cut operation where current mining advances in a westerly direction based on dragline strips approximately 60 m in width. Overburden is removed by two methods: a truck and excavator operation, and through the use of a dragline. Coaling is undertaken by a truck and excavator operation.

The Project Boundary for the entire Bengalla Lease encompasses an area of 2,341 ha. The Survey Area within the Project Boundary relevant to this report encompasses an area of 1,370 ha which includes a Disturbance Boundary of 964 ha. A soil survey covering 390 ha of the Project Boundary has been previously undertaken by Global Soil Systems (GSS) as documented in *Bengalla Coal Mine: Soil Survey Report* (GSS, 2005). The soils component of this report focuses on the Disturbance Area of 1,370 ha, the majority of which occurs west of Dry Creek.



BENGALLA MINE

Regional Locality

FIGURE 1

1.2 Assessment Objectives

The major objectives of the assessment undertaken by GSSE were to:

Objective 1 Classify and provide a description and mapping of the soil types within the Project Boundary;

Objective 2 Provide a description and mapping of the pre and post mining land capability within the Project Boundary;

Objective 3 Provide a description and mapping of the pre and post mining agricultural suitability within the Project Boundary;

Objective 4 Provide recommendations for stripping depths of proposed disturbance areas, including any recommendations for topsoil handling, stockpiling and amelioration for reuse in rehabilitation; and

Objective 5 Describe necessary erosion and sediment control measures to manage disturbed in-situ and stockpiled soil resources.

This report outlines the methodology and results of the soil and land capability assessment conducted to satisfy the assessment objectives. This includes background research, field assessment, laboratory analysis of soil samples sourced from within the Project Boundary and proposed soil management measures.

1.3 Standards

To satisfy Objective 1 of the Soil and Land Capability Impact Assessment (the Assessment):

- The soil taxonomic classification system utilised was the Australian Soil Classification System (Isbell, 1996);
- The soil survey system implemented with regard to survey type and scale was the *Guidelines for Surveying Soil and Land Resources* (NCST, 2008). This is a recognised guideline for Australian soil and land capability assessments; and
- The soil survey system to be applied with regards to recording information from field soil survey observations is the *Australian Soil and Land Survey Field Handbook* (NCST, 2009). This is a recognised guideline for Australian soil and land capability assessments.

To satisfy Objective 2 of the Assessment, Rural Land Capability classification was conducted in accordance with the requirements of the NSW Department of Trade and Investment, Regional Infrastructure and Services (DTIRIS). This system was introduced by the Soil Conservation Service of NSW and the relevant guideline is provided in *Systems Used to Classify Rural Lands in New South Wales* (Emery, 1986).

To satisfy Objective 3 of the Assessment, Agricultural Suitability Classification was conducted in accordance with the requirements of the DTIRIS. This system was introduced by the former NSW Agricultural & Fisheries Service of NSW and the relevant guideline is provided in the *Agricultural Suitability Maps – uses and limitations* (NSW Agricultural & Fisheries, 1990).

To satisfy Objective 4 of the Assessment, the system implemented to determine which soils are suitable for conserving and utilising in the Project's rehabilitation program was the *Soils and Extractive Industries* (Elliot & Reynolds, 2007). This procedure assesses soils based on grading, texture, structure, consistence, mottling, and root presence. The approach described in this guideline remains the benchmark for land resource assessment in the Australian mining industry.

To satisfy Objective 5 of the Assessment, the Australian guideline *Managing Urban Stormwater: Soils and Construction – Volume 2E Mines and Quarries* (Department of Environment and Climate Change, 2008) was utilised to describe the necessary erosion and sediment control measures to manage disturbed *in situ* and stockpiled soil resources.

1.4 Director General's Requirements

Director General's Requirements (DGRs) were issued on March 13th, 2012, for the Continuation of Bengalla Mine Project (SSD-5170). Within these DGRs, several are relevant for this report, namely:

The EIS must address the following specific matters:

- **Land Resources** – including an Agricultural Impact Statement and a detailed assessment of the potential impacts on:
    - Soils and land capability (including salinisation and contamination);
    - Landforms and topography, including steep slopes; and
- **Water Resources** – including:
    - Details and staging for the proposed Dry Creek re-diversion.

This report focusses on the Land Resources component of the EIS requirements (excluding contamination), although the Dry Creek diversion and issues surrounding it are also discussed here. These will be elaborated on in the forthcoming Bengalla Continuation Rehabilitation Management Strategy.

2.0 BIOPHYSICAL ENVIRONMENT

2.1 Climate

The Project Boundary is located in the Hunter region of NSW, typically having a cool temperate climate with moderately dry winters and wetter summers. The annual average rainfall is 622.3 mm with the majority of this rainfall falling in the summer months of December to February (Muswellbrook (Lower Hill St) Bureau of Meteorology (BOM) station No. 06012824, 2012). Temperatures within the region range from an average monthly maximum of 31.7 ^{0}C in January to an average monthly minimum of 3.8^{0}C in July (Jerry Plains Post Office BOM station No. 061086, 2011). The average annual evaporation within the Project Boundary ranges between 1400 - 1800 mm (Average pan Evaporation (Annual) Map 2008 BOM Product Code: IDCJCM0006) (BOM, 2008; 2012).

2.2 Hydrology and Topography

The Project Boundary is located within the Hunter River catchment, specifically the Hunter Residual sub-catchment. This sub-catchment is a planform controlled, meandering river, containing gravelly sediments and can be primarily characterised as a 'sediment transfer zone'. Medium energy flow transports sediment, gravel and sand in this sub-catchment.

The topography within the Project Boundary is typical of the Bayswater soil landscape unit (Kovac & Lawrie, 1991) and is characterised by low to undulating hills that range from Reduced Level (RL) 40 to 220 m with slopes generally ranging between 3 to 10%. Small areas have gently to moderately inclined slopes of 10-18%. A Hunter River tributary, Dry Creek is located to the within the Disturbance Boundary and drains in a southerly direction. This Creek is a minor tributary of the Hunter River and is ephemeral in nature, only flowing during periods of prolonged or intense rainfall. The Creek bed is predominately covered in grasses and weeds, with riparian vegetation scattered and severely disturbed after an extensive period of grazing. Erosion is evident in sections of the Creek and its tributaries.

2.3 Geomorphic Domains and Geology

Bengalla is located in the Central Lowlands topographic zone within the Sydney Basin geological province. Two soil landscape units underpin the Project Boundary. These are the Roxburgh and Bayswater soil landscapes as delineated by the Soil Landscapes of the Singleton 1:250,000 Sheet (Kovac & Lawrie, 1991).

The Bayswater soil landscape describes soils that have formed from the underlying Permian Singleton Coal Measures on landscapes with between 40-60 m RL (Reduced Level) with an elevation of RL 140 to 220 m. These measures are composed of sandstone shale, mudstone, conglomerate and coal parent material and have been derived from ancient marine sediments. Due to the sediments origin, salt levels are usually high and soils are often dispersive and highly erodible with sheet and gully erosion common landscape features.

The Roxburgh soil landscape also describes soils that have formed from Permian Singleton Coal Measures on slightly higher and steeper landscapes with between 60-120 m local relief. These measures also comprise sandstone, shale, mudstone, conglomerate and coal which has in situ weathered parent rock material derived from colluvium. The Roxburgh unit covers undulating low hills and undulating hills with an elevation of 80-370 m ASL (Above Sea Level) and minor to moderate sheet erosion. Soils are primarily yellow podzolic soils (Yellow Chromosols) on upper to midslopes with red solodic soils (Red Sodosols) and brown podzolic soils (Brown Chromosols) on upper concave slopes, and Lithosols (Rudosols/Tenosols) on steeper slopes.

2.4 Vegetation and Land Use

The Project Boundary has been mostly cleared for agriculture and is dominated by grasslands, although some areas of woodland remain. The original character of the vegetation has been greatly altered as a result of previous agricultural land use. Small patches of remnant woodland vegetation occur in the western portion of the Project Boundary, which provide the majority of habitat for flora and fauna including habitat for several threatened species.

Landuse in the surrounding area is a mixture of open cut mining activity and grazing. In areas close to the Hunter River, more intensive agricultural practices (e.g. cropping) are undertaken. The majority of the area surrounding Bengalla Mine has been heavily modified by agricultural practices and mining activity.

3.0 SOIL SURVEY AND ASSESSMENT

This section outlines the methods used to conduct the soil survey component of the assessment and reports the results of the survey.

3.1 Soil Survey Methodology

Both a field survey and a desktop study were undertaken within the Project Boundary.

3.1.1 Reference Map

An initial soil map (reference map) was developed using the following resources and techniques:

- **Aerial photographs and topographic maps;**

  Aerial photo and topographic map interpretation was used as a remote sensing technique allowing detailed analysis of the landscape, and mapping of features expected to be related to the distribution of soils within the Project Boundary.

- **Reference information;**

  Source materials were used to obtain correlations between pattern elements and soil properties that may be observable in the field. The materials included Cadastral data, prior and current studies of physiographic, geological, vegetation and water resource elements.

- **Previous reports;**

  - Soil Landscapes of the Singleton 1:250,000 Sheet (Kovac and Lawrie, 1991);
  - Soil Survey for the Proposed Bengalla Coal Mine (Envirosciences Pty Ltd, 1993);
  - Bengalla Coal Mine Soil Survey Report (GSS, 2005); and
  - Soil and Land Capability Impact Assessment, Bengalla Development Consent Modification (GSSE, 2010).

- **Stratified observations**

  Following the production of a broad soil map, surface soil exposures, topography and vegetation throughout the Project Disturbance Area were visually assessed to verify potential soil types, delineate soil type boundaries, and determine preferred locations for targeted subsurface investigations (hereafter referred to as soil pits).

3.1.2 Field Survey Methodology

Two approaches were used to map soils within the 1,370 ha Survey Area: a field survey, to cover the area which will be severely affected by the open cut mining process, and mapping extrapolated from the field survey, supporting information and reconnaissance for the area within the Disturbance Boundary that will be minimally affected by open cut mining.

The field survey was undertaken at a medium intensity scale of 1:50,000, enabling the production of a map sufficiently detailed for project and district-level planning. To satisfy this scale, in accordance with the *Guidelines for Surveying Soil and Land Resources* (NCST, 2008), the number of observations per unit area required is 4 observations per 100 ha. For the field survey area, 10 representative sites were selected for full soil profile descriptions (excavated pits). Additionally, numerous field observations (e.g. details recorded from cuttings, stream banks, shovel excavations) were taken where possible, satisfactory to meet the required observation density.

A description of the field observation categories is provided in **Table 1**.

Table 1 – Field Observation Categories

Class	Observation Type	Description	Actual Number for Project
1	Detailed profile description	Soil pit excavation with soil profile described in accordance with the *Australian Soil Survey Handbook* (NCST, 2009).	10
2	Deep borings	Deep borings examine material below the normal depth of the soil description and are important where subsolum and substrate properties influence land use. This is particularly so where irrigated land use is proposed. No irrigated land was assessed during the survey or is proposed for the Project, meaning that soil description beyond the normal depth, via deep borings, was not necessary.	0
3	Laboratory soil assessment	Samples were taken from 10 Class 1 observations (soil pits) with each identified layer assessed for many level C and D type analyses as specified in **Table 17.9** of the *Guidelines for Surveying Soil and Land Resources*.	10 (pits)
4	Minor field observations	Minor field observations are brief observations to confirm mapping boundaries, soil type distributions or other characteristics being mapped in the survey. These are always brief, and generally constitute the majority of field observations in soil surveys due to the efficiency in gathering good quality field data to supplement and refine detailed information collected using Type I observations. Mapping observations during the survey included exposed cuttings, exposure of topsoil to 40 cm using a spade, vegetation associations and rock outcrops.	20
Total			**40**

The field survey was undertaken as a 'Free Survey' where observations were irregularly located according to the survey team's judgement based on reference map interpretation with survey information obtained across traverses where soil type was expected to change. Observations were in the form of soil profile descriptions from pits and/or soil profile exposures. Detailed descriptions accompanied sampling of representative soil profiles for subsequent laboratory analysis.

3.1.2.1 Soil Field Assessment

Ten exposed soil profiles were assessed across the Project Boundary that focused on areas within the Disturbance Boundary. The soil profile locations are shown in **Figure 2**. Each soil profile exposure pit was excavated to the required depth of 1.2 m and to a suitable width to receive maximum light on the profile exposure from which the samples were removed. All pits were backfilled immediately after assessment. All soil profiles were assessed for soil type and distribution, with 31 samples taken from the ten pits for subsequent laboratory analysis.

Soil profiles within the Project Boundary were assessed in accordance with the Australian Soil and Land Survey Field Handbook (NCST, 2009) soil classification procedures. Detailed soil profile descriptions recorded information that covered the parameters as specified in **Table 2**. Soil profile logging was undertaken in the field using soil data sheets.

Global Positioning System (GPS) recordings were taken for all sites where detailed soil descriptions were undertaken. Vegetation type and land use were also recorded. Soil exposures from excavated pits were photographed during field operations as colour photography of profile sites is a useful adjunct to description of land attributes.

Soil layers from each test pit were also assessed according to a procedure adapted from Elliot and Reynolds (2007) for the recognition of suitable topdressing material. This procedure assesses soils based on grading, texture, structure, consistency, mottling and root presence. A more detailed explanation of the Elliot and Reynolds procedure is presented in **Section 5** of this report.

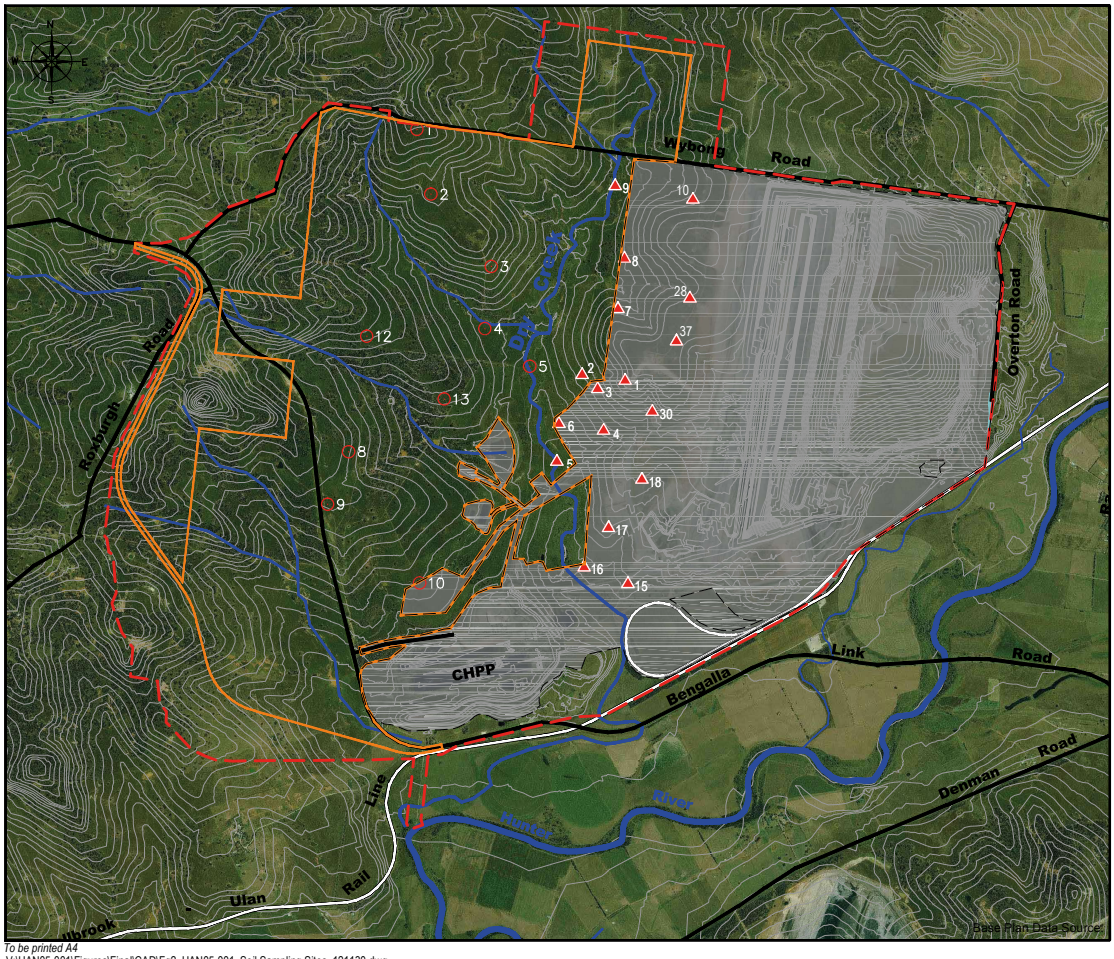
Table 2 – Detailed Soil Profile Description Parameters

Descriptor	Application
Horizon Depth	Weathering characteristics, soil development
Field Colour	Permeability, susceptibility to dispersion/erosion
Field Texture Grade	Erodibility, hydraulic conductivity, moisture retention, root penetration
Boundary Distinctness and Shape	Erosional/dispositional status, textural grade
Consistence Force	Structural stability, dispersion, ped formation
Structure Pedality Grade	Soil structure, root penetration, permeability, aeration
Structure Ped & Size	Soil structure, root penetration, permeability, aeration
Stones – Amount & Size	Water holding capacity, weathering status, erosional/ depositional character
Roots – Amount & Size	Effective rooting depth, vegetative sustainability
Ants, Termites, Worms etc	Biological mixing depth

3.1.2.2 Soil Laboratory Assessment

Soil samples from ten soil profile sites were utilised in a laboratory testing programme. Samples were analysed to determine:

- Soil taxonomy;
- Land capability and agricultural suitability classification; and
- Suitability of soil as topdressing media.



LEGEND

- Project Boundary (DA)
- Disturbance Boundary
- Approved Bengalla Mine
- Soil Pit Location (2005, GSSE)
- Project Soil Pit Location (2011, GSSE)
- Contours
- Creeks
- Rivers

0 500m 1.0km
Scale 1: 35 000

FIGURE 2

Soils Sampling Sites

Project:	Bengalla Continuation: Soil and Land Capability Report
Client:	Hansen Bailey
File:	Fg2_HAN05-001_Soil Sampling Sites_121130
Projection:	MGA94 Zone 56

Version:	Date:	Author:	Checked:	Approved:
1	30/11/12	KC	RW	AC

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Environmental, Land and Project Management Consultants

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The laboratory test results were used in conjunction with the field assessment results to determine the depth of soil material that is suitable for stripping and re-use for the rehabilitation of disturbed areas.

Soil samples of approximately 1 – 2 kg were collected from each soil layer. In total, 31 soil samples were sent to the Department of Lands (Scone Research Centre) for analysis. A certificate of analysis for these results is contained in **Appendix 2**. The selected physical and chemical laboratory analysis parameters, and their relevant application, are listed in **Table 3**.

All samples were laboratory tested for relevant physical and chemical parameters (**Table 3**). Their application to the soil and land assessment is also described in **Table 3** for each parameter. A description of the significance of each test and typical values for each soil characteristic is included in **Appendix 2**.

The laboratory test results were used in conjunction with the field assessment results to determine the depth of soil material that is suitable for recovery and use as a growth medium for rehabilitation of disturbed areas. Similarly, potentially unfavourable soil material was identified. The soil test results for the soil survey are provided in **Appendix 2**.

Table 3 – Laboratory Analysis Parameters

Property	Application
Physical:	
Colour	Soil colour based on Munsell Colour chart.
Coarse fragments (>2mm)	Soil workability; root development; droughtiness
Particle-size distribution (<2mm)	Nutrient retention; exchange properties; erodibility; droughtiness; workability; permeability; sealing; drainage; interpretation of most other physical and chemical properties and soil qualities
Aggregate stability (Emerson Aggregate Test)	Susceptibility to surface sealing under rainfall or irrigation; effect of raindrop impact and slaking; permeability; infiltration; aeration; seedling emergence; correlation with other properties
Chemical:	
Soil reaction (pH) (1:5, soil: water suspension)	Nutrient availability; nutrient fixation; toxicities (especially Al, Mn); liming; sodicity; correlation with other physical, chemical and biological properties
Electrical conductivity (EC) (1:5, soil: water suspension)	Appraisal of salinity hazard in soil substrates or groundwater, total soluble salts
Cation exchange capacity (CEC) and exchangeable cations	Nutrient status; calculation of exchangeable sodium percentage (ESP); assessment of other physical and chemical properties, especially dispersivity, shrink – swell, water movement, aeration
Organic Carbon (OC) (%)	Essential nutrient for plant growth

The laboratory methods used by Scone Research Centre for each physical and chemical parameter are provided in **Table 4**.

Table 4 – Laboratory Test Methods

Analyte	Method
Particle Size Analysis (PSA)	Sieve & hydrometer
pH	1:5 soil/water extract
Electrical conductivity	1:5 soil/water extract
Emerson Rating	Emerson Aggregate Test (EAT)
CEC & exchangeable cations	(AgTU)+ extraction

3.1.2.3 Mapping Observations

Mapping observations consisted of exposed cuttings (such as "cut" slopes), topsoil exposure of up to 40 cm using a spade, vegetation cover associations and rock outcrops. These were utilised to confirm mapping boundaries, soil type distributions and any other characteristics being mapped in the survey. This information generally constitutes the majority of field observation data collected in soil surveys (NCST, 2008) and is used to refine information collected from detailed soil profile observations.

3.1.3 Soil Classification

The applicable technical standard adopted for naming the types of soil identified within the Project Boundary is the Australian Soil Classification (ASC) system (Isbell, 1996).

3.2 Soil Survey Results

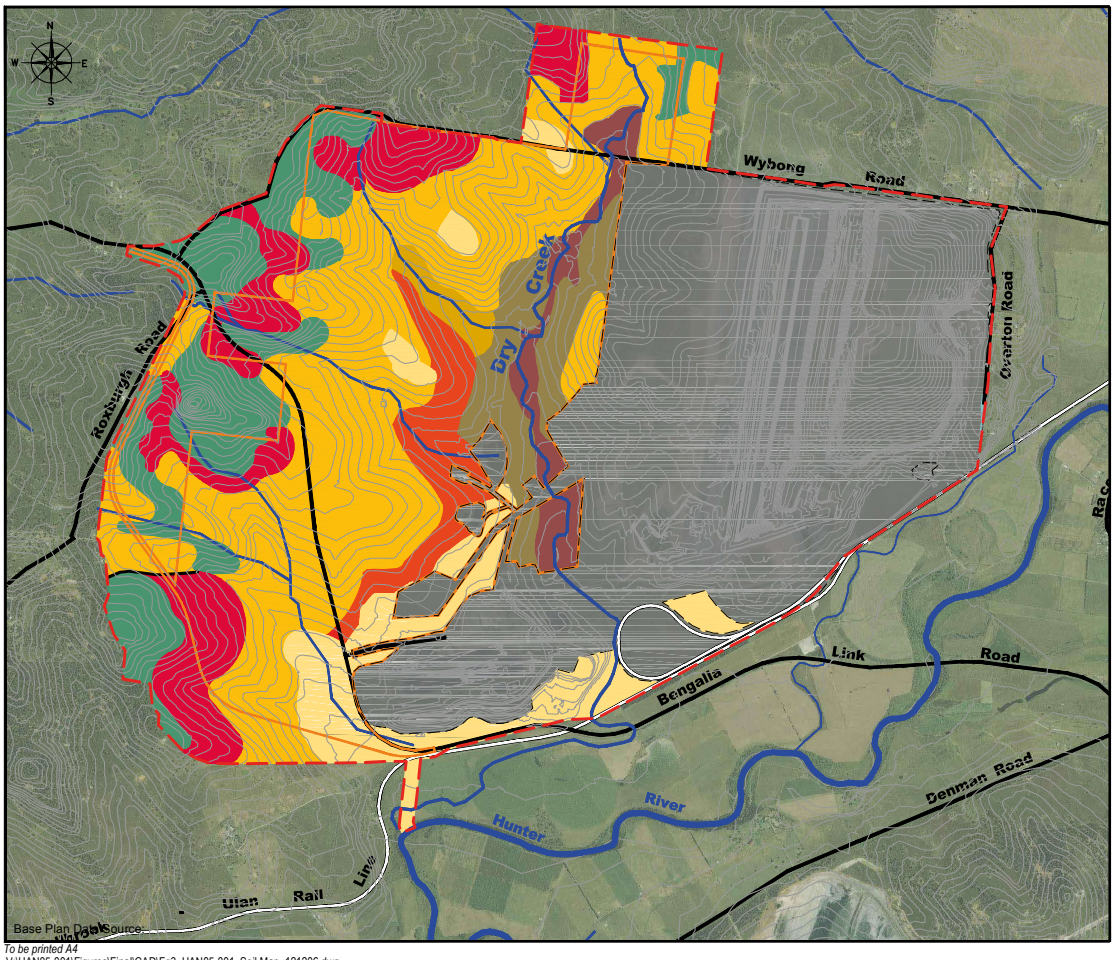
3.2.1 Soil Types Overview

Eight soil types were identified within the Project Boundary. **Table 5** provides an overview of each soil type and their quantitative distribution within the Project Boundary (final percentage is rounded). **Figure 3** illustrates the spatial distribution of soil types.

Table 5 – Soil Types Overview

Soil Type #	Australian Soil Classification Name	Survey Area	
		Area (%)	Area (ha)
1	Brown Chromosol	41.8	571
2	Red Chromosol	13.0	179
3	Brown Vertosol	11.7	161
4	Red Sodosol	5.0	69
5	Brown Kurosol	1.4	20
6	Deep Brown Sodosol	4.4	60
6(V)	Brown Sodosol	6.5	89
7	Rudosol	16.1	221
Total		100	1,370

The distribution of these soils is illustrated in **Figure 3**. Exposed profiles of major soil units and landscape photos of areas where each soil unit was observed are shown in **Plates 1** to **12.** A glossary of commonly used soils terms is presented in **Appendix 1**. All soil interpretations have been derived from Hazelton & Murphy (2007) unless otherwise stated. Colour was analysed on moist samples unless they were bleached layers.



LEGEND

- Project Boundary
- Disturbance Boundary
- Approved Bengalla Mine
- Red Chromosol
- Brown Chromosol
- Brown Vertosol
- Red Sodosol
- Brown Kurosol
- Deep Brown Sodosol
- Brown Sodosol
- Rudosol
- Contours

0 500m 1.0km
Scale 1: 35 000

FIGURE 3

Soils Map

Project: Bengalla Continuation: Soil and Land Capability Report

Client: Hansen Bailey

File: Fg3_HAN05-001_Soil Map_121206

Projection: MGA94 Zone 56

Version:	Date:	Author:	Checked:	Approved:
1	23/05/12	KC	RW	AC
2	28/06/12	ZJ	RW	AC
3	06/12/12	KC	RW	AC

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3.2.2 Soil Type 1 – Brown Chromosol

Soil Type 1 is a Brown Chromosol and covers 46.2% of the Project Boundary. A soil profile overview, physical characteristics and laboratory results are presented in **Table 6**. It is derived from sandstone shale, mudstone, conglomerate and coal parent materials from the Singleton Coal Measures. This soil type complex has well developed duplex profiles with fine loamy surfaces overlying dark brown clay subsoils containing red mottles.

This soil type is located on the less steep waning slopes (slope <5%). These soils are reasonably fertile and less susceptible to sheet and gully erosion when managed to their correct capacity, as compared to the soil covering the steeper waxing slopes. Land that is accessible for agriculture has been grazed in the past. Sheet erosion and gully erosion is likely to occur if protective vegetative cover is removed.

Table 6 – Overview: Brown Chromosol

Site Description	
	
Plate 1 – Profile (Pit 2)	**Plate 2 – Landscape (Pit 2)**
ASC Soil Type	Brown Chromosol; moderate
Sample Pit	2
Dominant Geology Association	Shale, conglomerate floaters (20-100 mm)
Dominant Slope Association	Mid-slope; very gently to gently inclined (3-10%)
Land Use and Vegetation	Cattle grazing, isolated ironbark, spear grass, wheat grass, red grass
Land Capability Class	Class V – limited by slope, sodicity, depth to BC
Erosion Risk Class	Topsoil K-factor = 0.04; moderate erosion risk
Soil Stripping Recommendation	0-0.10 m – Highly suitable; subsoil unsuitable due to fine texture and high dispersability

Physical Characteristics		
Horizon	**Depth (m)**	**Description**
A1	0.00 - 0.10	Dark Brown (7.5YR3/4) moderate consistence silty clay loam. Sub angular blocky 5-25 mm. Roots fine/medium and common. Boundary is clear and wavy.
B21	0.10 - 0.30	Dark Brown (7.5YR3/4) heavy clay, strong consistence, strong structure (angular blocky 25-50 mm). Roots fine/medium and common up to 60 cm. Boundary is gradual and wavy.
B22	0.30 - 0.60	Dark Brown (7.5YR3/4), strong consistence silty clay. Strong (prismatic 25-100 mm). Roots fine/medium and common up to 60 cm. Boundary clear and even.
BC	0.60 - 0.90	Red, strong consistence clay throughout, decomposing parent material. Sub angular blocky 50-100 mm, roots few and fine to 70 cm. Boundary is gradual and wavy.
C	0.90 - 1.40	Conglomerate, sandstone and shale.

Analytical Description							
Analyte	**Units**	**A1**		**B21**		**B22**	
Depth	m	0 - 0.1		0.1 - 0.3		0.3 – 0.6	
Colour	Munsell	Dark brown		Dark brown		Dark brown	
pH	pH unit	6.6	Neutral	5.9	Moderately acid	8.0	Moderately alkaline
EC	dS/m	0.2	Non-saline	0.02	Non-saline	0.3	Non-saline
CEC	meq/100g	25.4	High	26.9	High	31.7	High
ESP	%	3.9	Non-sodic	2.6	Non-sodic	11.4	Moderately sodic
EAT	Class	3(1)	Slight	3(3)	Moderate	2(1)	High-Moderate

3.2.3 Soil Type 2 – Red Chromosol

Soil Type 2 is a Red Chromosol and covers 7.6% of the Project Boundary. A soil profile overview, physical characteristics and laboratory results are presented in **Table 7**. It is derived from sandstone, shale, mudstone, conglomerate and coal parent materials from the Singleton Coal Measures. This soil type has well developed duplex profiles with silty clay loam surfaces overlying heavy clay to silty clay subsoils.

This soil type is located on the steeper waxing slopes (slope >5%). These soils are less susceptible to sheet and gully erosion when managed to their correct capacity, as compared to the less steep waning slope soils. They do not have sodic subsoils which are highly susceptible to sheeting when the surface is exposed or disturbed. Land that is accessible for agriculture has been grazed in the past. Sheet erosion and gully erosion is likely if protective vegetative cover is removed.

Table 7 – Overview: Red Chromosol

Site Description	
 **Plate 3 – Profile (Pit 9)**	 **Plate 4 – Landscape (Pit 9)**
ASC Soil Type	Red Chromosol
Sample Pit	9 – mapped as a Brown Chromosol but similar to soils found in this soil mapping unit
Dominant Geology Association	Shale, sandstone, mudstone, conglomerate
Dominant Slope Association	Upper slope; gently inclined (3-10%) & moderately inclined (10-18%)
Land Use and Vegetation	Grazing cattle; Red Ironbark, Kurrajong, Native Grasses
Land Capability Class	Class IV
Erosion Risk Class	Topsoil K-factor = 0.04; moderate erosion risk
Soil Stripping Recommendation	0-0.15 m – Highly suitable; subsoil unsuitable due to fine texture

Physical Characteristics		
Horizon	**Depth (m)**	**Description**
A1	0.00 - 0.15	Dark Brown (7.5YR3/4) moderate consistence silty clay loam. Moderate pedality rough faced peds (sub angular blocky 10-20 mm). Boundary clear and wavy.
B21	0.15 - 0.30	Yellowish Red (5YR4/6) strong consistence heavy clay. Strong pedality smooth faced peds (angular-blocky 20-50 mm). Roots course and abundant up to 30 cm. Boundary gradual and wavy.
B22	0.30 - 60	Dark Brown (7.5YR4/6) strong consistence silty clay. Moderate pedality smooth faced peds (sub angular blocky to prismatic 50-200 mm). Boundary clear and even to BC layer.

Analytical Description							
Analyte	**Units**	**A1**		**B21**		**B22**	
Depth	m	0.00 - 0.15		0.15 - 0.30		0.30 – 0.60	
Colour	Munsell	Dark Brown		Yellowish Red		Dark Brown	
pH	pH unit	6.8	Neutral	7.4	Mildly alkaline	8.5	Strongly alkaline
EC	dS/m	0.2	Non-saline	0.1	Non-saline	0.2	Non-saline
CEC	meq/100g	20.2	Moderate	29.5	High	34.5	High
ESP	%	4.3	Non-sodic	4.0	Non-sodic	4.6	Non-sodic
EAT	Class	3(1)	Slight	3(1)	Slight	4	Negligible

3.2.4 Soil Type 3 – Brown Vertosol

Soil Type 3 is a Brown Vertosol and covers 12.6% of the Project Boundary. A soil profile overview, physical characteristics and laboratory results are presented in **Table 8**. It is derived from sandstone, shale, mudstone, conglomerate and coal parent materials from the Singleton Coal Measures. This soil type exhibits a gradational profile and has a silty clay topsoil and heavy clay subsoil. Cracking was in evidence at the surface of this soil type.

This soil type is located on the plateaued benches of lower and midslopes, as well as lower slopes in the south of the Project Boundary. These soils are generally not susceptible to sheet or gully erosion when managed to their correct capacity, as compared to duplex soils with sodic characteristics. The land associated with this soil type has been extensively cleared for grazing, however, vegetation cover on the soil has largely been continual and this has prevented enhanced runoff and sheet erosion that is commonly associated with agricultural activities.

Table 8 – Overview: Brown Vertosol

Site Description: Soil Type 3	
 **Plate 5 – Profile (Pit 10)**	 **Plate 6 – Landscape (Pit 10)**
ASC Soil Type	Brown Vertosol
Sample Pit	10
Dominant Geology Association	Shale
Dominant Slope Association	Flat areas on mid-slopes/ lower slopes
Land Use and Vegetation	Grazing, isolated White Box with cotton bush shrubs and white top grasses (*Danthonia* spp.)
Land Capability Class	Class IV (sodicity at depth)
Erosion Risk Class	Topsoil K-factor = 0.025; moderate erosion risk
Soil Stripping Recommendation	0 – 0.20 m suitable for stripping; subsoil unsuitable because of texture, alkalinity and sodicity.

Physical Characteristics		
Horizon	**Depth (m)**	**Description**
A1	0.00 – 0.20	Dark Brown (7.5YR3/4) strong consistence silty clay. Moderate pedality (angular blocky 20-50mm) earthy face peds. Boundary gradual and wavy.
A21	0.20 – 0.30	Dark Reddish Brown (5YR3/4) strong consistence heavy clay. Strong pedality (angular blocky 20-50mm) smooth face peds. Boundary diffuse and irregular.
B1	0.30 – 0.60	Dark Reddish Brown (5YR3/4) strong consistence heavy clay. Strong pedality (angular blocky 50-100mm) smooth face peds. Boundary clear and irregular.
B2	0.60 – 1.10	Yellowish Brown (10YR5/6) moderate consistence silty clay. Moderate pedality (sub-angular prismatic 100-500mm) rough faced peds.

Analytical Description									
Analyte	**Units**	**A1**		**A21**		**B1**		**B2**	
Depth	m	0 – 0.20		0.20 – 0.30		0.30 – 0.60		0.60 – 1.10	
Colour	Munsell	Dark brown		Dark reddish brown		Dark reddish brown		Yellowish brown	
pH	pH unit	7.2	Neutral	8.2	Moderately alkaline	8.7	Strongly alkaline	9.2	Very strongly alkaline
EC	dS/m	0.1	Non-saline	0.2	Non-saline	0.2	Non-saline	0.7	Non-saline
CEC	meq/100g	26.4	High	37	High	37.3	High	37.9	High
ESP	%	3	Non-sodic	4.9	Non-sodic	5.9	Non-sodic	10.8	Moderately sodic
EAT	Class	8	Negligible	3(1)	Slight	3(1)	Slight	4	Negligible

3.2.5 Soil Type 4 – Red Sodosol

Soil Type 4 is a Red Sodosol and covers 13.9% of the Project Boundary. A soil profile overview, physical characteristics and laboratory results are presented in **Table 9**. It is derived from sandstone, shale, mudstone, conglomerate and coal parent materials from the Singleton Coal Measures. This soil complex has well developed duplex profiles with clay loam surfaces overlying heavy clay subsoils.

This soil type is located on the gently to very gently inclined midslopes (slope 3 - 10%). These soils are susceptible to sheet and gully erosion due to the dispersive nature of their subsoils. Incorrect management practices can lead to the topsoil being detached and cause enhanced erosion rates when the subsoil is exposed. Land that is accessible for agriculture has been grazed in the past but currently is not used for agriculture and the condition of the soil is improving due to the increased ground cover of native pastures and invading weeds. However, sheet erosion and consequential gully erosion is likely if protective vegetative cover is removed.

Table 9 – Overview: Red Sodosol

Site Description: Soil Type 4	
 **Plate 7 – Profile (Pit 13)**	 **Plate 8 – Landscape (Pit 13)**
ASC Soil Type	Red Sodosol
Sample Pit	13
Dominant Geology Association	Sandstone and shale
Dominant Slope Association	Midslope; gently to very gently inclined (3 - 10%)
Land Use and Vegetation	Cattle grazing; Forest Oak regrowth, native grasses, weed species
Land Capability Class	Class V
Erosion Risk Class	Topsoil K-factor = 0.03. Moderate risk
Soil Stripping Recommendation	0 – 0.20 m suitable for stripping; subsoil unsuitable because of texture and sodicity

Physical Characteristics		
Horizon	**Depth (m)**	**Description**
A1	0.00 – 0.20	Very Dark Brown (7.5YR2.5/3) weak consistence clay loam. Moderate pedality (sub-angular blocky 10-50 mm), earthy faced peds. Many course roots. Boundary clear and even.
B21	0.20 – 0.50	Dark Red (2.5YR3/6) strong consistence heavy clay. Strong pedality (angular blocky 20-50 mm) smooth faced peds. Fine and course roots common. Boundary diffuse and even.
B22	0.50 – 0.80	Yellowish Red (5YR4/6) strong consistence heavy clay. Strong pedality (angular blocky 20-50 mm) sandy faced peds. Fine common roots. Boundary clear and irregular.
BC	0.80 – 1.20	Yellowish Brown moderate consistence clay. Moderate pedality (sub angular – prismatic 100-500 mm) rough faced peds. Fine few roots.

Analytical Description							
Analyte	**Units**	**A1**		**B21**		**B22**	
Depth	m	0 – 0.20		0.20 – 0.50		0.50 – 0.80	
Colour	Munsell	Very dark brown		Dark red		Yellowish red	
pH	pH unit	6.6	Neutral	8.2	Moderately alkaline	8.9	Strongly alkaline
EC	dS/m	0.1	Non-saline	0.2	Non-saline	1.0	High – Very High
CEC	meq/100g	18	Moderate	31.6	High	39.4	High
ESP	%	3.9	Non-sodic	10.4	Moderately sodic	18.0	Strongly sodic
EAT	Class	2(1)	High-moderate	2(2)	High	2(2)	High

3.2.6 Soil Type 5 – Brown Kurosol

Soil Type 5 is a Brown Kurosol and covers 3.1% of the Project Boundary. A soil profile overview, physical characteristics and laboratory results are presented in **Table 10**. It is derived from sandstone, shale, mudstone, conglomerate and coal parent materials from the Singleton Coal Measures. This soil complex has well developed duplex profiles with loam to sandy loam surfaces overlying sandy clay subsoils.

This soil type is located on the level to very gently inclined slopes of lower slopes and drainage lines (slope 0 - 3%). These soils are susceptible to sheet and gully erosion due to the high erodibility and dispersive nature of their subsoils. Incorrect management practices can lead to the topsoil being detached and cause enhanced erosion rates when the subsoil is exposed. Land that is accessible for agriculture has been grazed in the past but currently is not used for agriculture. Sheet erosion and consequential gully erosion is likely if protective vegetative cover is removed by intensifying agricultural activity or by localised flooding.

Table 10 – Overview: Brown Kurosol

Site Description: Soil Type 5	
	
Plate 9 – Profile (Pit 4)	**Plate 10 – Landscape (Pit 4)**
ASC Soil Type	Brown Kurosol; deep
Sample Pit	4
Dominant Geology Association	Shale
Dominant Slope Association	Lower slope (within drainage line); level to very gently inclined (0 – 3%)
Land Use and Vegetation	Grazing cattle, native grasses and forbes; 100% ground cover
Land Capability Class	Class VI
Erosion Risk Class	Topsoil K-factor = 0.04; Moderate risk
Soil Stripping Recommendation	0-0.10 m suitable; 0.10-0.30 m marginally suitable; A2 and B2 subsoil unsuitable for stripping due to combination of acidity, sodicity and dispersability

Physical Characteristics		
Horizon	**Depth (m)**	**Description**
A11	0.00 – 0.10	Dark Brown (7.5YR3/3) weak consistence loam. Weak pedality (sub angular blocky 100-200 mm) earthy face peds. Boundary gradual and weak.
A12	0.10 – 0.30	Strong Brown (7.5YR4/6) weak consistence sandy loam. Apedal. Boundary diffuse and wavy.
A2	0.30 – 0.60	Bleached (7.5YR4/6) weak consistence clay loam. Apedal. Boundary clear and irregular.
B2	0.60 – 1.00	Strong Brown (7.5YR5/6) moderate consistence sandy clay. Sandy fabric (sub angular blocky 100-200 mm).

Analytical Description									
Analyte	**Units**	**A11**		**A12**		**A2**		**B2**	
Depth	m	0 – 0.10		0.10 – 0.30		0.30 – 0.60		0.60 – 1.00	
Colour	Munsell	Dark brown		Strong brown		Strong brown		Strong brown	
pH	pH unit	5.9	Moderately acid	5.5	Strongly acid	5.7	Moderately acid	4.9	Very strongly acid
EC	dS/m	0.08	Non-saline	0.02	Non-saline	0.02	Non-saline	0.09	Non-saline
CEC	meq/100g	7.3	Low	4.2	Very low	6.1	Low	12.1	Moderate
ESP	%	5.5	Non-sodic	4.8	Non-sodic	8.2	Moderately sodic	14.9	Strongly sodic
EAT	Class	8	Negligible	8	Negligible	2(1)	High-moderate	2(1)	High-moderate

3.2.7 Soil Type 6 – Brown Sodosol

Soil Type 6 is a Brown Sodosol; mapped at two depths within the Project Boundary. The Brown Sodosol – Deep (>100 cm) to weathered material covers 5.9% of the Project Boundary. A soil profile overview, physical characteristics and laboratory results are presented in **Table 11**. It is derived from sandstone shale, mudstone, conglomerate and coal parent materials from the Singleton Coal Measures.

The Brown Sodosol – Deep occurs on level to slightly undulating flats and gullies. Sheet erosion and gully erosion is likely if protective vegetative cover is removed due to localised flooding. The Brown Sodosol - Moderately Deep is located on the less steep waning slopes (slope <5%). These lower slope soils are more fertile and less susceptible to sheet and gully erosion when managed to their correct capacity, as compared to soils on steeper waxing slopes. Land that is accessible for agriculture is grazed.

A variant of this soil type (Soil Type 6V) is present as a Brown Sodosol - Moderately Deep (<75 cm). It covers 10.8% of the Disturbance Boundary. The laboratory and physical characteristics of the Brown Sodosol - Deep are representative for the variation (excluding depth range).

Table 11 – Overview: Brown Sodosol

Site Description: Soil Type 6	
 **Plate 11 – Profile (Pit 5)**	 **Plate 12 – Landscape (Pit 5)**
ASC Soil Type	Brown Sodosol – Deep (representative) & Brown Sodosol - Moderately Deep.
Sample Pit	5
Dominant Geology Association	Shale
Dominant Slope Association	Broad gully floor; level to very gently inclined (0-3%)
Land Use and Vegetation	Grazing; mixed grasses
Land Capability Class	Deep - Class VI; waterlogging potential with severe erosion possible; Moderately Deep – Class IV
Erosion Risk Class	Topsoil K-factor = 0.30, Moderate

Soil Stripping Recommendation	0 – 0.6 m: Highly suitable; subsoil unsuitable due to highly dispersive, sodic properties

Physical Characteristics

Horizon	Depth (m)	Description
A11	0.00 – 0.10	Dark Brown (7.5YR3/4) strong consistence clay loam. Moderate pedality (sub angular blocky 50-100 mm) earthy peds. Boundary is diffuse, even.
A12	0.10 – 0.30	Brown (7.5YR4/3) strong consistence clay loam. Moderate pedality (sub angular blocky 50-200 mm) earthy peds. Boundary is diffuse, even.
A13	0.30 – 0.60	Dark Brown (7.5YR3/4) strong consistence clay loam. Moderate pedality (sub angular blocky 100-200 mm) earthy peds. Boundary is clear, wavy.
B2	0.60 – 1.00	Brown (7.5YR4/4) moderate consistence light clay. Moderate pedality (sub angular blocky 100-200 mm) earthy peds.

Analytical Description

Analyte	Units	A11		A12		A13		B2	
Depth	m	0 - 0.1		0.1 - 0.3		0.3 – 0.6		0.6 – 1.00	
Colour	Munsell	Dark brown		Brown		Dark brown		Brown	
pH	pH unit	7.2	Neutral	7.3	Neutral	8.1	Moderately alkaline	9.1	Very strongly alkaline
EC	dS/m	0.0	Non-saline	0	Non-saline	0	Non-saline	0.2	Non-saline
CEC	meq/100g	21	Moderate	20.3	Moderate	18.4	Moderate	22.6	Moderate
ESP	%	1.9	Non-sodic	2.5	Non-sodic	3.8	Non-sodic	15.0	Strongly sodic
EAT	Class	8	Negligible	3(1)	Slight	3(2)	Slight	2(3)	Very high

3.2.8 Soil Type 7 – Rudosol

Soil Type 7 is a Rudosol; mapped from aerial reconnaissance information and existing soils maps; as such, no laboratory results are available. Rudosols, with a variable depth to bedrock, cover 16.1% of the Project Boundary. They are derived from sandstone shale, mudstone, conglomerate and coal parent materials from the Singleton Coal Measures (**Table 12**).

Rudosols occur primarily in the western area of the Project Boundary and occur on upper slopes to crests. Sheet and gully erosion is likely if protective vegetative cover is removed, however native vegetation is still commonly found on steeper, rockier slopes. Land that is accessible for agriculture is lightly grazed.

Table 12 – Overview: Rudosol

Site Description: Soil Type 7	
ASC Soil Type	Rudosol
Sample Pit	N/A – Inferred from supporting data and field observations
Dominant Geology Association	Shale, sandstone, mudstone
Dominant Slope Association	Upper slopes and crests (>10%)
Land Use and Vegetation	Light Grazing; native trees and mixed grasses
Land Capability Class	Class VII; shallow, sandy loam soils on steep slopes and crests
Erosion Risk Class	N/A
Soil Stripping Recommendation	0 cm: Not suitable; shallow, sandy with bedrock at 35 cm

4.0 LAND ASSESSMENT

The Project Boundary has been assessed for its Rural Land Capability and Agricultural Suitability classification. The methods and results for both these assessments are presented in this section fulfilling report Objectives 2 and 3.

4.1 Rural Land Capability Assessment

4.1.1 Methodology

The land capability system applied to the Project Boundary is in accordance with the DTIRIS (formerly the NSW Soil Conservation Service) classification system. The relevant guideline is called S*ystems Used to Classify Rural Lands in New South Wales* (Cunningham *et al*., 1988). This system classifies the land on its potential for sustainable agricultural use if developed, rather than its current land use, and includes three types of land uses:

- Land suitable for cultivation;
- Land suitable for grazing; and
- Land not suitable for rural production.

The system consists of eight classes, which classify the land based on the severity of long-term limitations. Limitations are the result of the interaction between physical resources and a specific land use. A range of factors are used to assess this interaction. These factors include climate, soils, geology, geomorphology, soil erosion, topography and the effects of past land uses. The principal limitation recognised by these capability classifications is the stability of the soil mantle and classes are ranked on their increasing soil erosion hazard and decreasing versatility of use. A description of the eight land capability classes (and special zonings) is provided in **Table 13**.

Table 13 – Rural Land Capability Classes

Class	Land Use	Management Options
I	Regular Cultivation	No erosion control requirements
II	Regular Cultivation	Simple requirements such as crop rotation and minor strategic works
III	Regular Cultivation	Intensive soil conservation measures required such as contour banks and waterways
IV	Grazing, occasional cultivation	Simple practices such as stock control and fertiliser application
V	Grazing, occasional cultivation	Intensive soil conservation measures required such as contour ripping and banks
VI	Grazing only	Managed to ensure ground cover is maintained
VII	Unsuitable for rural production	Green timber maintained to control erosion
VIII	Unsuitable for rural production	Should not be cleared, logged or grazed
Special Zonings		
U	Urban areas	Unsuitable for rural production
SF	State Forests	Unsuitable for rural production
M	Mining & quarrying areas	Unsuitable for rural production

Source: Cunningham et al., 1988

4.1.2 Land Capability Results

The relevant pre-mining land capability classification land within the Project Boundary is quantified in **Table 14**. The spatial distribution of the pre-mining land capability classification is shown in **Figure 4**.

4.1.2.1 Pre-Mining

The Project Boundary is composed of land capability classes II, IV, V, VI and VII. Overall, the major limitations impacting land capability classification within the Project Boundary are slope, soil depth, sodicity, acidity/alkalinity, waterlogging potential and erosion risk.

Class II Land

Class II land consists of Soil Type 3 (Brown Vertosol), specifically land located on low slope areas in the southern extent within the Project Boundary. This classification indicates that the land is suitable for regular cultivation and cropping.

Class IV Land

Class IV land consists of Soil Type 3 (Brown Vertosol), specifically land located on several flat areas west of Dry Creek. This classification indicates that the land is suitable for grazing with only occasional cultivation. This class of land is limited by its sodicity at depth. The choice of plants is restricted and the land requires careful management. This land is capable of pasture improvement and can be tilled for an occasional crop. The preferred pasture establishment method for this land class is no-till or zero tillage and pasture grass cover should be maintained at >70% with a minimum height of 5 cm.

Class V Land

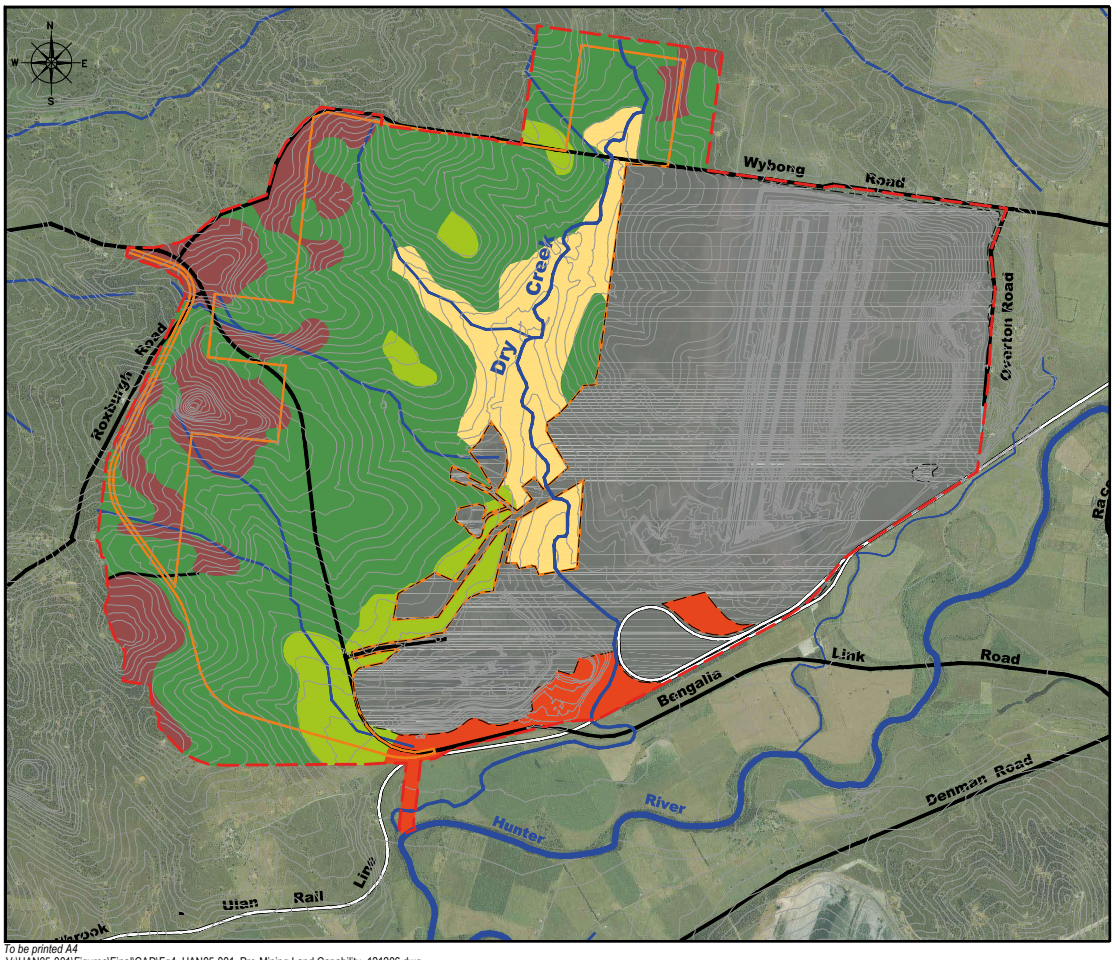
Class V land consists of Soil Types 1 (Brown Chromosol), 2 (Red Chromosol) and 4 (Red Sodosol). Class V land is only suitable for grazing with very occasional cultivation. If cultivated then intensive soil conservation measures are required such as contour ripping and banks. Similar to Class IV, this land is considered to be moderately productive and suited to improved pasture. However, higher level management practices are required due to slope and/or higher erosion risks as compared to Class IV land.

Class VI Land

Class VI land consists of Soil Type 5 (Brown Kurosol), Soil Type 6 and Soil Type 6 (V) (Brown Sodosol – Deep and Moderately Deep, respectively). This classification indicates that the land must not be cultivated for cropping or for establishing pasture, however, the land can be used for grazing if careful management and stocking practices are implemented.

Soil Type 5 is constrained by its shallow topsoil depth, acidity and susceptibility to erosion due to inherent sodicity. Pasture improvement is recommended via by no-till practices, specifically, aerial broadcasting of seed.

Soil Types 6 and 6 (V) are found in and adjacent to Dry Creek. It is likely that Soil Type 6 is a buried soil profile, with up to 60 cm of the upper profile material likely derived from erosional processes upslope. Whilst this material is of reasonable quality, the lower profile material is very alkaline, strongly sodic and highly dispersive and as a significant drainage line, prone to periodic high velocity water flows and waterlogging. This combination of factors makes it unsuitable for cultivation (which would exacerbate the erosion risk) and it is important for an adequate vegetation cover to be maintained to minimise erosion potential.



LEGEND

- Project Boundary
- Disturbance Boundary
- Approved Bengalla Mine
- Contours
- Class II - Simple requirements such as crop rotation and minor strategic works
- Class IV - Land suitable for grazing and occasional cultivation with soil conservation practices
- Class V - Land suitable for grazing but not suitable for cultivation on a regular basis. Structural soil conservation works required
- Class VI - Land suitable only for grazing providing stock limited
- Class VII - Land unsuitable for rural production; green timber should be maintained to control erosion

0 500m 1.0km

Scale 1: 35 000

FIGURE 4

Pre-Mining
Land Capability

Project:	Bengalla Continuation: Soil and Land Capability Report
Client:	Hansen Bailey
File:	Fg4_HAN05-001_Pre-Mining Land Capability_121206
Projection:	MGA94 Zone 56

Version:	Date:	Author:	Checked:	Approved:
1	06/12/12	KC	RW	AC

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Class VII Land

Class VII land consists of Soil Type 7 (Rudosol). This classification indicates that the land is unsuitable for rural production and green timber should be maintained to control erosion. Soil Type 7 tends to be sandy and of variable, shallow depth to bedrock and as such, has not been as extensively cleared as other soil types. It is often found in areas or rocky outcrop and becomes increasingly prevalent in the western areas of the Project Boundary, at higher elevations.

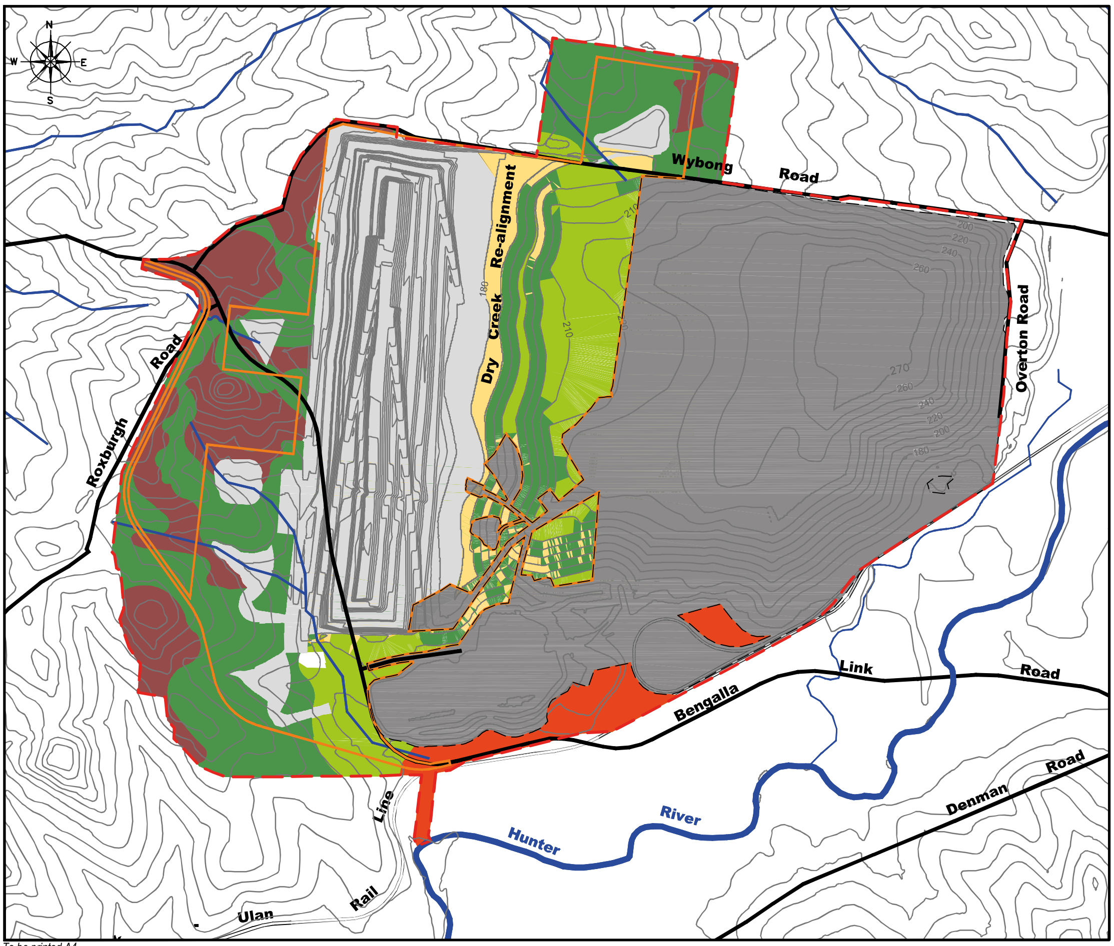
Table 14 – Pre-Mining Rural Land Capability for the Project Boundary

Class	Pre-Mining		
	Associated Soil Type	%	ha
I	-	Nil	Nil
II	3	4.1	56
III	-	Nil	Nil
IV	3	11.7	105
V	1, 2, 4	59.8	819
VI	5, 6, 6(V)	12.3	169
VII	7	16.1	221
VIII	-	Nil	Nil
M	-	Nil	Nil
Total		**100%**	**1,370**

4.1.2.2 Post-Mining

The post-mining Land Capability classification is indicative only, as the baseline data provided is illustrative of the conceptual 24 year mine plan. Post-mining land capability is illustrated in **Figure 5**. The landforms associated with the year 24 mining surface design for the Project Boundary are predominately flats and slopes, commonly up to 18% and occasionally up to 32%. These landforms are typically associated with Classes II to VI. Where the final void is located, steep slopes will likely render this land unsuitable for agricultural production and this land will be classified Rural Land Capability VIII. The conceptual 24-year mine plan currently shows this area as Special Zoning M (land disturbed by Mining).

Class II land can be re-instated where Brown Vertosol material is salvaged and then re-instated, although the total land area will be limited in extent. Class IV land can be extensively re-instated where slope varies between 3-10%. On slopes over 10%, land will require careful management and is limited to Classes V, VI or VII. This land is suitable for low intensity grazing only, or where the land falls under Class VII, land should be returned to green timber to stabilise slopes and minimise erosion.



LEGEND

- Project Boundary
- Disturbance Boundary
- Approved Bengalla Mine
- Contours
- Class II - Simple requirements such as crop rotation and minor strategic works
- Class IV - Land suitable for grazing and occasional cultivation with soil conservation practices
- Class V - Land suitable for grazing but not suitable for cultivation on a regular basis. Structural soil conservation works required
- Class VI - Land suitable only for grazing providing stock limited
- Class VII - Land unsuitable for rural production; green timber should be maintained to control erosion
- Class VIII - Mined Land/Dams/ Infrastructure/Rehabilitation Areas

0 500m 1.0km

Scale 1: 35 000

FIGURE 5

Year 24
Land Capability

Project: Bengalla Continuation: Soil and Land Capability Report

Client: Hansen Bailey

File: Fg5_HAN05-001_Year 24 Land Capability_121206

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4.2 Agricultural Suitability Assessment

4.2.1 Methodology

The Agricultural Suitability classification system applied to the assessment is in accordance with the NSW DPI (formerly NSW Agriculture & Fisheries) guideline. The relevant guideline is the *Agricultural Suitability Maps – Uses and Limitations* (NSW Agriculture & Fisheries, 1990). The system consists of five classes, providing a ranking of rural lands according to their productivity for a wide range of agricultural activities with the objective of determining the potential for crop growth within certain limits. Class 1 ranks the land as most suitable for agricultural activities and Class 5 the least suitable. Classes 1 to 3 are generally considered suitable for a wide variety of agricultural production, whereas, Classes 4 and 5 are unsuitable for cropping however are suitable for some grazing activities

The overall suitability classification for each specific soil type is determined by the most severe limitation, or a combination of the varying limitations. A description of each Agricultural Suitability Class is provided in **Table 15**.

Table 15 – Agricultural Suitability Classes

Class	Land Use	Management Options
1	Highly productive land suited to both row and field crops.	Arable land suitable for intensive cultivation where constraints to sustained high levels of agricultural production are minor or absent.
2	Highly productive land suited to both row and field crops.	Arable land suitable for regular cultivation for crops but not suited to continuous cultivation.
3	Moderately productive lands suited to improved pasture and to cropping within a pasture rotation.	Grazing land or land well suited to pasture improvement. It may be cultivated or cropped in rotation with pasture.
4	Marginal lands not suitable for cultivation and with a low to very low productivity for grazing.	Land suitable for grazing but not for cultivation. Agriculture is based on native or improved pastures established using minimum tillage.
5	Marginal lands not suitable for cultivation and with a low to very low productivity for grazing.	Land unsuitable for agriculture or at best suited only to light grazing.

Source: NSW Agriculture & Fisheries (1990)

4.2.2 Agricultural Suitability Results

The main soil properties and other landform characteristics considered significant for the Agricultural Suitability assessment are topsoil texture, topsoil pH, solum depth, external and internal drainage, topsoil stoniness and slope as well as bio-physical factors such as elevation, rainfall and temperature.

4.2.2.1 Pre-Mining

Table 16 quantifies the relevant pre-mining Agricultural Suitability classes for the Project Boundary. **Figures 6** and **7** shows the spatial distribution of the pre and post-agricultural suitability classes respectively.

Table 16 – Pre-Mining Suitability Classes

Agricultural Suitability Class	Land Capability Class	Soil Type #	Project Boundary	
			ha	%
2	II	3	56	4.1
3	IV, V	1, 2, 3, 4	924	67.5
4	VI, VII	5, 6, 6(V), 7	390	28.4

Class 2 Land

Class 2 land consists of Soil Type 3 (Brown Vertosol). This class indicates that the land is highly productive and suitable for regular cultivation for crops, but not suited to continuous cultivation. A limitation for land classified as Class 2 is the disjointed nature of the land and its close proximity to mining infrastructure.

Class 3 Land

Class 3 land consists of Soil Types 1 (Brown Chromosol), 2 (Red Chromosol), 3 (Brown Vertosol) and 4 (Red Sodosol). This class indicates that the land is moderately productive and well suited to grazing with pasture improvement, or to an occasional crop with a pasture rotation. A major limitation for land classified as Class 3 is slope gradient of up to 10%, and its main constraints limiting cultivation frequency are soil structure breakdown and erosion hazard. All soil types display a moderate erosion risk and soil conservation and drainage works are likely to be required if the land is to be used for anything other than grazing activity.

Class 4 Land

Class 4 land consists of Soil Types 5 (Brown Kurosol), Soil Type 6 and Soil Type 6 (V) (Brown Sodosol – Deep and Moderately Deep, respectively) and Soil Type 7 (Rudosols). This classification indicates that this land must not be cultivated for cropping or for establishing pasture grasses, however, the land can be used for grazing if careful management and stocking practices are implemented. Grazing productivity is low to very low and pastures are to be based on native or improved pastures established with zero or minimum tillage techniques. Although production may be high seasonally, the overall level of production is low as a result of a number of major constraints, both environmental and edaphic.

A major constraint for Soil Types 5, 6 and 6 (V) in this Class is their association with water and prolonged water logging conditions. Erosion risk in this environment is high due to periodic water flow combined with weak soil structure due to sodic subsoils. The cultivation of these soils for agriculture, which involves removal of the protective vegetative cover, will facilitate rapid erosion processes. These erosion processes typically take the form of tunnel and gully erosion leading to severe land degradation. Sodicity, in addition to increasing the tendency of the soil particles to disperse in wet conditions can also negatively affect plant root growth depending on plant type and other soil conditions.

4.2.2.2 Post-Mining

The conceptual post-mining landforms are typically associated with Agricultural Suitability Classes 3 and 4. Given the dominant existing surrounding land uses, the post mining land use of the Project Boundary is best suited to low intensity grazing. On areas where steeper slopes occur, cattle grazing should be minimised and a good cover of pasture maintained. The return of local box woodland species would also increase the habitat value of the land and addresses concerns of the Muswellbrook Shire Council (MSC, 2011) regarding increasing the amount of woody vegetation present on post-mining land forms.

The re-instated Dry Creek should be managed with particular care to ensure erosion is not exacerbated. Further discussion in relation to the reinstatement of Dry Creek is discussed in Section 5.5.1. Where possible, stock grazing should be minimised and riparian vegetation established to increase bank stability.

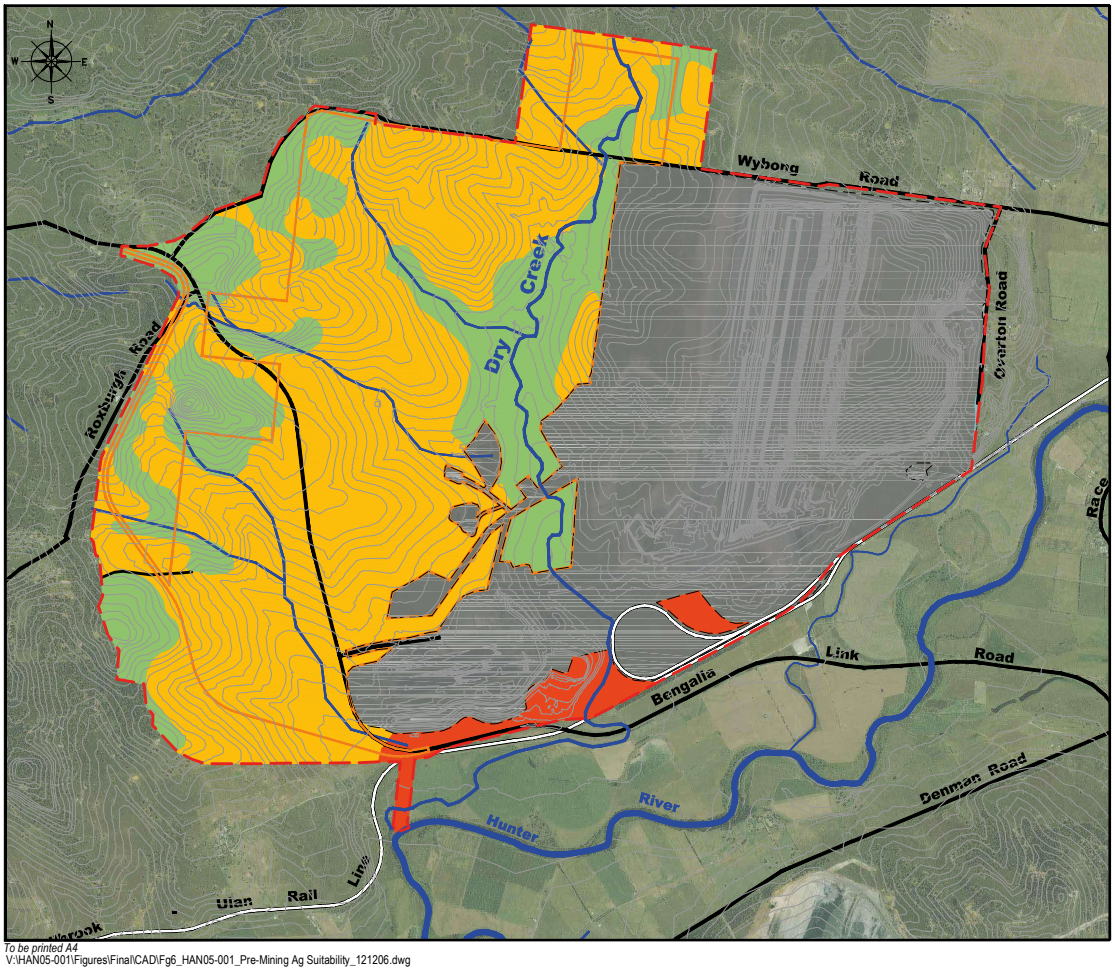

FIGURE 6

Pre-Mining Agricultural Suitability

Project:	Bengalla Continuation: Soil and Land Capability Report
Client:	Hansen Bailey
File:	Fg6_HAN05-001_Pre-Mining Ag Suitability_121206
Projection:	MGA94 Zone 56

Version:	Date:	Author:	Checked:	Approved:
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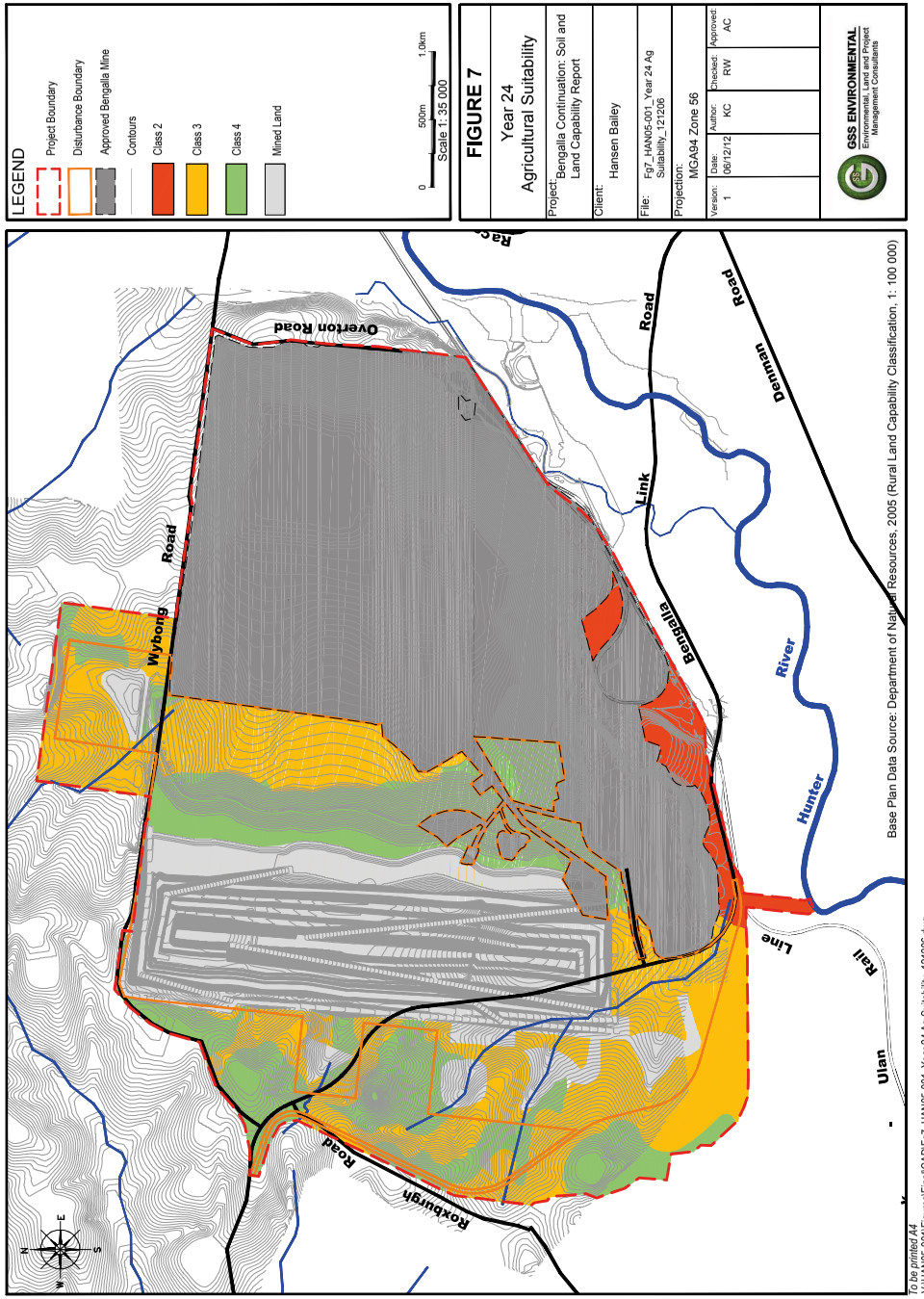

LEGEND
Project Boundary
Disturbance Boundary
Approved Bengalla Mine
Contours
Class 2
Class 3
Class 4
Mined Land
0
500m
1.0km
Scale 1: 35 000
FIGURE 7
Year 24
Agricultural Suitability
Project: Bengalla Continuation: Soil and Land Capability Report
Client: Hansen Bailey
File: Fg7_HAN05-001_Year 24 Ag Suitability_121206
Projection: MGA94 Zone 56
Version: 1
Date: 06/12/12
Author: KC
Checked: RW
Approved: AC
GSS ENVIRONMENTAL
Environmental, Land and Project Management Consultants
Overton Road
Wybong Road
Bengalla Link Road
Denman Road
Hunter River
Ulan - Rail Line
Roxburgh Road
Base Plan Data Source: Department of Natural Resources, 2005 (Rural Land Capability Classification, 1: 100 000)
To be printed A4
V:\HAN05-001\Figures\Final\CAD\Fg7_HAN05-001_Year 24 Ag Suitability_121206.dwg

4.3 Strategic Regional Land Use Policy – Upper Hunter

The Draft Upper Hunter Strategic Regional Land Use Plan (DP&I, 2012) (SRLUP) is a component of the broader Strategic Regional Land Use Policy, which consists of various initiatives to manage land use conflicts in regional areas, in relation to agriculture, coal mining and coal seam gas. The plan defines strategic agricultural land as:

> *"…highly productive land that has both unique natural resource characteristics (such as soil and water resources) as well as socio-economic value (such as high productivity, infrastructure availability and access to markets)."* (DP&I 2012).

The plan defines areas of both Biophysical Strategic Agricultural Land (BSAL) and Critical Industry Clusters, including clusters for the equine and viticulture industries. A description of the interactions between mapped strategic agricultural land and the Project is provided below.

The Project is moving in a general westerly direction away from the Hunter River alluvial floodplain and mapped BSAL.

The important values and criteria that relate to BSAL are outlined in **Table 17**, which also shows where each is addressed in this report. The Gateway Criteria (and where they are addressed in this report) are outlined in **Table 18**.

Table 17 – Strategic Agricultural Land Values and Criteria

Value	Criteria	Where Addressed
Biophysical Strategic Agricultural Land	• Land that falls under soil fertility classes 'high' or 'moderately high' under the Draft Inherent General Fertility of NSW (OEH), and • Land capability classes I, II or III under the Land and Soil Capability Mapping of NSW (OEH), and • Reliable water of suitable quality, characterised by having rainfall of 350mm or more per annum (9 out of 10 years); or properties within 150m of a regulated river, or unregulated rivers where there are flows for at least 95% of the time (i.e. the 95th percentile flow of each month of the year is greater than zero) or 5th order and higher rivers; or groundwater aquifers (excluding miscellaneous alluvial aquifers, also known as small storage aquifers) which have a yield rate greater than 5L/s and total dissolved solids of less than 1,500mg/L. • land that falls under soil fertility classes 'moderate' under the Draft Inherent General Fertility of NSW (OEH), and • land capability classes I or II under the Land and Soil Capability Mapping of NSW (OEH), • AND • reliable water of suitable quality, characterised by having rainfall of 350mm or more per annum (9 out of 10 years); or properties within 150m of a regulated river, or unregulated rivers where there are flows for at least 95% of the time (i.e. the 95th percentile flow of each month of the year is greater than zero) or 5th order and higher rivers; or groundwater aquifers (excluding miscellaneous alluvial aquifers, also known as small storage aquifers) which have a yield rate greater than 5L/s and total dissolved solids of less than 1,500mg/L.	• Section 4.3.1 of this report • Section 4.1 of this report • Agricultural Impact Statement (Scott Barnett & Associates, 2013) • Agricultural Impact Statement (Scott Barnett & Associates, 2013)
Critical Industry Cluster (Equine and Viticulture)	• Industry clusters that meet the following criteria: o There is a concentration of enterprises that provides clear development and marketing advantages and is based on an agricultural product; o The productive industries are interrelated; o It consists of a unique combination of factors such as location, infrastructure, heritage and natural resources; o It is of national and/or international importance;	• Main Volume of EIS

Value	Criteria	Where Addressed
	○ It is an iconic industry that contributes to the region's identity; and ○ It is potentially substantially impacted by coal seam gas or mining proposals. ○	

Source: Draft Upper Hunter Strategic Regional Land Use Plan, (DP&I, 2012)

Table 18 – Gateway Criteria

Value	Gateway Criteria	Where Addressed
Site Verification	• Whether the mapped land does not meet the criteria for biophysical strategic agricultural land and/or the critical industry cluster	• Throughout report
Biophysical Strategic Agricultural Land	• Impacts on the land through surface area disturbance and subsidence; • Impacts on: ○ Soil fertility ○ Rooting depth, or ○ Soil profile materials and thickness. • Increases in land surface microrelief or soil salinity, or significant changes to soil PH, and • Impacts on Highly Productive Groundwater, including the provisions of the Aquifer Interference Policy and the advice on the Minister for Primary Industries (note that the Minister for Primary Industries will be required to take into account the advice of the Commonwealth Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development in providing advice in this stage).	• Section 4.3.1 of this report • Section 4.3.1 of this report • Section 3; 4.3 • Agricultural Impact Statement (Scott Barnett & Associates, 2013)
Critical Industry Cluster (Equine and Viticulture)	• Whether the proposal would lead to significant impacts on the critical industry cluster through:	
	○ Surface area disturbance	Agricultural Impact Statement (Scott Barnett & Associates, 2013)
	○ Subsidence	Not Applicable
	○ Reduced access to agricultural resources	Agricultural Impact Statement (Scott Barnett & Associates, 2013)
	○ Reduced access to support services and infrastructure	Agricultural Impact Statement (Scott Barnett & Associates, 2013)
	○ Reduced access to transport routes	Agricultural Impact Statement (Scott Barnett & Associates, 2013)
	○ Loss of scenic and landscape values	Agricultural Impact Statement (Scott Barnett & Associates, 2013)

4.3.1 Biophysical Strategic Agricultural Land

The Study Area has been assessed against the maps and criteria provided with the SRLUP and ground truthed during the soil and land capability survey, to gain an appreciation of the extent and likely impact of the Project on potential Biophysical Strategic Agricultural Land (BSAL).

The Project is located adjacent to the Hunter River alluvial floodplain which is mapped under the criteria for BSAL (Scott Barnett & Associates, 2013). Approximately 28 ha of BSAL falls within the Project Boundary.

This area of mapped BSAL within the Project Boundary is largely associated with the Approved Bengalla Mine or is currently used for grazing associated with dairying. A small area of approximately 1 ha of BSAL mapped land is located within the Disturbance Boundary and is associated with the realignment of Bengalla Road.

4.3.2 Critical Industry Cluster (Equine & Viticulture)

The Project Boundary, based on Map 6 of the SRLUP, also contains a small area of land which occurs within the Equine Critical Industry Cluster as defined as having a slope of less than 18% and being within the 2km of the Muswellbrook Denman Road (DP&I, 2012).

There is no land within the Disturbance Boundary which occurs within into the Equine Critical Industry Cluster.

The Appendix of the SRLUP provides a definition for the Viticulture Critical Industry Cluster as presented on Map 6 of the SRLUP (DP&I, 2012). This definition and how it has been used to verify the Viticulture Critical Industry Cluster in detailed in the Agricultural Impact Assessment (Scott Barnett & Associates, 2013).

Table 19 – Viticulture Critical Industry Cluster

Definition	Where Addressed
The Viticulture Critical Industry Cluster is spatially defined as the following land (excluding State Forests and National Park):	
• The Broke-Fordwich and Pokolbin Geographical Indicators (GI) sub-regions;	Not Applicable
• The parish of Belford and the suburbs of Lovedale, Nulkaba, Mount View and Rothbury;	Not Applicable
• Properties proximate to the Hunter Wine Country Private Irrigation District pipeline to the east of Lovedale Road as well as those properties bounded by Mears Lane, Majors Lane and the Suburb of Lovedale; and	Not Applicable
• Land (excluding National Park and State Forests) within 20 km of Denman; and that falls under soil fertility classes 'high', moderately high, moderate or moderately low under the Draft Inherent General Fertility of NSW (OEH, 2012a), and land capability classes I, II, III, IV or V under the Land and Soil Capability Mapping of NSW (OEH, 2012b) and is within 2 km of a mapped alluvial water source.	Not Applicable

Table 20 - Viticulture Critical Industry Cluster Verification

Definition	Within Project Boundary
• Land (excluding National Park and State Forests) within 20 km of Denman; and	Yes - Agricultural Impact Statement (Scott Barnett & Associates, 2013)
• Falls under soil fertility classes 'high', moderately high, moderate or moderately low under the Draft Inherent General Fertility of NSW (OEH, 2012a); and	Yes – See Section 4.3.3
• Land capability classes I, II, III, IV or V under the Land and Soil Capability Mapping of NSW (OEH, 2012b); and	Yes – See Section 4.2.2
• Is within 2 km of a mapped alluvial water source.	Yes – Agricultural Impact Statement (Scott Barnett & Associates, 2013)

As described above the Project Boundary lies within the Equine Critical Industry Cluster, the Viticulture Critical Industry Cluster and mapped BSAL, an assessment has been conducted against the gateway criteria for BSAL and the Equine and Viticulture Critical Industry Clusters as provided in the SRLUP.

No existing vineyards occur within the Project Boundary or Disturbance Boundary. The nearest operating vineyards are located approximately 6 km south of the south east corner of the Project Boundary and 14.5 km west of the western Project Boundary (Scott Barnett & Associates, 2013).

There is limited area of 494 ha within the Project Boundary mapped as Viticulture Critical Industry. The verified Viticulture Critical Industry Cluster within the Disturbance Boundary is 369 ha. The Agricultural Impact Assessment has determined that the Project will not impact significantly on Viticulture Critical Industry Cluster nor any component of the viticulture industry in the Hunter Valley (Scott Barnett & Associates, 2013).

In the 1,370 ha of land assessed in this report, only 56 ha is mapped as Class II land, with all the remaining land mapped as Class IV or higher. Some land in the south of the Project Boundary is Class II land, given its location relative to Hunter River alluvials and other soils in the area being mapped as Class II land in similar landscape locations.

However, only 1 ha of Class II land is located within the Disturbance Boundary, the remaining Class II land will remain undisturbed and continue to be used for agricultural purposes.

Despite the existence of this Class II land within the Project Boundary, the operations of the Project are likely to have little to no impact on this land which is currently being used for agricultural production, which will continue. Future mining disturbance will not affect this area and as such there is unlikely to be surface area disturbance, soil fertility or rooting depth effects, or other physical / chemical effects on the soil.

4.3.3 Soils and the SRLUP

The assessment of soil fertility results conducted on nine of the samples for the soil survey indicates that all soils have low to moderate fertility under the Draft Inherent General Fertility of NSW OEH, 2012a).

Table 21 - Inherent and Interpreted Soil Fertility

Soil Type	OEH Draft Inherent Fertility	Interpreted Fertility	Soil Test Sample ID (see Appendix 3)
Red Chromosol	Moderate	Moderately Low	Sample P9-1
Brown Chromosol	Moderate	Moderately Low	Sample P2-1, P8-1, P-12-1
Brown Vertosol	Moderate	Moderate	Sample P3-1
Red Sodosol	Moderately Low	Moderately Low	Sample P13-1
Brown Kurosol	Moderately Low	Moderately Low	Sample P4-1
Deep Brown Sodosol	Moderately Low	Moderately Low	Sample P5-1
Brown Sodosol	Moderately Low	Moderately Low	Not Tested
Rudosol	Low	Low	Not Tested

With the exception of the Brown Vertosol, all soil types are extremely low to very low in nitrogen and phosphorus. This led to the interpreted fertility in **Table 21** being slightly different to the OEH Inherent Fertility. **Appendix 3** contains full details of the soil fertility test data run on nine samples (sample depth of 0-10 cm).

Salinity is not an issue for topsoil management. Only the Red Sodosol soil type displays salinity (at depth in the B horizon), however this material is not recommended for stripping due to a range of other physical and chemical attributes.

4.3.4 Acid Sulphate Soils

Acid sulfate soils are naturally occurring soils, sediments or organic substrates (e.g. peat) formed under waterlogged conditions that contain iron sulfide minerals (predominantly as the mineral pyrite) or their oxidation products. When exposed to the air following the lowering of the water table (through, for example. dewatering, groundwater abstraction, drainage or excavation) the sulfides in these soils readily oxidise, releasing sulfuric acid and iron into the soil and groundwater. This acid can, in turn, release aluminium, nutrients and heavy metals (particularly arsenic) held within the soil matrix (Ahern et al., 2004).

Acid sulfate soils, which are the main cause of acid generation within the soil mantle, are commonly found less than 5 m above sea level, particularly in low-lying coastal areas. Bengalla Mine is located within Upper Hunter Valley region (approximately 130 km from the coast) and has an elevation range of 40–220 m above sea level. It is therefore unlikely that acid sulfate soils (to a depth of 1.5 m) are present at Bengalla.

Given that any identified BSAL is likely to remain under agricultural production (grazing and cropping) and no land currently within the Project Boundary is utilised for any equine industry related uses, the continuation of Bengalla Mine should not trigger any issues with the Equine Critical Industry Cluster located in the area.

5.0 IMPACT ASSESSMENT AND MITIGATION MEASURES

Continuation of mining will disturb land to the west of the current Bengalla Mine. This land has been widely cleared and is primarily used for cattle grazing, with some small areas of remnant (albeit modified) native vegetation, primarily Grassy Box woodland. Each component of the Project has a construction and operational disturbance footprint with some parts of the disturbance footprint being progressively rehabilitated immediately after construction with the remainder being rehabilitated at the end of operational use.

This report provides information on the following key areas related to the management of topsoil resources for the area within the Disturbance Boundary:

- Dry Creek Reinstatement;
- Soil erosion hazard assessment which assesses potential soil erosion during land disturbance activities;
- Soil resource assessment which assesses soil quality for salvage and re-use for rehabilitation works;
- Topsoil management recommendations of stripped and salvaged soil resources; and
- Erosion and sediment control recommendations to be implemented on the site.

Soil to be disturbed has been assessed to determine its capability for stripping and re-use on rehabilitation sites. This assessment is an integral process for successful rehabilitation within the Project. This report provides information on the following key areas related to the management of the topsoil resources at Bengalla:

- Topsoil stripping assessment which provides a topsoil stripping plan indicating recommended stripping depths for topsoil salvage and re-use as topdressing media in rehabilitation; and
- Topsoil management for soil that is stripped, stored and re-spread as a topdressing material for rehabilitation.

5.1 Dry Creek Reinstatement

Dry Creek is an ephemeral creek that generally only flows following intense rainfall periods due to its relatively small catchment area. Dry Creek occasionally holds small pools of water for a few days following rainfall events. As mining progresses to the west, it is anticipated that Dry Creek will be intercepted at Year 2 of operations. As such, the construction of a water storage dam and interim diversion of Dry Creek will be required to divert clean water around mining operations through the use of a pipe network. Prior to the completion of mining, a permanent re-alignment of Dry Creek will be constructed to ensure successful stabilisation.

The predominant soil type identified in Dry Creek is a deep Brown Sodosol. It should be noted that in the vicinity of the sample pit (the southern portion of the Project Boundary), it appears as though the original soil profile has been buried by eroded material up to 50 cm in depth. This material is a clay loam with minimal profile development. It is likely this is colluvial material derived from adjacent low hills and from higher up in the Dry Creek catchment and its minor tributaries.

5.2 Soil Erosion Hazard

5.2.1 Methodology

Soil erosion can be a significant hazard on and downstream of construction sites where vegetative cover is disturbed and the soil is subject to the erosive agents of water and wind. Soil erosion and sedimentation occurs when soil particles detach and are transported offsite. This detachment is affected by a range of site specific factors. The main factors to consider for the assessment of the Disturbance Boundary are soil erodibility and steepness of terrain.

Soil erodibility is quantified using the soil erodibility factor (hereafter referred to as the K factor, derived from the Universal Soil Loss Equation). Soil texture is the principle component affecting K, however, other factors such as soil structure, soil organic matter content as well as soil profile permeability also contribute to the soil's inherent soil erodibility. Soils that have the highest erodibility are those which have weak bonds between soil particles and contain an abundance of easily transportable soil particles. Soil erodibility has been determined on the A1 topsoil texture class, with interpretation based on Hazelton & Murphy (2007).

5.2.2 Soil Erosion Hazard Assessment

The Project Boundary covers land that has a moderate K-factor and soil erosion hazard ratings. This hazard is predominately present due to the sodicity and fine texture (high clay content) of many soils in the B horizon. **Table 23** summarises the erosion hazard ratings for the Project Boundary.

Table 23 – Soil Erosion Hazard

Soil Type	Project Boundary		Dominant Slope	K Factor[1]	Erosion Hazard
	Ha	%	Description	Rating	Rating
Brown Chromosol	571	41.8	Very gently to gently inclined	0.04	Moderate
Red Chromosol	179	13.0	Gently to moderately inclined	0.04	Moderate
Brown Vertosol	161	11.7	Level to very gently inclined	0.025	Moderate
Red Sodosol	69	5.0	Very gently to gently inclined	0.03	Moderate
Brown Kurosol	20	1.4	Level to very gently inclined	0.04	Moderate
Deep Brown Sodosol	60	4.4	Level to very gently inclined	0.03	Moderate
Brown Sodosol	89	6.5	Very gently to gently inclined	0.03	Moderate
Rudosol	221	16.1	Moderately to steeply inclined; crests	N/A	High
Total	1,370	100			

[1] K – factor determined on A1 topsoil texture class, with interpretation based on Hazelton & Murphy (2007)

5.3 Soil Stripping Resource Assessment

5.3.1 Methodology

Determination of suitable soil to conserve for later use in mine rehabilitation has been conducted in accordance with Elliott and Reynolds (2007). This procedure involves assessing soils based on a range of physical and chemical parameters. These are summarised in **Table 24** and further discussed in the text below.

Table 24 – Topsoil Stripping Suitability Criteria

Parameter	Desirable Criteria
Structure Grade	>30% peds
Coherence	Coherent (wet and dry)
Mottling	Absent
Macrostructure	>10 cm
Force to Disrupt Peds	≤ 3 force
Texture	Finer than a Fine Sandy Loam
Gravel and Sand Content	<60%
pH	4.5 to 8.4
Salt Content	<1.5 dS/m

Structural grade is important in terms of the soil's ability to permeate and hold water as well as provide for adequate aeration. These characteristics are essential for the germination and establishment of plants. The ability of water to enter soil generally varies with structure grade and depends on the proportion of coarse peds in the soil surface. Better-structured soils have higher infiltration rates and better aeration characteristics. Structureless soils, without pores, are considered unsuitable as topdressing materials.

Soils with structural grades of 'weak' or 'moderate' are considered of low capability for salvage and revegetation works as soil peds are likely to be destroyed and structure can become massive following mechanical work associated with the excavation, transportation and spreading of topdressing material. Consequently, surface sealing and reduced infiltration of water may occur, which will restrict the establishment of plants.

The force to disrupt peds, when assessed on soil in a moderately moist state, is an indicator of solidity and the method of ped formation. Dispersive (or deflocculated) soils are hard when dry and slake when wet, whereas flocculated soils produce crumbly peds in both the wet and dry state. The deflocculated soils are not suitable for revegetation and may be identified by a strong force required to break aggregates.

The presence of mottling within the soil may indicate reducing conditions and poor soil aeration. These factors are common in soil with low permeabilities; however, some soils are mottled due to other reasons, including proximity to high water tables or inheritance of mottles from previous conditions. Reducing soils and poorly aerated soils are generally unsuitable for revegetation purposes.

Gravel and sand content, pH and salinity were determined for all samples using the laboratory test results. Texture was determined in the field and cross-referenced with laboratory results, specifically particle size analysis. All other physical parameters outlined in **Table 24** were determined during the field assessment.

5.3.2 Soil Stripping Assessment

The assessment has shown that the capability of the soil subject to disturbance has a recommended stripping depth stripping depth of 0 – 0.6 m, varying between soil types. The recommended depths correspond to salvage depths via the stripping process and re-used in progressive and post construction rehabilitation works.

All subsoils were undesirable for use because of severe physical and/or chemical limitations. The Brown Kurosol topsoils are acidic and would benefit from amelioration with lime to increase soil pH. **Table 25** details the maximum recommended stripping depths for each soil type and their major constraints. **Figure 8** provides the spatial distribution of the recommended stripping depths.

Table 25 – Topsoil Stripping Depths

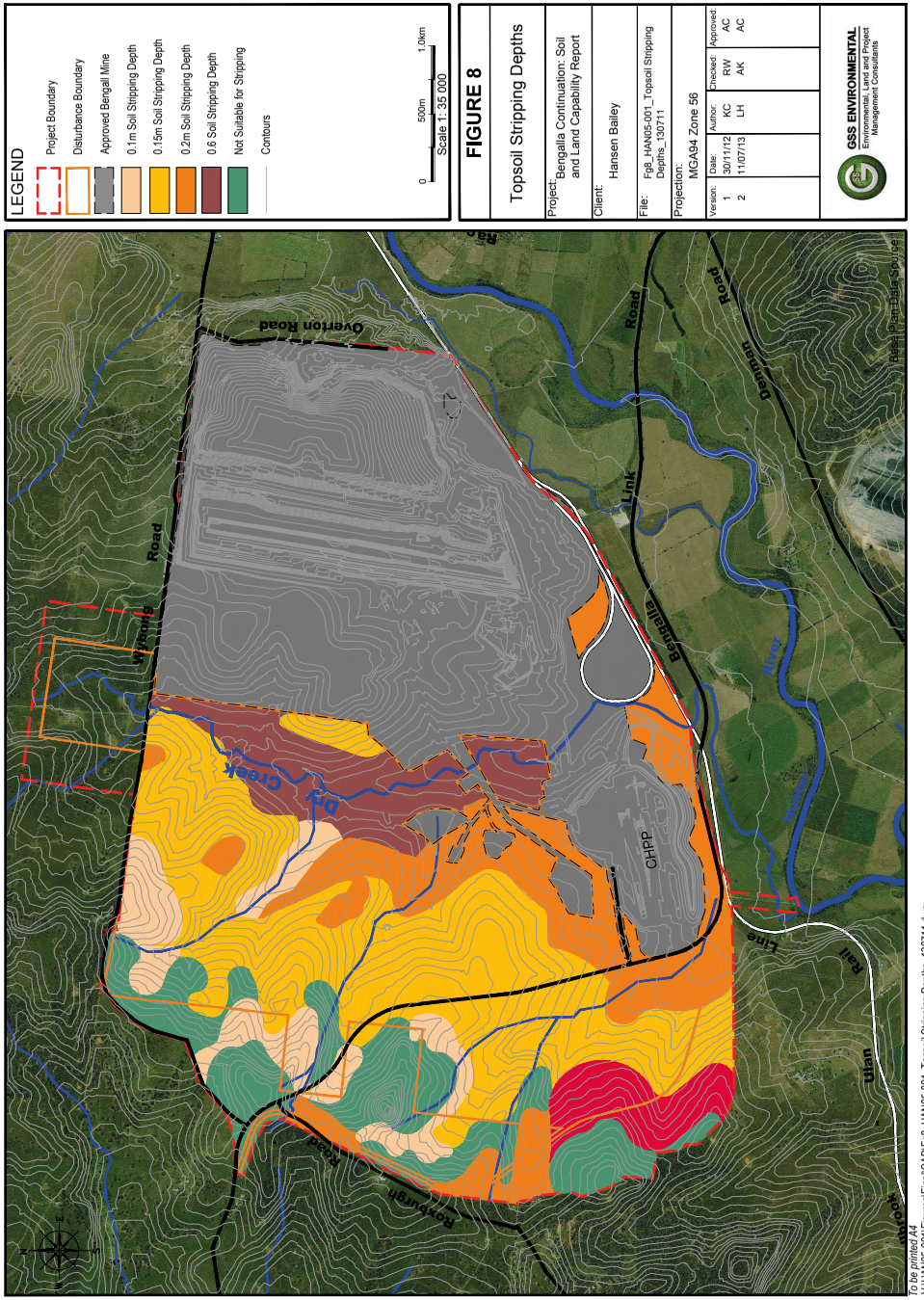
Soil Type		Recommended Stripping Depth	Main Limitation(s)	Capability
#	ASC Name	m	Description	
1	Brown Chromosol	0 – 0.10	Slope, texture	Highly Suitable
2	Red Chromosol	0 – 0.15	Slope, texture	Highly Suitable
3	Brown Vertosol	0 – 0.20	Texture; chemical properties of subsoil	Highly Suitable
4	Red Sodosol	0 – 0.20	Texture; sodicity in B horizon	Highly Suitable
5	Brown Kurosol	0 – 0.10	Texture, chemical properties of subsoil	Suitable
6	Brown Sodosol (Deep)	0 – 0.60	B horizon sodic, alkaline and highly dispersive	Highly Suitable
6(V)	Brown Sodosol (Moderately Deep)	0 – 0.60	B horizon sodic, alkaline and highly dispersive	Highly Suitable
7	Rudosol	0	Slope; variable depth to bedrock; texture	Unsuitable

Laboratory soil analytical results were used in conjunction with the field assessment (refer **Appendix 2**) to determine the depth of soil material suitable for recovery and re-use as a topdressing material in rehabilitation. Structural and textural properties of subsoils, dispersion potential, sodicity and acidity/alkalinity are the most common and significant limiting factors in determining depth of soil capability for re-use.

Allowing for a 10% handling loss, approximately 1,549,800 m^3 of suitable topdressing is available within the entire Disturbance Boundary. The Brown Sodosol and Red & Brown Chromosol soils will generate the largest topsoil resource. **Table 26** below provides the recommended stripping depth for each soil unit within the Disturbance Boundary together with the land area occurrence for each soil type and the calculated volume of available soil for re-use in rehabilitation activities.

Table 26 – Recommended Stripping Depths

Soil Type	Topsoil		
	Recommended Stripping Depth (m)	Stripping Area (ha)	Soil Volume m^3
1	0.10	42	42,000
2	0.15	356	534,000
3	0.20	81	162,000
4	0.20	68	136,000
5	0.10	20	20,000
6, 6(V)	0.60	138	828,000
7	0	0	0
Total Volume			1,722,000
Total Volume with 10% handling loss allowance			1,549,800


LEGEND
Project Boundary
Disturbance Boundary
Approved Bengall Mine
0.1m Soil Stripping Depth
0.15m Soil Stripping Depth
0.2m Soil Stripping Depth
0.6 Soil Stripping Depth
Not Suitable for Stripping
Contours
0
500m
1.0km
Scale 1: 35 000
FIGURE 8
Topsoil Stripping Depths
Project: Bengalla Continuation: Soil and Land Capability Report
Client: Hansen Bailey
File: Fg8_HAN05-001_Topsoil Stripping Depths_130711
Projection: MGA94 Zone 56
Version: 1 2
Date: 30/11/12 11/07/13
Author: KC LH
Checked: RW AK
Approved: AC AC
GSS ENVIRONMENTAL
Environmental, Land and Project Management Consultants
Overton Road
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Muswellbrook Road
Roxburgh Road
Dry Creek
Hunter River
CHPP
Rail Line
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5.4 Topdressing Management

Topsoil Stripping and Handling

The following topsoil handling techniques are recommended to prevent excessive soil deterioration.

- Strip material to the depths stated in Section 5.3, subject to further investigation as required.
- Topsoil should be maintained in a slightly moist condition during stripping. Material should not be stripped in either an excessively dry or wet condition.
- Place stripped material directly onto reshaped overburden and spread immediately (if mining sequences, equipment scheduling and weather conditions permit) to avoid the requirement for stockpiling.
- Grading or pushing soil into windrows with graders or dozers for later collection by open bowl scrapers, or for loading into rear dump trucks by front-end loaders, are examples of preferential less aggressive soil handling systems. This minimises compression effects of the heavy equipment that is often necessary for economical transport of soil material.
- Soil transported by dump trucks may be placed directly into storage. Soil transported by scrapers is best pushed to form stockpiles by other equipment (e.g. dozer) to avoid tracking over previously laid soil.
- The surface of soil stockpiles should be left in an as coarsely textured condition as possible in order to promote infiltration and minimise erosion until vegetation is established, and to prevent anaerobic zones forming.
- As a general rule, maintain a maximum stockpile height of 3 m. Clayey soils should be stored in lower stockpiles for shorter periods of time compared to sandier soils.
- If long-term stockpiling is planned (i.e. greater than 12 months), seed and fertilise stockpiles as soon as possible. An annual cover crop species that produce sterile florets or seeds should be sown. A rapid growing and healthy annual pasture sward provides sufficient competition to minimise the emergence of undesirable weed species. The annual pasture species will not persist in the rehabilitation areas, but will provide sufficient competition for emerging weed species and enhance the desirable micro-organism activity in the soil.
- Prior to re-spreading stockpiled topsoil onto reshaped overburden (particularly onto designated tree seeding areas), an assessment of weed infestation on stockpiles should be undertaken to determine if individual stockpiles require herbicide application and / or “scalping” of weed species prior to topsoil spreading.
- An inventory of available soil should be maintained to ensure adequate topsoil materials are available for planned rehabilitation activities.
- Topsoil should be spread to a minimum depth of 0.1 m, more where the resource is available.

5.5 Topsoil Balance

An approximate topsoil balance has been determined based on the Year 24 landform. Using this as a basis (and excluding the pit void area), approximately 38 ha will be classed as a “Dry Creek re-alignment area”; 118 ha as Class IV land (lower slopes) and 117 ha as Class V/VI land (moderate slopes).

It is suggested that the Dry Creek realignment re-instate 0.4 m of topsoil, for which there is adequate resource available from the recommended stripping regime. It is also suggested, where possible, to replace approximately 0.4 m of subsoil in the Dry Creek realignment area in addition to the topsoil. For the low slope Class IV land, it is suggested a minimum of 0.2 m of topsoil over 0.4 m of subsoil be re-instated. Again, there are adequate topsoil resources available to fulfil this objective.

Finally, for the Class V/VI land, a minimum or 0.1 m but preferably 0.2 m of topsoil should be re-instated. Where possible, up to 0.2 m of subsoil should also be re-instated. If subsoil is re-instated, 0.1 m of topsoil will be adequate. At this stage of final landform planning, there is adequate topsoil resource available to re-instate 0.2 m of topsoil on the Class V/VI areas. Volumes needed and available for topsoil use are outlined in **Table 27**.

Table 27 – Year 24 Landform Topsoil Balance

Land Class	Ha	Topsoil Depth (m)	Required Volume (m^3)	Soil Type For Use	Available Volume (m^3)
Class IV	118	0.2	236,000	1, 2	576,000
Class V + VI	117	0.2	234,000	1, 2	576,000
Dry Creek Re-alignment	38	0.4	152,000	3, 6, 6(V)	990,000

5.6 Erosion and Sediment Control Recommendations

The land within the Disturbance Boundary has a moderate erosion hazard rating and as such appropriate erosion and sediment controls will be implemented to ensure that adverse effects of construction and operations activities are minimized. A detailed *Erosion and Sediment Control Plan* will be developed prior to the commencement of construction works. The principle objectives of the *Erosion and Sediment Control Plan* are outlined below.

5.6.1 Minimising Disturbance

Land disturbance will be minimised by clearing the smallest practical area of land ahead of construction, as well as ensuring the land is disturbed for the shortest possible and practical time. This will be achieved by:

- Limiting the cleared width to that required to accommodate the proposed operations;
- Staging the clearing activities where ever possible so that only the areas which are being actively cleared, therefore, limiting the time the areas are exposed; and
- Rehabilitating topsoil stockpiles as soon as practical.

General vegetation clearing and soil stripping should not be undertaken until earthwork and construction operations are ready to commence. All proposed erosion and sediment control measures will be implemented in advance of, or in conjunction with, clearing activities.

Prior to clearing and soil stripping commencing, the limits of these works should be clearly delineated by pegs placed at intervals on each side of the disturbed area by a suitably qualified supervisor. All operations will be planned to ensure that there is no damage to any trees and pasture areas outside the limits to be cleared.

Rehabilitation strategies and concepts proposed below have been formulated according to results of industry-wide research and experience.

5.6.2 Post Disturbance Regrading

The main objective of regrading is to produce slope angles, lengths and shapes that are compatible with the proposed land use and not prone to an unacceptable rate of erosion. Integrated with this is a drainage pattern that is capable of conveying runoff from the newly created catchments whilst minimising the risk of erosion and sedimentation.

5.6.3 Control Options

The most significant means of controlling surface flow on disturbed areas is to construct contour furrows or contour banks at intervals down the slope. The effect of these is to divide a long slope into a series of short slopes with the catchment area commencing at each bank or furrow. This prevents runoff from reaching a depth of flow or velocity that will cause significant erosion. As the slope angle of the land increases, the banks or furrows must be spaced closer together, although on steeper slopes a point is reached where these structures are so close together as to be no longer effective.

5.7 Summary of Mitigation

Bengalla mine has in place comprehensive rehabilitation commitments and these are outlined in the existing Rehabilitation Management Plan (BMC, 2013a) and Landscape Management Plan (BMC, 2013b). Key to these documents are management commitments for soil stripping and management (further detailed within this document), revegetation, progressive rehabilitation, erosion and sediment control, overburden management and reshaping, final void management, monitoring and maintenance and completion criteria.

It is suggested that the Dry Creek realignment re-instate 0.4 m of topsoil, and approximately 0.4 m of subsoil in the Dry Creek realignment area in addition to the topsoil. For the low slope Class IV land, it is suggested a minimum of 0.2 m of topsoil over 0.4 m of subsoil be re-instated, while for the Class V/VI land, a minimum or 0.1 m but preferably 0.2 m of topsoil should be re-instated. Where possible, up to 0.2 m of subsoil should also be re-instated.

As part of the EIS process for the Bengalla Continuation Project, a Rehabilitation Management Strategy is currently being developed which will address the DGRs regarding rehabilitation and set long term goals for the rehabilitation and relinquishment of the site. The rehabilitation and post-mining management at Bengalla will continue to build upon commitments made in existing documents and will also build upon successful techniques developed and applied at the site.

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Glossary of Terms and Definitions

APPENDIX 1

Glossary of Terms and Definitions

Term	Definition
Acidity	A property expressed by the pH value when this is below 7.0 in a soil/water suspension.
Aggregate	A unit of soil structure usually formed by natural processes in contrast with natural processes, and generally <10 mm in diameter.
Alkalinity	A property expressed by the pH value when this exceeds 7.0 in a soil/water suspension.
Availability	General expression referring to the ease with which plants can absorb a particular nutrient form the soil.
Available Water Capacity	The amount of water in the soil, generally available to plants, that can be held between field capacity and the moisture content at which plant growth ceases. Sometimes also known as the *Plant Available Water Capacity.*
Bulk Density	The mass of dry soil per unit bulk volume; a measure of soil porosity, with low values meaning a highly porous soil and vice versa. It does not, however, give any indication of the number, sizes, shapes, distribution or continuity of soil pores.
Cation	An element with a positive charge.
Cation Exchange	Process whereby cations interchange between the soil solution and the clay or organic matter complexes in the soil.
Cation Exchange Capacity	The total amount of exchangeable cations that a soil can adsorb, expressed in centimoles of positive charge per kilogram of soil
Clay	A soil separate consisting of particles <0.002 mm in equivalent diameter.
Consistence Force	Consistence force refers to the strength of cohesion and adhesion in the soil.
Course Fragments	Particles greater than 2mm
Electrical Conductivity	A measure of the conduction of electricity through water or a water extract of soil. It can be used to determine the soluble salts in the extract and hence soil salinity. The unit of electrical conductivity is the Siemens and soil salinity is normally expressed as decisiemens per meter at 25 ℃ (dS/m).
Emerson Aggregate Test	A classification of soil aggregates based on their coherence in water.
Exchangeable Cation	A positively charged ion held on or near the surface of a solid particle by a negative surface charge of a colloid and which may be replaced by other positively charged ions in the soil solution.

Term	Definition
Exchangeable Sodium Percentage	Exchangeable sodium fraction expressed as a percentage.
Field Texture Grade	Field texture is a measure of the behaviour of a small handful of soil when moistened and kneaded into a ball and then passes out between thumb and forefinger. The recommended field texture grades are characterised by the behaviour of the moist bolus.
Field Colour	The colour of soil material is determined by comparison with a standard Munsell colour chart.
Gravel	A mixture of coarse mineral particles larger than 2 mm, but less than 75 mm in diameter.
Hydraulic Conductivity	The flow of water through soil per unit of energy gradient. For practical purposes, it may be taken as the steady state of percolation rate of a soil when infiltration and internal drainage are equal, measured as depth per unit time.
Infiltration	The downward entry of water into the soil through the soil surface.
Leaching	The removal of materials in solution from the soil.
Mottles	Spots, blotches or streaks of subdominant colours different from the matrix colour and also different from the colour of the ped surface.
Organic Carbon	Gives an estimate of the amount of organic matter in a soil as a percentage by weight.
Organic Matter	Is the sum of all natural and thermally altered biologically derived organic materials found in the soil. These materials, in various states of decay, include leaf litter, plant roots, branches, living, and dead organism, and excreta.
pH (soil)	A measure of the acidity or alkalinity of a soil. It represents the negative logarithm of the hydrogen ion concentration in a specified soil/water suspension on a scale of 0 to 14.
Parent Material	The unconsolidated and more or less chemically weathered mineral or organic matter form which the solumn of soils is developed by pedogenic processes.
Particle Size Analysis	The laboratory determination of the amounts of the different separates in a soil sample such as clay, silt, fine sand, coarse sand and gravel. The amounts are normally expresses as percentages by weight of dry soil.
Ped	A unit of soil structure such as an aggregate, crumb, prism, block or granule, formed by natural processes (in contrast with a clod which is artificially formed).
Permeability (soil)	The ease with which gases, liquids or plant roots penetrate or pass through a bulk mass of soil or layer of soil.
Physical Properties (soil)	Those characteristics, processes or reactions of a soil which is caused by physical forces and which can be described by, or expressed in, physical terms or equations. These can be difficult to separate from chemical properties; hence terms, physical-chemical or physico-chemical.

Term	Definition
Pores	The part of the bulk volume of the soil not occupied by soil particles.
Sampling Site	A georeferenced point within a monitoring unit where one or more samples are taken for analysis.
Sand	A soil particle that in the USDA soil texture system is of size 0.05 mm to 2.0 mm in diameter.
Silt	A soil particle that in the USDA soil texture system is of size 0.002 mm to 0.05 mm in diameter.
Sodicity	A property expressed by the amount of exchangeable sodium present relative to the cation capacity of a soil horizon.
Soil Classification	The systematic arrangement of soils into groups or categories on the basis of similarities and differences in their characteristics.
Soil Consistence	The resistance of soil material to deformation or rupture.
Soil Erodibility	The susceptibility of a soil to the detachment and transportation of soil particles by erosive agents.
Soil Horizon	A layer of soil or soil material approximately parallel to the land surface and differing from adjacent genetically related layers in physical, chemical, biological properties such as colour structure, texture, consistency, kinds and number of organisms present, degrees or acidity or alkalinity.
Soil Profile	A vertical section of the soil through all its horizons.
Soil Salinity	The amount of soluble salts in a soil. The convention measure of soil salinity is the electrical conductivity of a saturation extract.
Soil Structure	Refers to the way soil particles are arranged and bound together to form aggregates or peds.
Soil Texture	The relative proportions of the various soil separates in as soil as described by the classes of soil texture. It is the general coarseness or fineness of soil material as it affects the behaviour of a moist ball (bolus) when pressed between the thumb and forefinger.
Solum	The upper part of a soil profile above the parent material, in which current processes of soil formation are active. The solum consists of either the A and B horizons or the A horizon alone when no B is present.
Structure Pedality Grade	Is the degree of development and distinction of ped.
Structure Ped and Size	Refers to the distinctness, size and shape of peds.
Subsoil	Refers to B soil horizon
Topsoil	Refers to A1 and A2 soil horizons.

Soil Laboratory Results

APPENDIX 2

NSW GOVERNMENT Soil Conservation Service

SOIL TEST REPORT

Scone Research Centre

REPORT NO:	SCO12/040R3
REPORT TO:	Adele Calandra GSS Environmental PO Box 907 Hamilton NSW 2303
REPORT ON:	Thirty three soil samples Ref: HAN05-001
PRELIMINARY RESULTS ISSUED:	3 March 2012
REPORT STATUS:	Final
DATE REPORTED:	3 March 2012
METHODS:	Information on test procedures can be obtained from Scone Research Centre

TESTING CARRIED OUT ON SAMPLE AS RECEIVED

SR Young
(Laboratory Manager)

Scone Research Centre, PO Box 283 Scone 2337, 709 Gundy Road Scone 2337
Ph: 02 6545 1666, Fax: 02 6545 2520

SOIL CONSERVATION SERVICE
Scone Research Service Centre

Report No: SCO12/040R3
Client Reference: Adele Calandra
GSS Environmental
PO Box 907
Hamilton NSW 2303

Lab No	Method	P7B/2 Particle Size Analysis (%)					P9B/2	Colour	
	Sample Id	clay	silt	f sand	c sand	gravel	EAT	Dry	Moist
1	P1-1	nt	nt	nt	nt	nt	nt	7.5YR5/3	7.5YR3/3
2	P1-2	nt	nt	nt	nt	nt	nt	5YR6/4	5YR4/4
3	P2-1	38	25	28	8	1	3(1)	7.5YR5/4	7.5YR3/4
4	P2-2	59	22	16	3	0	3(3)	7.5YR5/4	7.5YR3/4
5	P2-3	51	27	18	4	<1	2(1)	7.5YR5/4	7.5YR3/4
6	P3-1	31	27	28	14	<1	8	7.5YR5/3	7.5YR3/2
7	P3-2	41	25	26	8	<1	8	7.5YR4/2	7.5YR3/2
8	P3-3	55	32	7	6	<1	4	10YR6/4	10YR4/6
9	P4-1	17	15	35	33	0	8	10YR5/4	7.5YR3/3
10	P4-2	16	12	36	36	<1	8	10YR6/4	7.5YR4/6
11	P4-3	24	10	34	31	1	2(1)	7.5YR7/4	7.5YR4/6
12	P4-4	35	3	28	33	1	2(1)	7.5YR6/6	7.5YR5/6

SRJ

SOIL CONSERVATION SERVICE
Scone Research Service Centre

Report No: SCO12/040R3
Client Reference: Adele Calandra
GSS Environmental
PO Box 907
Hamilton NSW 2303

Lab No	Method	P7B/2 Particle Size Analysis (%)					P9B/2	Colour	
	Sample Id	clay	silt	f sand	c sand	gravel	EAT	Dry	Moist
13	P5-1	32	13	47	8	0	8	7.5YR5/4	7.5YR3/4
14	P5-2	32	15	45	8	0	3(1)	7.5YR5/4	7.5YR4/3
15	P5-3	29	12	50	9	0	3(2)	7.5YR4/6	7.5YR3/4
16	P5-4	37	9	41	13	0	2(3)	7.5YR5/4	7.5YR4/4
17	P8-1	29	26	40	5	0	8	7.5YR5/4	7.5YR2.5/2
18	P8-2	64	18	16	2	<1	3(1)	5YR5/4	5YR3/4
19	P8-3	66	21	10	3	<1	4	5YR5/6	5YR4/6
20	P9-1	28	34	34	4	<1	3(1)	7.5YR5/4	7.5YR3/4
21	P9-2	61	23	15	1	0	3(1)	5YR5/4	5YR4/6
22	P9-3	58	25	16	1	<1	4	7.5YR5/4	7.5YR4/6
23	P10-1	43	27	24	5	1	8	7.5YR4/4	7.5YR3/4
24	P10-2	63	19	14	3	1	3(1)	5YR4/4	5YR3/4
25	P10-3	59	19	17	5	0	3(1)	5YR4/4	5YR3/4
26	P10-4	55	32	8	4	1	4	10YR6/4	10YR5/6

SOIL CONSERVATION SERVICE
Scone Research Service Centre

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Lab No	Method	P7B/2 Particle Size Analysis (%)					P9B/2	Colour	
	Sample Id	clay	silt	f sand	c sand	gravel	EAT	Dry	Moist
27	P12-1	27	17	33	23	0	8	7.5YR4/3	7.5YR2.5/3
28	P12-2	58	11	19	12	0	5	7.5YR4/6	7.5YR3/4
29	P12-3	61	11	23	5	0	4	5YR5/4	5YR3/4
30	P12-4	52	10	18	11	9	4	5YR5/4	5YR4/6
31	P13-1	31	14	35	19	1	2(1)	7.5YR4/3	7.5YR2.5/3
32	P13-2	57	9	21	12	1	2(2)	2.5YR4/4	2.5YR3/6
33	P13-3	68	8	14	9	1	2(2)	5YR5/6	5YR4/6

SOIL CONSERVATION SERVICE
Scone Research Service Centre

Report No: SCO12/040R3
Client Reference: Adele Calandra
GSS Environmental
PO Box 907
Hamilton NSW 2303

Lab No	Method	C1A/4	C2A/3	C2B/3	C5A/3 CEC & exchangeable cations (me/100g)						C6A/2
	Sample Id	EC (dS/m)	pH	pH ($CaCl_2$)	CEC	Na	K	Ca	Mg	Al	OC (%)
1	P1-1	nt	nt	nt	nt	nt	nt	nt	nt	nt	3.03
2	P1-2	nt	nt	nt	nt	nt	nt	nt	nt	nt	0.72
3	P2-1	0.20	7.0	6.6	25.4	1.0	1.7	11.5	9.8	nt	3.14
4	P2-2	0.02	7.1	5.9	26.9	0.7	1.5	9.0	12.7	nt	1.24
5	P2-3	0.34	8.9	8.0	31.7	3.6	0.3	12.9	16.1	nt	nt
6	P3-1	0.14	6.8	6.3	32.0	0.5	2.6	19.9	7.4	nt	6.34
7	P3-2	0.04	7.0	6.1	33.2	0.5	1.6	20.0	8.1	nt	4.88
8	P3-3	0.09	8.9	7.9	28.1	0.5	0.9	21.0	7.9	nt	nt
9	P4-1	0.08	6.4	5.9	7.3	0.4	0.6	4.0	1.7	nt	1.71
10	P4-2	0.02	6.4	5.5	4.2	0.2	0.4	1.7	1.1	0.2	0.40
11	P4-3	0.02	6.7	5.7	6.1	0.5	0.3	1.6	3.3	0.2	nt
12	P4-4	0.09	6.0	4.9	12.1	1.8	0.2	2.0	5.6	0.2	nt

SOIL CONSERVATION SERVICE
Scone Research Service Centre

Report No: SCO12/040R3
Client Reference: Adele Calandra
GSS Environmental
PO Box 907
Hamilton NSW 2303

Lab No	Method	C1A/4	C2A/3	C2B/3	C5A/3 CEC & exchangeable cations (me/100g)						C6A/2
	Sample Id	EC (dS/m)	pH	pH ($CaCl_2$)	CEC	Na	K	Ca	Mg	Al	OC (%)
13	P5-1	0.06	7.2	6.4	21.0	0.4	1.1	10.9	5.9	nt	1.71
14	P5-2	0.03	7.3	6.3	20.3	0.5	1.2	10.6	5.7	nt	1.14
15	P5-3	0.02	8.1	6.6	18.4	0.7	0.5	9.4	6.4	nt	nt
16	P5-4	0.16	9.1	7.8	22.6	3.4	0.3	8.8	8.0	nt	nt
17	P8-1	0.02	6.3	5.3	15.7	0.5	1.0	9.5	2.9	<0.1	nt
18	P8-2	0.01	7.0	5.7	22.8	0.7	0.7	13.3	6.1	<0.1	nt
19	P8-3	0.12	8.6	7.6	35.8	0.8	0.5	26.3	8.4	nt	nt
20	P9-1	0.07	6.8	6.3	16.3	0.7	0.7	8.6	3.8	<0.1	nt
21	P9-2	0.04	7.4	6.4	27.8	1.1	0.6	12.4	8.8	nt	nt
22	P9-3	0.18	8.5	7.6	32.6	1.5	0.4	20.0	10.1	nt	nt
23	P10-1	0.05	7.2	6.5	26.4	0.8	1.3	13.3	7.0	<0.1	nt
24	P10-2	0.15	8.2	7.4	37.0	1.8	1.0	18.2	12.6	nt	nt
25	P10-3	0.17	8.7	7.7	37.3	2.2	0.7	20.4	14.9	nt	nt
26	P10-4	0.71	9.2	8.3	37.9	4.1	0.9	20.1	15.6	nt	nt

SOIL CONSERVATION SERVICE
Scone Research Service Centre

Report No: SCO12/040R3
Client Reference: Adele Calandra
GSS Environmental
PO Box 907
Hamilton NSW 2303

Lab No	Method	C1A/4	C2A/3	C2B/3	C5A/3 CEC & exchangeable cations (me/100g)					C6A/2
	Sample Id	EC (dS/m)	pH	pH ($CaCl_2$)	CEC	Na	K	Ca	Mg	Al	OC (%)
27	P12-1	0.18	6.9	6.7	20.2	0.2	1.0	12.6	3.8	<0.1	nt
28	P12-2	0.10	7.6	6.9	29.5	0.5	1.1	17.8	7.8	nt	nt
29	P12-3	0.15	8.3	7.5	34.5	0.4	0.7	21.4	8.4	nt	nt
30	P12-4	0.11	8.7	7.8	34.7	0.5	0.3	22.4	10.0	nt	nt
31	P13-1	0.09	6.6	6.0	18.0	0.7	0.9	7.1	5.4	<0.1	nt
32	P13-2	0.21	8.2	7.1	31.6	3.3	0.5	10.0	15.2	nt	nt
33	P13-3	0.96	8.9	8.2	39.4	7.1	0.3	15.7	18.2	nt	nt

nt = not tested

END OF TEST REPORT

Soil Laboratory Results - Fertility

APPENDIX 3

Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: **EB1217097**	Page	: 1 of 4
Client	: **GSS ENVIRONMENTAL**	Laboratory	: Environmental Division Brisbane
Contact	: MR MATT HEMINGWAY	Contact	: Customer Services
Address	: LEVEL 1241 DENISON STREET BROADMEADOW NEWCASTLE NSW AUSTRALIA 2292	Address	: 32 Shand Street Stafford QLD Australia 4053
E-mail	: hemingway@gssenvironmental.com	E-mail	: Brisbane.Enviro.Services@alsglobal.com
Telephone	: ----	Telephone	: +61 7 3243 7222
Facsimile	: ----	Facsimile	: +61 7 3243 7218
Project	: ----	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: ----	Date Samples Received	: 28-JUN-2012
Sampler	: ----	Issue Date	: 12-JUL-2012
Site	: ----		
		No. of samples received	: 9
Quote number	: BN/372/11	No. of samples analysed	: 9

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

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

NATA Accredited Laboratory 825

Accredited for compliance with ISO/IEC 17025.

Signatories

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

Signatories	*Position*	*Accreditation Category*
Andrew Epps	Metals Production Chemist	Brisbane Inorganics
Ankit Joshi	Inorganic Chemist	Sydney Inorganics
Stephen Hislop	Senior Inorganic Chemist	Brisbane Inorganics
Stephen Hislop	Senior Inorganic Chemist	Stafford Minerals - AY

Page	:	2 of 4
Work Order	:	EB1217097
Client	:	GSS ENVIRONMENTAL
Project	:	---

General Comments

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

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

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

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

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

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

Page : 3 of 4
Work Order : EB1217097
Client : GSS ENVIRONMENTAL
Project : ----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	P2-1 0 - 10	P3-1 0 - 10	P4-1 0 - 10	P5-1 0 - 10	P8-1 0 - 10
			Client sampling date / time	[28-JUN-2012]	[28-JUN-2012]	[28-JUN-2012]	[28-JUN-2012]	[28-JUN-2012]
Compound	CAS Number	LOR	Unit	EB1217097-001	EB1217097-002	EB1217097-003	EB1217097-004	EB1217097-005
EA055: Moisture Content								
Moisture Content (dried @ 103°C)	----	1.0	%	5.0	5.7	10.9	4.6	3.2
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	40	40	40	30	20
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	0.9	5.7	4.1	0.5	2.7
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	20	mg/kg	3390	5830	1580	1460	1820
EK062: Total Nitrogen as N (TKN + NOx)								
^ Total Nitrogen as N	----	20	mg/kg	3390	5840	1580	1460	1820
EK072: Phosphate Sorption Capacity								
Phosphate Sorption Capacity	----	250	mg P sorbed/kg soil	1210	871	677	571	923
Phosphate Sorption Index	----	1	mgkg-1/log10	36	29	30	28	30
EK074: Fluoride Extractable Phosphorus (Bray)								
Fluoride Extractable P (Bray)	----	1.0	mg/kg	2.6	4.6	2.7	1.8	2.8
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	3.25	5.92	1.69	1.72	2.84

Page : 4 of 4
Work Order : EB1217097
Client : GSS ENVIRONMENTAL
Project : ----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	P9-1 0 - 10	P10-1 10 - 20	P12-1 0 - 13	P13-1 0 - 20	----
			Client sampling date / time	[28-JUN-2012]	[28-JUN-2012]	[28-JUN-2012]	[28-JUN-2012]	----
Compound	CAS Number	LOR	Unit	EB1217097-006	EB1217097-007	EB1217097-008	EB1217097-009	----
EA055: Moisture Content								
Moisture Content (dried @ 103°C)	----	1.0	%	3.3	5.4	6.0	3.6	----
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	20	10	50	20	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	0.8	1.6	4.3	0.9	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	20	mg/kg	1410	1740	3030	1570	----
EK062: Total Nitrogen as N (TKN + NOx)								
^ Total Nitrogen as N	----	20	mg/kg	1410	1740	3030	1570	----
EK072: Phosphate Sorption Capacity								
Phosphate Sorption Capacity	----	250	mg P sorbed/kg soil	714	1130	736	1160	----
Phosphate Sorption Index	----	1	mgkg-1/log10	30	34	31	36	----
EK074: Fluoride Extractable Phosphorus (Bray)								
Fluoride Extractable P (Bray)	----	1.0	mg/kg	1.3	1.1	2.7	2.0	----
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	1.88	1.98	2.83	2.32	----