Muswellbrook Coal Continuation Project

Rehabilitation and Closure Strategy

Prepared for Muswellbrook Coal Company | 27 April 2016

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Muswellbrook Coal Continuation Project

Final

Report J16011RP1 | Prepared for Muswellbrook Coal Company | 27 April 2016

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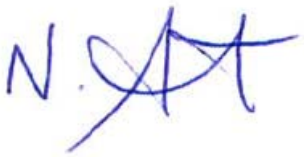
Signature		Signature	
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1 Introduction

1.1 Overview

Muswellbrook coal mine (MCM) is an open cut coal mine operated by Muswellbrook Coal Company Limited (MCC). MCM is located, 3 kilometres (km) north-east of the township of Muswellbrook, in the Muswellbrook local government area (LGA) in New South Wales (NSW) (see Figure 1.1).

MCC has a long history of mining in the Muswellbrook area, with underground operations commencing at MCM in 1907 and open cut operations commencing in 1944. Underground operations ceased in the late 1990s; however open cut mining continues. MCC has development consent from Muswellbrook Shire Council (MSC) to mine within the No. 1 Open Cut Extension Area (Open Cut 1) (Development Consent No. DA 205/2002, as modified), with operations to be completed by 2020.

Additional coal resources have been identified within a previously rehabilitated area adjacent to Open Cut 1. While this area is within the development consent boundary, a modification to the existing development consent is required to modify the conceptual mine plan to allow mining of these additional resources, as well as extending the approved mine life and modifying the conceptual final landform (the modification).

The modification would maximise the recovery of coal resources within ML 1562, ML 1304 and CCL 713 and would enable the recovery of approximately 4.2 million tonnes (Mt) of additional coal resources.

In summary the modification involves:

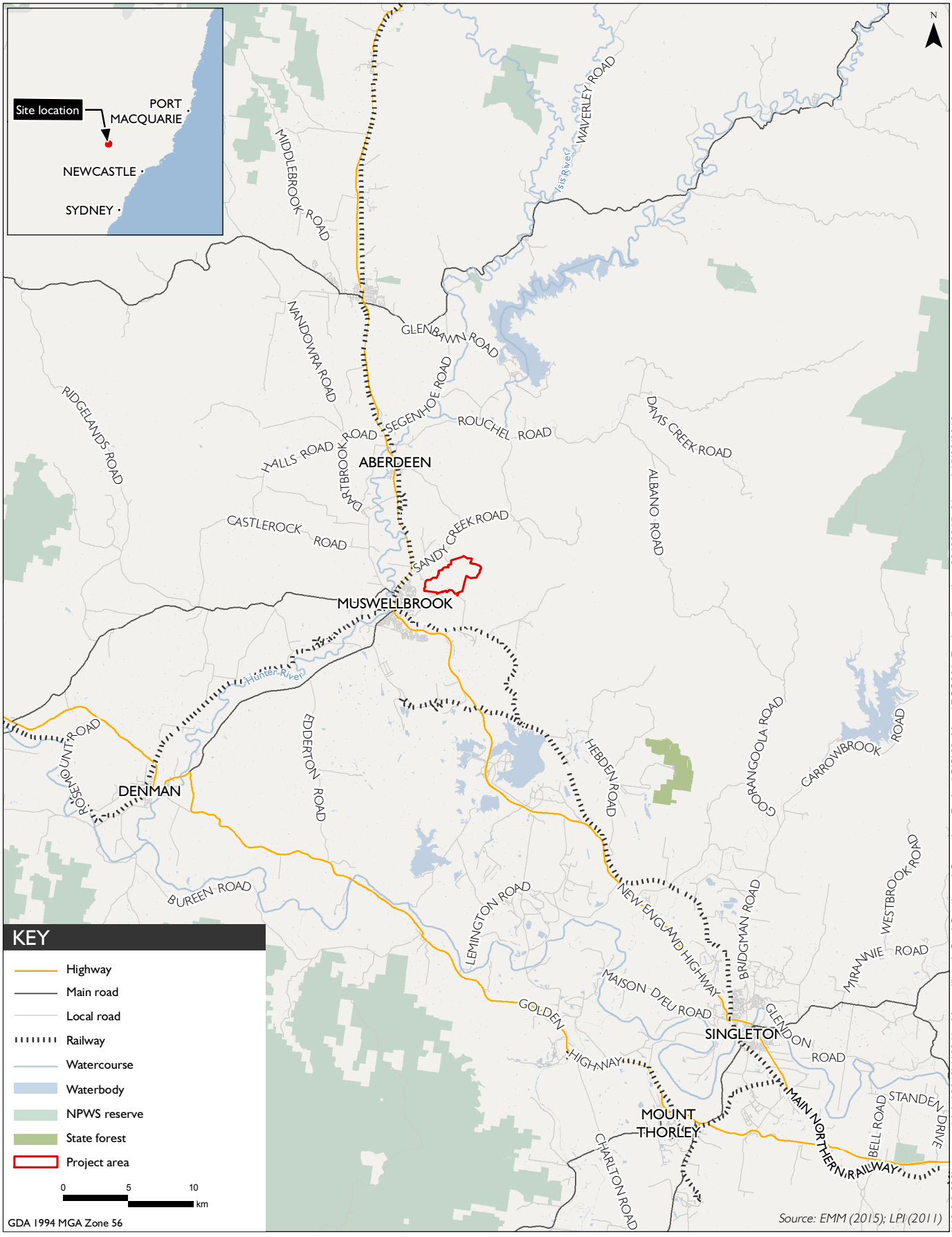
- extension of open cut mining operations in Open Cut 1;
- extension of the mine life, with operations to cease by the end of 2025;
- changes to the conceptual final landform within the modification area; and
- overburden emplacement in both Open Cut 1 and Open Cut 2, so as to achieve the conceptual final landform.

As the modification involves mining of a previously disturbed area that was used as an overburden dump, there would be no direct impact to previously undisturbed land.

No changes are proposed to the currently approved maximum production rate of 2 Mtpa, mining methods, coal processing, blasting methods, water management, waste management and handling, coal transport, access to site, employee numbers, hazardous substances and dangerous goods management and environmental management.

1.2 Approval process

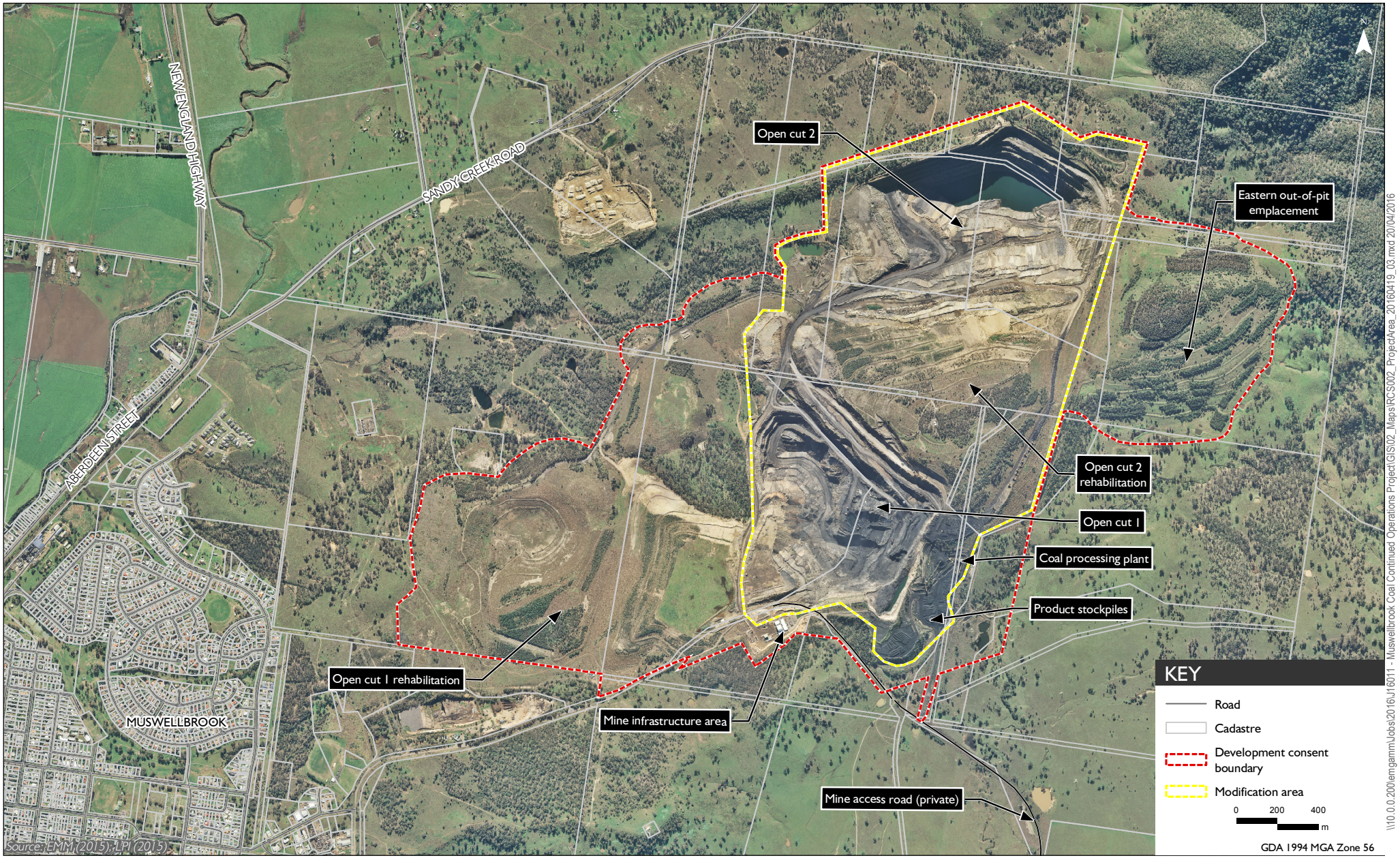
MSC requires the submission of a Statement of Environmental Effects (SEE) to support the application for modification of the existing consent (DA 205/2002) (the proposed modification) under section 96 (2) of the *Environmental Planning and Assessment Act 1979* (EP&A Act).



Regional setting

Muswellbrook Coal Continuation Project
Rehabilitation and Closure Strategy

Figure 1.1



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Modification area

Muswellbrook Coal Continued Operations Project
Rehabilitation and Closure Strategy
Figure 1.2

1.3 Relevant legislation, guidelines and standards

Relevant legislation, guidelines and standards which have guided the preparation of this rehabilitation and closure strategy are discussed in Chapter 3, and include:

- NSW *Mining Act 1992*;
- NSW *Protection of the Environment Operations Act 1997* (POEO Act);
- State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007 (Mining SEPP);
- *ESG3 – Mining Operations Plan (MOP) Guidelines* (NSW Department of Trade and Investment – Division of Resources and Energy 2013) (the MOP guidelines);
- *The Strategic Framework for Mine Closure* (ANZMEC and MCA 2000);
- *Leading Practice Sustainable Development Program for the Mining Industry* (Australian Government, 2011);
- *Guidance Paper - Financial Assurance for Mine Closure and Reclamation* (ICMM 2006);
- *Enduring Value: The Australian Minerals Industry Framework for Sustainable Development* (2004);
- *Synoptic Plan – Integrated Landscapes for Coal Mine Rehabilitation in the Hunter Valley of NSW* (Department of Mineral Resources 1999); and
- *Muswellbrook Shire Council – Land Use Development Strategy* (Muswellbrook Shire Council 2013).

The relevance of each of the guidelines is discussed in Section 3.1.

1.4 Purpose of this report

The purpose of this report is to prepare a conceptual rehabilitation and closure strategy that addresses the appropriate sections of the MOP guidelines, focussing on those sections of this guideline relevant to rehabilitation, closure and post mining land uses (ie section 3 to section 9 of the guideline).

This report has been prepared in recognition that the MOP will be updated in accordance with legislative requirements and changes under the modification, and submitted to DRE. It has also been prepared to address specific matters identified by Muswellbrook Shire Council (MSC) relating to rehabilitation and closure, in its letter dated 22 December 2015.

2 Current operations and proposed modification

2.1 Current operations

2.1.1 Mining

Mining operations are truck and excavator multi-seam coal mining within Open Cut 1. MCM has a maximum approved coal production rate of 2 Mtpa.

Mining involves removal of vegetation and stripping of topsoil, and if required, drilling and blasting overburden material. Overburden is removed using a fleet of excavators and trucks, and re-used as fill in mine voids. Once overburden is removed, coal is extracted from the exposed coal seams by excavator or front end loader (FEL), and transported by dump trucks to the run-of-mine (ROM) coal receival area.

ROM coal is crushed on-site at the coal crushing plant, after which the coal is sorted into high and low ash. High ash coal is washed in the coal preparation plant (CPP) prior to stockpiling, while low ash coal is stockpiled as product coal ready for transport.

Overburden emplacement is generally within Open Cut 1. Inert capping material is placed in Open Cut 2 where required for spontaneous combustion management and landform shaping.

2.1.2 Rehabilitation and final landform

Rehabilitation activities are generally undertaken on a progressive basis to achieve the approved rehabilitation objectives, final landform and final land use. Rehabilitation is undertaken in accordance with the approved Closure Mining Operation Plan (MOP).

There are three main areas of completed or partially completed rehabilitation at MCM:

- Open Cut 1 rehabilitation area, located in the western portion of the development consent boundary;
- Open Cut 2 rehabilitation area, a former overburden dump, located between Open Cut 1 and Open Cut 2; and
- the eastern emplacement, located in the north-eastern portion of the development consent boundary.

Rehabilitation activities are completed progressively, and include filling mined voids with overburden material, planting a combination of pasture and native trees so that vegetation is consistent with the local area, establishment of a vegetation corridor, weed control and rehabilitation monitoring. Rehabilitation aims to make the site compatible with the surrounding land, and have safe and stable final voids, in accordance with the approved MOP.

Muswellbrook coal mine has an obligation to undergo rehabilitation works during the life of the mine with time for completion after mining has ceased.

i Rehabilitation objectives

The objective of rehabilitation following mine closure at MCC is to establish a stable, self-sustaining landform of pasture and native woodland that fulfil designated land uses including sustainable grazing (pasture) and nature conservation (native vegetation). The rehabilitation framework includes:

- development of an integrated, free-draining final landform that is consistent with the principles of the *Synoptic Plan: Integrated Landscapes for Coal Mine Rehabilitation in the Hunter Valley of New South Wales* (Department of Mineral Resources 1999);
- represent what can be achieved using cost-effective rehabilitation procedures that reflect mining industry current best practice;
- reflect the composition of pre-mining communities and representative unmined reference sites;
- provide habitat for a range of fauna species;
- reflect the findings of on-site and other relevant research into the establishment of biodiversity and ecosystem function;
- be compatible with MCC's overall whole-of-lease land management approach and the Environmental Management Plans, which includes sustainable grazing on pasture areas, management of remnant bushland on the mining lease and the use of corridors to link remnant vegetation;
- take into account the views of the MCC Community Consultative Committee and other relevant stakeholders; and
- result in no measurable or no unacceptable off-site impacts, including the protection of water quality.

ii Conceptual final landform

The approved conceptual final landform comprises shaped areas of overburden with the majority of slopes less than 10 degrees, steeper in localised areas of up to 14 degrees, excluding the final void batters which are slopes of up to 18 degrees. The approved conceptual final landform is in Figure 2.1. The maximum heights of the approved conceptual landform are RL 340 m in the eastern emplacement and RL 310 m in the Open Cut 2 rehabilitation area.

The drainage pattern of the final landform would be designed to be compatible with the drainage of the surrounding area and would include permanent diversion drains and contour drains constructed progressively over the life of the mine.

iii Final voids

The approved conceptual final landform includes a total of three final voids. A memorandum of understanding (MoU) exists between MCC and MSC for the potential future use of the void in the Open Cut 1 rehabilitation area for waste management. The remaining two voids in Open Cut 1 and Open Cut 2 would fill with water and act as sinks as part of the final landform.

Management of the final voids is in accordance with a Final Void Management Plan (FVMP). The potential future uses considered for the final void in the current FVMP include:

- underground entry point to Sandy Creek Colliery reserves (from Open Cut 2) – while Sandy Creek Colliery is approved, there are no current plans to commence mining in this area at present;
- a waste management facility for MSC – an MoU is in place for the potential use of the void in the Open Cut 1 rehabilitation area;
- a regional waste management facility – there are currently no plans in place for this option; and
- a passive recreational facility – there are currently no plans in place for this option.

2.1.3 Final land use

The final land use includes a combination of approximately 50% pasture and 50% native trees, with a vegetation corridor between Bells Mountain and Skellatar Ridge. Final land use is discussed further in Chapter 4.

2.1.4 Spontaneous combustion

MCC mine the Greta Coal Measures (the coal seams), which include coal, carbonaceous shale (interburden) and overburden. The interburden and overburden are both considered reactive spoil. Incidences of spontaneous combustion have taken place over a number of years at MCM because of the reactive spoil, resulting in smoke and odour which in the past has created amenity issues for neighbours to the mine.

MCC has participated in research programs such as the Australian Coal Association Research Program (ACARP) Project 1609 (the research program) to identify the causes and develop control measures for spontaneous combustion. The research program found that the coal seams contain coal, carbonaceous shale including remnant coal and sulfide as pyrite (reactive overburden), which when exposed to oxygen oxidates in an exothermic reaction producing heat. Once hot enough, the reactive overburden spontaneously combusts. Further, because the spoil emplacement areas have historically been left uncovered rainfall infiltration has been found to move heat deeper into the spoil emplacement areas, acting as a catalyst resulting in wide spread heating and spontaneous combustion.

The research program identified four strategies to manage the risk of spontaneous combustion:

- reduce the overall fuel (carbon) content;
- selectively place and rapid burial of spoil with a high carbonaceous content and remnant coal;
- building spoil emplacement areas in low lifts 5 – 15 m to increase compaction from traffic resulting in a smaller air filled void space, noting that air is required for oxidation; and
- cover spoil emplacement area batters with non-reactive spoil and compact wherever possible.

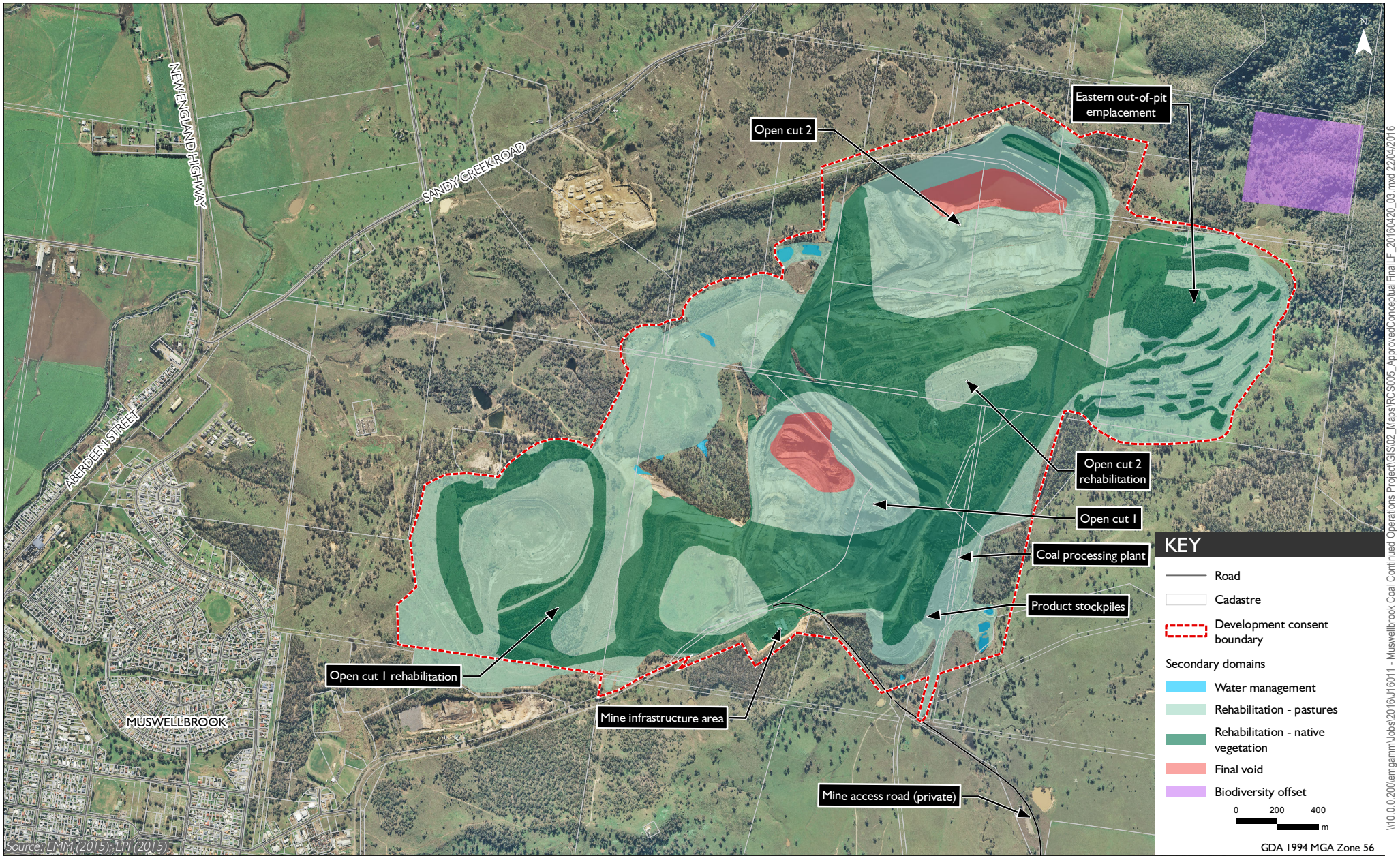
Spontaneous combustion at MCM has been noted in the spoil emplacement area on the western side of Open Cut 1, which has been encapsulated with 10 m of non reactive overburden to exclude oxygen and rainfall infiltration, and in the No. 2 underground roadway. MCC has reduced the potential for spontaneous combustion at the mine by using the following strategies during mining:

- removing fuel by mining the coal and using the coal washery to increase the recovery of carbon shale and remnant coal;
- cooling heated areas with water before mining (water infusion);
- minimising areas of coal exposed to the air prior to mining;
- retaining 5 m of non reactive overburden above workings to exclude oxygen from areas not immediately required for mining operations;
- sealing of decommissioned underground workings with clay or non reactive overburden to exclude oxygen;
- rapidly burying of reactive overburden to minimise the time that it is exposed to oxygen and rainfall infiltration;
- selective placement of reactive overburden so that it is in the lower portions of the spoil emplacement areas for deep burial (encapsulation) to exclude oxygen and rainfall infiltration; and
- limiting spoil emplacement area lifts, under normal conditions, to a height of 10 – 15 m to exclude oxygen and rainfall infiltration.

The management of spontaneous combustion specific to the modification is discussed in Section 2.2.3.

2.1.5 Decommissioning and mine closure

A decommissioning and demolition strategy will be developed for the site prior to closure and will include engaging structural engineers and appropriate technical experts with experience in demolition and the application of relevant Australian Standards and guidelines. A detailed investigation of all structures will be completed to determine the appropriate techniques, equipment required, and the sequence for decommissioning and removal required to execute the demolition activities safely.



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Conceptual final landform - approved

Muswellbrook Coal Continued Operations Project
Rehabilitation and Closure Strategy
Figure 2.1

2.2 Proposed modification

2.2.1 Mining

The modification would increase the approved extraction area in the Open Cut 1 by around 16.5 ha, an increase to the Open Cut 1 extension area of approximately 10%. The modification would also extend the life of mining operations by five years.

Mining operations in Open Cut 1 would general advance in a north-easterly direction from the existing Open Cut 1. The general sequencing of mining and progressive rehabilitation would be as follows (see Figures 2.2-2.7):

- Year 1 (indicatively 2017) – soil stripping and overburden removal would commence in a north-easterly direction. Overburden emplacement occurs in Open Cut 1 and 2.
- Year 2 (indicatively 2018) – mining progresses to the north-east. Overburden emplacement occurs in Open Cut 1 and 2.
- Year 3 (indicatively 2019) – mining progresses to the north. Overburden emplacement occurs in Open Cut 1 and 2. Rehabilitation is commenced in the south of the modification area.
- Year 4 (indicatively 2020) – mining progresses to the north. Overburden emplacement occurs in Open Cut 1 and 2. Rehabilitation progresses north in the south of the modification area.
- Year 5 (indicatively 2021) – mining progresses to the most northern point. Overburden emplacement occurs in Open Cut 1 and 2.

Overburden emplacement would continue sequentially in the void of Open Cut 1 and Open Cut 2. There are no changes to the approved minimum and maximum RL of overburden emplacement as a result of the modification. Consideration would be given to the carbonaceous content and likelihood of spontaneous combustion, which would continue to be managed in accordance with the MOP and Spontaneous Combustion Management Plan. Selective stockpiling of inert materials with no carbonaceous content would continue for use as cover material in the final voids to aid in the prevention of potential spontaneous combustion. The management of spontaneous combustion is discussed further in Section 2.2.3.

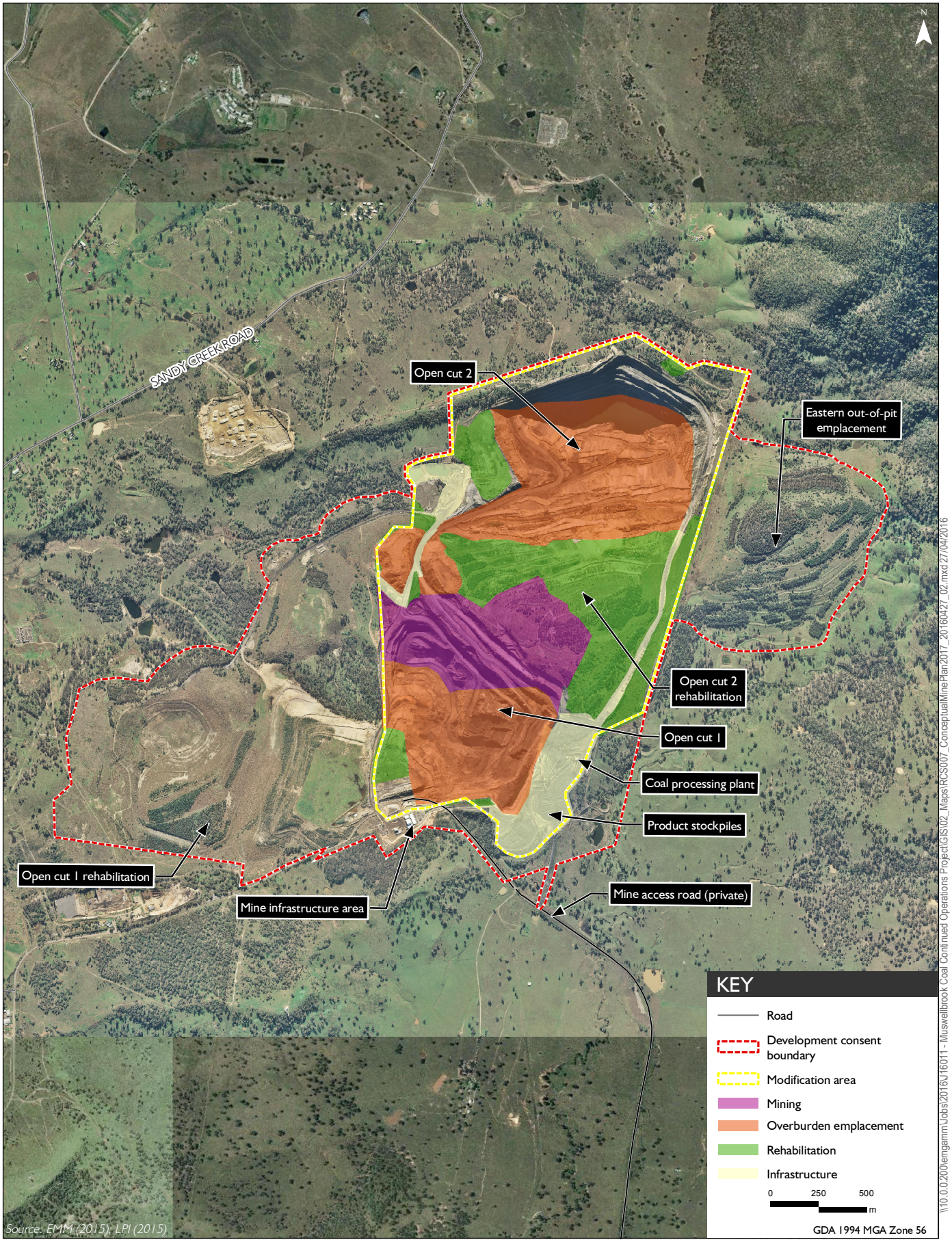
The modification will result in an extension of the mine life by five years, with completion of mining and rehabilitation activities by the end of 2025. Progress of rehabilitation post-mining is shown in Figure 2.7.

2.2.2 Rehabilitation and conceptual final landform

No changes to the approved rehabilitation objectives are proposed under the modification. There would also be no change to completed rehabilitation outside of the modification area.

The modification would disturb an area of partially completed rehabilitation (approximately 45.2 ha). The modification would also generate additional overburden to be shaped as part of the final landform.

There would be modest changes to the shape of the conceptual final landform in the modification area as a result of the changes to the conceptual mine plan; however there would be no changes to the maximum RL heights. The landform would be shaped such that it would form an integrated landform with the rest of the rehabilitation and final landform features in the development consent boundary. The proposed conceptual final landform is shown in Figure 2.8.



Conceptual mine plan - Year 1

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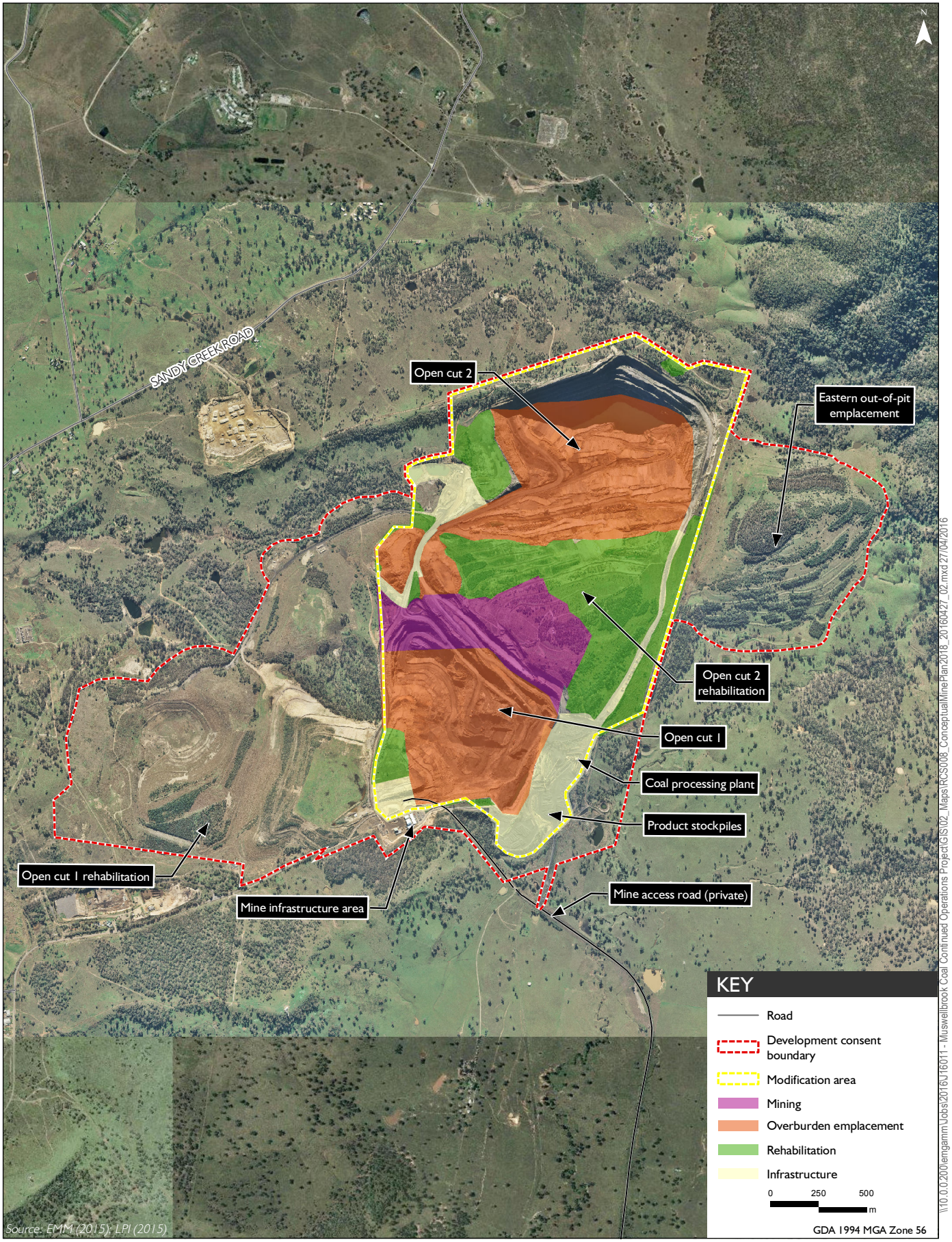
Rehabilitation and Closure Strategy
Figure 2.2



Conceptual mine plan - Year 2

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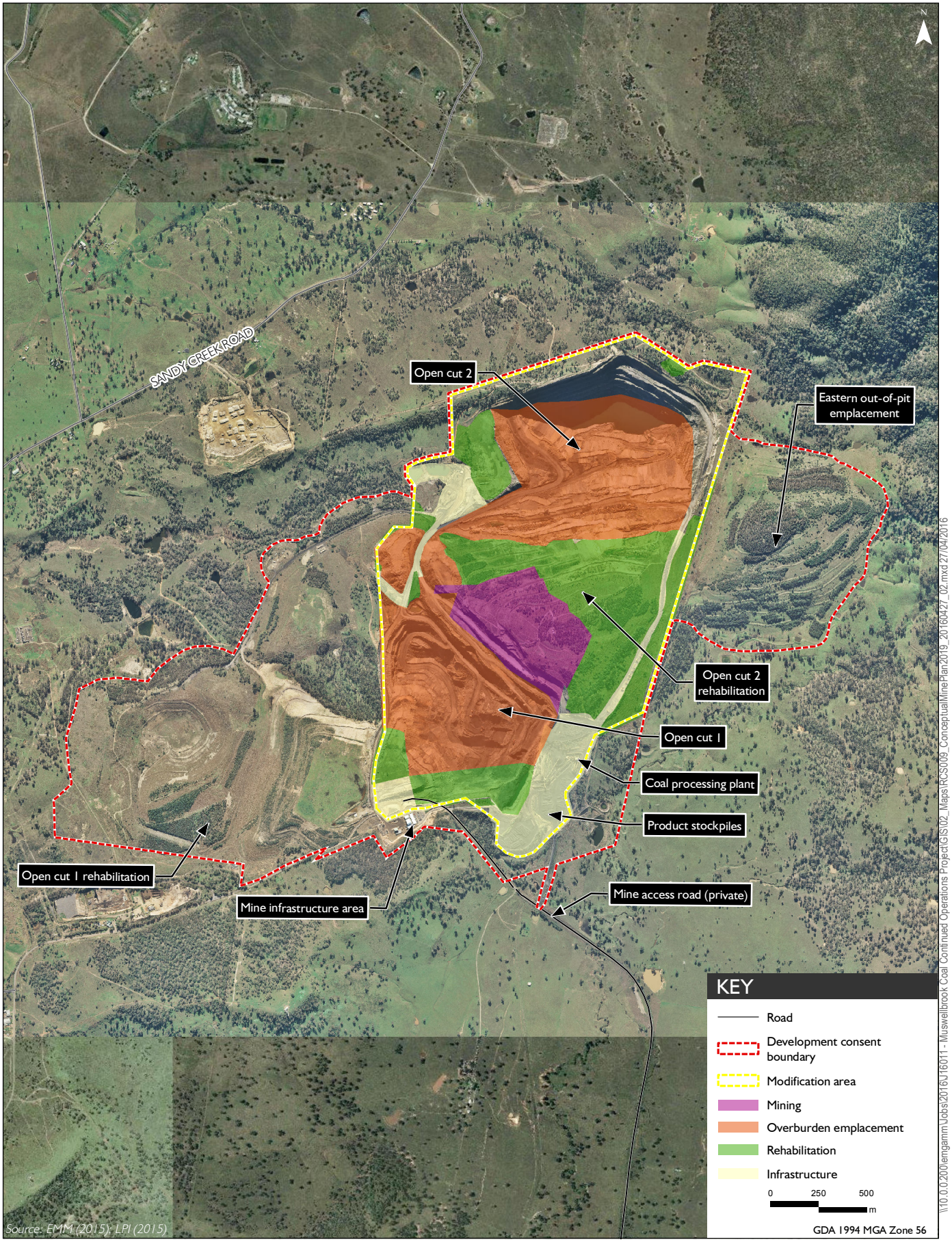
Rehabilitation and Closure Strategy
Figure 2.3



Conceptual mine plan - Year 3

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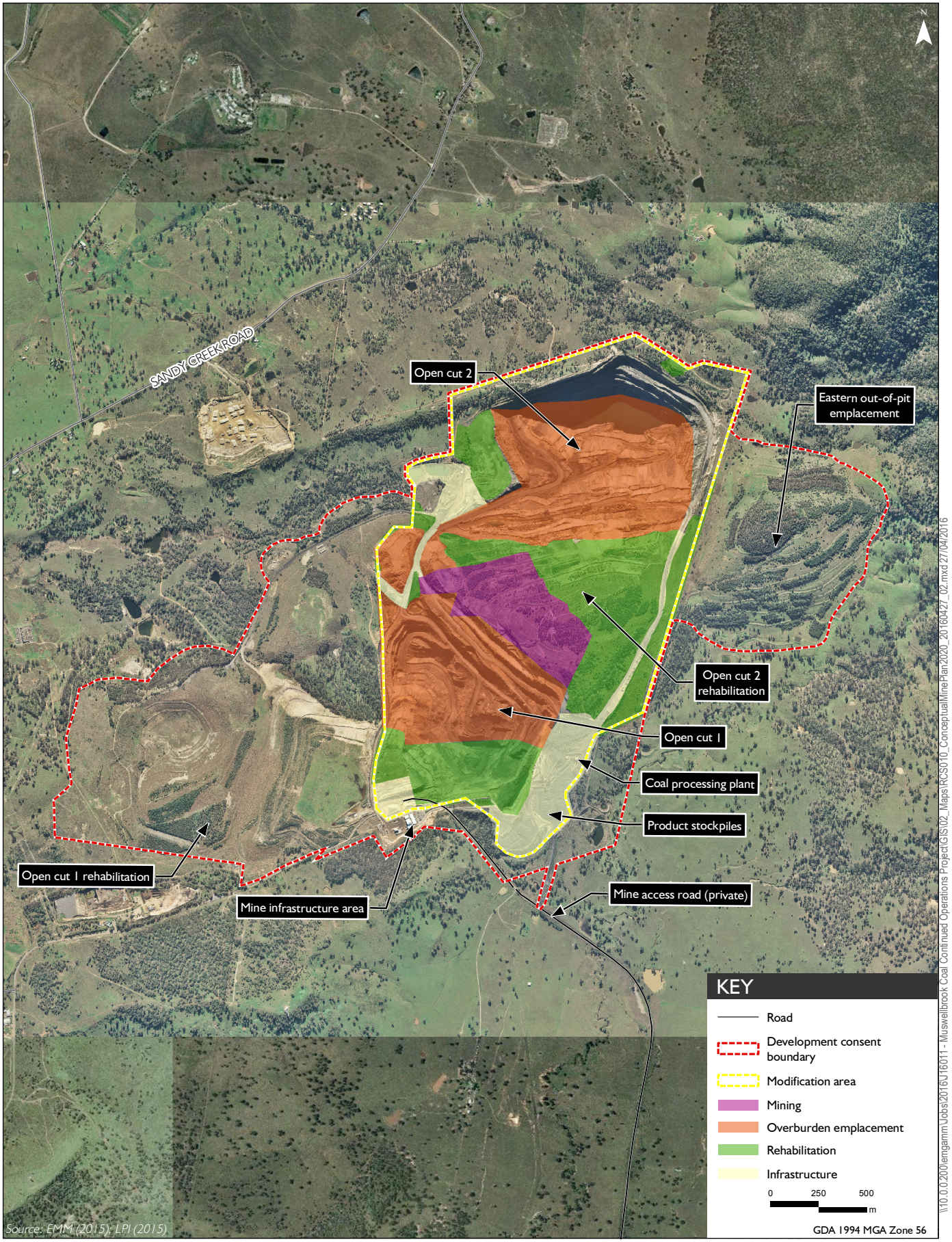
Rehabilitation and Closure Strategy
Figure 2.4



Conceptual mine plan - Year 4

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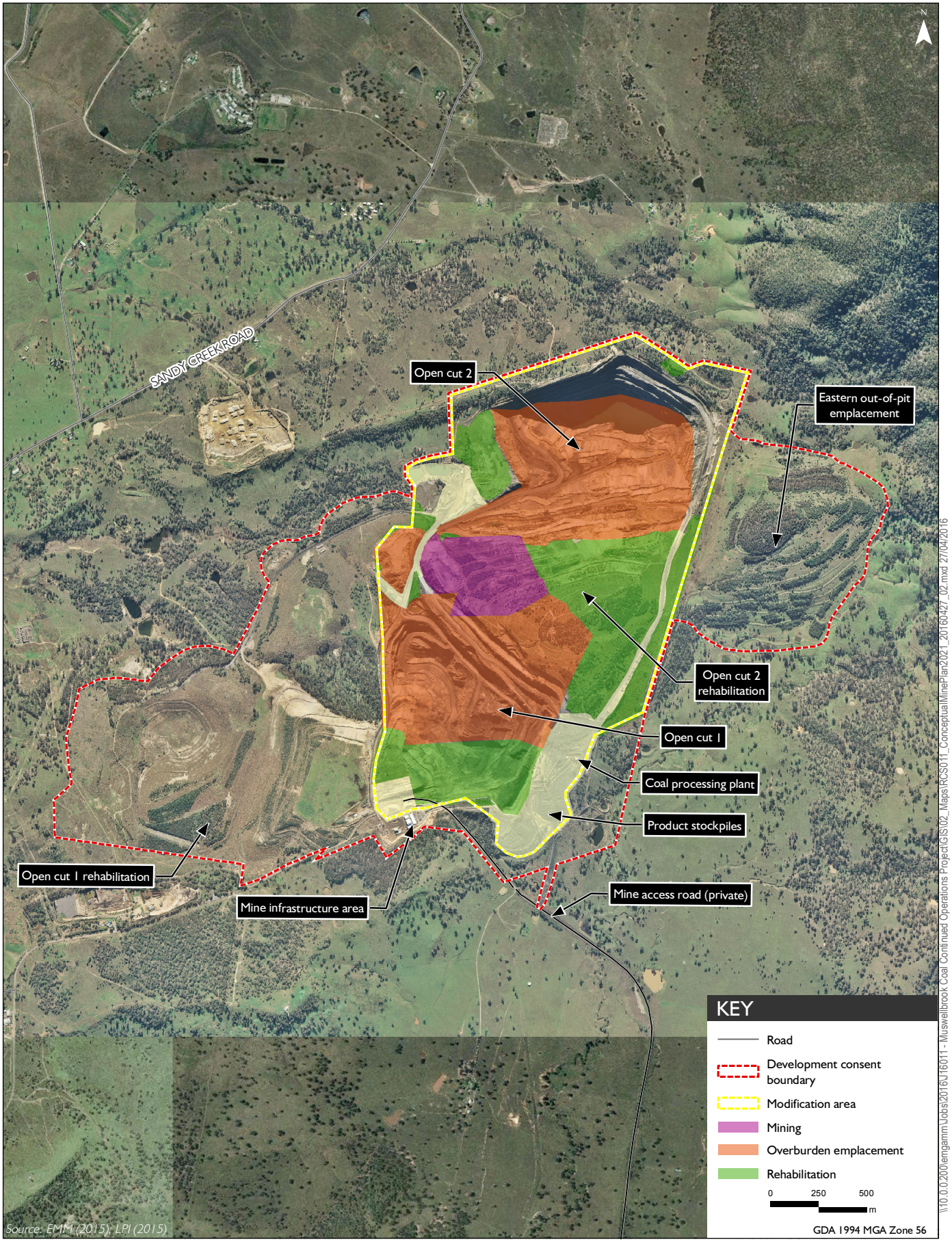
Rehabilitation and Closure Strategy
Figure 2.5



Conceptual mine plan - Year 5

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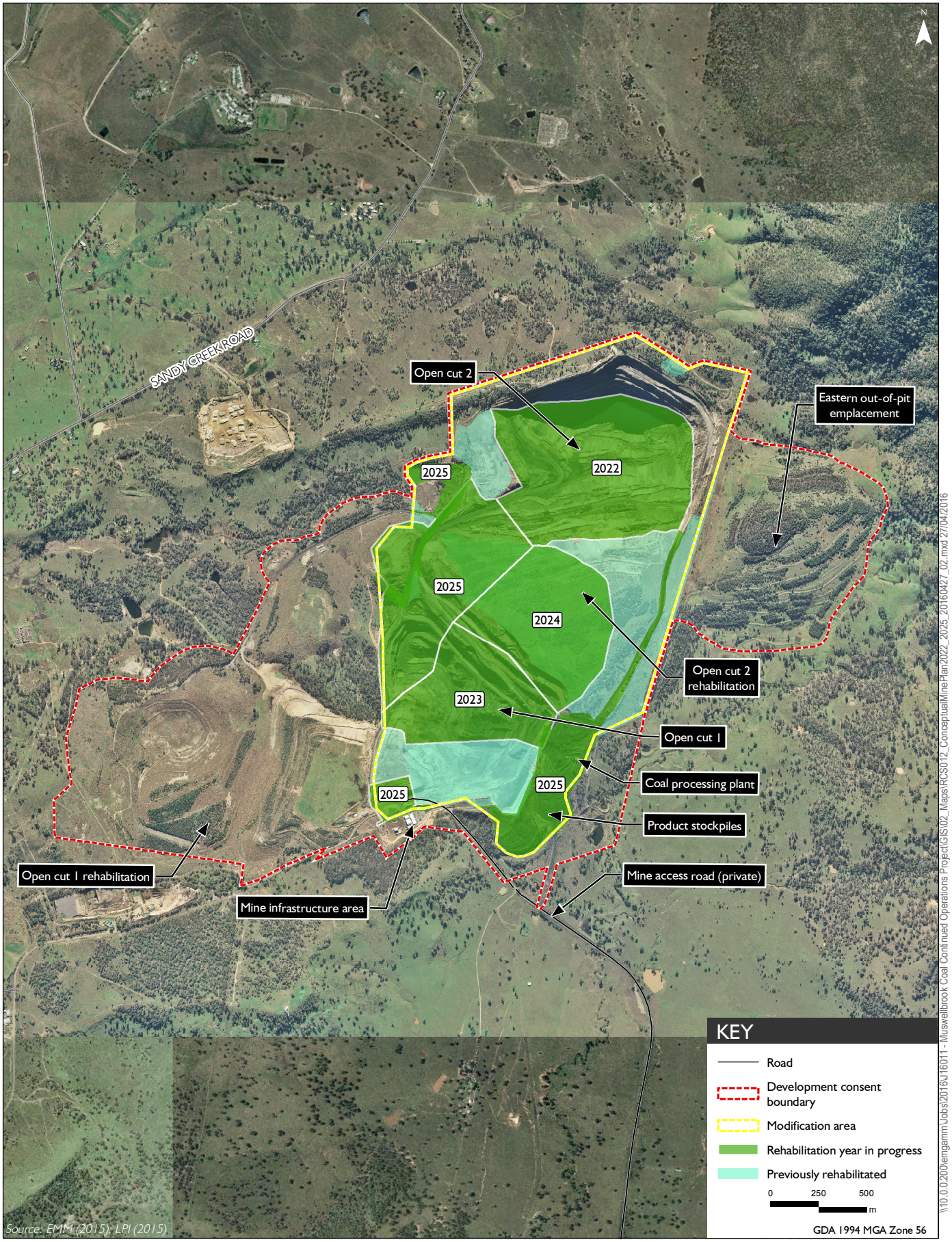
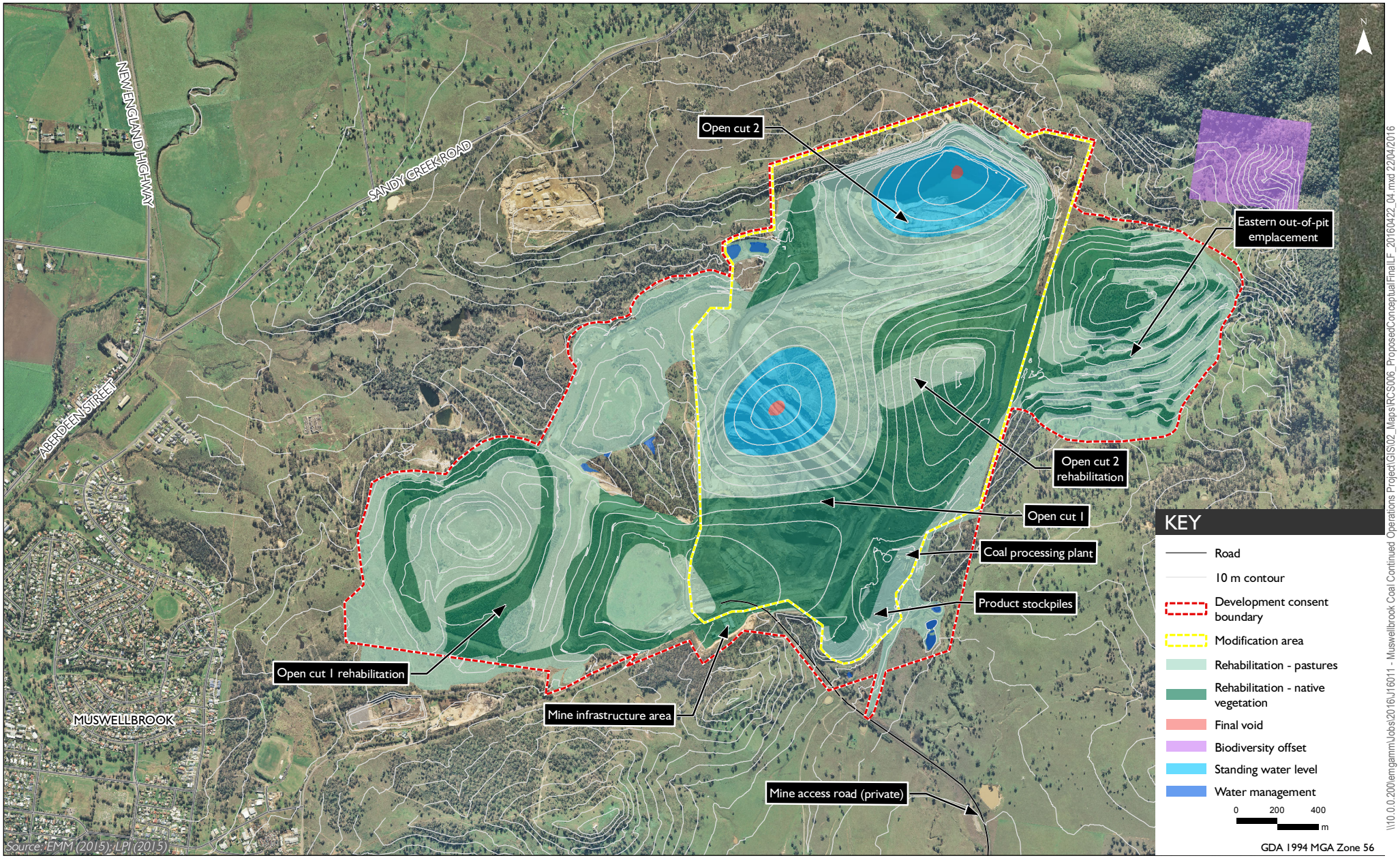
Rehabilitation and Closure Strategy
Figure 2.6



Conceptual mine plan - rehabilitation

Muswellbrook Coal Continued Operations Project
Rehabilitation and Closure Strategy
Figure 2.7



Conceptual final landform - proposed

Muswellbrook Coal Continued Operations Project
Rehabilitation and Closure Strategy
Figure 2.8

Rehabilitation will continue to be undertaken progressively, as soon as reasonably practicable, as shown in Figures 2.2 - 2. 7. This will reduce the amount of disturbed land at any one time and minimise the areas requiring water management. Results of progressive rehabilitation will continue to be used to refine rehabilitation methods for future application such as the selection of appropriate drainage measures and plant species for re-establishment.

The approved conceptual final landform includes three final voids as described in Section 2.1.2. The modification will not result in a change to the number of final voids. However, as part of the modification, changes are proposed to the bulk shaping of the final voids to reduce the size of the Open Cut 1 and Open Cut 2 voids compared to the approved conceptual final landform. The bulk shaping would also result in both voids having slopes of less than 14 degrees, compared to 18 degrees in the approved conceptual final landform.

Management of the final voids would continue to be in accordance with the FVMP. The changes to the final voids as a result of the modification may affect the potential future uses of the final voids, which would be reviewed as part of an updated to the FVMP, should approval be granted for the modification.

Final voids would be established as safe and stable for closure and would be designed to prevent the likelihood of spontaneous combustion in accordance with DRE guidelines.

The changes to the conceptual final landform would not result in changes to the approved final land use of the site, which is approved to include a combination of approximately 50% pasture and 50% native trees, with a vegetation corridor between Bells Mountain and Skellatar Ridge. Post mining land use, including options considered and additional detail on the development of the conceptual final landform, is discussed further in Chapter 4.

2.2.3 Spontaneous combustion management

The modification would enable progression of mining operations in Open Cut 1, and subsequently extend the life-of-mine. Construction of the spoil emplacement areas would continue sequentially in the void of Open Cut 1, as well as into Open Cut 2, with consideration given to reactive overburden identification, management and placement (using the management options described above in Section 2.1.4) to reduce the potential for future spontaneous combustion risk.

Reactive overburden would be identified during mining by:

- examining the surface for any physical effects of spontaneous combustion such as brown or dying vegetation and increased surface temperature;
- using infra-red photography, where appropriate, to show areas of increased temperature;
- measuring borehole temperatures; and
- measuring ground surface temperatures.

If an increased risk of spontaneous combustion is identified during the mining of the modification area, then it would be managed by the following addition management strategies to those already described for the current operation:

- any blast hole which shows signs of spontaneous combustion or is allowing air into areas of spontaneous combustion would be bagged off or backfilled;

- water infusion or water sprays would be used in accordance with the relevant safe work procedure;

- coal subject to active spontaneous combustion would be removed, and spread out on the ground surface to allow it to cool; and

- loose heaps of coal that are subject to spontaneous combustion would be spread out and compacted with a dozer and saturated with water from the water cart.

The modification would not disturb the western spoil emplacement area in Open Cut 1, and therefore would not increase the potential risk of spontaneous combustion being reactivated at this location. After rehabilitation, exposed coal and reactive overburden in Open Cuts 1 and 2 would be encapsulated by the final landform, which is to be formed by partially backfilling the voids and dozing the slope angle down to 14 degrees. Coal and reactive overburden would be encapsulated in the void walls by at least 10 m of non reactive overburden. In addition, the groundwater assessment for the modification (SLR 2016) confirmed that both Open Cut 1 and Open Cut 2 voids would act as groundwater sinks, and as such groundwater recharge in both voids would flood the base of the voids saturating exposed coal and reactive overburden in the walls of the void. Water saturation would remove oxygen thereby removing the potential for spontaneous combustion.

The risk of spontaneous combustion in the final landform would be further managed by:

- selective placement of reactive overburden so that it is in the lower portions of the spoil emplacement areas for deep burial (encapsulation) to exclude oxygen and rainfall infiltration, noting that some of the reactive overburden will be flooded by groundwater recharge into the void;

- limiting spoil emplacement area lifts, under normal conditions, to a height of 10 – 15 m to exclude oxygen and rainfall infiltration; and

- encapsulating reactive overburden and remnant coal in non reactive overburden.

During shaping of the final landform, the volume of inert material required to cover the carbonaceous material at the completion of mining is estimated to be 24.2 Mbcm. It is estimated that a surplus of inert material, in the order of 32.7 Mbcm, would be available. Therefore, there is sufficient inert material available for the final landform.

3 Regulatory framework

3.1 Regulatory requirements

The following section summarises the regulatory framework, standards and policies relevant to the closure of MCC.

3.1.1 Mining Act 1992

The *Mining Act 1992* regulates environmental protection, rehabilitation and closure conditions included in all mining leases. It specifies such matters as the demolition, removal and making safe of mine infrastructure, and requires the progressive rehabilitation of areas disturbed by mining, as well as the utilisation of a security deposit provision linked to a mine sites' MOP.

Furthermore, the mining lease is subject to a condition that the holder will not suspend mining operations in the mining area otherwise than in accordance with the written consent of the Minister. Such consent requires the documentation of a systematic and timely decommissioning, clean up and rehabilitation plan in the final MOP.

The mining leases that apply at MCC are outlined in Table 3.1 and illustrated on Figure 3.1.

Table 3.1 MCC mining leases

Lease	Authority	Validity periods
Consolidated Coal Lease (CCL) 713	DRE	5 May 1990 – 24 November 2024
Mining Lease (ML) 1304	DRE	12 January 1993 – 24 November 2024
Mining Lease 1562	DRE	16 February 2005 – 16 February 2026

Conditions within these mining leases that are relevant to mine closure are presented in Table 3.2.

Table 3.2 Rehabilitation and closure related mining lease conditions

Lease	Condition
Rehabilitation	
CCL713	Condition 7: Rehabilitation – disturbed land must be rehabilitated to a sustainable/agreed end land use to the satisfaction of the Director-General.
ML1304	Condition 2: Rehabilitation – any disturbance resulting from the activities carried out under this mining lease must be rehabilitated to the satisfaction of the Minister.

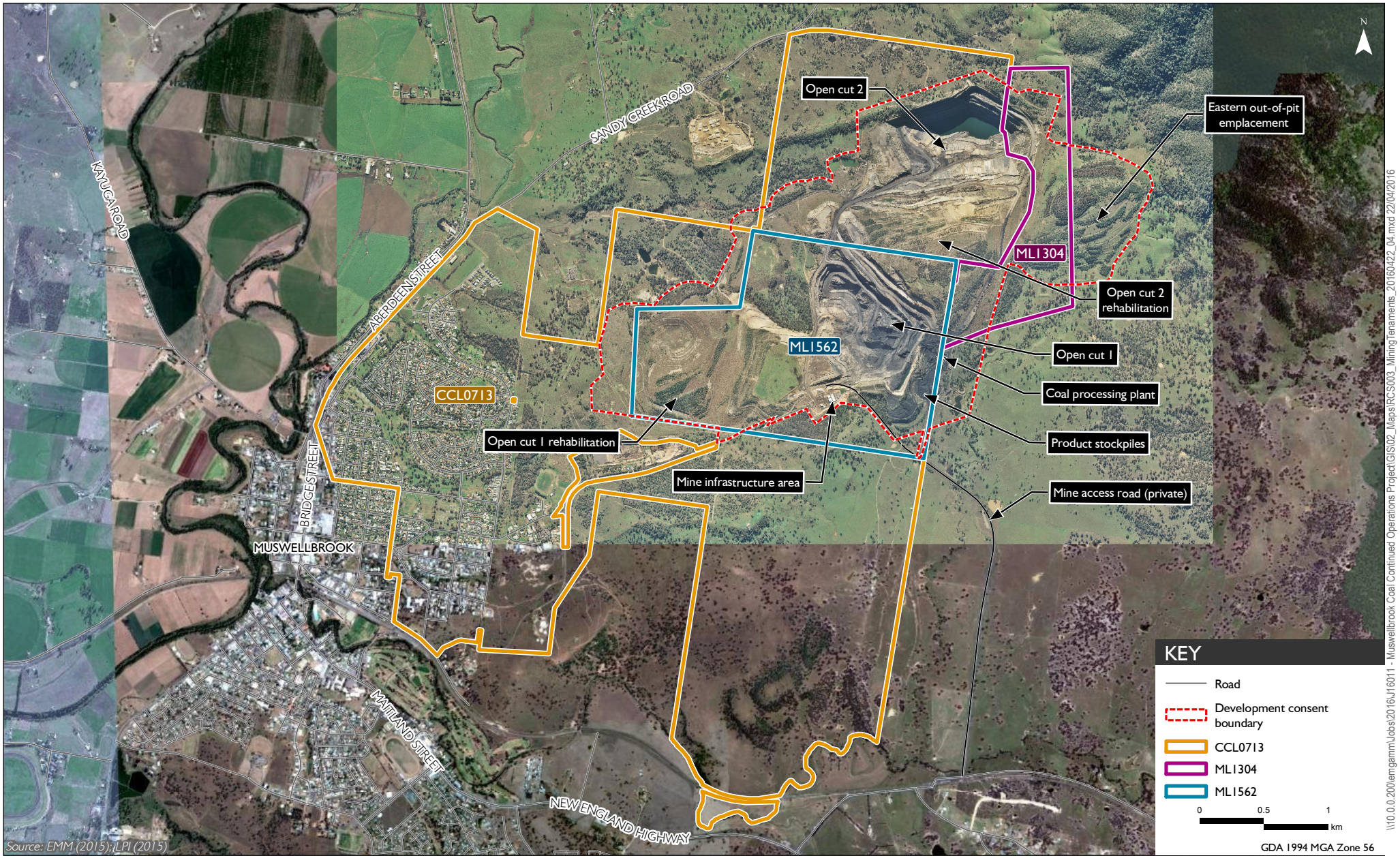
Table 3.2 Rehabilitation and closure related mining lease conditions

Lease	Condition
ML1562	Condition 13: Rehabilitation – Land disturbed must be rehabilitated to a stable and permanent form suitable for a subsequent land use acceptable to the Director General and in accordance with the Mining Operations Plan so that: There is no adverse environmental effect outside the disturbed area and that the land is properly drained and protected from soil erosion. The state of the land is compatible with the surrounding land and land use requirements. The landforms, soils, hydrology and flora require no greater maintenance than that in the surrounding land. In changes where revegetation is required and native vegetation has been removed or damaged, the original species must be re-established with close reference to the flora survey included in the Mining Operation Plan. If the original vegetation was not native, any re-established vegetation must be appropriate to the area at an acceptable density. The land does not pose a threat to public safety.
	Condition 14: The Lease holder must comply with a direction given by the Director General regarding the stabilisation and revegetation of any mine residues, tailings or overburden dumps situated on the lease area.
CCL 713	Condition 9: The lease holder must Ensure that at least 66 competent people are efficiently employed on the lease area on each week day except Sunday or any week day that is a public holiday, OR Expend on the operations carried out in the course of prospecting or mining the lease area, an amount of not less than $1,155,000 per annum whilst the lease is in force.
ML 1562	Condition 5: The lease holder must Ensure that at least 13 competent people are efficiently employed on the lease area on each week day except Sunday or any week day that is a public holiday, OR Expend on the operations carried out in the course of prospecting or mining the lease area, an amount of not less than $227,500 per annum whilst the lease is in force.
	NOTE: above two labour and expenditure requirements were aggregated in September 2006. (ML1562, ML1304, CCL713 AND ML1513 Sandy Creek - Aggregated 23 workers or $402,500). TOTAL 102 employees OR $1,785,000.

3.1.2 Environmental Planning and Assessment Act 1979

The *Environmental Planning and Assessment Act 1979* (EP&A Act) is the principal piece of legislation overseeing the assessment and determination of development proposals in NSW. Objectives of the EP&A Act include:

> (a) to encourage:
>
> (i) the proper management, development and conservation of natural and artificial resources, including agricultural land, natural areas, forests, minerals, water, cities, towns and villages for the purpose of promoting the social and economic welfare of the community and a better environment,
>
> (ii) the promotion and co-ordination of the orderly and economic use and development of land,
>
> (vi) the protection of the environment, including the protection and conservation of native animals and plants, including threatened species, populations and ecological communities, and their habitats, and
>
> (vii) ecological sustainable development ...



Mining tenaments

Muswellbrook Coal Continued Operations Project
Statement of Environmental Effects
Figure 3.1

MCC operates under a number of development consents issued by MSC. The primary consent is DA 205/2002, which was approved by MSC in 2003 for the operation of the No. 1 Open Cut extension. This DA has been modified on several occasions. MCC's planning approvals are summarised in Table 3.3.

Table 3.3 MCC development consents

Date	Development Consent Number	Consent
11 Aug 1982	Minister for Planning and Environment.	Surface facilities for the Underground Mine *(now decommissioned and removed).*
27 Mar 1972	DA 277 (MSC).	No.2 Open Cut.
16 Aug 1985	DA 721 (MSC).	Coal Washery as part of existing coal handling facilities.
13 Apr 1989	DA 18/88 (MSC).	Coal Haul Road and Road Haulage.
14 Oct 1992	DA 78/92 (MSC).	Eastern Area of No.2 Open Cut.
12 Apr 1999	DA 86/98 (MSC).	Approval for Sandy Creek Underground Mine.
1 Sep 2003	DA 205/2002 (MSC).	Approval for Extension of MCC No.1 Open Cut.
19 Dec 2005	DA 205/2002 (MSC) – Amendment to Condition 1.1.	Power line relocation and additions to Workshop.
13 July 2009	DA 205/2002 (MSC) Amendment to 1.1 and 11.3.	Relocate office buildings, workshop and bath-house.
23 Dec 2010	DA 205/2002 (MSC) Amendment to 11.1.	Extension of mining into Area C.
29 Oct 2013	DA 205/2002 (MSC) Amendment to 1.1(a), 31, 33, 39, 45 and 58.	Revision to Mining Infrastructure Building Requirements and Rehabilitation Plan Revision to permit the continuation of mining operations for an additional 5 years.
12 Dec 2013	DA 205/2002 (MSC) Amendment to 1.1, 1.2 & 6.3.2 and additional conditions 59 & 60.	Modification to Permit the Continuation of Mining Operations at Muswellbrook Coal Mine for an Additional Five (5) Years- Multiple Allotments- Coal Road Muswellbrook.

3.1.3 Protection of the Environment Operations Act 1997

The *Protection of the Environment Operations Act 1997* (POEO Act) establishes the State's environmental regulatory framework and includes licensing requirements for certain activities. The objectives of the POEO Act that relate to decommissioning and rehabilitation include protecting, restoring and enhancing the environment, reducing risks to human health and prevention of degradation of the environment.

MCC operates under Environment Protection Licence (EPL) 656, issued by the EPA under the POEO Act. Upon cessation of mining and completion of rehabilitation activities, the EPA would need to be satisfied that there is no offsite pollution from the site before the EPL could be surrendered. An application to surrender the licence would therefore need to be supported by sufficient environmental monitoring data providing supporting evidence of a stable, non-polluting rehabilitated site.

3.1.4 State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007

State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007 (Mining SEPP) aims to provide for the proper management and development of mineral, petroleum and extractive material resources for the social and economic welfare of NSW. The SEPP provides that development for the purpose of mining may be carried out with development consent, and defines mining developments that are prohibited, exempt or complying development. Exempt development listed under the Mining SEPP, which specifically relates to the decommissioning process, includes the demolition of a building or structure that is carried out in accordance with Australian Standard AS2601-2001, Demolition of Structures, but only if the building or structure is not a heritage item or in a heritage conservation area and the demolition takes place on an approved mine site and is of minimal environmental impact.

3.1.5 Polices and Guidelines

i Mining Operations Plan Guidelines

The MOP guidelines provide an overview of the approval process for mining developments in NSW, and provide content and formatting requirements for MOPs and Annual Reviews. The purpose of these documents is to *"ensure that all mining operations are safe, the resources are efficiently extracted, the environment is protected and rehabilitation achieves a stable and satisfactory outcome"*. Specifically, the MOP must meet the content and format as set out in the MOP guidelines as well as:

- be consistent with any development consent requirements;
- be consistent with safety management plans;
- be based on objectives and outcomes developed with stakeholder involvement;
- provide sufficient detail, supported by scientific and engineering assessment and/or peer review where appropriate, to clearly demonstrate that the objectives and outcomes defined in the MOP will be met; and
- where necessary, contain an environmental assessment of any impacts associated with the implementation of the MOP, where the activities have not been previously assessed under the EP&A Act.

As noted in the MOP guidelines, a MOP is intended to fulfil the function of both a rehabilitation plan and a mine closure plan. A MOP also forms the basis for the estimation of the security deposit imposed to ensure compliance with conditions of authorisation granted under the *Mining Act 1992.* This estimation of costs will be presented in the MOP.

This rehabilitation and closure strategy has been prepared to address the various requirements of the closure and rehabilitation aspects of MOP requirements. An updated MOP will be prepared and submitted to DRE following approval of the modification. An approved MOP must be in place prior to commencing any significant surface disturbing activities associated with the modification.

ii Strategic Framework for Mine Closure, Minerals Council of Australia

The Strategic Framework for Mine Closure has evolved as a cooperative development between the Australian and New Zealand Minerals and Energy Council (ANZMEC) and the Australian Minerals Industry (represented by the Minerals Council of Australia (MCA)). It is designed to provide a broadly consistent framework for mine closure across various Australian jurisdictions.

The objective of the Strategic Framework for Mine Closure is to encourage the development of comprehensive closure plans that return all mine sites to viable, and whenever practicable, self-sustaining ecosystems, and that these plans are adequately financed, implemented and monitored within all jurisdictions.

The Strategic Framework for Mine Closure is structure around a set of objectives and principles under six key areas:

- stakeholder engagement - to enable all stakeholders to have their interests considered during the mine closure process;
- planning - to ensure the process of closure occurs in an orderly, cost effective and timely manner;
- financial provisioning - to ensure the cost of closure is adequately represented in company accounts and that the community is not left with a liability;
- implementation - to ensure there is clear accountability, and adequate resources, for the implementation of the closure plan;
- standards - to establish a set of indicators which will demonstrate the successful completion of the closure process; and
- relinquishment - to reach a point where the company has met agreed completion criteria to the satisfaction of the responsible authority.

i. Mine Rehabilitation – Leading Practice Sustainable Development Program for the Mining Industry

The aim of the MR Handbook is to provide guidelines to promote 'leading practice' sustainable mine plan and rehabilitation design, considering environmental, economic, and social aspects to support on-going sustainability of a mining development. The MR Handbook recommends procedures and mitigation measures that should be considered during mine plan and rehabilitation design, including stakeholder consultation, material and handling, water balance, final landform design, top soil management, vegetation and fauna habitat re-establishment and rehabilitation, and agriculture/commercial forestry suitability. The MR Handbook also provides relevant mine development case studies supporting the recommended procedures and mitigation measures. Where relevant to the MCM, the above principals have been addressed in this closure and rehabilitation strategy.

iii Mine Closure and Completion - Leading Practice Sustainable Development Program for the Mining Industry

The aim of the Mine Closure and Completion Handbook is to provide guidelines to promote 'leading practice' sustainable mine closure and completion, minimising any long-term environmental, economic, and social impacts and resulting in a suitable final land form for an agreed land use. Specifically, the Mine Closure and Completion Handbook provides that a progressive rehabilitation plan, which is a key principle of this closure and rehabilitation strategy, should be developed for mine closure.

iv Guidance Paper - Financial Assurance for Mine Closure and Reclamation (ICMM 2006)

This document has been prepared by the International Council of Mining and Metals (ICMM) and considers environmental financial assurance measures. It looks at issues and current policies in the use of financial assurances through the industry; analysing trends that were revealed through a survey of the industry, governments and financial institutions.

Environmental financial assurance for mine closure ensures that funds are available for decommissioning and reclamation of a site if an operator does not fulfil its obligations. It provides confidence to both governments and communities that satisfactory closure will be achieved.

This document provides guidance on environmental financial assurance for both operators and regulators, and covers the following areas:

- the case for financial assurance;
- key issues associated with the application of financial assurance policies; and
- recommendations for improving standards of practice relating to financial assurance.

v Leading Practice Sustainable Development Program for the Mining Industry (Australian Government, 2011)

This guideline consolidates a series of handbooks relevant to all stages of a mine's life – exploration, feasibility, design, construction, operation, closure and rehabilitation. The aim of this guideline is to identify key issues affecting sustainable development in the mining industry, and provide information and case studies to enable a more sustainable basis for its operation.

vi Enduring Value: The Australian Minerals Industry Framework for Sustainable Development (2004)

Australia's minerals industry has adopted Enduring Value, the Australian Minerals Industry Framework for Sustainable Development. It is the centre piece of the Australian mining industry's commitment to achieving continual improvement in its environmental, social and economic performance, accountability, and ensuring that it operates in a manner that is attuned to community expectations.

The framework commits to excellence in sustainable development performance through the implementation of the following principles and their related elements:

- Implement and maintain ethical business practices and sound systems of corporate governance.
- Integrate sustainable development considerations within the corporate decision-making process.
- Uphold fundamental human rights and respect cultures, customs and values in dealings with employees and others who are affected by mining activities.
- Implement risk management strategies based on valid data and sound science.
- Seek continual improvement of health and safety performance.
- Seek continual improvement of environmental performance.
- Contribute to conservation of biodiversity and integrated approaches to land use planning.
- Facilitate and encourage responsible product design, use, reuse, recycling and disposal of products.
- Contribute to the social, economic and institutional development of the communities in which mines operates.
- Implement effective and transparent engagement, communication and independently verified reporting arrangements with stakeholders.

vii NSW Trade and Investment (Resources and Energy) Guidelines

DRE has a series of policy guidelines or environmental management guidelines that are either directly or indirectly relevant to mine closure issues. Closure related works will need to be undertaken in accordance with these guidelines, which include:

- Guideline ESG3 – Mining Operations Plan (MOP) Guidelines (DRE, September, 2013) (addressed in this section);
- Policy EDP11– Rehabilitation Security Deposits Policy (DRE, 2012);
- ESB26 – Rehabilitation Cost Calculation Tool V1.12 (Excel Spreadsheet Tool used to calculate mine security deposits) (DRE);
- Guideline ESB26A – Division of Resources and Energy – Schedule of Rehabilitation Costs V1.12; and
- ESG1 Rehabilitation Cost Estimate Guidelines (Industry and Investment NSW, 2010).

viii Synoptic Plan – Integrated Landscapes for Coal Mine Rehabilitation in the Hunter Valley of NSW

The Hunter Valley Synoptic Plan (Department of Mineral Resources 1999) is a strategic document that looks at the progressive integration of mining and natural landscapes across the upper Hunter Valley. It looks to achieve visual amenity, biodiversity conservation and integrated land management practices for Ecological Sustainable Development (ESD). Further to that described above, the Synoptic Plan includes a specific paper by Greg Summerhayes (1999) titled *"The Rehabilitation of Coal Mines and Opportunities for Integrated Post Mining Land Uses".*

The fundamental principles outlined in these documents have been considered in the rehabilitation planning undertaken by MCC, and in the development of this Mine Closure Strategy. Specifically, MCC intends to link existing remnant vegetation in the Bells Mountain and Skellatar Ridge areas north and south of the mine site by planting corridors of native vegetation across the site, creating a viable wildlife corridor, as illustrated on the approved conceptual final landform (Figure 2.1). Sections of the corridor are currently in place across Open Cut 2 and infill tree plantings will be conducted to complete a continuous corridor. Rehabilitation planning for the Open Cut 1 includes the incorporation of native vegetation areas to continue the corridor from the Open Cut 2.

ix Muswellbrook Shire Council – Land Use Development Strategy (Coal Mining Land Use Strategy)

MSC's Land Use Development Strategy (LUDS) (MSC 2013) is an overarching internal policy framework to guide the long term strategic direction of the Shire in terms of land use and development. This document includes a Coal Mining Land Use Strategy, which sets six strategic objectives for coal mining activities with particular emphasis on the rehabilitation of land. In particular the policy requires that the use of land for coal mining purposes should not fetter the future use of land for more sustainable purposes and that mined land is rehabilitated to a satisfactory standard for future use. In addition, intensification of existing and approved mining activities (such as at MCM) are favoured over an increase in the footprint of mining activities.

Some of the key aspects of the Coal Mining Land Use Strategy which are of particular relevance to closure planning at MCC are as follows:

- The policy requires that 70% of the disturbed area across a mine site be returned to high density tree plantings. High density tree plantings may include open woodland to closed forest as may be suitable for biodiversity conservation land use.
- Rehabilitation strategies and/or management plans must allow for the development of best practice techniques and encourage trials of the rehabilitation techniques to investigate:
    - geomorphology;
    - soil ameliorants;
    - vegetation community establishment; and
    - run-off controls.
- Modified slopes facing the township of Muswellbrook must be regenerated to 100% woody vegetation at the first reasonably practicable opportunity.
- Council will not support any proposal that contemplates a final void unless:

- it is proposed for ongoing mining;

- it is in the vicinity of a main road and can be set aside for use as waste landfill (accompanied by a supportive economic and infrastructure assessment); or

- the proposed void will remain filled with water. Any such void must have adequate freeboard so as not to require a spillway considering catchment area, rainfall, runoff factor, evaporation and seepage rates.

The rehabilitation strategy developed for MCC is considered to be consistent with the strategic directions set out in the MSC LUDS, particularly as it focuses on the establishment of native habitat and woodland corridor areas which link with the surrounding vegetation in the Bells Mountain and Skellatar Ridge areas. In addition the options for the final voids are consistent with those listed in the LUDS. In particular, the groundwater assessment prepared for the modification (SLR 2016) found that there would be adequate freeboard in the voids in Open Cut 1 and 2 that would remain as sinks in the post mining landform (refer to Section 4.5).

4 Conceptual final landform and post mining land use

4.1 Rehabilitation objectives

The rehabilitation objectives at MCM are considered in Section 2.2. No changes to rehabilitation objectives are proposed under the modification.

4.2 Reshaped landform

Several landform options were considered in the project planning phase of the modification, with the final landform being the key driver in determining the conceptual mine plan, overburden emplacement schedule and the sequencing of mine progression.

The objectives considered in determining the final landform included:

- achieving acceptable slopes in both Open Cut 1 and Open Cut 2 (ie less than 18 degrees);
- minimising the haulage distance of overburden;
- minimising the amount of bulk shaping required after the cessation of coal extraction; and
- minimising the size and depth of the voids remaining at the end of mine life.

To achieve these objectives, four final landform options were considered, as described below. After consideration of all four options, Option 3 was determined to be the most favourable on the basis that it would result in slopes of less than 14 degrees in both open cuts, and would leave smaller voids than the other options considered, in accordance with the requirements of MSC (refer Table 1.1).

i Option 1 – Economic option

This option was considered as it would be the most economic option for MCC, involving the shortest haul routes for overburden emplacement. The majority of overburden under this scenario would be emplaced in Open Cut 2, resulting in the smallest void in Open Cut 2 of the four options considered. However, this would mean a large void remaining in Open Cut 1, with this void comprising slopes of greater than 20 degrees. Despite the economic benefits of this option, it was considered unacceptable due to this steep final slope in Open Cut 1.

ii Option 2 – Open Cut 2 at 10 degrees

This option was based on achieving an optimal final slope of 10 degrees in Open Cut 2. As per option 1, this would also result in a large void remaining in Open Cut 1 with final slopes once again greater than 20 degrees. This option would also require significant bulk shaping of 13 million bank cubic metres (Mbcm) at the end of coal extraction.

iii Option 3 – Open Cut 2 at 14 degrees

This is the option proposed under the modification, and would enable slopes of less than 14 degrees to be achieved in both Open Cut 1 and 2, resulting in smaller voids in both open cuts. This option has the disadvantage of requiring bulk shaping of 14 Mbcm at the cessation of mining to achieve the 14 degree final slope in Open Cut 1 (compared with 9.5 Mbcm to achieve a slope of 18 degrees).

The proposed conceptual final landform has been modified from the approved landform such that all slopes, including final void batters, will be equal to or less than 14 degrees, except for the highwall in Open Cut 2, which would be up to 50 degrees.

Rehabilitation will continue to be undertaken progressively, as soon as reasonably practicable. This will reduce the amount of land disturbed at any one time and minimise the areas requiring water management. Notwithstanding, opportunities for progressive rehabilitation with the modification area will be reasonably limited, as described below.

As mining operations progress north, some of the overburden will be hauled to Open Cut 2 for emplacement, and the remainder to Open Cut 1. As mining operations move north in Open Cut 1, small areas will become available for rehabilitation on the southern end of the overburden dump. However, the available areas will be limited due to the inert material having to be stockpiled at the top of the dumps to be bulk pushed over the carbonaceous material that will be emplaced in the pit at the end of active mining, in approximately year 4 of the modification.

The remaining overburden material to be disposed of will be hauled to Open Cut 2, with the last of the required material dumped into the pit in year 4 after which bulk pushing for rehabilitation can commence.

Where possible, results of progressive rehabilitation will continue to be used to refine rehabilitation methods for future application such as the selection of appropriate drainage measures and plant species for re-establishment.

iv Option 4 – Open Cut 2 at 18 degrees

The final option considered would result in the smallest void in Open Cut 1 compared with the other options considered; however would leave a steep slope of 18 degrees into Open Cut 2. It would also result in an increased height of the Open Cut 1 overburden emplacement of greater than RL 264m.

4.3 Drainage and micro relief

The final landform will be internally draining since it is lower than the original landform. The drainage pattern of the final landform will be designed to be compatible with the drainage of the surrounding area. It will include permanent diversion drains and contour drains constructed over the life of the mine (where possible) and at the completion of coal extraction.

MCC will seek to enhance the final landform at the mine by designing the landform so that it is in sympathy to the adjoining natural landscape. The final landform will be hydrologically, geomorphically and visually compatible with the surrounding topography. Nature provides analogues landscapes for landforms in terms of hill slope forms and gradients. In nature, hill slopes have a convex upper profile with a concave profile lower down slope. Therefore, where practical concave slopes (microrelief) for the landform will be adopted.

While it is recognised that conventional landforms (ie straight slopes with bench and drop drains) can reduce erosive potential, very few straight slopes with benches are observed in nature. In landscapes it is well understood that linear slopes will erode to microrelief profiles over time, thus increasing the sediment loss of the profile until a stable microrelief has been achieved. Also, over the long term, benches are prone to failure, and once failure has occurred they channel water in concentrated flow paths, leading to severe gullying (Gyasi-Agyei and Willgoose 1996).

Where possible, the final landform will be designed to take advantage of microrelief to better mimic natural flow patterns and integrate the final landform with the surrounding topography. While an attempt has been made to incorporate the principles of microrelief into the drainage design in and around the final voids, the volume of overburden material to be emplaced within the modification area and the resulting overall shape of the voids limits the potential for microrelief and as such, traditional drainage control structures will be required to safely convey runoff over the final landform.

Based on the principles of the Blue Book (Landcom, 2004), disturbed landforms require benching (in the form of contour drains) and drop structures to safely convey runoff and reduce the potential for erosion (rilling and gullying) to develop. Based on previous experience in final landform design, due to the slope and length of the batters in the final landform a series of contour banks and drop structures will be essential within the final voids and on surrounding surfaces to safely convey runoff over the land surface and into the relevant water management dams.

The final landform will have maximum slope gradients of up to 14 degrees within the final shaped voids with slope lengths of between 200 – 700m from the void crest to the base of the void. It is noted that the lower portion of the voids will fill with water over time (as discussed in Section 4.5) and, as such, the slope lengths will be reduced to a maximum length of approximately 600m.

Based on the principles of the Blue Book, benching (contour banks) would be required at a spacing of 60 – 100m (depending upon the slope gradient) within the voids to safely convey runoff down the slopes. Subsequently, drop structures will also be required to convey concentrated flow captured by these contour banks into the base of the final voids. Without such drainage control structures, it is expected that rilling and gullying would occur on the landform which would destabilise the soils and reduce the overall effectiveness of rehabilitation.

4.4 Cover

No changes to the type cover for the final landform are proposed under the modification, which would be a combination of pasture and native vegetation. There would be some changes to the distribution of pasture and native vegetation species based on changes to the shape of the final landform; however, it would generally be consistent with the approved final landform.

Revegetation would continue to be undertaken consistent with current practices at the mine. Where possible, exposed areas are covered with up to 0.1 m of soil and seeded, with maintenance done as required. Erosion and sediment control measures will be implemented if required.

Selected grass and tree species (see Section 5.3.4) will be supported by soil conditions and will be consistent with the final land use. Agreed completion criteria for revegetated pasture and native vegetation are presented in Chapter 6.

4.5 Final voids

As part of the modification, changes are proposed to the bulk shaping of the final voids in Open Cut 1 and Open Cut 2, which would result in the two voids being smaller than the approved conceptual final landform. In order to facilitate the widest possible range of options for future land use of the approved open cut mining operation and the modification, the preferred rehabilitation strategy is to maximise backfilling of the voids during operation which will improve the land and soil capability post rehabilitation.

The conceptual final landform would involve the backfilling and reshaping of around 14 Mbcm which will result in smaller residual voids and lower slope angles than the approved final landform. The slope angles within the rehabilitated voids in Open Cut 1 and 2 will not exceed 14 degrees from the crest of the slope to the floor of the backfilled void. This represents a decrease in the overall slope of these voids compared to the approved conceptual landform.

The voids in Open Cut 1 and Open Cut 2 would be stabilised and allowed to fill with water. The Muswellbrook Coal Continuation Project Groundwater Assessment (SLR 2016) modelled standing water levels in each final void. These are predicted to be:

- RL 192 m in Open Cut 1; and
- RL 165 m in Open Cut 2.

These levels represent a standing water level of 26 m and 33 m respectively. These levels are below the background standing water level of RL 210 m. Therefore the final voids are expected to remain a groundwater evaporative sink and would not contribute water to the groundwater system(s).

The third final void in the Open Cut 1 rehabilitation area (outside the modification area) has a potential future use as a waste management facility (discussed in Section 2.1.2). This void has been built to MSC's specifications and is not free draining. The final landform will not change as a result of this modification. The modification would not affect the proposed final land use for this void.

Final voids would be established as safe and stable for closure and would be designed to prevent the likelihood of spontaneous combustion in accordance with DRE guidelines. Management of the final voids would continue to be in accordance with relevant management plans.

4.6 Land and soil capability class after rehabilitation

Soil sampling was completed in the Open Cut 2 rehabilitation area to determine soil types (EMM 2016). The remainder of the modification area is subject to mining operations and therefore was not sampled. The sampling determined that the soils are spolic anthroposols, which are manmade. The current LCS class of the modification area is Class 6, with the following limitations:

> Low capability land: Land has very high limitations for high-impact land uses. Land use restricted to low-impact land uses such as grazing, forestry and nature conservation. Careful management of limitations is required to prevent severe land and environmental degradation.

The area to be disturbed by the modification would be rehabilitated to similar to its current condition, which would include the spolic anthroposols soil type. The remainder of the modification area is subject to mining operations, but would also comprise the spolic anthroposols soil type once rehabilitated.

As described in this chapter, the additional area disturbed by the modification would be rehabilitated to a similar form to its current condition. It is estimated that the final landform in the modification area (excluding voids) would achieve a land and soil capability class of Class 6 (low capability land). Therefore, there would be no net change in the land and soil capability class as a result of the modification.

4.7 Post mining land use

The approved conceptual final land use of the site comprises a combination of approximately 50% pasture and 50% native trees with a vegetation corridor between Bells Mountain and Skellatar Ridge. No significant changes are proposed to the final land use under the modification, as discussed below. The proposed conceptual final land uses are shown in Figure 2.2.

After rehabilitation, the modification area is expected to have a land and soil capability of Class 6 (EMM 2016), which would limit the land use capacity. Land uses which are described for land with an land and soil capability of Class 6, as discussed in Section 4.6, include:

- grazing – the final rehabilitated landform will include approximately 50% pasture, which would be suitable for grazing;
- forestry – the final land use objectives are aimed at achieving vegetated linkages between rehabilitation at MCM and other remnant vegetation in the surrounding area, and have therefore favoured establishment of native woodland vegetation rather than forestry; and
- nature conservation – the final land use objectives are aimed at achieving native vegetation linkages between rehabilitation at the mine and other remnant vegetation in the surrounding area (Bells Mountain and Skellatar Ridge) consistent with the *Synoptic Plan – Integrated Landscapes for Coal Mine Rehabilitation in the Hunter Valley of NSW* (Department of Mineral Resources 1999).

Based on the land and soil capability of Class 6, it is unlikely that the rehabilitated land would be capable of supporting intensive industries such as horticulture. On this basis, such land uses have not been considered further.

Other future land use options would be limited but might include:

- Landfill for the neighbouring Muswellbrook and Singleton town communities – as discussed in Section 2.1.3, a memorandum of understanding is in place with MSC regarding use of the void in Open Cut 1 rehabilitation area for use as a waste management facility. The life of this void as a waste facility is substantial and would be sufficient such that consideration of the remaining voids for landfilling is not necessary.
- Future industrial development – future industrial use would require areas of relatively flat land with good access to the local and regional road network. The MSC LUDS identifies the potential for future industrial development opportunities in conjunction with the development of the Muswellbrook bypass. This would be dependent on the location of the bypass, as well as consideration of demand for industrial land at the time, and potential opportunities for well serviced land with good access and other features as identified in the LUDS.

Based on the above, and primarily due to the limitations presented by the soil type and final landform resulting in an land and soil capability of Class 6, the changes to the conceptual final landform by the modification would not result in changes to the approved final land use of the site, which would continue to include a combination of approximately 50% pasture and 50% native trees, with a vegetation corridor between Bells Mountain and Skellatar Ridge.

5 Rehabilitation planning and implementation

5.1 Domain selection

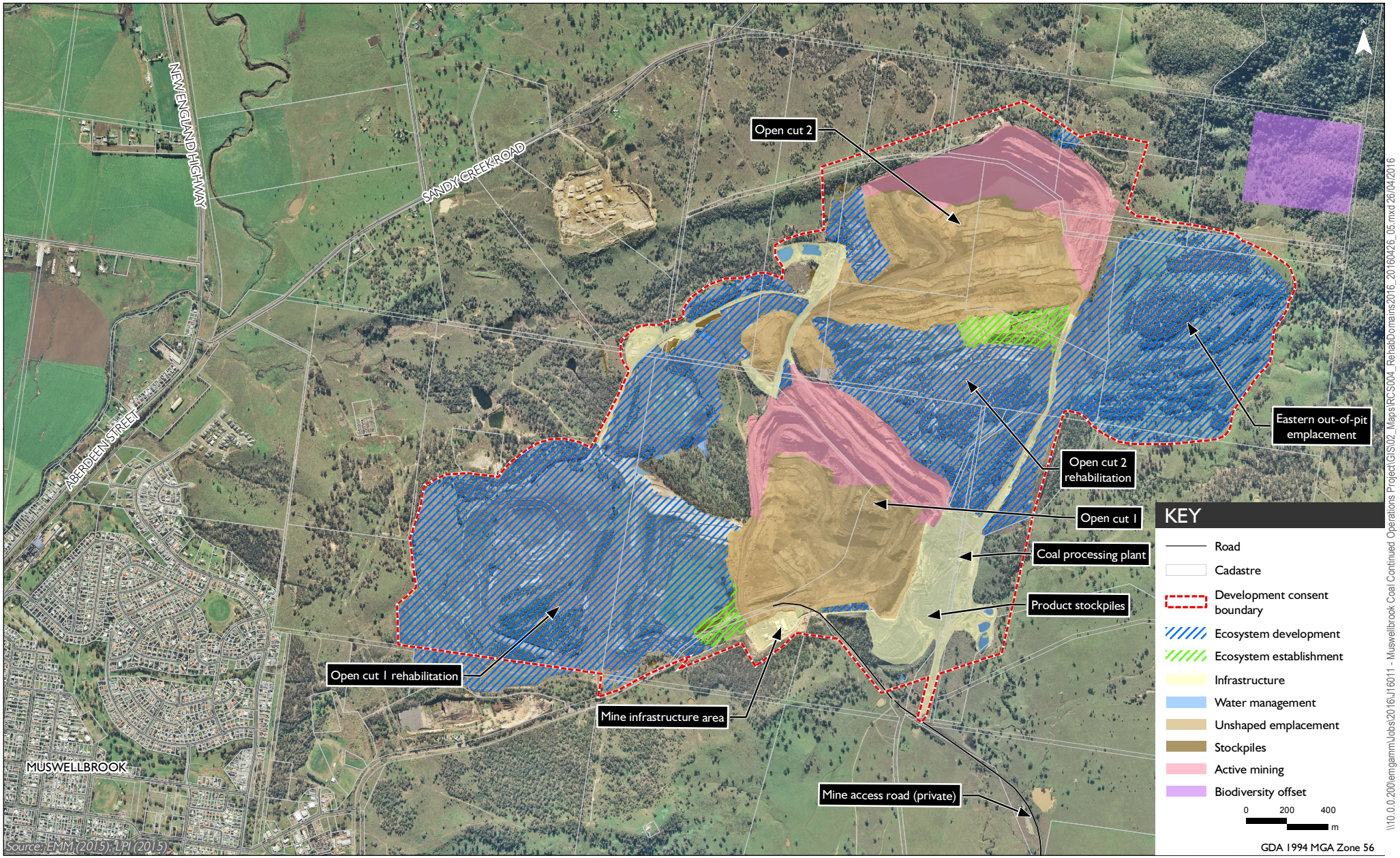
Domains have been established based on the MOP guidelines:

- Primary domains (operational domains) defined on the basis of land management units within the mine site, usually with unique operational and functional purpose and therefore have similar geophysical characteristics (ie during mining).
- Secondary domains (post mining land use domains) are defined as land management units characterised by a similar post mining land use objective (ie following mining).

Each domain requires particular rehabilitation objectives and methodologies to achieve the desired final land use outcomes. The primary and secondary domains identified for MCC's current operations (for 2016) are shown on Figure 5.1 and are defined in Table 5.1.

Table 5.1 Domains at MCC

Domain	Code	Description
Primary		
Infrastructure Area	1	Administration and workshop facilities, and existing access tracks, car parks and haul roads. Also includes any areas outside the open cut pit shells disturbed to stockpile topsoil and vegetation for reuse in rehabilitation.
Water Management Area	2	Network of dams, channels and associated water management infrastructure (pipelines and pumps etc.).
Overburden Emplacement Area	3	Footprints of out of pit and in pit waste rock dump areas.
Stockpiled Material	4	Stockpiles of topsoil and other growth ameliorants for use in rehabilitation.
Void	5	Footprint of mining voids.
Rehabilitation Area – Pasture	6	Areas that have been rehabilitated with pasture species.
Rehabilitation Area – Trees	7	Areas that have been rehabilitated with tree species.
Biodiversity Offset Area	8	Area that has been dedicated as an area to offset impacts to biodiversity from mining operations. It is noted that this area is outside the modification area and is not discussed in detail in this document.
Secondary		
Water Management Area	A	Water management structures that will be retained at mine closure.
Rehabilitation Area – Pasture	B	Areas that will be rehabilitated with pasture suitable for grazing.
Rehabilitation – Woodland	C	Areas that will be rehabilitated with trees suitable as a vegetation corridor between Bells Mountain and Skellatar Ridge. Tree areas will also provide protection for grazing livestock on the pasture areas.
Final Void	D	Areas retained as voids for future waste management areas or as water storages.
Biodiversity Offset Area	E	Area that is retained to offset impacts to biodiversity from mining activities. It is noted that this area is outside the modification area and is not discussed in detail in this document.



Mine domains - 2016

Muswellbrook Coal Continued Operations Project
Rehabilitation and Closure Strategy
Figure 5.1

5.2 Domain rehabilitation objectives

The rehabilitation objectives for the primary and secondary domains identified for MCC's operations are defined in Table 5.2.

Table 5.2 Domain rehabilitation objectives

Domain	Code (Primary/ Secondary)	Description
Infrastructure Area	1/-	Infrastructure will be progressively decommissioned when no longer required and the area will be rehabilitated.
Water Management Area	2/A	The post mining landform is safe, stable and non-polluting. All hazardous and/or contaminated materials are removed and disposed of appropriately. Storages will be maintained in final landscape to provide water resources for stock.
Overburden Emplacement Area	3/-	Final landform will be safe, stable, adequately drained and non-polluting. Final landforms will be shaped to be appropriate for the final land use, have slopes generally less than 14 degrees, and integrate with the surrounding landscape.
Stockpiled Material	4/-	The stockpiles will be used in the rehabilitation process.
Void	5/D	Final void is safe, profiled for long term stability and non-polluting. Low walls will be battered back generally to less than or equal to 14 degrees. High walls will be constructed and stabilised in accordance with design criteria developed by geotechnical engineers. Batters and the void floors will be rehabilitated with suitable vegetation.
Rehabilitation Area – Pasture	6/B	The post mining landform is safe, stable and non-polluting. The areas have been rehabilitated with pastures suitable for sustainable grazing.
Rehabilitation Area – Trees	7/C	The post mining landform is safe, stable and non-polluting. The areas have been rehabilitated with species consistent with surrounding native vegetation.
Biodiversity Offset Area	8/E	Area will be protected in perpetuity to the satisfaction of Muswellbrook Shire Council.

5.3 Rehabilitation methodology

Rehabilitating disturbed lands at MCC will require a sequence of conceptual rehabilitation stages to achieve a final land use that is self-sustaining. These phases of rehabilitation are described in Table 5.3. These phases apply to all of the Primary Domains.

Table 5.3 Rehabilitation phases

Phase	Description	Timing
Decommissioning	The process of removing plant and equipment from active services and rendering the area safe.	This phase will commence when all mining operations have ceased and infrastructure is no longer required. It is anticipated that this phase will take 18-24 months to be completed from when it is first commenced until all areas are completed.
Landform Establishment	The process of shaping unformed rock of other sub-stratum material into a desired land surface profile. This includes earthworks activities such as cut and fill, rock raking, water storage and drainage construction.	This phase will be ongoing throughout the life of the MOP as areas become available for final shaping. It is anticipated that it will take approximately 6 months to establish each area once shaping commences. This will be dependent on the size of each area.
Growth Medium Development	The process of establishing and enhancing the physical structure, chemical properties and biological properties of a soil stratum suitable for plant growth. This includes placing and spreading soil and applying ameliorants.	This phase will commence following landform establishment of an area and will take approximately 3 months to complete. This will be dependent on the size of each area.
Ecosystem and Land Use Establishment	The process of seeding, planting and transplanting plant species.	This phase will commence following the growth medium development phase of an area and will take approximately 3 months to complete. This will be dependent on the size of each area.
Ecosystem and Land Use Development	The process of applying management techniques to encourage an ecosystem to grow and develop towards a desired and sustainable post mining land use outcome.	This phase will commence following ecosystem and land use establishment of an area and will take approximately 5 years to complete. This will be dependent on the size of each area, weather conditions and other factors affecting development of an ecosystem.

The following sections provide a general overview of the rehabilitation methodology for each rehabilitation phase and for each domain.

5.3.1 Decommissioning phase

MCC will decommission fixed plant, built infrastructure and services progressively when infrastructure items and plant become redundant. All mining related infrastructure will ultimately be removed at mine closure. Decommissioning activities include:

- disconnection of all above ground and buried services and removal of associated infrastructure;
- removal of all built infrastructure and plant;
- removal of all wastes and hazardous materials; and
- removal (or on-site remediation) of any contaminated soils in accordance with a contaminated land assessment (where required).

Preliminary indicators and completion criteria for the Decommissioning Phase are provided in Chapter 6.

5.3.2 Landform establishment phase

Landform establishment is the process of shaping the final landform to a safe, stable and free draining landform that is appropriate for the desired final land use and consistent with the surrounding landscape. Preliminary indicators and completion criteria for the Landform Establishment Phase are provided in Chapter 5.

The final shaped landform will be constructed in accordance with the approved MOP. Rehabilitation will be undertaken progressively, generally commencing as soon as practical following the completion of mining related activities.

Key landform establishment activities are outlined below.

i Bulk pushing and minor earthworks

Bulk pushing and minor earthworks are undertaken to achieve the required depths of cover, and shape the constructed landform to the desired profile.

Exposed coal seams and other carbonaceous materials on the void floor, pit walls and the highwall will be capped and include at least 15 m of cover over the exposed seams.

ii Construct final landform drainage structures

Final landform drainage structures will be designed and constructed to be consistent with the conceptual design included in the MOP. If there is significant variation from the concept design, appropriate advice/approval will be sought from the DRE prior to construction. Rehabilitation areas will be surveyed and drainage structures (eg channels and contour banks) will be constructed in accordance with the survey design to produce a free draining final landform.

iii Spoil amelioration and deep ripping

Emplacement of dispersive materials will be avoided near the surface of the final landform where practical to minimise potential for significant scouring or land slumping. Where dispersive soils and spoils are emplaced at or near the surface, the material will be ameliorated (for example with lime or gypsum). Once spoil is re-shaped, further ameliorants (if necessary) are applied and the ameliorants are incorporated into the soil profile.

The soil from rehabilitated sections of Open Cut 2 may not be suitable for use in rehabilitation (due to the top layer of soil containing seeds from species not desirable for future rehabilitation – see Section 5.3.8(ii)). MCC will consider the following strategies to amend spoil for direct seeding with grasses and trees if topsoil is in short supply:

- Add composite green waste, organic growth medium or mulch (organic matter) – in 2007 direct planting into spoil using organic growth medium was trialled at MCM. Organic growth medium, sourced from MSC, was applied to a rehabilitation trial in Open Cut 2 in place of soil (topsoil and subsoil) before seeding with both pasture and trees. The organic growth medium was added to assist plant growth, availability of plants nutrient and improve the water retaining properties of the spoil. The trial indicated that organic matter will need to be applied at a rate of 100 tonnes per hectare (t/ha).

- Trial the addition of fertiliser and gypsum – Direct seeding of grasses and trees into spoil may be possible by amendment with fertiliser and Gypsum; however, the mine will further assess the appropriate application rates prior to implementing this amendment strategy. MCC currently successfully amends soil by the application of fertiliser and gypsum as required.

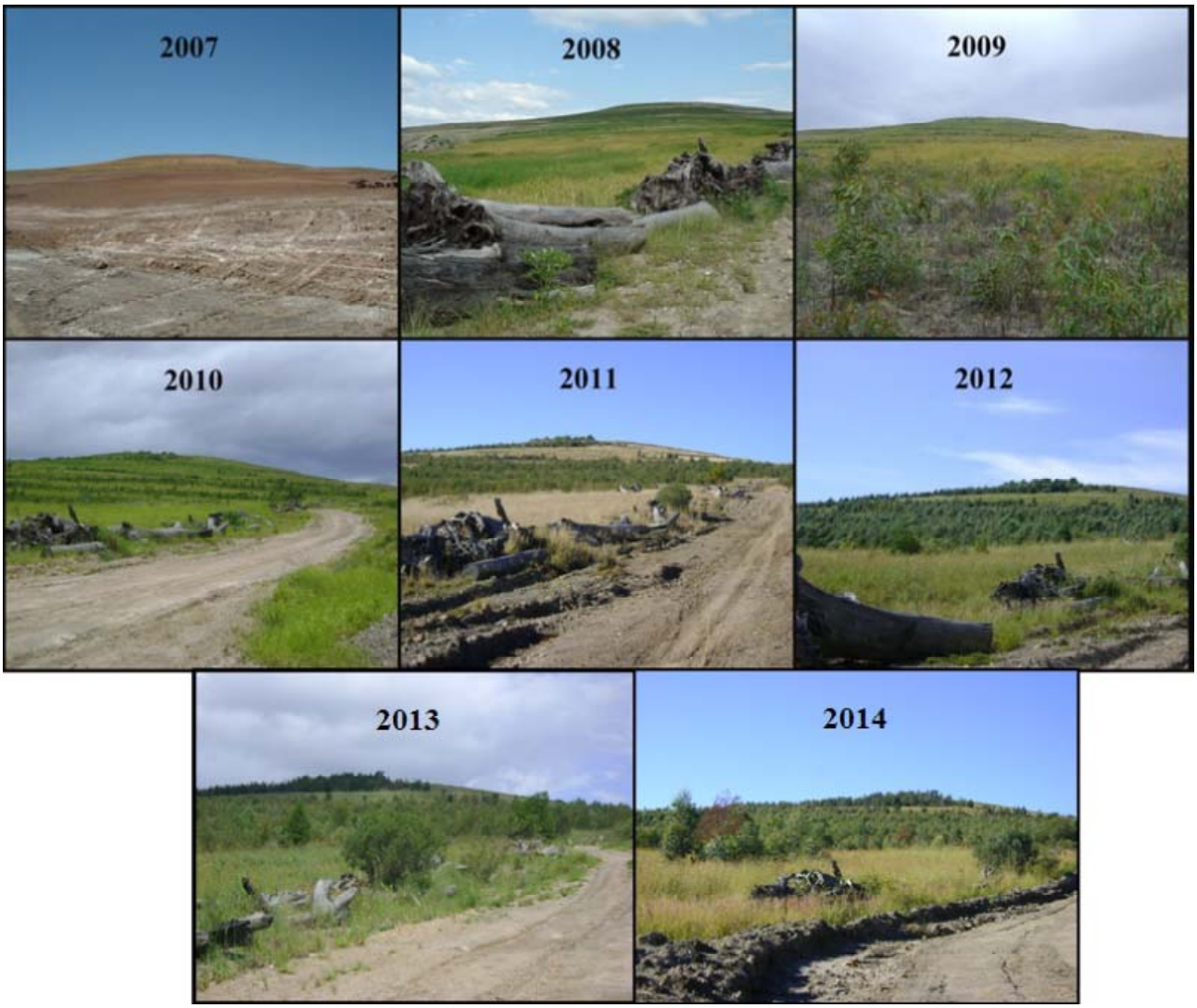


Plate 5.1 Rehabilitation of Open Cut 2 using organic growth matter

iv Water management structures

Final landform profiles and drainage are designed and constructed in accordance with the relevant industry guidelines, particularly the Blue Book Vol. 1 and Vol. 2c (Landcom 2004, DECC 2008). Elements such as drainage paths, contour drains, ridgelines, and emplacements will be shaped, as much as practical, to undulating profiles in keeping with natural landforms of the surrounding environment. Contour and catch drains are designed to collect surface runoff from rehabilitation or disturbed areas and direct flows to sediment dams that will be retained in the final landform.

All structures are designed to accommodate anticipated peak flows and in accordance with the specifications provided in the Blue Book Vol. 1 and Vol. 2c (Landcom 2004, DECC 2008). Particular focus will be placed on appropriate amelioration of foundation materials for earthworks structures such as contour banks.

Access to sedimentation dams will be preserved for the duration of rehabilitation works to facilitate maintenance including dam de-silting.

v Final voids

The final voids remaining at MCC will be made safe and stable by:

- battering back the low walls and high wall to minimise potential for failures and mass movement. An appropriately qualified Geotechnical Engineer will be consulted on final high wall design which may incorporate intermediate benching;
- capping (or excavating) exposed coal seams with inert material to prevent ignition from spontaneous combustion, bushfires or human interference;
- where deemed appropriate, constructing a physical barrier to isolate the perimeter of the void to prevent human access;
- suitable signs, clearly stating the risk to public safety and prohibiting public access will be erected; and
- constructing water management structures to achieve clean water diversion around the voids and limit the slopes and slope lengths conveying runoff generated on the low walls and high walls.

5.3.3 Growth media development phase

Growth media development encompasses activities to reinstate soils with the initial physical, chemical and biological characteristics required to establish the desired vegetation community. Ongoing management actions to develop self-sustaining soil profiles are discussed in the ecosystem development rehabilitation phase.

Preliminary indicators and completion criteria for growth media development phase domain are listed Chapter 6.

5.3.4 Ecosystem and land use establishment phase

Ecosystem establishment includes activities to establish the desired floristic composition (species diversity and density). Activities include:

- seeding and selective tubestock planting; and
- activities to enhance successful vegetation establishment such as weed management, erosion control and bushfire mitigation.

Key activities in the ecosystem and land use establishment phase are outlined in the sections below. Preliminary indicators and completion criteria for each domain are listed Chapter 6.

i Native vegetation seeding

Native vegetation seed may be sown simultaneously with the pasture species seeding, preferably in the warmer months between late September and March. Sowing should occur as soon as possible after seedbed preparation to optimise the conditions for germination prior to surface crust development.

Native vegetation establishment relies on initial establishment of local pioneer species to condition the soil for successive plant regeneration. These include wattles and grass species known to occupy disturbed environments throughout the local area.

Species selection is designed to promote the development of forest and woodland with structured understorey, mid-storey and tree canopy coverage. This will enhance overall biodiversity values and promote survival of these vegetation types in the post-mining landscape.

Tree seed mixtures generally contain a combination of *Acacia* and *Eucalypt* species. Native vegetation areas are an important component of the site rehabilitation strategy for MCC with woodland corridors planned to provide connectivity with surrounding vegetation. Trees provide a stable long term landform and add to the visual amenity of the surrounding area. Trees also provide the necessary habitat for the reconstruction of valuable ecosystems that assist in the re-colonisation of fauna across the mine site and provide a corridor for movement into adjacent remnant vegetation.

A review of the native vegetation seed mix was undertaken in 2015, with the recommended native vegetation seed mix listed in Table 5.5. The native vegetation seed mix is based on species that were present in the area prior to mining and is based on the Central Hunter Grey Box-Ironbark Woodland. Use of these species is dependent on availability of seed.

Table 5.4 Recommended species list for native vegetation

Botanical Name	Common Name
Eucalyptus crebra	Narrow-leaved Ironbark
Eucalyptus tereticornis	Forest Red Gum
Acacia decora	Western Silver Wattle
Acacia falcata	Sally Wattle
Acacia implexa	Hickory Wattle
Acacia paradoxa	Kangaroo Thorn
Cassinia aculeata	Dolly Bush
Brachychiton populneus	Kurrajong
Bursaria spinosa	Blackthorn
Indigofera australis	Australian Indigo
Austrodanthia bipartite	Wallaby Grass
Austrodanthia racemose	Wallaby Grass
Chloris ventricosa	Plump Windmill Grass
Desmodium brachypodum	Tick-trefoil
Calotis lappulacea	Yellow Burr-daisy
Eremophlia debilis	Winter Apple
Veroncia calycina	Hairy Speedwell
Cyperus gracilis	Slender Flat-sedge
Cheilanthes sieberi	Poison Rock Fern
Glycine tabacina	-

Table 5.4 Recommended species list for native vegetation

Botanical Name	Common Name
Eucalyptus moluccana	Gum Topped Box
Enchylaena tomentosa	Ruby Saltbush
Hardenbergia violacea	False Sarsaparilla
Goodenia hederacea	Forest Goodenia
Myoporum montanum	Western Boobialla
Geijera parviflora	Wilga
Lomandra confertifolia	Mat-Rush
Lomandra filiformis	Mat-Rush
Lomandra multiflora	Mat-Rush

ii Tubestock planting

Native vegetation establishment may be supplemented with tubestock. Tubestock planting is generally be undertaken in spring and autumn when weather conditions are optimised for vegetation establishment, however opportunistic rehabilitation may be undertaken in summer and winter months if areas become available and prevailing weather conditions are favourable. Only frost tolerant species are planted in winter due to avoid frost damage to newly planted tubestock.

iii Pasture species mix

Pasture mixtures used in rehabilitation generally consist of Couch, Pioneer Falcata, Wimmena Rye, Perennial Rye Lucerne, Haifa White Clover and sub-clover. During the summer months Japanese Millet is added to the mix, whilst Oats are added during the colder winter months. The legumes are inoculated and lime coated. Fertilizer in the form of Granulock 15 has been incorporated at a rate of approximately 200 kg/Ha with the pasture mix. The species mix has been based on the pasture establishment recommendations for the Hunter Valley in the book *Mine Rehabilitation: A Handbook for the Coal Mining Industry* (Hannan, J.C., 1995). This seed mix has been modified over time based on site experience and monitoring results. The recommended species list for pasture is shown in Table 5.5.

Table 5.5 Recommended species list for pasture

Botanical Name	Common Name
Pennisetum clandestinum	Kikuyu grass
Cynodon dactylon	Couch
Lolium rigidum	Annual Rye grass
Lolium perenne	Perennial Rye grass
Setaria sphacelata	Setaria
Medicago sativa	Lucerne
Trifolium repens	White Clover
Trifolium subterraneum	Subterranean Clover
Phalaris aquatic	Phalaris
Festuca arundinacea	Tall Fescue
Bromus wildenowie	Prairie Grass (sown in Autumn only)

5.3.5 Ecosystem and land use sustainability phase

The (former) Commonwealth Department of Industry, Tourism and Resources (DITR) publication Leading Practice Sustainable Development Program for the Mining Industry (DITR 2006) defines a functional ecosystem as one that is:

- stable (not subject to high rates of erosion);
- effective in retaining water and nutrients; and
- self-sustaining (DITR 2006).

The ecosystem and land use sustainability phase represents those activities required to develop sustainable ecosystems that have characteristics comparable to similar undisturbed vegetation associations in the area.

Key activities in the ecosystem and land use development phase are described below. Preliminary indicators and completion criteria for the ecosystem and land use sustainability phase are included Chapter 6.

i Routine ongoing maintenance

Rehabilitation area maintenance activities will be determined by the outcomes of the rehabilitation monitoring programs as detailed in Chapter 7. The scope of routine rehabilitation maintenance during the ecosystem and land use sustainability phase may include the following:

- weed and feral animal control of rehabilitation;
- erosion control works;
- maintenance fertilising;
- re-seeding; and
- repair of fence lines, access tracks and other general related land management activities.

ii Weed management including Acacia saligna

Existing rehabilitation within the modification area includes *Acacia saligna*, a Western Australian species that was acceptable for use in rehabilitation in NSW up until about 2013. *Acacia saligna* is no longer used in rehabilitation, and it is acknowledged that DRE no longer supports the use of *Acacia saligna* for mine rehabilitation in the Hunter Valley. *Acacia saligna* was removed from the MCC rehabilitation species list prior to 2013 (as reported in the *2013-2014 Annual Environmental Management Report*).

The species is non-endemic to the Hunter Valley and there is concern that the species may become a dominant monoculture. MCC has not removed any previously sown *Acacia saligna*, except in areas where established rehabilitation has been disturbed.

Acacia saligna and soil will be removed from partially rehabilitated areas (*only* where it is overabundant; soil from other areas will be salvaged) to be disturbed under the modification. The primary control strategy for managing the removal and disposal of *Acacia saligna* in the areas to be disturbed under the modification will be physical removal and burial of Acacia saligna plant matter and disposal at the base of the overburden emplacement area followed by placement of soil from areas where *Acacia saligna* is overabundant.

In rehabilitated areas, management options for *Acacia saligna* include:

- using the 'cut stump' method whereby the stumps of the plant are cut off and painted with herbicide and stumps are left in situ;
- out competing the Acacia saligna with taller overstorey species; and
- using grazing pressures to reduce the growth of young saplings.

The suitability of each management option depends on the location, size and land use of rehabilitation areas and the density of *Acacia saligna*.

iii Intervention and adaptive management

Where monitoring results reveal that indicators are not trending towards the completion criteria as predicted, plans are executed to investigate causes for poor rehabilitation performance and, where appropriate, undertake re-work and/or modify management practices to achieve the desired rehabilitation results.

5.4 Rehabilitation implementation

This section provides an overview of the rehabilitation activities proposed to be implemented on a domain by domain basis during each of the rehabilitation phases.

5.4.1 Infrastructure area

This domain will remain active until mining has ceased at MCC. Following completion of mining these areas will be progressively rehabilitated. Rehabilitation activities proposed in this domain include the following:

- Removal of services including power lines, pipe lines, pumps and sewer treatment facilities (unless agreed to leave in place for future land uses).
- Removal of buildings including offices, workshop, CPP and CHPP (unless agreed to leave in place for future land uses).
- Removal of hydrocarbon storage facilities.
- Treatment of hydrocarbon contaminated material.
- Removal of sealed car parks (unless agreed to leave in place for future land uses).
- Bulk pushing and minor earthworks to shape the constructed landform to the desired profile.

- Install drainage structures that have been designed and constructed in accordance with relevant industry guidelines.
- Spread topsoil and other ameliorants, as required, to establish physical, chemical and biological characteristics required to establish the desired vegetation community.
- Seeding of areas with appropriate seed mix required to establish the desired vegetation community.
- On-going management of the area to reach final closure criteria. These management actions include weed and feral animal control, bushfire management, and erosion and sediment control.
- On-going monitoring to demonstrate achievement of completion criteria.

MSC and DRE would be consulted regarding existing services and roads (including the private mine access road to Muscle Creek Road) prior to rehabilitation to determine whether these can be used for any potential future land use opportunities.

5.4.2 Water management area

This domain will remain active until mining has ceased at MCC. Water management dams are proposed to remain in situ following completion of mining. Rehabilitation activities proposed in this domain include the following:

- On-going management of the area to reach final closure criteria. These management actions include weed and feral animal control, bushfire management, and erosion and sediment control.
- On-going monitoring to demonstrate achievement of completion criteria.

5.4.3 Overburden emplacement area

This domain will be progressively rehabilitated as areas become available for final rehabilitation. Rehabilitation activities proposed in this domain include the following:

- Bulk pushing and minor earthworks to shape the constructed landform to the desired profile.
- Install drainage structures that have been designed and constructed in accordance with relevant industry guidelines.
- Spread topsoil and other ameliorants, as required, to establish physical, chemical and biological characteristics required to establish the desired vegetation community.
- Seeding of areas with appropriate seed mix required to establish the desired vegetation community.
- On-going management of the area to reach final closure criteria. These management actions include weed and feral animal control, bushfire management, and erosion and sediment control.
- On-going monitoring to demonstrate achievement of completion criteria.

5.4.4 Stockpiled material

As other areas become available for rehabilitation stockpiled material in this domain will be progressively removed for use in rehabilitation activities. After the material is removed the disturbed footprint will be seeded with a species mix that is consistent with the surrounding area.

5.4.5 Final void

This domain will remain active until mining has ceased at MCC. Following completion of mining these areas will be progressively rehabilitated. Rehabilitation activities proposed in this domain relate to voids in Open Cut 1 and 2 and include the following:

- Bulk pushing and minor earthworks to shape the constructed landform to the desired profile.
- Install drainage structures that have been designed and constructed in accordance with relevant industry guidelines.
- In areas above the high water mark, spread topsoil and other ameliorants, as required, to establish physical, chemical and biological characteristics required to establish the desired vegetation community, and seeding of these areas with appropriate seed mix required to establish the desired vegetation community.
- On-going management of the area to reach final closure criteria. These management actions include weed and feral animal control, bushfire management, and erosion and sediment control.
- On-going monitoring to demonstrate achievement of completion criteria.

5.4.6 Rehabilitation areas – pasture

This domain relates to areas that have had final shaping and seeding activities undertaken. Activities in this domain will relate to maintenance of rehabilitation and will include the following:

- On-going management of the area to reach final closure criteria. These management actions include weed and feral animal control, bushfire management, reseeding, and erosion and sediment control.
- On-going monitoring to demonstrate achievement of completion criteria.

5.4.7 Rehabilitation areas – trees

This domain relates to areas that have had final shaping and seeding activities undertaken. Activities in this domain will relate to maintenance of rehabilitation and will include the following:

- On-going management of the area to reach final closure criteria. These management actions include weed and feral animal control, bushfire management, reseeding, and erosion and sediment control.
- On-going monitoring to demonstrate achievement of completion criteria.

5.4.8 Biodiversity offset area

This domain relates to an area that has been established to offset impacts to biodiversity. This domain is shown on Figure 5.1, and is outside the modification area. As such, it is not discussed further in this document.

6 Performance indicators and completion/relinquishment criteria

Current rehabilitation objectives, performance indicators and completion criteria for each rehabilitation phase/domain within the modification area are presented in the following tables (Table 6.1 – 6.5). The completion criteria are based on the approved MOP for MCM, which have been developed based on industry standards and guidelines, site history and monitoring results with consideration given to the final land use. The criteria would be reviewed as part of updates to the MOP.

Table 6.1 Rehabilitation Objectives for Decommissioning Phase

Domain	Domain Objective	Performance Indicator	Completion Criteria
Infrastructure	Built infrastructure will be progressively decommissioned when no longer required and the area will be rehabilitated. No contaminated soils, materials or wastes remain on site.	Services are disconnected. Infrastructure is removed. All hardstands and car parks are removed. Contaminated land identified and rehabilitated. No hazardous materials remain.	Services have been disconnected. Infrastructure has been removed. Hardstands and car parks have been removed. Contaminated land assessment indicates contamination levels are acceptable for grazing and vegetation establishment. All hazardous materials have been removed.
Water Management Area	Water management structures are suitable for final land use.	Water quality monitoring results show the water is suitable for beef cattle consumption. Water management structures are designed to capture runoff from rehabilitated surfaces.	Water quality is suitable for livestock consumption. Criteria to be meet are: Calcium-1,000 mg/L Nitrate-1,500 mg/L Sulfate-1,000 mg/L TDS-4,000 mg/L Water management structures are designed to capture runoff from a 1 in 20 year (24-hour) storm event.
Overburden Emplacement Area	Exposed overburden emplacement areas do not form part of final landform.	Overburden emplacement areas are reshaped to the relevant slope angles and rehabilitated.	No exposed overburden dumps remain in the final landform.
Stockpiled Material	Stockpiled material is used in rehabilitation.	No remaining stockpiles.	All stockpiles are removed.
Void	Void does not pose a risk to the public	Installation of safety fences and/or berms above the high wall of Open Cut 2 void.	Where deemed appropriate, safety fences and/or berms are installed to prevent public access.

Table 6.2 Rehabilitation Objectives for Landform Establishment Phase

Domain	Domain Objective	Performance Indicator	Completion Criteria
Infrastructure	A safe and stable landform supportive of the final land use.	Landform is regraded to a stable grade.	Slope on final landform is <14°.
		Land surfaces are free of obstacles, other than those to be retained in the final landform.	Land surface has no obstacles present, other than those to be retained in the final landform such as habitat structures.
		A free draining and stable landform is established.	Landform is free draining with no unplanned pooling of water or identifiable rill or sheet erosion.
Water Management Area	As all the water management structures are to be retained in the final landform this phase is not applicable to this domain.		
Overburden Emplacement Area	A safe and stable landform supportive of the final land use.	Landform is regraded to a stable grade.	Slope on final landform is <14°.
		Reconstructed landforms are stable with no evidence of slumping.	Land surface has no evidence of slumping that is affecting stability.
		Land surfaces are free of obstacles, other than those to be retained in the final landform.	Land surface has no obstacles present, other than those to be retained in the final landform such as habitat structures.
		A free draining and stable landform is established.	Landform is free draining with no unplanned pooling of water or identifiable rill or sheet erosion.
Stockpiled Material	As this is stockpiled to be used in the rehabilitation process this phase does not apply to this domain.		
Void	A safe and stable landform supportive of the final land use.	High walls are made stable through blasting and profiling to slopes.	Exposed coal seams have a minimum cover of 15 m of inert material.
	Final land use is not compromised by spontaneous combustion.	Exposed coal seam and other carbonaceous materials on the void floor and in the walls have been sealed and covered.	
Rehabilitation Area – Pasture	A safe and stable landform supportive of the final land use.	Landform is regraded to a stable grade.	Slope on final landform is <14°.
		Reconstructed landforms are stable with no evidence of slumping.	Land surface has no evidence of slumping that is affecting stability.
		Land surfaces are free of obstacles, other than those to be retained in the final landform.	Land surface has no obstacles present, other than those to be retained in the final landform such as habitat structures.
		A free draining and stable landform is established.	Landform is free draining with no unplanned pooling of water or identifiable rill or sheet erosion.

Table 6.2 Rehabilitation Objectives for Landform Establishment Phase

Domain	Domain Objective	Performance Indicator	Completion Criteria
Rehabilitation Area – Trees	A safe and stable landform supportive of the final land use.	Landform is regraded to a stable grade.	Slope on final landform is <14°.
		Reconstructed landforms are stable with no evidence of slumping.	Land surface has no evidence of slumping that is affecting stability.
		Land surfaces are free of obstacles, other than those to be retained in the final landform.	Land surface has no obstacles present, other than those to be retained in the final landform such as habitat structures.
		A free draining and stable landform is established.	Landform is free draining with no unplanned pooling of water or identifiable rill or sheet erosion.

Table 6.3 Rehabilitation Objectives for Growth Medium Development Phase

Domain	Domain Objective	Performance Indicator	Completion Criteria
Infrastructure	Growth media is suitable for establishing the desired vegetation community.	Compacted areas do not hinder vegetation establishment.	Compacted surfaces have been deep ripped along the contour.
		Adequate topsoil and/or ameliorants have been spread on the rehabilitation.	Approximately 100 mm of topsoil and/or ameliorants spread over the area.
		Key soil characteristics are within 10% variance of analogue sites.	Analysis of soil samples record results within 10% of the analogue sites. Soil analysis will include: pH, EC, carbon, nitrogen, metals and nutrients.
Water Management Area	As all the water management structures are to be retained in the final landform this phase is not applicable to this domain.		
Overburden Emplacement Area	Growth media is suitable for establishing the desired vegetation association.	Compacted areas do not hinder vegetation establishment.	Compacted surfaces have been deep ripped along the contour.
		Adequate topsoil and/or ameliorants have been spread on the rehabilitation.	Approximately 100 mm of topsoil and/or ameliorants spread over the area.
		Key soil characteristics are within 10% variance of analogue sites.	Analysis of soil samples record results within 10% of the analogue sites. Soil analysis will include: pH, EC, carbon, nitrogen, metals and nutrients.
Stockpiled Material	As the material stored in these stockpiles is used as the growth medium for this phase objectives have not been developed for this domain.		
Void	Growth media is suitable for establishing the desired vegetation association.	Compacted areas do not hinder vegetation establishment.	Compacted surfaces have been deep ripped along the contour.
		Adequate topsoil and/or ameliorants have been spread on the rehabilitation.	Approximately 100 mm of topsoil and/or ameliorants spread over the area.
		Key soil characteristics are within 10% variance of analogue sites.	Analysis of soil samples record results within 10% of the analogue sites. Soil analysis will include: pH, EC, carbon, nitrogen, metals and nutrients.

Table 6.3 Rehabilitation Objectives for Growth Medium Development Phase

Domain	Domain Objective	Performance Indicator	Completion Criteria
Rehabilitation Area – Pasture	Growth media is suitable for establishing the desired vegetation association.	Key soil characteristics are within 10% variance of analogue sites.	Analysis of soil samples record results within 10% of the analogue sites. Soil analysis will include: pH, EC, carbon, nitrogen, metals and nutrients.
Rehabilitation Area – Trees	Growth media is suitable for establishing the desired vegetation association.	Key soil characteristics are within 10% variance of analogue sites.	Analysis of soil samples record results within 10% of the analogue sites. Soil analysis will include: pH, EC, carbon, nitrogen, metals and nutrients.

Table 6.4 Rehabilitation Objectives for Ecosystem and Land Use Establishment Phase

Domain	Domain Objective	Performance Indicator	Completion Criteria
Infrastructure	Establish vegetation profile consistent with the planned final land use.	Revegetation mix is representative of the final land use. Installation of habitat enhancement such as micro-habitats (tree hollows, stags and stumps) and nesting boxes. Weeds are not competing or impacting on vegetation on rehabilitated areas. Grazing by pest and feral animals are not adversely impacting on vegetation on rehabilitated areas. The rehabilitation area does not constitute an erosion hazard.	Rehabilitation monitoring reports confirm that after two years from planting, >80% of the species established are comparative to the seed mix and the respective analogue sites. Habitat enhancement such as micro-habitats (tree hollows, stags and stumps) and nesting boxes has been installed and established. Rehabilitation monitoring reports confirm that two years after seeding weeds represent less than 20% of projected foliage cover or are comparable to analogue sites. Rehabilitation monitoring reports confirm that two years after seeding grazing is impacting on less than 20% of projected foliage cover or are comparable to analogue sites. Total projected foliage cover is greater than or equal to 70% or are comparable to analogue sites.
Water Management Area	As all the water management structures are to be retained in the final landform this phase is not applicable to this domain.		
Overburden Emplacement Area	Establish vegetation profile consistent with the planned final land use. Maintenance of stock watering locations and	Revegetation mix is representative of the final land use. Installation of habitat enhancement such as micro-	Rehabilitation monitoring reports confirm that after two years from planting, >80% of the species established are comparative to the seed mix and the respective analogue sites. Habitat enhancement such as micro-habitats (tree

Table 6.4 Rehabilitation Objectives for Ecosystem and Land Use Establishment Phase

Domain	Domain Objective	Performance Indicator	Completion Criteria
	fencing in the final landform.	habitats (tree hollows, stags and stumps) and nesting boxes.	hollows, stags and stumps) and nesting boxes has been installed and established.
		Weeds are not competing or impacting on vegetation on rehabilitated areas.	Rehabilitation monitoring reports confirm that after two years after seeding weeds represent less than 20% of projected foliage cover or are comparable to analogue sites.
		Grazing by pest and feral animals are not adversely impacting on vegetation on rehabilitated areas.	Rehabilitation monitoring reports confirm that two years after seeding grazing is impacting on less than 20% of projected foliage cover or are comparable to analogue sites.
		The rehabilitation area does not constitute an erosion hazard.	Total projected foliage cover is greater than or equal to 70% or are comparable to analogue sites.
		Dams are incorporated into the final landform for stock watering.	There are adequate stock watering dams in the final landform and in paddocks that directly adjoin the rehabilitation areas.
Stockpiled Material	As the material stored in these stockpiles are not part of the final landform objectives have not been developed for this domain.		
Void	Establish vegetation profile consistent with the planned final land use.	Revegetation mix is representative of the final land use.	Rehabilitation monitoring reports confirm that after two years from planting, >80% of the species established are comparative to the seed mix and the respective analogue sites.
		Weeds are not competing or impacting on vegetation on rehabilitated areas.	Rehabilitation monitoring reports confirm that after two years after seeding weeds represent less than 20% of projected foliage cover or are comparable to analogue sites.
		Grazing by pest and feral animals are not adversely impacting on vegetation on rehabilitated areas.	Rehabilitation monitoring reports confirm that two years after seeding grazing is impacting on less than 20% of projected foliage cover or are comparable to analogue sites.
Rehabilitation Area – Pasture	Establish vegetation profile consistent with the planned final land use.	Revegetation mix is representative of the final land use.	Rehabilitation monitoring reports confirm that after two years from planting, >80% of the species established are comparative to the seed mix and the respective analogue sites.
	Maintenance of stock watering locations and fencing in the final landform.	Installation of habitat enhancement such as micro-habitats (tree hollows, stags and stumps) and nesting boxes.	Habitat enhancement such as micro-habitats (tree hollows, stags and stumps) and nesting boxes has been installed and established.
		Weeds are not competing or impacting on vegetation on rehabilitated areas.	Rehabilitation monitoring reports confirm that after two years after seeding weeds represent less than 20% of projected foliage cover or are comparable to analogue sites.
		Grazing by pest and feral animals are not adversely impacting on vegetation on rehabilitated areas.	Rehabilitation monitoring reports confirm that two years after seeding grazing is impacting on less than 20% of projected foliage cover or are comparable to analogue sites.
		Dams are incorporated into the final landform for stock watering.	There are adequate stock watering dams in the final landform and in paddocks that directly adjoin the rehabilitation areas.

Table 6.4 Rehabilitation Objectives for Ecosystem and Land Use Establishment Phase

Domain	Domain Objective	Performance Indicator	Completion Criteria
Rehabilitation Area – Trees	Establish vegetation profile consistent with the planned final land use.	Revegetation mix is representative of the final land use.	Rehabilitation monitoring reports confirm that after two years from planting, >80% of the species established are comparative to the seed mix and the respective analogue sites.
	Maintenance of stock watering locations and fencing in the final landform.	Installation of habitat enhancement such as micro-habitats (tree hollows, stags and stumps) and nesting boxes.	Habitat enhancement such as micro-habitats (tree hollows, stags and stumps) and nesting boxes has been installed and established.
		Weeds are not competing or impacting on vegetation on rehabilitated areas.	Rehabilitation monitoring reports confirm that after two years after seeding weeds represent less than 20% of projected foliage cover or are comparable to analogue sites.
		The rehabilitation area does not constitute an erosion hazard.	Total projected foliage cover is greater than or equal to 70% or are comparable to analogue sites.
		Dams are incorporated into the final landform as appropriate to the final land use.	

Table 6.5 Rehabilitation Objectives for Ecosystem and Land Use Sustainability Phase

	Domain Objective	Performance Indicator	Completion Criteria
Infrastructure	Rehabilitation is self-sustaining and ecologically diverse.	Weeds are appropriately controlled and not impacting on rehabilitation areas.	Monitoring confirms, that after 5 years from planting, weeds represent <10% of total plant species and <10% of total plant cover or are comparable to analogue sites.
	Runoff water quality is considered clean.	Species diversity consistent with relevant analogue sites.	Monitoring confirms that, after 5 years from planting, >80% of total plant species in rehabilitation areas are present in analogue sites.
		Vegetation is self-sustaining.	Monitoring confirms:
		Water quality monitoring results show the water is suitable for beef cattle consumption.	- evidence of new growth of endemic species;
			- evidence of successive generations of endemic species; and
			- no further active weed control required (beyond that considered necessary at analogue sites).
			Water quality is suitable for livestock consumption.

Table 6.5 Rehabilitation Objectives for Ecosystem and Land Use Sustainability Phase

	Domain Objective	Performance Indicator	Completion Criteria
Water management	Water management structures are suitable for final land use	Water quality monitoring results show the water is suitable for beef cattle consumption.	Water quality is suitable for livestock consumption. Criteria to be meet are: Calcium-1,000 mg/L Nitrate-1,500 mg/L Sulfate-1,000 mg/L TDS-4,000 mg/L
Overburden emplacement area	Rehabilitation is self-sustaining and ecologically diverse. Runoff water quality is considered clean. Final land use is not compromised by spontaneous combustion. Maintenance of fencing in the final landform.	Weeds are appropriately controlled and not impacting on rehabilitation areas. Species diversity consistent with relevant analogue sites. Vegetation is self-sustaining. Water quality monitoring results show the water is suitable for beef cattle consumption. Rehabilitation areas are not being adversely affected by spontaneous combustion. Stock fencing is incorporated into the final landform as appropriate to the final land use.	Monitoring confirms, that after 5 years from planting, weeds represent <10% of total plant species and <10% of total plant cover or are comparable to analogue sites. Monitoring confirms that, after 5 years from planting, >80% of total plant species in rehabilitation areas are present in analogue sites. Monitoring confirms: - evidence of new growth of endemic species; - evidence of successive generations of endemic species; and - no further active weed control required (beyond that considered necessary at analogue sites). Water quality is suitable for livestock consumption. No visual evidence of spontaneous combustion affecting any areas of rehabilitation. Stock fencing has been installed.
Stockpiled Material	As the material stored in these stockpiles are not part of the final landform objectives have not been developed for this domain.		

Table 6.5 Rehabilitation Objectives for Ecosystem and Land Use Sustainability Phase

	Domain Objective	Performance Indicator	Completion Criteria
Void	Rehabilitation is self-sustaining and ecologically diverse. Final land use is not compromised by spontaneous combustion. Maintenance of fencing in the final landform.	Weeds are appropriately controlled and not impacting on rehabilitation areas. Species diversity consistent with relevant analogue sites. Vegetation is self-sustaining. Rehabilitation areas are not being adversely affected by spontaneous combustion. Stock fencing is incorporated into the final landform as appropriate to the final land use.	Monitoring confirms, that after 5 years from planting, weeds represent <10% of total plant species and <10% of total plant cover or are comparable to analogue sites. Monitoring confirms that, after 5 years from planting, >80% of total plant species in rehabilitation areas are present in analogue sites. Monitoring confirms: - evidence of new growth of endemic species; - evidence of successive generations of endemic species; and - no further active weed control required (beyond that considered necessary at analogue sites). No visual evidence of spontaneous combustion. Stock fencing has been installed.
Rehabilitation Area – Pasture	Landforms, soils, hydrology and flora require no greater maintenance than the surrounding land. Rehabilitation is self-sustaining and ecologically diverse. Sustainable grazing of rehabilitation areas is maintained. Runoff water quality is considered clean. Final land use is not compromised by spontaneous combustion.	Rehabilitation areas require no greater maintenance than the surrounding land. Weeds are appropriately controlled and not impacting on rehabilitation areas. Species diversity consistent with relevant analogue sites. Vegetation is self-sustaining. The grazing land is productive and is economically and environmentally sustainable. Water quality monitoring results show the water is suitable for beef cattle consumption. Rehabilitation areas are not being adversely affected by spontaneous combustion.	The maintenance program on the rehabilitation areas is comparable to the maintenance program on surrounding land. Monitoring confirms, that after 5 years from planting, weeds represent <10% of total plant species and <10% of total plant cover or are comparable to analogue sites. Monitoring confirms that, after 5 years from planting, >80% of total plant species in rehabilitation areas are present in analogue sites. Monitoring confirms: - evidence of new growth of endemic species; - evidence of successive generations of endemic species; and - no further active weed control required (beyond that considered necessary at analogue sites). The stocking rates on the rehabilitated land are consistent with stocking rates on similar quality lands in the region. Water quality is suitable for livestock consumption. No visual evidence of spontaneous combustion.

Table 6.5 Rehabilitation Objectives for Ecosystem and Land Use Sustainability Phase

	Domain Objective	Performance Indicator	Completion Criteria
Rehabilitation Area – Trees	Landforms, soils, hydrology and flora require no greater maintenance than the surrounding land. Rehabilitation is self-sustaining and ecologically diverse. Runoff water quality is considered clean. Final land use is not compromised by spontaneous combustion.	Rehabilitation areas require no greater maintenance than the surrounding land. Weeds are appropriately controlled and not impacting on rehabilitation areas. Species diversity consistent with relevant analogue sites. Vegetation is self-sustaining. Highly mobile fauna species are utilising the rehabilitation areas as wildlife corridors Water quality monitoring results show the water is suitable for beef cattle consumption. Rehabilitation areas are not being adversely affected by spontaneous combustion.	The maintenance program on the rehabilitation areas is comparable to the maintenance program on surrounding land. Monitoring confirms, that after 5 years from planting, weeds represent <10% of total plant species and <10% of total plant cover or are comparable to analogue sites. Monitoring confirms that, after 5 years from planting, >80% of total plant species in rehabilitation areas are present in analogue sites. Monitoring confirms: - evidence of new growth of endemic species; - evidence of successive generations of endemic species; and - no further active weed control required (beyond that considered necessary at analogue sites). Monitoring confirms that, after 10 years from planting, the number of highly mobile fauna species in rehabilitation areas are within 10% of the species in the analogue sites. Water quality is suitable for livestock consumption. No visual evidence of spontaneous combustion.

7 Rehabilitation monitoring

7.1 Rehabilitation monitoring method

The current rehabilitation monitoring program at MCC was developed in 2015 and is based on the *BioBanking Assessment Methodology and Credit Calculator Operational Manual* (Department of Environment and Climate Change (DECC) 2008). The methods have been developed in accordance with the completion criteria listed in Chapter 6 and monitoring requirements for areas of rehabilitation requiring annual performance assessments.

Additional monitoring methods associated with assessing the performance of fauna habitat and wildlife corridor connectivity conditions have also been included in the rehabilitation monitoring program.

Monitoring methods associated with completion criteria listed in Chapter 6 requiring specialised single occurrence monitoring (eg compliance surveys and, geotechnical assessments) have not been included as part of the rehabilitation monitoring program.

The rehabilitation monitoring program would continue to be undertaken annually during spring, with results reported in the AEMR.

To demonstrate compliance with the completion criteria, monitoring results are compared to benchmarks derived by MCC through the monitoring of analogue sites (see Section 7.8).

7.1.1 Sampling intensity and frequency

The level of survey effort across the rehabilitation must be consistent with the practice of random stratified sampling. Plots and transects must be established randomly, or stratified randomly, accounting for the level of variation in broad condition of the pasture and woodland domain areas.

To provide information on the performance and establishment of the existing rehabilitation domains over time, the existing rehabilitation has been divided into three distinct blocks with each block accounting for differences in landform, broad rehabilitation techniques and age.

Establishing or stratifying plots and transects randomly may be done by marking points randomly in the rehabilitation assessment area and establishing plots and transects at all or some of these points in each domain. Alternatively plots and transects can be established by pacing a random distance into or within each of the rehabilitated blocks. The survey data must be collected from that point, with the process repeated elsewhere within the domain (Department of Environment and Climate Change, 2008).

The minimum number of transects and plots detailed in Table 7.1 will be used for monitoring each domain of rehabilitation with an aim for monitoring rehabilitation performance for the different ages of rehabilitation across the entire site.

If the broad condition state of the tree (woodland) and/or pasture rehabilitation areas is more variable (ie different species composition or soils type etc.) additional transects and plots may be required to take a representative sample. The requirement to establish additional transects will be assessed on an annual basis with any changes to the monitoring program reported in the AEMR.

Table 7.1 Minimum number of transects and plots

Size of rehabilitation blocks (ha)	Minimum number of transects/plots
0-4	1 transect/plot per 2 ha (or part thereof) or 1 transect/plot if vegetation is in low condition
>4-20	3 transects/plots or 2 transects/plots if vegetation is in low condition
>20-50	4 transects/plots or 3 transects/plots if vegetation is in low condition
>50-100	5 transects/plots or 3 transects/plots if vegetation is in low condition
>100-250	6 transects/plots or 4 transects/plots if vegetation is in low condition
>250-1000	7 transects/plots or 5 transects/plots if vegetation is in low condition. More transects/plots may be needed if the condition of the vegetation is variable across the rehabilitated block.

7.2 Rehabilitation measurements

7.2.1 Floristic species richness

Floristic assessments for species richness are conducted in a 20 m x 20 m plot. This method provides a measure of both species presence and abundance. Within each plot the attribute for native and exotic species is recorded in accordance with the *BioBanking Assessment Methodology 2014* (Office of Environment and Heritage (OEH) 2014).

7.2.2 Native over-storey cover

Native over-storey is the tallest woody stratum present (including emergent, mid-storey species and all woody vegetation above 1 m) and includes all species native to New South Wales (ie native species not local to the area can contribute to over-storey structure). In a woodland community the over-storey stratum is the tree layer, and in a shrub land community the over-storey stratum is the tallest shrub layer. Some vegetation types (eg grasslands) may not have an over-storey stratum.

Over-storey cover is estimated as percent foliage cover, which is equivalent to the amount of shadow that would be cast on the ground if there were a light source directly overhead. It is estimated in accordance with the *BioBanking Assessment Methodology 2014* (OEH 2014).

7.2.3 Ground cover

Ground cover is assessed to determine the percentage of the following:

- native grasses, shrubs and other (herbs and forbs) plants;
- exotic plant cover; and
- bare ground, litter, cryptogram or rock.

i Native Ground Cover

Native ground cover contains all native vegetation below 1 m in height and includes all species native to New South Wales (ie it's not confined to species indigenous to the area). Native ground cover is estimated for native grasses, shrubs and other (herbs and forbs) as follows (Department of Environment and Climate Change, 2008):

- At 50 points along the 50 m transect (ie every 1 m) record whether a native plant intersects that point. For each plant type divide the total of 'hits' by the number of points measured along the transect (ie 50).

ii Exotic Ground Cover

Exotic ground cover plants include all grasses, shrubs and other (herbs and forbs) in the ground layer below 1 m in height not native to Australia. Exotic ground cover plants are estimated for all exotic grasses, shrubs and other (herbs and forbs) as follows:

- At 50 points along the 50 m transect (ie every 1 m) record whether an exotic plant intersects that point. For each plant type divide the total of 'hits' by the number of points measured along the transect (ie 50).

iii Bare ground, litter, rocks and cryptogram

The percentage of bare ground, litter accumulation, cryptogram or rock is also recorded during the ground cover assessment as follows:

- At 50 points along the 50 m transect (ie every 1 m) record whether bare ground, litter, rocks or cryptogram intersects that point. Divide the total of 'hits' by the number of points measured along the transect (ie 50) to determine the percentage of bare ground, litter, rocks and cryptogram.

iv Exotic Plant Cover

Exotic plants are vascular plants not native to Australia. Exotic plant cover is measured as total percent foliage cover of all exotics in all strata. If the exotics are in the over-storey, then measure by using the same method as for native over-storey cover (see above). If exotics are in the ground stratum, then measure by using the same method as for ground cover (see above) (Department of Environment and Climate Change 2008).

7.2.4 Regeneration

Regeneration is measured as the proportion of native over-storey species present in the rehabilitation that are regenerating (ie with diameter at breast height <5 cm). For example, if there are three tree species present in the rehabilitation but only one of these species is regenerating, then the value is 0.33. The maximum value for this measure is 1 (Department of Environment and Climate Change, 2008).

7.2.5 Carrying capacity and pasture condition

Carry capacity and pasture condition are only conducted in pasture reference sites and pasture rehabilitation sites. The pasture condition will influence the appropriate stocking rates (carrying capacity) of the rehabilitation areas.

i Carrying Capacity (Stocking Rates)

Different grazing animals have different feed needs. Feed requirements also vary with different growth phases. Hence a standard basis of comparison is required; traditionally this is a dry sheep. A Dry Sheep Equivalent (DSE) is the amount of feed consumed in a month by a 50 kg mature sheep that is not lactating or breeding (commonly known as a wether). Common DSE ratings for different cattle growth phases are shown in Table 7.2.

Table 7.2 Typical DSE Equivalents

Cattle Enterprises	Typical DSE Equivalents
3 to 6 month old calf, not yet weaned.	3.8 DSE
450 kg dry stock (non-lactating, non-pregnant cow)	6.0 DSE
Average for a 450 kg cow and weaner calf	13.5 DSE
350 kg yearling maintaining weight	5.3 DSE
350 kg yearling gaining 1 kg/day	10.4 DSE
540 kg (EU) bullock gaining 1 kg/day	12.1 DSE

Source: Beef stocking rates and farm size – Hunter Region, Department of Primary Industries, 2006

Estimated carrying capacities for pasture types in the Upper Hunter are listed in Table 7.3.

Table 7.3 Estimated Carrying Capacities for Pasture Types in the Upper Hunter

Pasture Types	Range (DSE/ha)	Average (DSE/ha)
Native unimproved – low fertility (e.g. dominated by Parramatta grass, barbwire grass, wiregrass, red grass)	1.0-2.5	1.8
Native unimproved – moderate fertility (no seed or fertiliser added)	1.5-4.0	2.8
Native semi-improved – high fertility (clover + fertiliser added)	3.8-8.0	5.8
Improved pasture – moderate fertility (perennial temperate grasses, clover + fertiliser)	5.0-12.0	8.5
Improved pasture – moderate fertility (tropical grasses, clover + fertiliser)	7.0-10.0	8.5
Improved pasture – high fertility (perennial grasses, clover + regular fertiliser)	10.0-20.0	15.0
Lucerne – moderate to high fertility (extensively grazed)	7.0-12.0	9.5
Lucerne – moderate to high fertility (rotationally grazed)	10.0-15.0	12.5

Source: Department of Primary Industries, 2006

ii Pasture condition

Pasture condition assessments aid in determining the pasture types and broad carrying capacities for the pastures in the reference and rehabilitation areas. Pasture condition assessments also provide practical data to allow for comparison between pasture reference sites and rehabilitation sites, and useful data for determining appropriate grazing management strategies. Pasture condition is based on an assessment of pasture quantity, pasture quality and species composition.

iii Pasture quantity and quality

The critical herbage mass for sheep is in the range 400–1700 kg DM/ha, and for cattle 700–2900 kg DM/ha (Bell, 2006). Pasture quantity can be estimated by measuring the average height of the pasture.

Table 7.4 Average Height of Green Plants and 'Indicative' Herbage Mass

Average Plant Height (cm)	'Indicative' Herbage Mass (kg green DM/ha)
1	400
2	700
4	1200
6	1600
8	2000
10	2400
12	2800
14	3200
>14	>3200

Pasture quality can be qualitatively assessed by estimating the digestible percentage.

iv Pasture species composition

Pasture species composition can be taken from the results of the floristic species richness assessments. Species composition' refers to the species present, and the proportion of each of these species, in the pasture. What is important from a practical viewpoint is the proportion of legume. Legumes usually have a higher digestibility than grasses at the same stage of maturity (Bell, 2006).

7.3 Erosion

Rehabilitation designs are in most cases water shedding (free draining) due to the dispersive nature and salinity content of the overburden. Areas where water tends to pond after rainfall present a high risk to tunnel and gully erosion. Depressions can be identified during field surveys through signs of water ponding, localised differences in vegetation growth (bald areas or areas with high density of growth), surface salt accumulations from capillary action and evaporation processes, and visual identification of local differences in topography.

Signs of the following evidence of soil erosion are required to be assessed within and surrounding each rehabilitation monitoring site:

- Rills, gullies and tunnel inlet and outlets.
- Fine soil accumulation or the presence of lag material at the bottom of slopes or in depressions.
- Holes through drainage structures.
- Loss in depth of topsoil/growth medium.
- Loss of topsoil due to wind and sheet flow.
- Hummocking and pedestalling.

- Root exposure.
- Bare patches where groundcover vegetation has been denuded.

Erosion is to be classified as per the *Australian Soil and Land Survey - Field Handbook. 2nd ed (1990)* (ie active, stable, depth, type etc).

7.4 Landform stability

Landform stability is assessed through the use of field survey erosion assessments at MCM.

Where possible, areas of settlement in rehabilitation are assessed by visual inspections during rehabilitation monitoring.

7.5 Soil monitoring

Soil samples are undertaken using standard soil sampling techniques at 5 m intervals along each 50 m transect with a core sampler. At least 10 cores are taken at each site and bulked together. Soil samples are sent to a National Association of Testing Authorities (NATA) accredited laboratory for analysis. Soil analysis consist of assessing the parameters, pH, EC, Available Ca, Mg, K, Ammonia, sulphur, organic matter, exchangeable Na, Ca, Mg, K, H, Al, cation exchange capacity, available and extractable phosphorus, micronutrients (Zn, Mn, Fe, Cu, B), Total Carbon and Nitrogen.

A report with analysis and appropriate recommendation is provided by the laboratory. Exchangeable Sodium Percentages are calculated as a measure of sodicity or dispersion.

7.6 Additional monitoring requirements

7.6.1 Fauna habitat

To assist with habitat recreation tree hollows, stags and stumps, where practical, are relocated to areas adjacent to the mining operations that lack appropriate micro-habitat structures. Micro-habitat structures will contribute to the faster establishment of ecosystem reconstruction on rehabilitation areas.

It is a requirement within land use establishment phase that inspection records and photographs of habitat structures are provided in the rehabilitation monitoring report.

7.6.2 Wildlife corridor functionality

To provide quantitative data as to determine the level of functionality of the of the woodland rehabilitation areas for wildlife corridor function, it is proposed that a vertebrate monitoring program for highly mobile fauna species (ie bird and bat species) be incorporated into the reference and rehabilitation sites. The level of functionality will be determined based on the percentage of those species utilising the reference woodlands and rehabilitated woodland areas.

The vertebrate monitoring program has been designed to take into account the slow recovery time for species re-colonisation and the time it will take for revegetation areas to develop habitat attributes. The monitoring program is focused on key indicator fauna species as opposed to attempting to monitor all species found on site in a broad brush approach. The vertebrate monitoring will focus on diurnal birds and microchiropteran bats. A large proportion of the threatened species belong to these groups. Furthermore, monitoring these groups will provide valuable information on the progress of the rehabilitation as they depend on the development of good quality habitats with complex structure for foraging, roosting and breeding habitat.

It is proposed that fauna monitoring be undertaken annually for the first three years, followed by a review of the data collected to determine if the frequency of subsequent monitoring may be reduced.

Details of the vertebrate survey methodology are provided in Table 7.5.

Table 7.5 Variables to be measured during vertebrate monitoring

Species/Group	Methods	Effort per Site	Frequency	Season
Diurnal Birds	Point bird census	15 minutes each for two mornings	Once per year	Spring-Summer
Microchiropteran bats	Ultrasonic call detection (Anabat)	2 consecutive nights	Once per year	Spring-Summer
Terrestrial Mammals and Vertebrate Pest	Infra-red/motion sensor cameras	6 cameras for 3 nights (24 trap nights)	Once per year	Spring-Summer

7.7 Supplementary information

Photographs will be taken at the start and finish of each cover transect as a permanent visual record of the development of the rehabilitation. A list of all weed species with a subjective record of their abundance as sparse, moderately abundant or abundant will be recorded and included in the final report. Any potential pest species impacts on rehabilitated areas will be noted.

A measurement of the slope, plot landform location (upper, middle, lower slope) and plot aspect will be recorded.

7.8 Research and rehabilitation trials and use of analogue sites

Previous ACARP studies that MCC have participated in are:

- C13048 – Development of Rehabilitation Completion Criteria for Native Ecosystem Establishment of Coal Mines in the Hunter Valley, March 2005.
- C9031 – Rehabilitation for Spontaneous Combustion Prone Spoil Piles.
- C9062 – Infra-Red Thermography for Monitoring Spoil Piles.

A rehabilitation trial conducted in 2007-2008 to evaluate soil structure and fertility with use of composted green waste from the MSC Waste facility indicated that the compost was very effective in helping to establish newly seeded pasture areas and young tree seedlings. With this success, the application of 100 tonnes per hectare of composted green waste, when available, has become an option for MCC's rehabilitation process.

In 2007, Organic Growth Medium (OGM) was applied to a rehabilitation area in No.2 Open Cut in place of topsoil before seeding operations for both pasture and trees commenced. OGM is designed to assist plant growth and plant nutrient and water retaining properties. The use of this material has proven to be quite successful and has become another viable option when topsoil is in short supply.

MCC are involved in a study into the beneficial uses of voids that is being conducted by the Upper Hunter Mining Dialogue.

Rehabilitation performance is compared to analogue sites as part of the rehabilitation monitoring program. Throughout the remaining mine life and closure activities MCC will continue to support feasible rehabilitation trials and research projects.

7.9 Water monitoring

MCC undertake a surface and groundwater monitoring program with sampling locations on site and surrounding the site. This program has been ongoing for many years and will continue post closure.

The surface water monitoring program includes the following in accordance with the Surface and Groundwater Monitoring Plan (SGMP):

- monthly monitoring of mine site storage dams (Dam 1, Final Settling Pond, and the No.1 and No.2 Open Cut voids) for pH, Electrical Conductivity (EC) and Total Suspended Solids (TSS);
- quarterly monitoring of MCC 7, MCC8, MCC9, MCC23, MCC24, MCC25, MCC26 and MCC27 for pH, EC and TSS; and
- comprehensive water quality analysis is conducted annually.

The groundwater monitoring program is conducted on a monthly basis, measuring:

- ground water level;
- pH; and
- EC.

Comprehensive groundwater quality analysis is conducted annually.

7.10 Other monitoring programs

Other monitoring programs that are implemented to demonstrate criteria are being met include:

- decommissioning reports to confirm that infrastructure has been removed;
- contamination report to confirm that soil is suitable for final land use;
- survey reports to confirm that rehabilitated landform is consistent with MOP requirements;
- inspections, photographs and reports confirm that safety fences and/or berms have been installed around high walls; and

- inspections, photographs and reports confirm that the land surface is free of obstacles, is free draining, has no evidence of unacceptable slumping, show depth of topsoil and ameliorants, fences are installed to control stock grazing.

7.11 Reporting

Rehabilitation monitoring and independent environmental audit results are reported in the AEMR. The AEMR discusses monitoring outcomes against completion criteria, and compliance with regulatory requirements and MCC's project commitments.

In the event that potential rehabilitation failure has been identified that requires intervention any responses such as adaptive management or modification to rehabilitation methodologies will be reported in the AEMR.

AEMRs and independent audits will be submitted to relevant government agencies and made publically available via MCC's website.

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