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New way, New value

Minerva Mine

Rehabilitation Management Plan

Version: 1.1 (8 November 2021)

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Executive Summary

1 Environmental Authority EPML00668613 includes a condition that a Rehabilitation Plan must be developed by 1st July 2015. The Minerva Mine Rehabilitation Management Plan (Version 1.0) was submitted to the administering authority by the due date. The Environmental Authority requires any update to the RMP be submitted to the administering authority. Minor updates have been made to the Minerva Mine Rehabilitation Management Plan in the current version (Version 1.1) to make it consistent with a new Residual Void Investigation Report (5 November 2021) (prepared in accordance with Environmental Authority Condition F8). Certain other minor changes have been made to reflect current terminology.

2 The Rehabilitation Management Plan (RMP) outlines how the rehabilitation goals, objectives and strategies have been established and managed at Minerva Mine and has been formulated from various sources including:

- **a** Statutory documents e.g. Plan of Operations, Environmental Authority and Guideline EM1122-*Rehabilitation requirements for mining resource activities*;
- **b** *Minerva Mine Environmental Management Plan***;**
- **c** *Supplementary Report on Land Capability, Minerva Mine;*
- **d** Rehabilitation monitoring data;
- **e** Aerial images, maps and plans, and
- **f** Plan of Operation disturbance statistics.

3 The results of rehabilitation monitoring at Minerva Mine will be used to update this RMP (Rehabilitation Management Plan) to review objectives for the final rehabilitation of the site as well as drive the landform criteria and surface treatments. Monitoring provides a clear understanding that the primary driver for rehabilitation at the site is to achieve, safe, stable and sustainable landforms on a basis which recognises the challenging nature of the spoil material, the harsh climate, the elevated spoil landforms and the scarcity of topsoil resources.

4 The major aspect which is delivering change to the rehabilitation concept for the site relates to pre-strip spoil placement. This has by far the most important controlling influence on final landform and its ultimate stability. Current concepts involve in-pit dumping sequentially during mine life to enable in-pit disposal of large quantities of pre-strip material, thus reducing spoil elevation to enhance overall final landform stability.

5 In addition, the use of rock mulch in rehabilitation of fragile spoil batters offers an effective means of stabilizing steep slopes, particularly in conjunction with pastures and native trees/shrubs. Operations to end of mine life will encounter significant volumes of competent basalt strata. Salvage of this rock will allow the mine to apply competent rock mulch over any existing slopes where erosion is evident or planned future slopes where erosion risks may be elevated because of poor dispersive spoil sediment presence. Minerva Mine plans to implement this practice solely as a means of improving long term stability of outer slopes that may already exhibit or be at risk of unacceptable sediment loss. To implement these risk mitigation measures with due regard to Safe, Stable and Sustainable outcomes, it is proposed;

- **a** Basalt and/or competent Permian Sandstone strata is to be placed on final dump batter slopes to enhance integrity of the long term stability and surface erosion attributes of these surfaces;
- **b** Placement of Basalt and/or competent Permian Sandstone rock mulch over unconsolidated batter surfaces to a depth of approximately 50 cm in erosion susceptible areas will mimic existing natural stable rock scree landforms in the area.
- **c** These rock mulched areas are then to be topsoiled, deep ripped and seeded with a grass/tree seed mix to promote the development of a stable bushland habitat for these dump slope areas;

6 An approach of rock mulching dump batters followed by the establishment Acacia and Eucalypt species reflecting Regional Ecosystems in the area with similar slope attributes will result in the following enhanced environmental values;

a Reduced potential sediment load runoff concerning downstream water quality attributes off lease;

b Increased stable landform features reflecting slope and rock scree attributes of adjoining Regional Ecosystems in the area that provide reference with regard to weathering process consequences in terms of geomorphological time frames;

c Increased flora biodiversity thus resulting in a wider array of fauna habitat types over the longer term.

7 Spoil characterisation is an integral tool in the rehabilitation process with regard to achieving safe and stable landforms. It allows a greater opportunity for spoil dumps to be planned with rehabilitation in mind, as well as providing a means for opportunistic salvage of competent rock material suitable for rehabilitation purposes. Spoil strata characterisation enables competent material to be identified and salvaged on a planned basis. Reference to *Supplementary Report on Land Capability, Minerva Mine* concerns characterisation of soils and overburden plus land capability assessment for Minerva Coal Mine prior to the commencement of operations. Findings as related to physical and chemical characterisation support Minerva Mine's proposal to rock mulch dump batter slopes with appropriate Basalt and/or competent Permian Sandstone strata.

8 Application of this rehabilitation methodology is enhanced via operational integration of excavation/dumping schedules for the selection and placement of competent rock strata for final surface thus greatly reducing the possible end of mine life liability to rock armour unstable batter slopes.

9 This RMP provides direction for all aspects of the rehabilitation of lands disturbed by mining and associated activities. The RMP is a 'moving' document which will evolve with the Project. It is subject to annual review so that changes which occur over time such as the mine plan, rehabilitation methods, new technologies or legislative requirements are incorporated in a timely manner.

1 Introduction

Purpose

10 The primary purpose of this Rehabilitation Management Plan (RMP) is to address the ***Minerva Mine Environmental Authority EPML00668613 (EA)*** requirements to review the site's rehabilitation commitments and program as well as facilitate a mechanism for ongoing update and refinement of key aspects of mine rehabilitation which include;

a Construction of stable self-sustaining landforms in designated mine disturbance areas,

b Long term rehabilitation planning on the basis of the latest long term mine plan,

c Strategies for preservation and enhancement of existing Regional Ecosystems and adjoining grazing lands,

d Identification of opportunities and strategies for enhancement of corridor connectivity and biodiversity,

e Monitoring programs verify that rehabilitation performance criteria are being met and designs are appropriate.

11 This RMP outlines how the rehabilitation goals, objectives and strategies have been established and managed at Minerva Mine and has been formulated from various sources including:

a Statutory documents e.g. Plan of Operations, Environmental Authority and EHP Guideline EM1122-*Rehabilitation requirements for mining resource activities*;

b *Minerva Mine Environmental Management Plan***;**

c *Supplementary Report on Land Capability, Minerva Mine;*

d Rehabilitation monitoring data;

e Aerial images, maps and plans, and

f Plan of Operation disturbance statistics.

12 A key component of the rehabilitation program is the demonstration of satisfactory rehabilitation performance; thus rehabilitation monitoring sites are to be established to test performance across site variability in spoil characteristics, topography and rehabilitation methods. Representative areas of undisturbed nearby land will also be monitored for comparison purposes.

13 Once sites are deemed to have fulfilled and maintained rehabilitation criteria for appropriate time periods, they will progress to 'demonstration' site status (i.e. monitoring indicates that stable or improving conditions are occurring in soil profile chemistry, erosion, mass stability, vegetative abundance and diversity). The success of rehabilitation performance for other areas may then be compared with these sites.

14 Minerva Mine continues to develop Life of Mine (LOM) based plans and is progressively improving methods in stabilizing mine disturbed land. The process of refining rehabilitation methods for spoil areas, including pre-strip spoil dumps, ramps and voids plus developing appropriate land use goals for land disturbed by mining is on-going. Thus changed rehabilitation treatments and different performance criteria may be implemented, particularly for newly disturbed and future disturbed areas in response to site experience and final landform plan development. This RMP will be updated before significant landform or rehabilitation criteria are implemented.

2 Regulatory Requirements

15 This RMP is based upon ***Environmental Authority EPML00668613*** in which condition F3 states the operator must:

a A Rehabilitation Plan must be developed by 1 July 2015 by a suitably qualified person and implemented. The Rehabilitation Plan and must include:

i Rehabilitation objectives to achieve the rehabilitation goals for all disturbed areas;

ii Detailed rehabilitation methods for each disturbed area;

iii Rehabilitation indicators to measure the success of the rehabilitation against the rehabilitation objectives;

iv Final completion criteria that will achieve the rehabilitation goals and objectives; and

v Details of appropriate monitoring and maintenance of rehabilitation.

Environmental Management Plan

16 Minerva Mine submitted an ***Environmental Management Plan*** (EMP) to Queensland EHP in October 2007. This document *Minerva Mine Environmental Management Plan* is referred to as an Environmental Management Plan (EM Plan). The EM Plan provides supporting information on how the site is managed and has been used to establish the conditions of the ***Environmental Authority***. However, it must be noted that this EM Plan is no longer a regulatory requirement. The EM Plan is a valuable reference document that describes the proposed outcome for the rehabilitation of mined land (spoil areas) as a mosaic of pasture and bushland habitats in the following three general land types;

a Bushland habitat areas, which are seeded with a mixture of native species, which include trees, shrubs and grass.

b Open grassland habitat areas seeded with a mixture of native and exotic grass and legume species. Grasslands are included to provide habitat diversity and facilitate protection against erosion processes.

c Rugged topography with water storage areas, vegetation establishment will be dependent on spoil type and slope.

Lease Surrender

17 The QLD Regulator has developed guidelines for surrender of mining leases which require that at lease surrender, the lease holder must lodge a Mining Lease Surrender form to the Department of Environment and Heritage Protection accompanied by an audit report confirming that requirements for rehabilitation and decommissioning as described in the ***Environmental Authority EPML00668613*** and ***MJV Plan of Operations*** have been met. In addition, a Final Rehabilitation Report (FRR) shall be submitted which describes the status of rehabilitation work. The Regulator should be advised within 14 days of proposed cessation of operations and plans should be submitted within one month.

18 Environmental Authorities may be surrendered at any time with written notice.

19 The Regulator may accept surrender only if satisfied that the lease holder has rehabilitated the land in a manner described in the Environmental Authority and / or lease conditions. The Regulator may give further directions to the lease holder if not satisfied with any details of the request. Authority to accept a lease surrender request may be delegated to regional Departmental staff depending on the magnitude and impact of the project. There is no defined time period in which the Regulator must accept or reject a lease surrender request.

3 Rehabilitation Objectives

20 Growing evidence from over 30 years of rehabilitation monitoring in spoil regimes in the Bowen Basin indicates that rehabilitation based on duplication of adjoining natural ecosystems is unrealistic. The major reason being the significant differences between mine spoil and natural soil profiles and topography. Rehabilitated landscapes are often elevated with greater slope gradients; growth mediums are often unweathered, unconsolidated, sodic, saline and quite different in physical chemical makeup than surrounding natural soils.

21 The objectives for rehabilitation at Minerva Mine are based on an understanding of the Regulatory requirements for acceptable rehabilitation when considered against the array of background limits and opportunities posed by characterisation of the mine site and the results of the sites rehabilitation monitoring to date. That is, whilst endeavouring to comply with the regulatory requirements; the environmental and physical constraints of the site must be the primary drivers in setting strategies and performance outcomes. It is imperative that spoil, topsoil and climatic characteristics plus mining programs which deliver the final landform underpin the rehabilitation objectives.

22 Characteristics important to the identification of the rehabilitation goals and objectives are briefly explained in various sections of this report. The overall requirements for rehabilitation of the Minerva Mine site recognise government policies as defined through the following guidelines;

a EHP Guideline EM1122-*Rehabilitation requirements for mining resource activities*.

b ***Environmental Authority EPML00668613***

Environmental Authority Requirements

23 The existing regulatory pertinent requirements for rehabilitation for mined landform outcomes which are stated in ***Environmental Authority EPML00668613*** and the commitment provided by Minerva mine to achieve these conditions are outlined in **Error! Reference source not found.**.

EA Condition	Interpreted Requirement - Objectives
Rehabilitation	
F1 All areas **significantly disturbed** by mining activities must be **rehabilitated** to achieve the following rehabilitation goals: a) Safe to humans and wildlife; b) Stable; c) Non-polluting; d) Self-sustaining for the post-mining land use.	Landform stability is paramount. Appropriate final surface treatment and sustainable vegetation cover is a key objective with regard to prevention of erosion, land degradation and off lease /downstream impacts.
F2 Rehabilitation must commence progressively in accordance with the plan of operations.	Areas available will be determined by the mine plan.
F3 A Rehabilitation Plan must be developed by 1 July 2015 by a suitably qualified person and implemented.	Minerva Mine Rehabilitation Plan to be submitted to administering authority by 1 July 2015.
F4 The Rehabilitation Plan and must include: a) Rehabilitation objectives to achieve the rehabilitation goals for all disturbed areas; b) Detailed rehabilitation methods for each disturbed area; c) Rehabilitation indicators to measure the success of the rehabilitation against the rehabilitation objectives; d) Final completion criteria that will achieve the rehabilitation goals and objectives; and e) Details of appropriate monitoring and maintenance of rehabilitation.	Minerva Mine Rehabilitation Plan to be submitted to administering authority by 1 July 2015.
F5 The environmental authority holder must notify the administering authority of any changes to the Rehabilitation Plan, and submit to the administering authority.	Notification and submission of the Minerva Mine Rehabilitation Plan to the administering authority will be undertaken with regard to update and amendment of this document.
F6 All areas significantly disturbed by mining activities must be rehabilitated in accordance with the Rehabilitation Plan to achieve the final completion criteria.	Rehabilitation methodology and approach will be defined within the Minerva Mine Rehabilitation Plan concerning achievement of final completion criteria for all areas significantly disturbed by mining activities.
Residual Void	
F7 Residual voids must not cause any serious environmental harm to land, surface waters or any recognised groundwater aquifer, other than the environmental harm constituted by the existence of the residual void itself and subject to any other condition within this environmental authority.	In recognition of the principles of safe, stable and sustainable, Minerva Mine plans to optimise current in-pit dumping practices to backfill the main void to the most cost effective and practicable extent during operations. Refer to the Residual Void Investigation Report (5 November 2021) which provides an update of the planned likely extent of final void at closure and treatment strategies.

EA Condition	Interpreted Requirement - Objectives
F8 If residual voids are to be left an investigation into residual void options and landform design are to be completed. The subsequent report is to be submitted to the administering authority proposing acceptance criteria to meet the outcomes in condition **F7**, landform design criteria in **Table F1**, void volume reduction options and options to reduce the height of the main dumps by **1 December 2009**. The investigation shall be completed by a competent person, and include detailed research and modelling and at a minimum include the following: a) a study of options available for minimising residual void area and volume; b) a void hydrology study, addressing the long-term water balance in the voids, connections to groundwater resources and water quality parameters in the long term; c) a pit wall stability study, considering the effects of long-term erosion and weathering of the pit wall and the effects of significant hydrological events; d) a hydrological study into the long-term risk of the Sandhurst Creek / final void interaction, including erosion of the banks and spoil and extreme hydrological events, and the consequences of such interaction to the long-term stability of the final voids; e) a study of void capability to support native flora and fauna; and f) a proposal/s for end of mine void rehabilitation success criteria and final void areas and volumes.	Draft Residual Void Investigation submitted to EHP 9th April 2010. A final Residual Void Investigation Report (5 November 2021) has been submitted to the administering authority.
Topsoil	
F9 Topsoil resources that are suitable for use in rehabilitation must be identified and salvaged ahead of mining for strategic use in rehabilitation of the mine area.	Stripping depths of topsoil removal ahead of mining operations are expedited as per soil survey data and attributes defined within *Supplementary Report on Land Capability, Minerva Mine.*
F10 Where practicable stripped topsoil must be directly placed on rehabilitation areas. Where direct placement is not practicable, topsoil must be stored in stockpiles less than **four (4) metres** high and vegetated.	Where mine schedule does not allow for direct placement onto rehabilitation, topsoil stockpiles established will be below 4 metres with location tracked via GIS (Geographic Information System).
F11 An inventory of topsoil resources must be maintained.	Topsoil inventories are maintained via GIS and updated on an annual basis. Data from these inventories is then detailed in the annual Plan of Operations.
Infrastructure	
F12 All infrastructure, constructed by or for the environmental authority holder during the mining activities including water storage structures, must be removed from the site prior to mining lease surrender, except where agreed in writing by the post mining land owner/holder.	All infrastructure including water storage structures will be removed from site unless otherwise agreed in writing by the post mining land owner/holder.

Table 1 – EA Requirements and Minerva Mine Commitments.

General and Specific Rehabilitation Goals

General Rehabilitation Goals

24 The Queensland Government policy objectives for rehabilitation are described as Rehabilitation Goals to distinguish them from the Rehabilitation Objectives selected by mining companies in their rehabilitation strategies for a particular mine.

25 The four general Rehabilitation Goals set by the Queensland regulator requires that areas disturbed by mining are rehabilitated to a safe, stable, non-polluting state with an agreed post mine land use. This RMP provides meaningful site wide strategies on how the Queensland Government's rehabilitation goals will be achieved with due regard to the physical and environmental characteristics of the site. This is effectively what the RMP is meant to deliver. These strategies that Minerva Mine has developed to deliver these outcomes are outlined in **Error! Reference source not found.** (EHP Guideline EM1122-*Rehabilitation requirements for mining resource activities*).

EHP Rehabilitation Goals	Minerva Mine Overall Rehabilitation Strategy
Safe to humans and wildlife	• Spoil dump slopes will be regraded to allow safe access for humans and wildlife and possibly livestock in selected areas. • Mine voids will be backfilled to the most practicable and cost effective extent during operations. • Sumps, pits and areas of unstable ground will be stabilized as appropriate to ensure that there is no risk to stock, fauna or humans.
Non-polluting	• Leachate will be prevented from mobilization from potential sources of contaminants such as spoil and coal fines to watercourses or useful groundwater.
Stable	• All residual slopes will be geotechnically and erosionally stable, areas of dispersible mine spoil will strategically be covered with more competent Basalt spoil.
Able to sustain an agreed post-mining land use	• The mine-scape (areas previously mined, excavated, dumped over or topsoil stripped) will be formed into a mosaic of bushland habitat and grassland areas.

Table 2 – Summary of Guideline EM1122 Goals and Minerva Mine Commitments

Rehabilitation Hierarchy

26 Guideline EM1122 states that in assessing the acceptability of rehabilitation objectives, indicators and completion criteria that may be proposed for a mining project, that EHP will have regard to a hierarchy for mine rehabilitation that is similar to the waste hierarchy. That is in order of decreasing capacity to prevent or minimize environmental harm.

27 The Regulators preference is that strategies listed higher in the hierarchy should be adopted in preference to those listed lower, unless there are significant environmental, economic or social issues that override such a selection. This RMP provides a range of supporting information on how Minerva Mine has adopted the most feasible strategy for the final land use of the site. Minerva Mine's overall reasoning as to the setting of an appropriate hierarchical rehabilitation land use strategy is outlined in Table 3.

28 The final land use objectives for domains which have been greatly affected by mining are of a lower value in terms of potential economic yield, but offer improved prospect for longer term stability. This is aligned with the Guideline EM1122 which states that:

a "*Developing a lower value use may be acceptable if that use is acceptable to the relevant stakeholders and all higher strategies are impractical*" and "*While it may be appropriate to attempt*

to restore the pre-mining conditions after mining has ceased for some smaller mines and mines in areas with special values, this may not be possible or an optimum result across mine sites particularly in specific domains."

29 This may be the case for some mine spoil and void domain areas at Minerva Mine. Other areas of the lease excluding areas with inherent residual risk such as final void or areas of known conservation significance (e.g. offsets) will return to a grazing or grazing support use. This is feasible, given that a portion of land within the Minerva Mining Leases will not be significantly disturbed by mining or mining relating activities.

4 Environmental Characterisation

Pre-Mining Land Suitability and Use

30 Details for pre-mining land use and soils have been described by Ison *et al* (1996) indicating the land in general was capable of supporting crop and pastoral development predominantly ranging from Shallow to Deep Black Vertisols on Tertiary Basalt interspersed by Red Brown Non-Cracking Clays and Duplex soils on Permian Sediments. Summaries of this information are included in the ***EMP*** (Minerva Mining 2007).

31 The pre-mining landscape was a flat to gently rolling terrain with occasional hill features with maximum variation over the area of around 14m. Nearby to the west and south, there are a number of relic basalt flows and intrusive volcanic plugs that form steep hills and ridges up to 250m above the surrounding black soil plains. This backdrop of steep sided basalt formations forms the dominant visual character of the locality.

Climate

32 The climate for the area is typical of the region with high daytime summer temperatures, mild winters and low-moderate humidity. Rainfall is highly variable and seasonal with most recorded during the warmer months from December to March (Table 4). Average annual rainfall at the Springsure weather station is 689 mm.

33 As there were some gaps in Bureau of Meteorology (BOM) data at stations nearest to the study area, the following were selected to best represent local conditions:

a Seasonal long term climate and rainfall statistics - Springsure Comet St (ID: 35065);

b Seasonal monthly rainfall statistics – Woorarra (ID: 35205).

34 In cases where rainfall data was not recorded during a particular month at the above stations, results were taken from Ronnoc Downs (ID: 35212).

35 Table 4 rainfall data shows that 65% of annual rainfall is received in the November to March period, with 45% of the annual total received in the three month period December to February. Rainfall of medium to high intensity can occur during the November to March period due to cyclonic rain depressions or summer thunderstorms. A typical rainfall pattern for Minerva may include:

a Thunderstorms during late spring/early summer (i.e. October – December) with erratic frequency and rainfall.

b Wet season rainfall (typically through January – March) with heavy soaking falls for periods of up to several days.

c Dry season winter/early spring (i.e. April – September) with infrequent falls from passing cold fronts.

36 High rainfall events are common hence surface runoff can be substantial. As for the region, evaporation greatly exceeds precipitation, hence water stress is expected to be significant factor in the performance of future rehabilitation of disturbed land, particularly on slopes and or where topsoil thickness is limited and the under lying spoil may be compacted.

EHP Guideline EM1122 Hierarchy	Site Capabilities
Avoid disturbance that will require rehabilitation	Not applicable for areas of existing mine disturbance or for areas properly set aside for future mining. Limit mining area to that which is necessary for efficient exploitation of the coal resource.
Reinstate a "natural" ecosystem as similar as possible to the original ecosystem	RMP intent is the development of a mosaic of bushland habitat and grassland areas that reflects Regional Ecosystems in the area. Where feasible bushland habitat areas will entail rock mulching dump batters followed by application of topsoil that is subsequently deep ripped and seeded to a mix of tree and shrub species reflecting Regional Ecosystems in the area with similar slope attributes. This approach will result in the following enhanced environmental values; ➢ Reduced potential sediment load runoff concerning downstream water quality attributes off lease; ➢ Increased stable landform features reflecting slope and rock scree attributes of adjoining Regional Ecosystems in the area that provide reference with regard to weathering process consequences in terms of geomorphological time frames; ➢ Increased flora biodiversity thus resulting in a wider array of fauna habitat types over the longer term. As per abovementioned rationale with regard to reflecting Regional Ecosystems with similar slope attributes, grassland areas are to be established on slopes of less than 5 %. The abovementioned approach is to be implemented for erosive prone areas or current rehabilitation domains that have failed. Reconciliation of rehabilitation monitoring concerning reference sites and treatment areas will provide appropriate criteria and a means of validation of rehabilitation treatment approach.
Develop an alternative outcome with a higher economic value than the previous land use	Not feasible in this region considering the large area of disturbed land and the grazing/cropping land use to which it was utilized for prior to mining.
Reinstate previous land use (e.g. grazing or cropping)	ACARP research in 1996 suggested a number of parameters which are indicative of mine rehabilitation which is suitable for a sustained grazing use. A major parameter identified was slope gradient for areas in excess of 12% slope would not be suited to grazing due to excessive risk from erosion. However, it proposed that selected low slope areas below 5 % reflecting comparable unconsolidated sediment land types in the region may be appropriate for grazing land use. Rehabilitation monitoring will facilitate validation of this attribute of rehabilitation hierarchy.
Develop lower value land use	The proposed land use for mining disturbed areas – spoil and voids is that of a mosaic of bushland habitat and grassland areas. Development of safe, stable and self-sustainable landforms that are non-polluting is the primary consideration with regard to achievement of Regulatory Goals defined in this RMP.
Leave the site in an unusable condition or with a potential to generate future pollution or adversely affect environmental values.	Minerva Mine acknowledges that leaving land in an unstable or polluting state is unacceptable and that the principal objective is to achieve safe, stable and sustainable outcomes that do not generate pollution or affect regional environmental values. This RMP provides an overview of the site's environmental and physical characteristics; as well summarizes the historical rehabilitation performance and proposes means to improve the stability and sustainability of spoil landforms.

Table 3 – Guideline EM1122 Hierarchical Rehabilitation Goals and Minerva Mine Position

Month	Temperature (°C)		Relative Humidity %		Wind (km/hr)	Rainfall (mm)		
	Average Min	Average Max	9am	3pm	3pm	Mean	Highest Daily	Highest Monthly
	1938-2014	1938-2014	1938-2010	1966-2010	1965-2010	1865-2014	1865-2014	1865-2014
Jan	20.8	34	61	38	5.8	108.9	172	768.3
Feb	20.5	32.4	66	44	5.7	109.6	171.5	552.7
Mar	18.8	31.6	62	38	5.7	70.1	129	326.4
Apr	14.9	29	59	38	5.9	39.8	129	240.6
May	10.9	25.3	60	39	5.1	35.5	104.5	263
Jun	7.2	22.2	62	40	5.7	37.8	92.7	296
Jul	6.3	22.1	60	36	6.2	28.2	119.4	244.5
Aug	7.5	24	54	30	6.3	24	63.9	200.7
Sep	11.2	27.6	52	29	6.7	29.7	90.2	324.2
Oct	15.2	30.6	52	30	6.8	47.1	86	237
Nov	17.9	32.8	55	33	7.3	65	156.2	355.9
Dec	19.8	34	57	37	6.1	93.2	110.5	522

Climate statistics taken from BOM station at Springsure Comet St (ID: 35065).

Table 4 – Long Term Climate Statistics (1865 to 2014)

37 High rainfall events are common hence surface runoff can be substantial. As for the region, evaporation greatly exceeds precipitation, hence water stress is expected to be significant factor in the performance of future rehabilitation of disturbed land, particularly on slopes and or where topsoil thickness is limited and the under lying spoil may be compacted.

Spoil Characteristics

38 Spoil characterisation is an integral tool in the rehabilitation process with regard to achieving safe and stable landforms. It allows a greater opportunity for spoil dumps to be planned with rehabilitation in mind, as well as providing a means for opportunistic salvage of competent rock material suitable for rehabilitation purposes. Spoil strata characterisation enables competent material to be identified and salvaged on a planned basis. Reference to *Supplementary Report on Land Capability, Minerva Mine* (ESys Consulting Pty. Ltd. May 2005) concerns characterisation of soils and overburden plus land capability assessment for Minerva Coal Mine prior to the commencement of operations.

39 Overburden and inter-burden (collectively referred to as spoil henceforth) was assessed by Ison Environmental Planners (1996a). This assessment comprised two drill holes located in the centre and north-west of the deposit. Ninety-five metres of spoil was collected for sampling from DH 1078 (deposit north-west) to a depth of 118m and approximately 46m from DH1043C (deposit centre) to a depth of 54m. Composites samples were formed over depth increments ranging from 1 to 21m with an average increment of 6.4m. Spoil composites were tested for pH, salinity, major cations and metals.

40 Seven additional holes were sampled as part of this supplementary programme increasing the holes sampled from two to nine and increasing the vertical sampling depth by 323m. Drill hole samples were still held in storage by New Hope Corporation and additional drilling was being conducted at the time of this study in 2004. A selection of holes representing different geologies across the deposit from within the available holes was made with the assistance of the project geologist. Four holes were selected from the drill programme with a further three holes selected from the New Hope core library. Each core was sampled at approximately 1m increments. Adjacent samples within a core that were logged within the bore log as of similar geology were later combined into a single composite. The maximum increment was 8m with the average increment thickness being 2.6m.

41 All composites were crushed by ALS (NATA registered laboratory) until at least 80% of the sample passed through a 2.36mm sieve. Each sample was tested for pH and EC on a 1:5 spoil: water ratio by volume. Twenty-two spoil classes were formed based on similarity of geology, underlying coal seam, weathering, pH and EC. ESys Consulting Pty. Ltd. (May 2005) defined these resulting spoil classes as per Table 5.

Spoil class	Seam ID		Dominant lithology	Drilled	Metres included in composite
1	Funnel	unweathered	siltstone & sandstone		8
2	Funnel	weathered	siltstone & sandstone		19
3	Lexington	unweathered	siltstone	1995	16.5
4	Lexington	unweathered	siltstone & sandstone	2004	60
5	Minerva	unweathered	siltstone & sandstone	1995	22
6	Minerva	unweathered	siltstone & sandstone	2004	77
7	Sandhurst	unweathered	siltstone & sandstone		3
8	Wills	unweathered	siltstone & sandstone		24.5
9	Wurba	unweathered	siltstone & sandstone		50
10	Wurba	weathered	sandstone		28
11		unweathered	coal		3
12	Wills	unweathered	basic intrusion		4
13	Minerva	unweathered	sandstone		24
14	Minerva	unweathered	siltstone		65.5
15	Minerva 1	unweathered	siltstone & sandstone		26
16	Minerva 2	unweathered	siltstone & sandstone		18.5
17	Minerva 3	unweathered	siltstone & sandstone		28.5
18	Minerva 4	unweathered	siltstone & sandstone		20.5
19	Minerva 5	unweathered	siltstone & sandstone		7.5
20	Sandhurst 1	unweathered	siltstone & sandstone		2
21	Sandhurst 2	unweathered	siltstone & sandstone		1
22	Minerva	unweathered	mudstone		9.5

Table 5 – MJV Spoil Classification Extract

42 Composite samples were forwarded to NATA registered laboratories for chemical and physical testing that included pH, electrical conductivity, fertility, soil particle size/dispersion, metals and acid production potential. Attributes described by ESys Consulting Pty. Ltd. (May 2005) are as follows:

a *Soil reaction*: Most of the spoil classes (87% of material forming the composites) were mildly to strongly alkaline with two classes being strongly acid. These latter spoil classes represented the siltstones and sandstones associated with the Sandhurst 1 seam. The remaining spoil classes (12% of material forming the composites) were mildly acid or neutral.

b *Salinity*: Most of the spoil classes were non-saline (89%of the composite material) with the remaining spoil classes having medium to high salinity. The saline spoil classes were lithologies over the Sandhurst 1 seam, coal and the weathered material above the Funnel seams.

c *Major elements*: All spoil types were very low in nitrogen and phosphorus being characteristic of spoils in Central Queensland. Potassium was acceptable or marginally low in most spoil classes with the notable exception of weathered spoil above the Funnel seams and lithologies above the Wurba seam. Calcium, magnesium and sulphur levels were acceptable in all spoil classes tested.

d *Trace elements*: All trace elements were at acceptable levels. Notably, boron was low in these Permian lithologies as compared to the basalt derived soils. Boron toxicity is not expected.

e *Chemical induced dispersion*: Sodicity was present in all spoil classes but not excessive ranging from 7-14%. The calcium-magnesium ratio is low in most of the unweathered spoil classes. This characteristic is common to Central Queensland spoils.

f *Mechanical dispersion*: The dispersion indices of all tested spoil classes other than Wurba sandstone were moderate again suggesting some mechanical dispersion.

g *Erodibility*: Soil erodibility of the spoil classes were generally on par or lower than that of the soils tested. A K factor exceeding 0.045 is considered erodible. The USLE K factor for the tested spoil classes were ranked as follows:

i Funnel 0.052>Wurba 0.43-0.46>Lexington 0.04>Wills 0.038>Minerva 0.028.

h *Acid production potential*: Eighteen of the 22 spoil classes were tested for acid production potential. The untested spoil classes represented either weathered spoil or composite samples represented better by other spoil classes. The spoil is generally neutralising with only two spoil classes exhibiting net acid production. The spoil classes have been placed into five groups as per Table 6.

Acid production potential	Net acid production potential (kg H_2SO_4/t)	Spoil classes
None (neutralising)	< -15	Lexington, Minerva 4 and 5 lithologies
None (neutralising)	-15 to -10	Wills, Minerva 1 to 3 lithologies
Very low (low neutralising)	-10 to 0	Lexington siltstone, Minerva 5, Sandhurst 2 and Minerva mudstone lithologies
Low (low acid)	0 to 5	Funnel lithologies
Moderate	>5	Sandhurst 1 lithologies

Table 6 – MJV Spoil Acid Production Potential Classification Extract

The low net acid production potential of the Funnel lithologies can be neutralised either with limestone (2-5t/ha) if the spoil appeared on the surface or by mixing this material with other spoil in a ratio of 3:1 Funnel to any other lithology other than Sandhurst 1. The main limitation with this material would relate more to the impact on nutrient availability rather than adverse acid affects. It is recommended that this material should not be placed within 2m of the surface. As the soils of the area are alkaline, surface expression of acid is not expected. Acid mine drainage into aquifers is not expected from this material.

The unweathered Sandhurst 1 seam lithologies represent the only net acid material of concern. Though the acid potential is not sufficiently high to warrant encapsulation, this material should not be placed within 10m of the surface. Mixing with any other spoil class other than Funnel material in a 1:1 ratio would be sufficient to neutralise potential acid. There is ample neutralising capacity in the remaining spoil to neutralise any resulting leachate.

i *Metals:* All seam lithologies were tested for environmental metal levels though Minerva and Sandhurst seams were not tested individually. The materials were analysed for arsenic, chromium, copper, lead, nickel, zinc, cadmium and mercury. Cadmium and mercury levels were below detection levels throughout. The metal levels of the Permian coal measures were less than 40% of investigation threshold levels QDME (1993) in all materials for all metals except Minerva mudstone which recorded a level of 60% of the threshold level for zinc. In general, the levels were less than 20% of the respective investigation threshold levels.

The basic intrusion sample exhibited elevated chromium, copper and nickel levels. While the chromium and copper levels were below the investigation threshold levels, the nickel level was 220% of the investigation level. The basic intrusions have surface expression in the vicinity of the mine and consequently, localised elevated nickel may occur elsewhere. Furthermore, the volume of basic intrusion in the spoil is very low and the likelihood of this material occurring on

the surface is low. Any surface expression of basic intrusion in the spoil should be covered with topsoil.

43 The use of rock mulch in rehabilitation of fragile spoil batters offers an effective means of stabilizing steep slopes, particularly in conjunction with pastures and native trees/shrubs. Operations to end of mine life will encounter significant volumes of competent basalt strata as per below Figure 1 depicted with regard to conceptual depths of basalt strata on site. Salvage of this rock will allow the mine to apply competent rock mulch over any existing slopes where erosion is evident or planned future slopes where erosion risks may be elevated because of poor dispersive spoil sediment presence. Minerva Mine plans to implement this practice as a means of improving long term stability of outer slopes that may already exhibit or be at risk of unacceptable sediment loss.

44 Application of this rehabilitation methodology is enhanced via operational integration of excavation/dumping schedules for the selection and placement of competent rock strata for final surface thus greatly reducing the possible end of mine life liability to rock armour unstable batter slopes.

45 The major variables for rehabilitation performance are spoil physical and chemical attributes, slope gradient, use of topsoil, seasonal weather, initial vegetation establishment and age of rehabilitation.

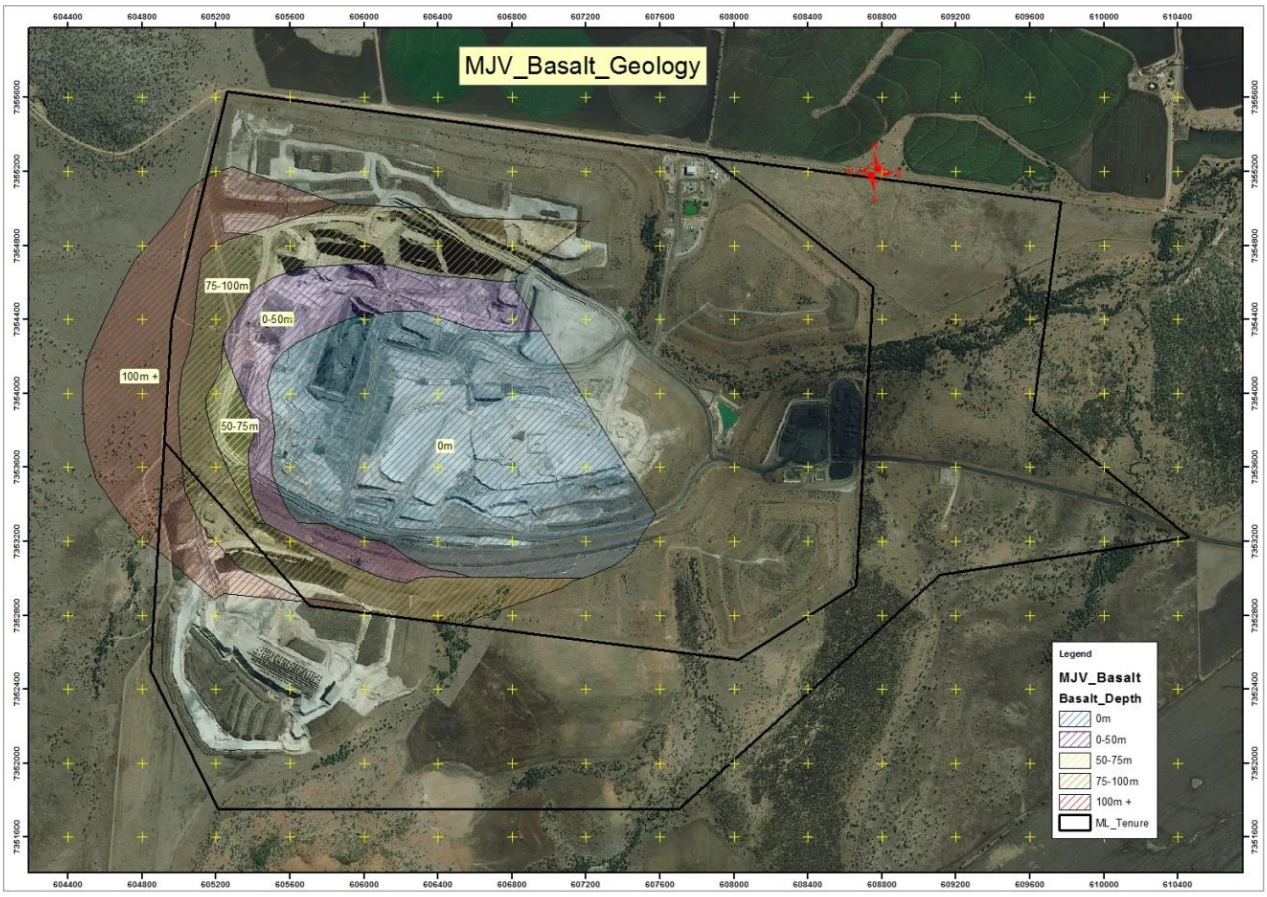


Figure 1 – MJV Conceptual Basalt Model

Topsoil Resources

46 Topsoil inventories are maintained via GIS and updated on an annual basis. Data from these inventories is detailed in the Plan of Operations.

47 Pending final landform planning outcomes, topsoil application rates will have to be reduced for strategic areas to cover the entire disturbed area.

48 An approach of rock mulching erosive prone dump batters followed by reduced topsoil application rates that are subsequently deep ripped and seeded to a mix of Acacia and Eucalypt Species reflecting Regional Ecosystems in the area with similar slope attributes will need to be employed. Hence in these circumstances topsoil is being utilized as an inoculation and germination resource for the development of bushland habitat areas.

49 Topsoil resources have been assessed for soil type and pre-mining land suitability with stripping depths formulated as per *Supplementary Report on Land Capability, Minerva Mine* (ESys Consulting Pty. Ltd. May 2005). As previously described soils predominantly range from Shallow to Deep Black Vertisols on Tertiary Basalt interspersed by Red Brown Non-Cracking Clays and Duplex soils on Permian Sediments. All topsoil in advance of mining is stripped to recommended depths and either stockpiled or replaced over rehabilitation.

Water Quality Aspects

50 Minerva Mine is located in the upper catchment of Sandhurst Creek which drains to the Comet River near its confluence with the Mackenzie River. For the purposes of the Queensland Water Quality Guidelines, Sandhurst Creek is located in the western tributaries of the Comet River sub-region, in the Fitzroy River basin (Basin 130) which is part of the Central Coast Region (QWQG, 2009; FBA, 2010).

51 The waterways on Minerva Mine, and within 10kms downstream, are ephemeral with flow only after significant rainfall and for limited periods each year. The catchment area upstream and downstream of mining is predominately rural cropping and grazing land and natural bushland.

52 The creeks in the study area generally receive no permanent groundwater base flow that contributes to surface flows, with the exception of sections of Sandhurst Creek near the Gregory Highway which is thought to be replenished by local spring water (pers.comm, Downstream Landholder, 2014)

53 Detailed surface water monitoring programs have been maintained over a life of mine and have developed a strong profile of water quality and variability in mine disturbed areas plus natural areas.

54 Minerva Mine water resources are obtained predominately from pit dewatering to onsite mine water dams. The mine water management system comprises a drainage network, which captures all mine affected water. A series of catch drains, pipelines, dams and pumping infrastructure is used to convey mine water that is used for dust mitigation purposes as related to haul road circuits and ROM/Train Load Out infrastructure. These operational demands are supplemented with groundwater from the licenced site bore field.

55 *Minerva Mine Hazardous Dam Inspection and Category Review-2014* identified all storage structures as being of a Low Hazard Category status.

56 *Minerva Mine Receiving Environment Monitoring Program (REMP)-2014* concluded, changes in median water quality after mining were within acceptable limits for slightly-to-moderately disturbed systems or remained within applicable guidelines or trigger values.

Spoil Runoff Quality

57 Pit/spoil water quality as reflected by mine water and sediment dam water quality data is variable across the site. Table 7 provides *in situ* values of pH and conductivity for site mine water and sediment dam storages measured in December 2014 as depicted in Figure 2.

58 The below data provides indication that runoff from spoil areas is alkaline and saline.

Dam Storage ID	Date	pH	Electrical Conductivity uS/cm
IND DAM 1	16/12/2014	7.26	145
IND DAM 2	16/12/2014	8.18	701
DAM 4	16/12/2014	8.75	3320
DAM 7	16/12/2014	8.24	924
ROM 3	16/12/2014	8.41	1360
TLO DAM 2	16/12/2014	7.44	428
Crusher Pad Dam	16/12/2014	7.30	937

Table 7 – MJV Mine Water and Sediment Dam Water Quality - December 2014.

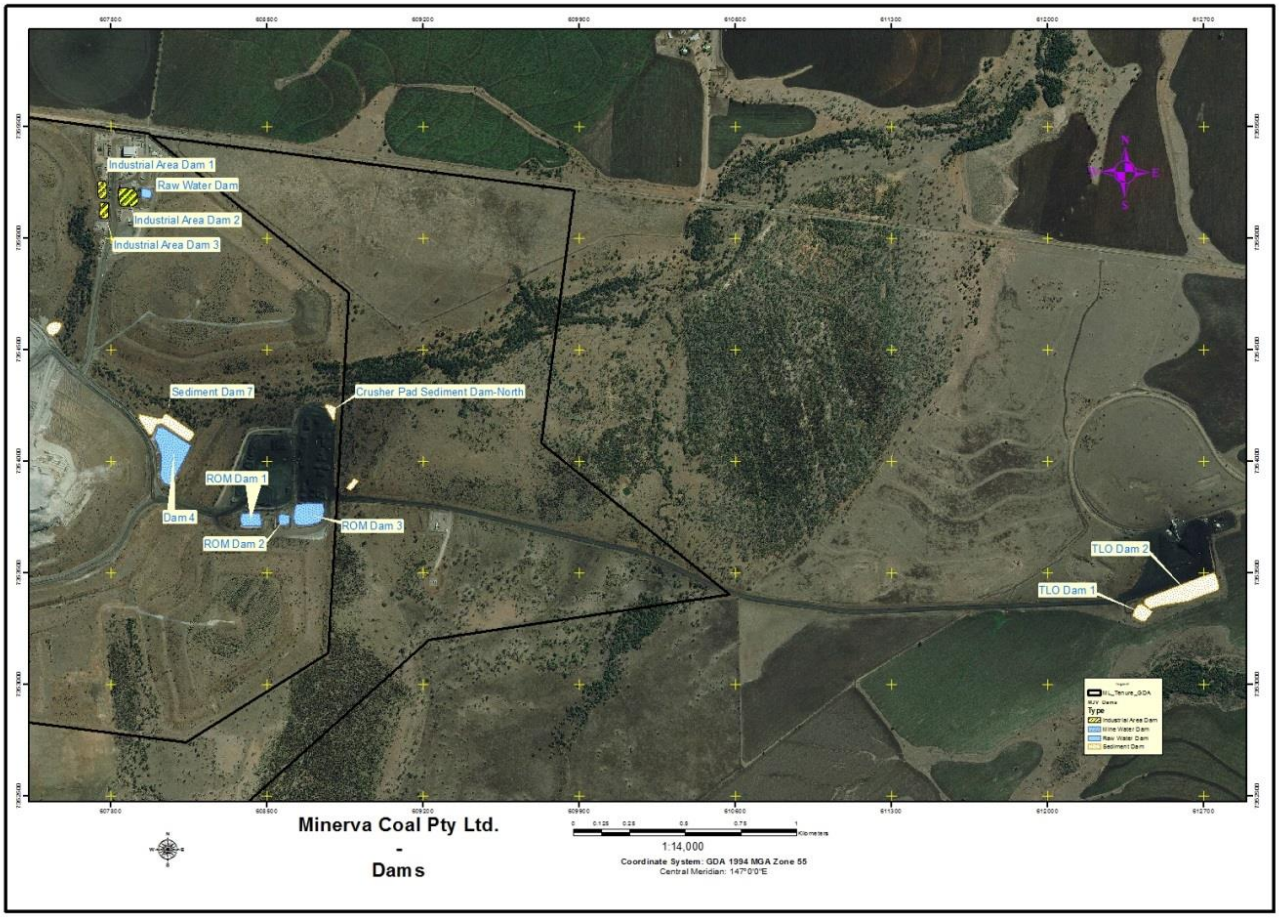


Figure 2 – MJV Mine Water and Sediment Dams

Groundwater Regime and Quality

59 The Minerva Mining Leases are within a Proclaimed Area under the *Water Resources Act 1989* and there are several bores licensed for the extraction of water present in the area. These bores are used primarily for irrigation of crops and water is sourced from within the basalt surrounding the coal deposit. There are no licensed bores within the Permian coal measures. Lexington property, within which the mine deposit resides, currently holds a water allocation for 400ML per year for irrigation use drawn from basalt aquifers. Studies undertaken by Waste Solutions Australia (1996, 1998) indicated no sizeable, useable groundwater resource to the east of the mine site.

60 The lack of extensive, hydraulic connections between the open pit area and the surrounding basalt aquifers suggests that any adverse impact of open pit mining on the basalt groundwater resources will be limited to areas around fault zones which connect aquifers within the basalt to the mine area (Waste Solutions Australia

1996a, 1996b). The main basalt aquifers appear to be several kilometres to the west of the mine area. These aquifers were originally formed in areas of major faulting within the basement rocks.

61 Pre-mining monitoring of ground water occurred between 1996 and 1998 and resumed late in 2004. A summary of groundwater quality is presented in Table 8. Sampling clearly indicates a decrease in water quality from the basalt aquifers to the water sourced from the intrusions with a further deterioration in water quality within the coal measures. Hydrology studies (Waste Solutions Australia 1996a) indicate that groundwater within the Reid Dome Beds is limited and expected to be confined to intrusions to the south east and west of the deposit. Groundwater yields in exploration drill holes varied between 0.25 and 0.6 L/s.

Parameter	**Units**	**Average ground water quality from different water sources**		
		Basalt aquifers	**Deposit intrusions**	**Coal measures**
Sample number		**9**	**3**	**7**
pH	N/A	7.7	8.4	7.8
TDS	mg/L	531	817	2039
EC	uS/cm	831	1260	3200
Cl	mg/L	57	170	521
SO4	mg/L	5.1	132	457
Na	mg/L	103	260	454
K	mg/L	3.9	4.9	14
Hardness	mg/L	213	57	636
Ca	mg/L	37	14	61
Mg	mg/L	30	5.4	119
Fe	mg/L	0.3	8.9	n.t.

Table 8 – Minerva Ground Water Quality

62 All ground waters were suitable for consumption by cattle as assessed by the above parameters, though the quality was poor for water from the coal measures. The basalt aquifers were suitable for irrigation of crops with low salt tolerance. Water sourced from the intrusions on average could be used to irrigate crops of moderate tolerance, albeit some samples exceeded recommended limits. Water from the coal measures was unsuitable for irrigation, especially when applied to clay soils.

63 There are several bores licensed for the extraction of water present in the area. These bores are used primarily for irrigation of crops and water is sourced from within the basalt surrounding the coal deposit. There are no licensed bores within the Permian coal measures. Sojitz Minerva Mining holds two water licences under the Department of Natural Resources and Mines (DNRM); Water Licence 405674 permits 100ML/yr of underground water to be extracted for irrigation purposes, and Water Licence 405647 permits the taking of 400ML/yr of underground water for industrial uses.

64 Monthly dipping, annual water sampling/analysis with subsequent Bore Field Performance Review of the monitoring bore network (i.e. as depicted by Figure 3) is conducted as per Water Licence 405647 requirements. The most recent Bore Field Performance Review concluded that there was no material departure of groundwater performance of the bore field and limited piezometric impact caused by the operation of the bore field on the surrounding aquifer.

65 EPML00668613 requires bi-annual water sampling/analysis of the Environmental Authority monitoring bores (1077, 1114 & 1116) depicted as per Figure 3.

66 A Residual Void Investigation Report (5 November 2021) has been prepared in accordance with Environmental Authority Condition F8. The report contains predictions of the long-term equilibrium water level and water quality in the Main (Western) and Southern residual voids. The report predicts the long-term the salinity of water in both residual voids will become unsuitable for irrigation initially, and subsequently become unsuitable for stock water for beef cattle. The voids would be unable to support a Post-Mining Land Use and would be Non-Use Management Areas. The void water would not, however, result in adverse environmental impacts on surrounding aquifers, including the basalt aquifer, as groundwater hydraulic gradients are expected to be maintained in perpetuity towards both voids. The maximum water level in the voids is 60m below the spill point and void water would not be released to

surface waters or surrounding lands. In conclusion, the residual voids would not cause any serious environmental harm to land, surface waters or any recognised groundwater aquifer, other than the environmental harm constituted by the existence of the residual void itself.

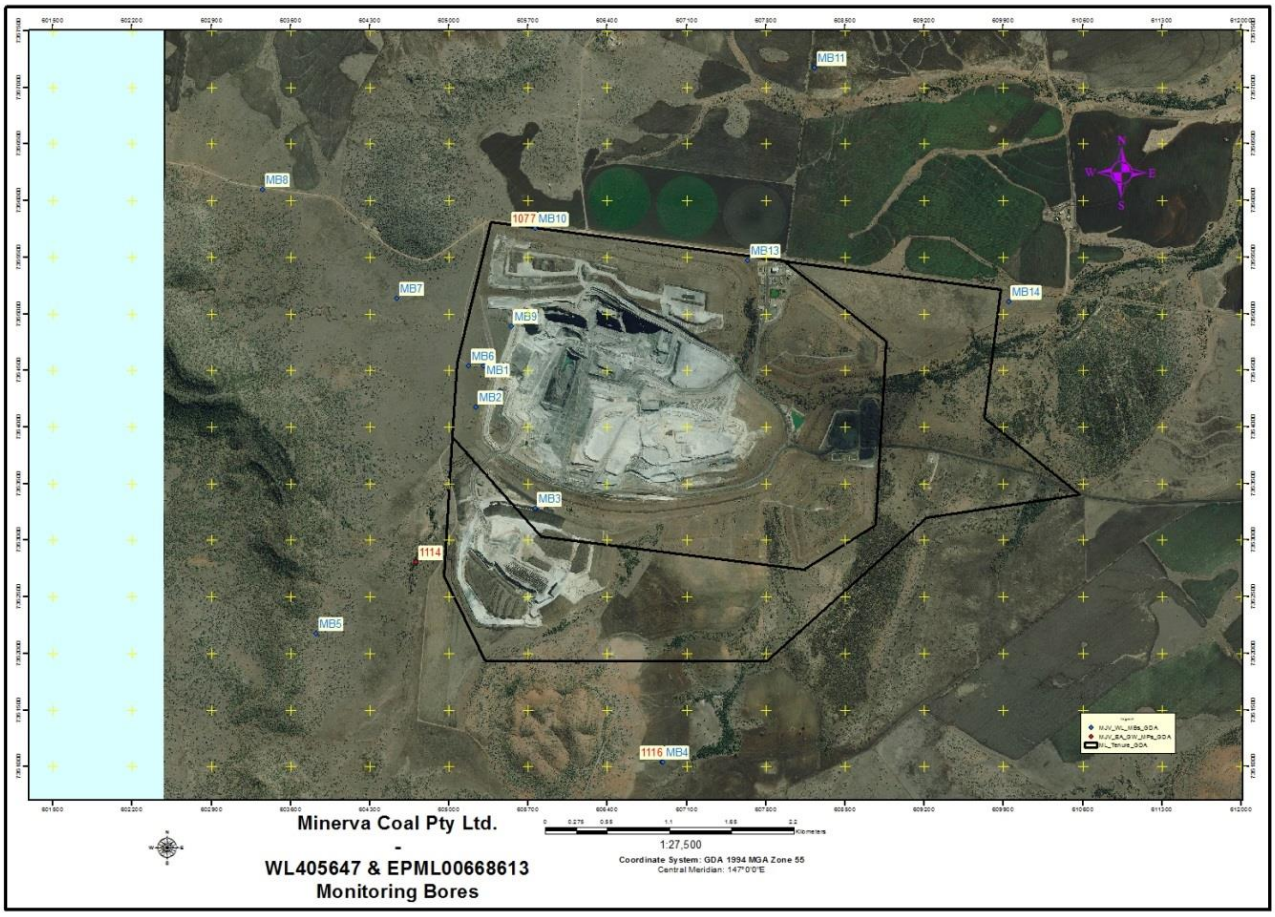


Figure 3 – MJV WL405647 & EPML00668613 Monitoring Bores

Contaminated Land

67 Records are maintained which show the type, location and extent of infrastructure and activities with potential to contaminate land. Hydrocarbon and metals analysis/assessment is captured via the Quarterly Dam sampling schedule and the Receiving Environment Monitoring Program.

Biodiversity

68 The Queensland Herbarium updated regional ecosystems in 2001 for central Queensland including the Minerva project area describing the regional ecosystems present within the Mining Lease. Table 9 provides an overview of current Regional Ecosystem mapping reconciliation and description within the Minerva Mine leases.

69 Figure 4 depicts the layout of these Regional Ecosystems and Non-Remnant areas within the Mine Lease.

70 Bluegrass grassland (RE 11.8.11) is considered endangered under the Commonwealth Environment Protection and Biodiversity Conservation Act 1999, and of concern under the Queensland Vegetation Management Act 1999. This Regional Ecosystem has been disturbed for cropping elsewhere in Queensland and has been impacted locally by grazing pressure and weed invasion (especially parthenium).

Regional Ecosystem	PERCENT	VMA_Class	Short Description	Total (Ha)
Non-Remnant	100			1235.65
11.8.5	100	Not of Concern	*Eucalyptus orgadophila* open woodland on Cainozoic igneous rocks.	138.73
11.8.11	100	Of concern	*Dichanthium sericeum* grassland on Cainozoic igneous rocks.	111.91
11.8.11a/11.4.9/11.3.25	50/40/10	Of Concern/Endangered/Not of Concern	*Dichanthium sericeum* grassland on Cainozoic igneous rocks that includes *Melaleuca bracteata* woodland drainage depressions **/** *Acacia harpophylla* shrubby woodland with *Terminalia oblongata* on Cainozoic clay plains / *Eucalyptus tereticornis* or *E. camaldulensis* woodland fringing drainage lines.	60.09
11.4.9	100	Endangered	*Acacia harpophylla* shrubby woodland with *Terminalia oblongata* on Cainozoic clay plains.	5.53
11.9.1	100	Endangered	*Acacia harpophylla-Eucalyptus cambageana* woodland to open forest on fine-grained sedimentary rocks.	3.87
11.8.11a/11.4.9	80/20	Of Concern/Endangered	*Dichanthium sericeum* grassland on Cainozoic igneous rocks that includes *Melaleuca bracteata* woodland drainage depressions / *Acacia harpophylla* shrubby woodland with *Terminalia oblongata* on Cainozoic clay plains / *Eucalyptus tereticornis* or *E. camaldulensis* woodland fringing drainage lines.	0.01
Total				1555.80

Table 9 – Minerva Mine Regional Ecosystems

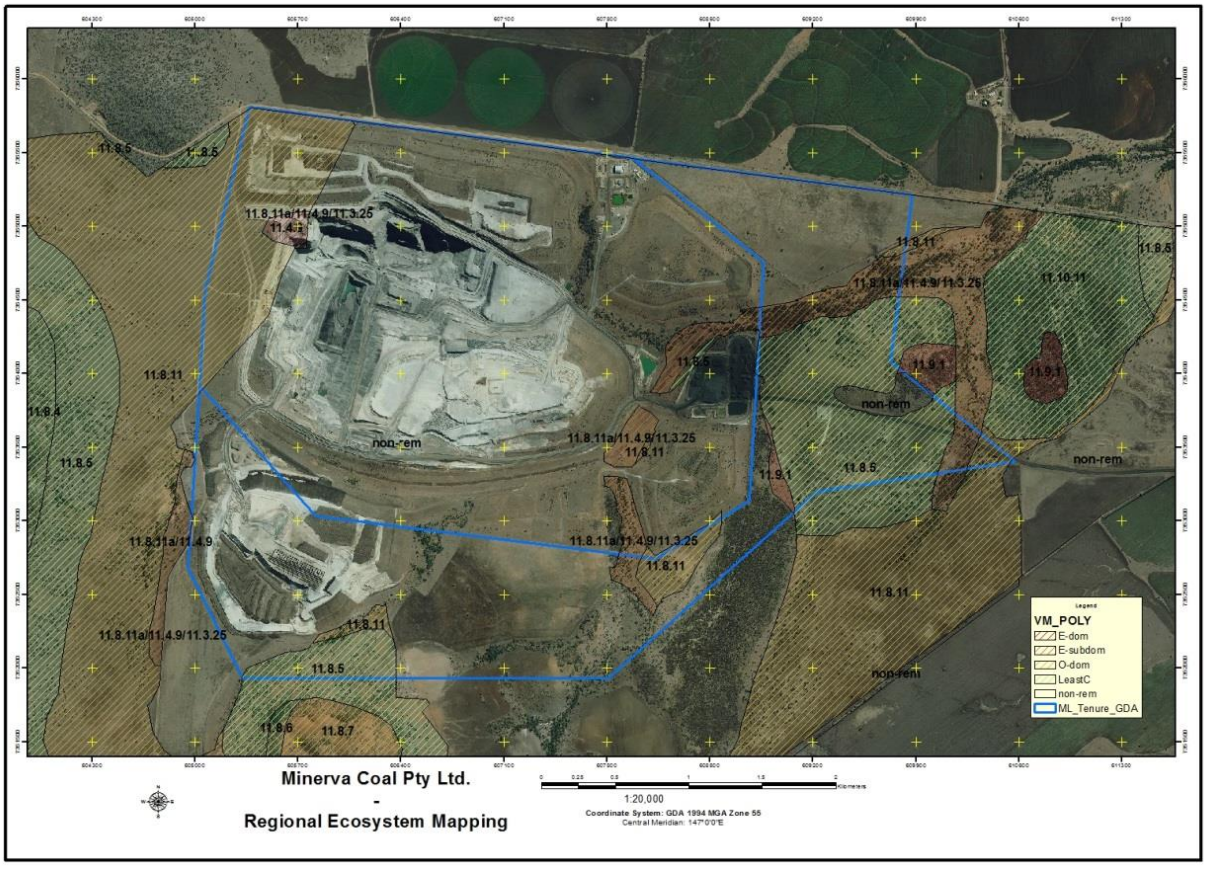


Figure 4 – Minerva Mine Regional Ecosystem Mapping

71 In March 2005, Sandhurst Mining Pty Ltd (now Sojitz Minerva Mining Pty Ltd) as operator of the Minerva mine (owned by Minerva Coal Pty Ltd), made application to the Commonwealth Department of Environment and Heritage (DEH) to disturb up to 133 ha of Regional Ecosystem 11.8.11. This ecosystem is dominated by *Dichanthium sericeum* grassland on Cainozoic igneous rocks and is listed under the Federal Environment Protection and Biodiversity Conservation Act (EPBC Act) as a threatened ecological community. The originally disturbed grassland area is located within the Lexington rural property and on Mining Lease 70145. The Approval Instrument was issued by DEH on 19 December 2005 subject to Conditions. One Condition required conservation of an offset area of 133 ha of RE 11.8.11 acceptable to DEH and managed in accordance with a management plan approved by DEH.

72 As there were no further areas of the RE on the mining lease, an agreement was reached with the landholder of Lexington Station at the time to secure an area of land to the east of the mining lease. An offset area on the Lexington property was selected and accepted by DEH based on a vegetation survey of the area. DEH required that the conservation of the proposed area was binding on future landholders and would accept a nature refuge under the Queensland Conservation Act over the area. Queensland Parks and Wildlife Services Emerald (QPWS) inspected the proposed offset area and being aware that acceptance of the area in principle was required by DEH, notified Sandhurst Mining by email on 11 November 2005 that the area was acceptable as a nature refuge. On the basis of this preliminary consent by the QPWS, the landholder of Lexington entered into a civil agreement dated 11 October 2005 with Sandhurst Mining to make application to protect the agreed 133 ha. DEH subsequently issued the Approval Instrument to Sandhurst Mining. The Management of Native Grasslands Plan for the proposed offset area was approved by DEH on 21 December 2005. This plan outlined a preferred pathway to apply for nature refuge status of the proposed offset area.

73 Minerva Mine is now the owner of Lexington Station that encompasses the defined offset area.

74 Given the difficulties with regard to attaining stakeholder ratification for the establishment of Nature Refuge tenure or the development of a Statutory Covenant, a Voluntary Declaration under the *Vegetation Management Act 1999* an application has been lodged concerning the protection of 133 Ha of native grasslands described as Regional Ecosystem 11.8.11 as depicted within Figure 5.

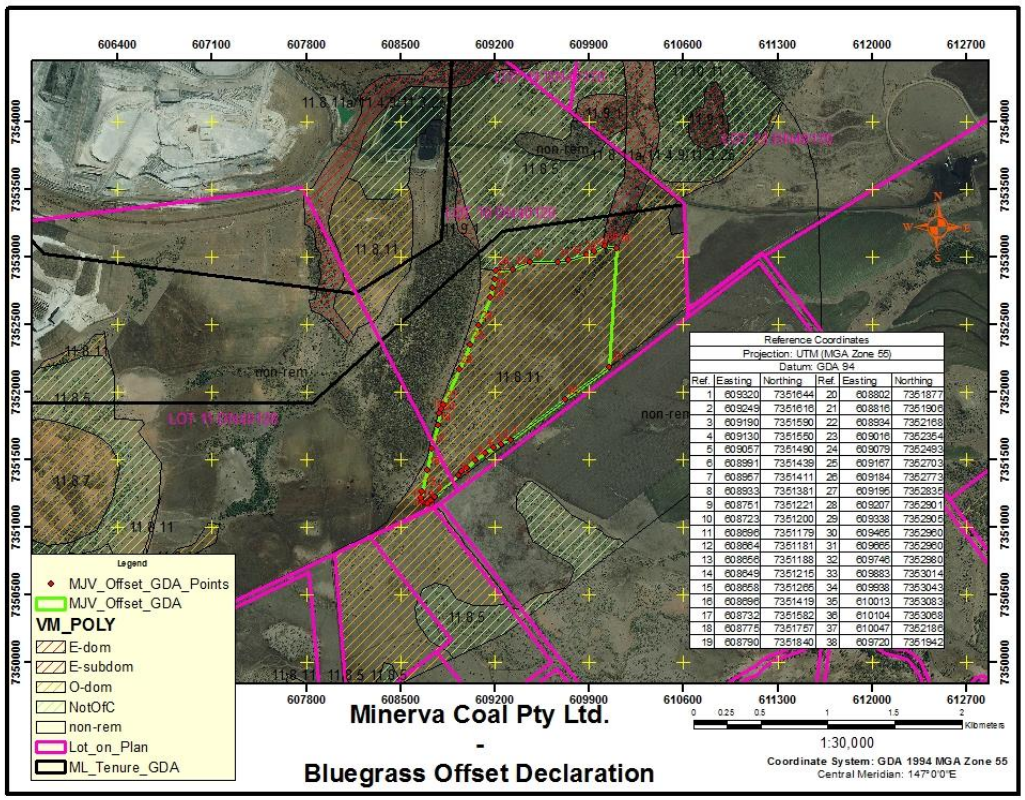


Figure 5 – Minerva Mine Bluegrass Offset Declaration

Fauna

75 The *Minerva Mine Environmental Management Plan* indicates that twenty-seven significant fauna species potentially occur within, or in the case of the single aquatic species, downstream of the site and are listed in Table 10. The actual rare and threatened fauna community of the site will be a subset of this list. This list was compiled by Earthworks Environmental Services after a site visit (EES 2004) and desktop review (EES 2005).

Biodiversity Area Protection Strategies

76 The preservation and enhancement of biodiversity values will be facilitated by;

- **a** All unnecessary clearing will be avoided and significant areas of remnant vegetation will be retained where possible. The clearing strategy will allow for linkages of vegetation throughout the Mine area where feasible and will aim to prevent isolation of vegetation;
- **b** Implementation and maintenance of appropriate buffer zones to conserve and protect riparian vegetation;
- **c** The removal of native habitats will be minimized where possible however, due to previous land clearing, some loss of connectivity between remnant groups may be unavoidable;
- **d** Dust settling on flora will be minimized through conventional dust suppression techniques (such as watering haul roads);
- **e** Speed limits and restrictions on access will be set to reduce the potential for accidents as well as impacts to fauna and cultural heritage areas;
- **f** Locate and assess values of rare or endangered fauna and flora;
- **g** Weed management strategies will be implemented throughout the life of the Mine;
- **h** Where practicable re-use cleared timber residue to create habitat refuges in appropriate areas.

Corridor Connectivity Assessment

77 The elements of corridor suitability include the width and length of desirable communities (i.e. endangered and of concern only) and the assessment of negative edge effects (based on ongoing mining activities, weed species, community intrusiveness from adjacent communities and habitat characteristics). These characteristics will determine the appropriate dedication of suitable areas.

5 Disturbance Type and Extent

Domains

78 The Regulator requires that the mine site be classified into a number of disturbance domains and that the rehabilitation objectives provided for each domain must provide a clear description of proposed rehabilitation outcomes within the individual domains in the mine site. Domains are defined as:

- **a** Land management units within a mine site, usually with similar geophysical characteristics.

79 Within domains, elements may be designated where different rehabilitation techniques and/or timing of work is required (i.e. an access road).

80 One domain may contain elements that require different rehabilitation treatments. If the elements are essential components of a single land management unit (i.e. a waste rock dump with battered slopes and a flat top), it is preferable for the elements to be included in the same domain with different treatments.

81 The principal domains are identified in Table 11 and cover all elements of mine disturbance.

82 From a cost perspective the spoil and void domains represent the most challenging areas.

Class	Scientific name	Common name	NCA status	EPBC status	Other[1] status	Habitat[2]	Comment
Birds	*Neochmia ruficaudus*	Star Finch	E	E		?	Not likely to use site
Reptiles	*Hemisapsis damelii*	Grey Snake	E			All	
Birds	*Geophaps scripta scripta*	Squatter Pigeon (southern subspecies)	V	V		11.8.5, 11.8.11	
Birds	*Neochmia phaeton (eastern)*	Crimson Finch	V			?	Not likely to use site
Birds	*Poephila cincta cincta*	Black-throated Finch	V	V		?	Not likely to use site
Reptiles	*Denisonia maculata*	Ornamental Snake	V	V		All	
Reptiles	*Egernia rugosa*	Yakka Skink	V	V		11.8.5, 11.3.25d	State wide distributions
Reptiles	*Furina dunmall*	Dunmall's Snake	V	V		All	Not likely to use site
Reptiles	*Paradelma orientalis*	Brigalow Scaly-foot	V	V		11.3.25d	Not likely to use site
Reptiles	*Rheodytes leukops*	Fitzroy River Turtle	V	V		Instream	Not likely in Sandhurst Ck
Birds	*Accipipter novaehollandiae*	Grey Goshawk	R			11.8.5, 11.3.25d	Highly mobile
Birds	*Lophoictinia isura*	Square-tailed Kite	R			11.8.5, 11.3.25d	Highly mobile
Birds	*Falco hypoleucos*	Grey Falcon	R			Aerial	Highly mobile
Birds	*Melithreptis gularis*	Black-throated Honey-eater	R			11.8.5, 11.3.25d	Highly mobile
Mammals	*Chalinolobus dwyeri*	Large-eared Pied Bat	R	V		11.8.5, 11.3.25d	
Mammals	*Chalinolobus picatus*	Little Pied Bat	R			11.8.5, 11.3.25d	
Reptiles	*Acanthophis antarcticus*	Common Death Adder	R			All	State wide distributions
Reptiles	*Anomalopus brevicollis*	Burrowing Skink	R			11.8.5, 11.3.25d	
Reptiles	*Furina barnardi*	Yellow-naped Snake	R			11.8.5, 11.3.25d	State wide distributions
Reptiles	*Strophurus taenicauda*	Golden-tailed Gecko	R			11.8.5, 11.3.25d	Not likely to use site
Birds	*Hirundapus caudacutus*	White-throated Needletail			Y	Aerial	Highly mobile
Birds	*Falco cenchroides*	Nankeen Kestrel			Y	11.8.5, 11.8.11	Highly mobile
Birds	*Merops ornatus*	Rainbow Bee-eater			Y	11.8.5, 11.3.25d	Highly mobile
Birds	*Falco longipennis*	Hobby			Y	11.8.5, 11.3.25d	Highly mobile
Birds	*Cuculus saturatus*	Oriental Cuckoo			Y	11.8.5, 11.3.25d	Highly mobile
Mammals	*Rattus sp cf villosisimus/sordidus*	Emerald Rat			Y	11.8.5, 11.8.11	

1. NCA/EPBC status: E – endangered, V – vulnerable, R rare; Other status: Listed as Migratory under EPBC (birds) or undescribed species (Emerald Rat)
2. Habitat is based on regional ecosystem codes identified for the site by Earthworks 2005.

Table 10 – Significant vertebrate fauna species potentially occurring at the Minerva site

Domain	Description
Undisturbed	That area of the ML which remains largely unaffected by mining activity includes areas cleared for grazing or for mining purposes.
Voids – Pits and Ramps	The open excavation – active or inactive mining voids and land pre-stripped of soil or benched forward of the highwall.
Spoil Domain	**Unreclaimed spoil:** Pre-strip Dumps comprising a range of spoil types including benign and hostile types. Plus: **Existing Rehabilitation Areas**: Areas that have been rehabilitated under a range of different treatment strategies, which may also differ from revised strategies outlined in this RMP. Areas may also be at various stages of rehabilitation – e.g. regraded, capped, topsoiled, ripped and seeded.
Stream Diversion and Drainage works	Dams, stream diversions, drainage lines
Infrastructure Areas	Areas under buildings, plant or hardstands, contaminated areas and areas which have been stripped of soil cover.

Table 11 – Minerva Mine Disturbance Domains

Map of Existing Rehabilitation Areas

83 Coal extraction at the Minerva Mine ceased in August 2021. Areas of disturbance and rehabilitation as at September 2021 are summarised in Table 12 with existing areas depicted in ***Appendix 1***. Details of mining methods over the projected life of the mine are discussed in the ***Environmental Management Plan*** and updated in annual Plans of Operations.

Area Category	Area Sept. 2021 (ha)
Total Lease Area	1,562.99
Undisturbed Area	474.92
Total Area of Disturbance	1,088.07
Disturbance Category	
Pit and Ramps	282.64
Tailings	0
Rejects	0
Active Dump	133.46
Infrastructure	145.16
Stockpiled topsoil	34.93
Diversions and dams	55.78
Rehabilitation - Topsoiled	2.83
Rehabilitation - Seeded	242.34
Rehabilitation - Established	190.92
Disturbance sub-total	1,088.07

Table 12 – Summary of Projected Disturbance Categories – September 2021

6 Final Landform Planning Program

Mine Life Protection

84 Coal mining at the Minerva Mine ceased in August 2021. A final landform design has been prepared based on the pit and dump surface configuration at the cessation of coal extraction.

85 The following criteria have been applied when optimising the design of the final landform:

- reshape the current low walls to 25% with 30m wide benches every 30m of vertical lift;
- Western pit reshaped to 210mRL with fill below this at angle of repose;
- Southern pit reshaped to 200mRL with fill below this at angle of repose;
- Southern pit south east highwall reshaped in part to reduce void area; and
- reshaped 25% slopes shall be capped with 0.5m of basalt rock mulch.

Long Term Planning and Spoil Fit Investigations

86 Pre-strip spoil placement has by far the most important controlling influence on final landform and its ultimate stability. Current operations involve backfilling to enable in-pit disposal of large quantities of pre-strip material to enhance final landform stability plus provide a cost effective means for spoil disposal. Investigations are in progress with regard to the extent of mine life in-pit dumping and interaction with possible underground development. These attributes will be major determinants with regard to final void extent.

87 Truck and shovel will continue to be the primary method for creating the final rehabilitation surface. A major aspect of the mine planning process will highlight locations of future overburden removal, volumes (swelled) and timing. Minerva Mine is developing a Spoil Placement Strategy which not only meets mining objectives but also develops preferred final landform configurations which maximize the proportion of better quality post-mine landform.

88 The final landform planning process recognises the requirement to optimise in-pit dumping as far as practicable during operations. Optimisation of in-pit dumping will increase the area of 'beneficial' rehabilitation as spoil dumps will consequently be lower and flatter. Going forward critical attributes pertaining to the Final Landform Planning process will entail;

a Optimisation of in-pit dumping taking into account potential underground development;

b Basalt excavation schedules with regard to rock mulching final batter surfaces.

89 Base case final landform planning review entailing life of mine spoil balance assessment and options analysis is work in progress by the Mine Planning Section. Options analysis will essentially relate to potential pit reconfiguration assessment and associated in-pit dumping strategies pertaining to interaction with potential underground development. Metrics of assessment include NPV (Net Present Value), Haul Cycle times and Dump RL.

Rehabilitation Cost - Risk Assessment

90 Risk assessment and cost ranging for rehabilitation outcomes is routine practice for industry. Embedded risk management processes into critical business systems enable the company to adopt a precautionary approach to business management.

91 Risk ranging and cost assessments conducted via the EWRM (Enterprise Wide Risk Management) Policy framework across industry have identified a number of common risks. Nearly all of these risks were related to landform stability and the adequacy of the site's rehabilitation programs. These risks included:

a Rehabilitation Criteria – company may not meet performance criteria or government raises goal posts.

b Landform Stability – if inadequate or poor design parameters are used, inherent high erosion risks would result.

c Final Voids – voids with incompetent wall and spoil materials may need substantial treatment.

d Community Pressure – possible community outrage if landforms fail.

e Water Management Criteria – if rehabilitation is ineffective, sediments and salts could migrate to creeks and rivers.

f Creek Diversions – If poorly designed or constructed, erosion of batters and siltation further downstream could occur.

g Groundwater – saline waters or draw down may impact on regional aquifer.

h Contaminated Sites – groundwater may be impacted by mobilization of contaminants.

i Infrastructure Workshop, ROM – decommissioning costs could be higher than expected.

j Haul Roads – decommissioning costs may be higher than expected.

92 Historical industry EWRM risk assessments show that the most substantive risks which have greatest potential impact to the business relate to the erosional and geotechnical stability of the final landform. Landscape disturbance is the major impact of open cut mine operations and represents by far the greatest element of the rehabilitation liability.

93 The EWRM process highlights that the final landform should not be considered as merely a consequence of an excavation program, but rather the outcome of a planned mining and spoil placement program by which a stable landform has been reinstated.

94 Ultimately the most substantive costs for an open cut mine site such as Minerva are associated with stabilizing large areas of elevated spoil and residual voids. These costs are typically an order of magnitude higher than for other mine disturbance categories. Thus spoil volume balance and placement studies have been instigated with a view to leaving the mine landform in which spoil elevation is reduced as much as is practicable, whilst allowing the mine to profitably extract its coal reserves.

95 Life of asset mine planning is underpinned by recognition that more conservative spoil treatments are required to achieve a stable and sustainable landform. This RMP describes how Minerva is endeavouring to align its whole of asset life mining program with the requirement to achieve stable and sustainable landforms. Strategies include optimisation of in-pit dumping operations plus regrading and rock mulching of spoil slopes reflecting Regional Ecosystems in the area with similar slope attributes. This approach is to be implemented for erosive prone areas or current rehabilitation domains that have failed.

96 There is an intimate cost relationship existing between mining schedules, spoil placement and ultimate mine closure costs. Current costs to rehabilitate the mine site are detailed in the ***Plan of Operations*** which is submitted to the administering authority.

Sustainable Landform Planning

97 The EWRM process facilitates re-evaluating the effectiveness of its rehabilitation and mine development processes. This includes designs for future spoil emplacement areas including residual voids in order to ensure that such areas are safe, stable and sustainable after cessation of operations.

98 Sustainable Landform Planning guides closure planning processes aimed at the achievement of sustainable rehabilitated landforms on a cost effective basis.

99 Rehabilitation of mine disturbed land is not simply an environmental task. The work is of a complex and expensive nature. Satisfactory outcomes can only be available if closure planning is embraced at the corporate, site management and operational levels.

100 Planning, design and scheduling of excavation/spoil placement should be aligned with a mine closure plan so that cost effective practices can be implemented during the operational phase of mining with a

goal of substantially reduced rehabilitation expenditures at closure. This is the essential basis of closure/ rehabilitation requirements.

101 A framework for implementation of the closure process is based on the following tenets:

a Embedding closure/landform requirements into the responsibilities and accountabilities of all senior personnel. This is necessary as the ability of the operation to implement satisfactory closure planning and implementation processes will necessarily impact on the business and its long term viability.

b Outlining preferred strategies/practices for improved spoil placement and reduction of void volume by closure, hence progressive backfill when practicable is encouraged.

c Describing various treatments which could be used to better stabilize spoil placement and in particular recognition that long dispersive spoil slopes are exceedingly difficult to stabilize without rock mulching.

102 Spoil characterisation is an integral tool in the rehabilitation process with regard to achieving safe and stable landforms. It allows a greater opportunity for spoil dumps to be planned with rehabilitation in mind, as well as providing a means for opportunistic salvage of competent rock material suitable for rehabilitation purposes. Spoil strata characterisation enables competent material to be identified and salvaged on a planned basis. Reference to *Supplementary Report on Land Capability, Minerva Mine* concerns characterisation of soils and overburden plus land capability assessment for Minerva Coal Mine prior to the commencement of operations. Findings as related to physical and chemical characterisation support Minerva Mine's proposal to rock mulch dump batter slopes concerning areas prone to erosion with appropriate Basalt and/or competent Permian Sandstone strata.

103 Application of this rehabilitation methodology is enhanced via operational integration of excavation/dumping schedules for the selection and placement of competent rock strata for final surface thus greatly reducing the possible end of mine life liability to rock armour unstable batter slopes.

104 In addition, consideration also needs to be directed towards rehabilitation resource inventory programs; given that rock mulching is seen to be an important aspect of stabilizing steep slopes. Knowledge of the available resource and routine salvage during stripping /excavation operations is essential.

105 The Minerva Mine RMP identifies the opportunity of progressive in-pit dumping during operations to improve spoil fit and reduce haul costs as well as minimise the amount of open void at cessation of mining. The Minerva Mine RMP will require annual updating to ensure that improvements in outcomes from operational experiences and learning's are retained.

106 The Minerva Mine RMP provides for a range of conservative treatments aimed at making spoil dumps and residual voids safe and stable once rehabilitation of the site has been completed. Thus previous commitments on landform design for spoil emplacement areas and voids contained in the ***Environmental Management Plan*** may need revision to assure uniformity, given the sites intentions to apply a more conservative approach to the treatment of these higher risk areas. Treatments discussed are intended as being applicable for future spoil placement and erosive prone areas.

7 Rehabilitation Design and Treatment Practice

Spoil Domain

107 Deeper mining practices in recent years is resulting in increased elevation of spoil emplacement areas, built by the truck and shovel fleet. The extent of dispersible spoil is increasing, spoil fit is becoming more confined and traditional regrade and topsoil rehabilitation treatments are not suitable in some areas. Thus Minerva Mine has developed a range of alternative spoil treatments which are aimed at improved erosional stability hence treatments for all major disturbance domains have been revised. The rehabilitation challenge is to create safe, stable and sustainable landforms from areas of elevated challenging spoil types.

108 Truck and shovel will continue to be the primary method for creating the final rehabilitation surface. In line with sustainable landform planning, Minerva Mine is developing long term spoil placement plans for the life of mine extent. It includes such considerations as total spoil volumes, expected final landform configurations, final surface material type, and alignment of in-pit dumping operations to optimise void infill opportunity. This work is ongoing and forms a key part of the Minerva Mine Life Plan.

109 Progressive rehabilitation will be undertaken throughout the mine life in conformance with planning requirements included in the Minerva Mine Life of Asset Plan. Specific annual rehabilitation targets will be reported in Plans of Operation.

110 Table 13 summarises the control strategies adopted for various aspects of the rehabilitation process.

Landform Element - Spoil Placement

111 Spoil should be placed according to mine plans and designs which meet key closure requirements for cost effective stable landform and rehabilitation outcomes. Strategies that are being implemented to meet closure requirements include:

a Progressive in-pit dump dumping to enable backfilling of redundant voids/ramps that have been identified as no longer needed for other strategic uses e.g. water supply/containment purposes;

b Batter surfaces with a grade of 25% slope or less providing;

i A minimum 0.5 metre depth of competent rock mulch is placed on final surface prior to application of topsoil;

ii Benching configuration is installed with lifts between benches being less than or equal to 15 m;

iii Bench width dimensions ensure;

- The establishment of an appropriate drainage containment bund structures to contain a maximum rainfall event;
- Allow sufficient width for equipment to import topsoil onto batter surfaces;

c Rock mulching operations will not be instigated for flatter plateau areas with slopes of less than 5 % or areas not prone to erosion. Historical rehabilitation areas where rock mulching has not been undertaken will be monitored. Remedial rock mulching works will be scheduled as required for those historical rehabilitation domains where monitoring data demonstrates a trend to failure.

d Taking into account material types and selective handling requirements. Overburden characterisation has complemented the development of an overburden model based on lithological interpretations and correlation of available geophysical data. It is intended that site waste rock strata modelling hence be embedded into the mine planning process, so that excavation/dumping schedules can be amended to ensure competent material is placed onto final surface as part of the operations and not as a separate process.

e Unless backfill is planned, rehabilitation of spoil adjacent to ramps and low walls should allow sufficient buffer width for future spoil regrade so that rehabilitation is not destroyed when these features are regarded.

Aspect	Controls
Spoil quality variation	Spoil and waste characterisation for mining areas; Monitoring of rehabilitation; Analysis of exploration core samples and logging.
Spoil Placement	Encapsulation of saline and dispersive spoil types. Selective handling of basalt strata to facilitate placement on final rehabilitation surface. Strata modelling to understand availability/volumes of basalt strata and excavation schedule for placement on final surface.
Landform design and stability	Planning to ensure that spoil can be accommodated in mined out areas rather than out-of-pit waste dumps. Spoil will be selectively placed or reshaped to create terraced landforms which will allow the return to a useful, stable capability. Spoil will be reshaped to slopes at no steeper than 25% clad with approximately 50cm of competent rock mulch material to prevent erosion and hence mimic steeper natural slope areas west of the mine lease that are underlain by a rock scree. Historical rehabilitation areas where rock mulching has not been undertaken will be monitored. Remedial rock mulching works will be scheduled as required for those historical rehabilitation domains where monitoring data demonstrates a trend to failure. Strategies for landform stability are based on self-sustaining vegetative cover and use of durable rock mulching rather than relying on artificial structures, such as graded banks and drop structures with ongoing maintenance requirements.
Vegetation establishment	Vegetation on flatter slopes is established by contour deep ripping simultaneously seeded to grasses and native tree/shrubs reflecting Regional Ecosystems in the area.
Drainage	Landforms are designed so as to facilitate the establishment and maintenance of stable vegetation cover by adequate infiltration and control of erosion from runoff. Rock mulching plus topsoil application is a key approach with regard to achievement of this outcome rather than reliance on artificial drop structures that are prone to long term failure. Bench and Plateau bunding is to be installed to contain a potential maximum rainfall event from these surface areas.
Performance of Rehabilitation	Regular monitoring of a range of representative sites for each proposed post-mining land type. Aspects to be monitored include erosive stability, soil profile development and vegetative cover, vigour and diversity. Monitoring data will form the basis of success criteria which determines when rehabilitation has reached a stable, acceptable 'steady-state'.
Use of Topsoil	Topsoil will be stripped and used strategically to a depth of 10 – 20 cm over rock mulched batter slope domains designated for bushland habitat with deeper applications for grassland areas as related to flatter aspects. Topsoil stripping is scheduled in the Plan of Operations and undertaken in accordance with soil survey recommendations.
Scheduling rehabilitation activity	The Plan of Operations establishes annual rehabilitation targets. Audits confirm the achievement of rehabilitation targets.

Table 13 – Overburden Spoil Rehabilitation – Aspects and Controls

Void Domain

112 This domain is characterised by two voids with associated steep highwalls. The pit floor generally comprises carbonaceous shales which under laid the mined out coal seam. Opposite to the highwall is the low wall which comprises angle of repose spoil rising to well above original ground level. The void is served with ramp structures which allow heavy vehicle access through mined out spoil into the pit. ***Minerva Mine Residual Void Investigation Report*** (5 November 2021) indicates extent of the projected Western (Main) and Southern final void areas. The hierarchy of preferred landform treatments which Minerva proposes to implement for the void domain are outlined below.

High Wall

113 Highwall geomorphic and geotechnical stability in perpetuity is paramount with regard to achievement of safe stable and sustainable landforms. Treatments for the highwall include:

a Sequential backfilling of final void with pre-strip spoil via current in-pit dumping operations;

b Pending geomorphic/geotechnical evaluation, regrading to a stable slope % and clad with competent rock mulch. Note that the lowwall should be regraded first to minimize the amount of natural ground that will be disturbed by regrading the highwall;

c In situ highwalls can remain with limited fence and bund treatment provided safe, sustainable and stable outcomes are demonstrated by a geotechnical assessment required as part of EA Condition F8. Reference to Figure 1 (MJV Conceptual Basalt Model) depicts depths of in-situ basalt strata of up to 100 metres. Steep sided natural basalt formations to the west of lease form the dominant visual character for the locality;

d Pending completion of groundwater investigations and geomorphic/geotechnical evaluation, it is most likely treatment expedited will be a combination of the above mentioned as related to the competency and lithology of material remaining.

Low Wall

114 Treatments for erosive prone low wall spoil areas include:

a Backfilled sequentially with mine spoil as related to in-pit dumping operations;

b Batter surfaces with a grade of 25% slope or less providing;

i A minimum 0.5 metre depth of competent rock mulch is placed on final surface prior to application of topsoil;

ii Benching configuration is installed with lifts between benches being 30 m;

Bench width dimensions ensure sufficient width for equipment to import of competent rock mulch and topsoil onto batter surfaces;

c Drainage off adjacent pre-strip dumps should be integrated into the low wall treatment design.

Ramp

115 Treatments for Ramps include:

a Backfilled sequentially with mine spoil as related to in-pit dumping operations;

b Batter surfaces with a grade of 25% slope or less providing;

i A minimum 0.5 metre depth of competent rock mulch is placed on final surface prior to application of topsoil;

ii Benching configuration is installed with lifts between benches being 30m;

Bench width dimensions ensure sufficient width for equipment to import of competent rock mulch and topsoil onto batter surfaces;

c Drainage off adjacent pre-strip dumps should be integrated into the ramp backfill design.

116 At Minerva Mine given the existence of significant areas of rehabilitation, the abovementioned revised landform and rehabilitation guidelines are to be implemented for erosive prone areas or current rehabilitation domains that have failed.

Steam Diversion and Channel Works Domain

117 Most water control structures will be retained as drainage pathways or permanent storages for use by cattle and wildlife in post mine landforms.

118 Minerva Mine has a licence under the Water Act for the diversion of Sandhurst Creek around mining operations to facilitate access to the coal resource. Batters and spillways may require stabilisation works such as the lowering of slope gradients to 25% or less and cladding with competent Basalt material plus topdressing with topsoil. Referable structures will be decommissioned according to requirements of the Administering Authority.

119 The primary focus of creek diversions in an operating mine is to prevent flooding of mining areas and not breach Environmental Authority conditions of downstream water quality. This is achieved with ongoing management which includes periodic inspections and maintenance works as required. The focus will vary in the end-of-mining scenario as permanent, self-sustaining stability is the basic objective. For this reason, remedial earthworks may be needed to facilitate ongoing stability.

120 If diversion of a major creek or waterway is necessary, the following matters should be considered.

a The investment decision includes a full realistic cost estimate for the construction of a diversion which meets at least the Department Natural Resources and Water (DNRW) 2005, Watercourse Diversions - Central Queensland Mining Industry Guideline Version No 1. This guideline is based on Earth Tech, (2002). Bowen Basin River Diversions, Design and Rehabilitation Criteria, Australian Coal Association Research Program (ACARP).

b If dispersive earth forms the embankments, batter slopes of less than 15%, are required unless the batters are lined with competent coarse durable sandstone, volcanic rock or some other equivalent permanently durable rock material.

c Maintain buffer around existing creeks, rivers and diversions sufficient to demonstrate that there is a 50 m wide clearance between crest of the creek, river or diversion embankment and the projected toe of the spoil emplacement after it has been regraded.

d Where practicable, the existing stream length should be re-established in the diversion planning. The Regulator does not often approve diversions which do not meet stream length / stream power criteria.

e Where existing diversions require realignment, sustainable channel and embankment designs need to adopt NRW guidelines. Early construction of the new channel forward of an upstream plug is preferred to enable enhanced establishment and stability of riparian vegetation, before the plug is excavated and the new channel is exposed to river flows.

Infrastructure Domain

121 The infrastructure domain includes the mine industrial area, roads, tracks, plant areas, built areas, hardstand areas, ROM, crusher pad, electrical infrastructure, water treatment plant, sewerage treatment plant etc. In summation, areas which have been disturbed for development of some structure, access, or lay down area. These areas for the main, following demolition of built infrastructure and decontamination require only minimal earthworks before conventional rehabilitation treatments such as ripping and seeding are undertaken. Some of these areas might remain post mining if useful for an intended purpose.

122 Records are maintained which show the type, location and extent of infrastructure and activities with potential to contaminate land. In future, all such facilities will be assessed by contamination surveys which will also provide strategies for their rehabilitation. Facilities not required after relinquishment of the leases will be rehabilitated after plant and equipment has been removed. Consultation with appropriate stakeholders is planned to determine preferred disposal or retention options. Contour deep ripping and

seeding will be the predominant method of surface preparation with the application of appropriate substrate material and topsoil. Haul roads will be further assessed and may have crushed aggregate either reclaimed for reuse, placed in voids or rehabilitated in-situ. Specific decommissioning plans will be finalized in association with key stakeholders for all facilities as actual closure draws near.

123 Areas shown to be contaminated will be rehabilitated in accordance with remediation standards in use in Queensland in consultation with the Regulator. The mine closure requirements for potentially contaminated areas will involve the following stages:

a Preliminary (Stage 1) Contaminated Land Assessment - Describes historical processes, locations and severity of sites with potential for contamination. It serves as a guide for detailed Stage 2 assessment of sites as having some potential for contamination.

b Stage 2 Assessment - The appropriate time to conduct a Stage 2 assessment will vary as some sites may become available for rehabilitation during the working life of the mine while many will not be available until actual mine closure. At an appropriate time, potentially contaminated sites identified in Stage 1 surveys will be individually sampled, analysed and rigorously assessed for contamination in line with Regulatory Guidelines.

c Contaminated Land Management Plan - This plan will be developed in conjunction with the Stage 2 assessment. The full scope of remedial works for each area of contamination are documented and accompanied with cost projections. Should contaminated materials requiring disposal be identified, the following options exist::

i Off Site Disposal – Contaminated material is transported to a registered landfill. The material is regulated waste and can only be transported and handled by persons registered to handle such waste. Samples of the material being moved must be taken and analysed for the identified contaminant. One sample per 25m^3 of soil is required.

ii On-Site Land Farming – This is an ongoing, regulated process with costs incurred in meeting analytical requirements and managing the facility (e.g., turning and irrigating soil), until remediation is complete.

iii On-site Disposal – The mine may register an on-site landfill for the purpose of disposing of contaminated material to a single location. This appears to be the preferred option for Minerva and needs to be done in consultation with the Regulator.

iv Import clean fill and rehabilitate area - Fill must be clean and may require analytical certification. The area may be topsoiled and seeded.

8 Rehabilitation Monitoring Performance

Existing-Future Rehabilitation Areas

124 When operations commenced in 2005, Minerva Mine lease rehabilitation efforts focused on the establishment of pasture based grazing systems on batter slopes at approximately 18% with tube stock forestry on dump plateau areas. This approach has been completed for the NE and SE Dumps that is a total area of 123 Ha.

125 An Environmental Authority amendment pertaining to EPML00668613 with regard to review of Landform Design Criteria was undertaken in February 2015. In summation, the intent of review relating to Landform Design Criteria proposed within this Environmental Authority amendment was as follows;

a Rehabilitation practices provide appropriate risk mitigation with regard to the ensuring post mining landform outcomes are aligned with EM Plan objectives to:

i Return landforms to the extent that they will be sufficiently stable such that vegetation is self-sustaining;

ii Return land to an agreed land use and capability;

iii Ensure downstream surface water quality is of agreed standard during and after mining;

iv Ensure surface water quality on the leases is of agreed standard after mining;

v Ensure that decommissioned landscapes are safe for humans and wildlife.

b Risk mitigation for post mining landforms and uses must recognise that completed areas of the waste dump rehabilitation are formed from unconsolidated sediments that carry a higher risk for erosion than the original undulating terrain formed on consolidated materials such as basalt flows, thus in some areas beneficial use of rock mulch is desirable on some of the existing and erosive prone outer batter slopes to hence mimic steeper natural slope areas west of the mine lease that are underlain by a rock scree;

c Use of rock mulch will allow external batters in erosive prone areas to be marginally steepened to 25% plus application of rock mulch to mitigate erosion to any existing slopes showing significant signs of erosion processes;

126 Following an onsite EHP inspection (9/12/14) of recent and older rehabilitation areas, it was identified that the application of metrics defined within Land Suitability/Capability Guidelines within the current Environmental Authority EPML00668613 at the time did not align with the core tenets of rehabilitation outcomes concerning the achievement of safe and sustainable landforms. It was therefore agreed that Land Suitability/Capability Guidelines within EPML00668613 needed to be removed.

127 The use of rock mulch in rehabilitation of fragile spoil batters offers an effective means of stabilizing steep slopes, particularly in conjunction with pastures and native trees/shrubs. Operations to end of mine life will encounter significant volumes of weathered and competent basalt strata. Salvage of this rock will allow the mine to apply competent rock mulch over any existing slopes where erosion is evident or planned future slopes where erosion risks may be elevated because of poor dispersive spoil sediment presence. Minerva Mine plans to implement this practice as a means of improving long term stability of outer slopes that may already exhibit or be at risk of unacceptable sediment loss. To implement these risk mitigation measures concerning post mine landform stability plus development of bushland habitat on outer batters, it is proposed;

a Basalt and/or competent Permian Sandstone strata is to be placed on final dump batter slopes to enhance integrity of the long term stability and surface erosion attributes of these surfaces;

b Placement of competent Basalt or Permian sandstone rock mulch over unconsolidated batter surfaces to a depth of approximately 50 cm in erosion susceptible areas will mimic existing natural stable rock scree landforms in the area.

c These rock mulched areas are then to be topsoiled, deep ripped and seeded with a grass/tree seed mix to promote the development of a stable bushland habitat for these dump slope areas;

d Dump plateau areas will not be rock mulched as erosion risks are minimal. Thicker topsoil may be applied in some areas to promote sustainable pasture cover in drought periods and provide improved grazing capability in stressful times.

128 An approach of rock mulching dump batters followed by topsoil application that is subsequently deep ripped and seeded to a mix of Acacia and Eucalypt Species reflecting Regional Ecosystems in the area with similar slope attributes will result in the following enhanced environmental values;

a Reduced potential sediment load runoff concerning downstream water quality attributes off lease;

b Increased stable landform features reflecting slope and rock scree attributes of adjoining Regional Ecosystems in the area that provide reference with regard to weathering process consequences in terms of geomorphological time frames;

c Increased flora biodiversity thus resulting in a wider array of fauna habitat types over the longer term.

129 The intent of the proposed Environmental Authority amendment (EPML00668613) was to enable Minerva Mine to implement a rock mulch/native vegetation strategy across some marginally steeper existing outer batters of the mine and erosive prone areas. This will enhance both the stability and visual amenity of the mine post closure. A slope limit of 25% will be maintained for these rock mulched areas. These measures are consistent with the Regulators guideline for safe, stable rehabilitation outcomes.

130 The primary rehabilitation objective for spoil areas at Minerva Mine is the creation of stable landforms occupied by a range of native trees, shrubs and pastures. This is essentially a bushland domain in which

occasional grazing may be feasible on flat to gently sloping spoil areas; however, the overall objective for the spoil areas being landform stability. The vegetated areas will provide useful fauna habitat as well as act as bushland corridors for surrounding natural habitat communities.

Overview of Rehabilitation Performance

131 Rehabilitation monitoring has been conducted at Minerva Mine since 2008; however no assessment/interpretation of data collected has been undertaken to define trends with regard to rehabilitation performance concerning attributes of profile leaching/nutrition, cover, species diversity and erosion. Characterisation of these attributes is defined within the rehabilitation monitoring methods section of this document.

132 Reconciliation of these attributes concerning applicable reference sites and rehabilitation treatments will then be required to facilitate the development of rehabilitation indicators and completion criteria.

Monitoring Sites

133 Rehabilitation monitoring with regard to characterisation of attributes concerning profile leaching/nutrition, cover, species diversity and erosion is to commence in 2015. The sites to be monitored are as follows.

- **a** 4 pre-existing sites on topsoiled side slopes of older spoil emplacements;
- **b** 1 new site on rock clad side slopes of a more recent emplacement;
- **c** 1 pre-existing natural site on flat bluegrass areas;
- **d** 3 new reference sites on unmined sloping basaltic landforms.

134 The natural/reference sites will facilitate develop of completion criteria as related to the rehabilitation treatments expedited.

135 This Rehabilitation Monitoring Plan will be updated with regard to coordinate locations of monitoring sites plus provision of aerial images depicting layout of monitoring sites.

Monitoring Methods

136 This section presents the proposed methodology as defined by B.R. Emmerton Pty. Ltd. of *Minerva Mine SE Waste Dump Grazing Trial Design and Monitoring Plan* (Chamberlain and Emmerton, 2014).to census long term monitoring sites at Minerva Mine. It documents the techniques and measurements to be used and data to be collected during monitoring events. Specifically, it describes the preferred techniques and measures to:

- **a** Describe, classify, sample and analyse topsoil and underlying spoil materials to investigate profile development and water relations under different monitoring scenarios;
- **b** Measure gross erosion features (calculated on a per hectare basis) to provide a practical local site based assessment of erosion status that can be compared with other sites and rehabilitation scenarios; and
- **c** Assess vegetation growth and ecological characteristics over time through the measurement of groundcover levels, species diversity, tree density/basal area and crown cover (in the upper-storey).

137 As a broad generalisation, the reasoning underlying the need for rehabilitation monitoring by mine site personnel and government regulators, has been seen as;

- **a** Primarily a requirement to determine success or failure of rehabilitation works; and
- **b** Secondarily as a basis for determining compliance categories in relation to environmental performance and security deposits.

138 It is recognised that the levels of environmental research required to unequivocally understand and document rehabilitation "success or failure", are time and cost prohibitive. Past monitoring activities on other mine sites have to date largely been concerned with the following three components:

a Soil/spoil profile monitoring;

b Vegetation monitoring; and

c Erosion monitoring.

139 These components have traditionally been assessed as the minimum basic building blocks required to achieve a functional understanding of the requirements for stable and sustainable post mining rehabilitation outcomes.

140 Ideally, assessment should be undertaken when a site is first established and then yearly for 3 years thereafter until an adequate baseline is established, followed by ongoing assessment at longer intervals for as long as monitoring is required. The program should undertake sufficient monitoring activities over an initial ten to twelve year period (i.e. at least several monitoring events) to provide the basis for review and to provide recommendations concerning the direction of future work. In particular, review is required to determine exactly where future resources should be best targeted to achieve an effective rehabilitation outcome**.**

Soil and spoil characterisation

141 The methodology presented below outlines the techniques and measurements to describe, sample, analyse and classify topsoil and underlying spoil materials at long term rehabilitation sites.

a Site transect location

i In the longer term, the initial selection of monitoring sites as rehabilitation progresses should ensure the site network adequately represents the diversity of soil, spoil and landform conditions known to occur, as well as the range of likely rehabilitation treatments to be implemented. Each site transect should be located so that it is broadly representative of the rehabilitation type in the immediate surrounding area and will be easily accessible for repeat monitoring activities in the future. It should also preferably be located in a lower slope position within the reshaped landform type to capture maximum effects associated with hydrologic and erosion processes operating at the site. Ideally, the site to be measured should be selected so that it represents an area which is borderline between obvious stability and obvious failure. By selecting sites in this manner it is hoped that in the longer term, combinations of maximum slope angle, maximum slope length and levels of vegetative cover required to achieve slope stability can be predicted for different spoil types.

ii Typically, a central 10m transect is marked by two permanent pegs that are carefully positioned at an angle to the contour and also to any rip lines or other rehabilitation features running through the site. In addition, the endpoints of a 50m transect are pegged along the same line 20m either side of the central points. Each transect is numbered and accurately located with GPS co-ordinates (local mine site datum) marking start and finish points of the central 10m transect. The central 10m monitoring transect is photographed at each monitoring event, typically looking upslope from the lower peg.

b Sampling of soil and spoil materials

i In rehabilitation sites, sampling of the soil/spoil profile in three locations to a depth of 1.0m (or deeper to ensure substrate is sampled if cladding is present) is undertaken in broadly relocatable positions approximately 3m downslope of the central 10m of the vegetation transect. Sampling is conducted at each census at all rehabilitation sites. In unmined sites (i.e. natural ecosystem comparative sites) only one location requires sampling. The following activities and measurements are typically undertaken during sampling at each site:

ii Document an overview of the site including rehab age, visible/perceived rehabilitation treatments, re-disturbance effects, fire history, storm events and general site condition.

iii Measure and record slope % up and down slope (using a clinometer or equivalent) and slope length above the central monitoring point (lower peg of the 10m central transect).

iv Core and sample three relocatable positions approximately 3m below the central 10m transect to a depth of 1.0m or greater using percussion driven, thin walled soil coring tubes to minimise site disturbance and destruction (if this is not possible, then hand augering is the next preferred option, but is more destructive of the site). On unmined or natural analogue sites one hand augered hole to 1.0m will generally suffice. In rock clad areas destructive sampling (cladding removal by backhoe or excavator) may be required to allow sampling of the cladding and also coring of the substrate below. Experience to date indicates core tubes and hand tools are typically unable to penetrate thicker rock cladding.

v Estimate and record the level (heavy, moderate, sparse, patchy) and type of vegetative cover in the immediate sampling area for each core.

vi Extract 1.0m cores and extrude for logging and sampling. Log the nature and depth of differing materials in each core according Australian Standards (National Committee on Soil and Terrain (2009)) particularly, colour, field texture, structure and consistence of all soil/spoil materials encountered. The presence of profile moisture and root density should also be recorded.

vii Classify soil materials (where present) according to Broad soil categories defined for rehabilitation purposes (Emmerton and Burgess pers. comm.) and the underlying spoil materials according to Spoil classification for rehabilitation purposes (Emmerton and Burgess pers. comm.).

viii Divide and sample cores in 0.1m increments and bag all increments separately. The immediate surface 0.1m and any interface zones within the core (e.g. soil/spoil boundary) should be sampled in 0.05m increments.

c pH and EC $_{1:5}$ analysis of soil and spoil materials

i Sampled 0.1m increments from each core at each monitoring site should be routinely analysed for pH and electrical conductivity (EC $_{1:5}$) according to the following methodology:

ii Samples will be air dried, crushed and sieved to <2mm.

iii pH and E.C. of each 0.1m increment (approximately 36 measurements per site) is measured using a standard 1:5 soil:water extract as detailed in Methods 3A1 and 4A1 from the Australian standard (ACLEP) laboratory handbook – *Australian Laboratory Handbook of Soil and Water Chemical Methods* (Rayment and Higginson 1992). All results should be reported in full and mean E.C. values graphed against profile depth at each census to track leaching.

iv The remainder of spoil samples not used for pH and E.C. analyses should be bulked for subsequent physical and chemical laboratory analysis if required.

d Full chemical and physical analysis of soil and spoil materials

i During initial monitoring events a representative bulk surface soil sample and a representative bulk spoil/subsoil sample (as well as a cladding sample if present) from each site should be sampled and analysed for the following parameters:

- pH, EC, Cl and sulphate (SO_4);
- exchangeable cations (CEC and ESP);
- PSA and R1 dispersion index;
- ⅓ and 15 bar moisture content;
- organic carbon;
- nitrate and total nitrogen;
- extractable and total phosphorus; and
- copper, manganese, iron and zinc.

ii In most subsequent sampling events, only topsoil materials require complete laboratory analyses to track nutritional and structural stability, although spoil/subsoil materials (as well as cladding samples if present) may be further analysed if different characteristics or

unusual behaviour are noted in the field or periodically as profile leaching progresses. Detailed descriptions of the analytical methodologies are available from the Australian Standard (ACLEP) laboratory handbooks *Australian Laboratory Handbook of Soil and Water Chemical Methods* (Rayment and Higginson 1992) and *Soil Physical Measurement and Interpretation for Land Evaluation* (McKenzie et al 2002).

e Description of soil and spoil

i Field observations collected include geology/parent material, landform (pattern and element) where relevant, slope, relief/modal slope class, substrate lithology, site disturbance, microrelief, surface rock, surface condition, detailed soil profile morphology, site drainage and permeability. Field assessment of soil profile/spoil morphology includes description of soil horizons, boundaries, texture, colour, mottling, bleaching, structure, consistence, gravel, segregations and substrate material (where present); as well as field assessment of sodicity, dispersive behaviour and likely sand/silt fractions. Soil profiles are examined and described in the field either from 32mm intact soil cores or hand auger exposures where access is limited. Detailed profile morphology is described to a depth of 1.0m or to impenetrable rock or gravel prior to sampling for subsequent laboratory analysis.

f Assessment of soil surface condition

i Surface soils exhibit a characteristic appearance/behaviour when dry which is often indicative of the physical nature of the material and also relevant to its behaviour following disturbance. Soil surface condition is examined and described in the field in accordance with standards outlined by the National Committee on Soil and Terrain (2009).

g Assessment of soil/spoil structure

i Soils with a high degree of aggregation (and associated void spaces) will generally have a high degree of porosity, while soils that lack aggregation and also possess a range of primary particle sizes can pack to form a dense soil mass which will have low porosity. Soil structure is described in terms of grade or distinctness of pedality, size of peds (average least dimension in mm) and type (or shape) of soil aggregates.

ii Visual assessment of the structural condition in the surface soil material at each site is undertaken within 5m of the lower vegetation transect peg, and usually below the central transect line. All surface structural data are collected in accordance with classes and standards outlined by the National Committee on Soil and Terrain (2009).

iii In practice, a 0.2m diameter surface soil plug to a depth of 0.3m is excavated with a drainage spade and examined in detail for evidence of existing/developing structural integrity. Ideally, assessment should be undertaken at each census event.

h Assessment of surface rock cover

i Lag gravel and rock cover play an important role in assisting surface stability and providing erosion control at rehabilitation sites. Ground cover estimations undertaken as part of vegetation monitoring assessments routinely record the abundance, size, nature and strength/hardness of gravel and rock cover (>6mm - >2000mm). Typically, surface gravel/rock cover data is presented as a summed figure for all coarse fragments as part of overall groundcover estimates. The individual gravel or rock data (size, abundance and strength) is useful however when looking at erosion processes operating at different sites and the possible effects lag surface cover may be having in moderating soil loss. In addition, collection of clearer information on the effect different size fractions and rock abundances have on surface stability is of increasing importance as the use of rock cladding in stabilizing landforms increases. All gravel and rock data are collected in accordance with classes and standards outlined by the National Committee on Soil and Terrain (2009).

i Broad soil categories defined for rehabilitation purposes

i Soils in the northern Bowen Basin have been extensively researched (Burgess 2003a, 2003b) and factors contributing to potential behaviour following disturbance are well understood. The availability of comprehensive, catchment based soil knowledge has enabled the development of a practical soil classification for rehabilitation purposes. The scheme groups known soil types from the northern Bowen Basin in terms of likely

behavioural characteristics, and classifies topsoil materials into seven broad categories. Categories are based on expected physical and chemical attributes and are ranked in order of increasing structural stability and erosion resistance from least stable to most resilient. The soil classification, when used in conjunction with the Bowen Basin spoil classification, presents a powerful planning tool for predicting rehabilitation response under differing scenarios. It is important to note that both the soil and spoil classifications are live documents and are under continued development (Emmerton and Burgess pers. comm.). The soil classification draws heavily on the soil data presented by Burgess (2003a, 2003b), as well as rehabilitation soil groupings previously developed by Emmerton (pers. comm.).

j Spoil classification for rehabilitation purposes

i Coal mining activities in the Bowen Basin have mostly targeted the same group of related seams along the north-south length of the outcropping strike. As a result, spoil materials left exposed by open cut operations show considerable repetition across different mine sites within the basin. Typically, the spatial distribution of different spoil types within open cut mining operations is controlled by two main factors, namely:

- The stratigraphic position of the spoil within the sedimentary (occasionally including igneous material) sequence; and
- The mining method used to excavate and place the spoil material.

ii In general, distinct phases of mining and spoil placement/handling occur during the life of a mine. Each phase differs significantly in terms of the spoil resource produced, particularly the spatial distribution, elevation and inherent characteristics of the material. Spoil generated by each phase includes:

- boxcut spoil which is variable in nature, often highly weathered, but exhibits some degree of spatial predictability;
- pre-strip spoil which is normally shifted by truck shovel operations and is highly variable and often highly weathered, and also spatially very unpredictable.

iii Substantial laboratory data and detailed field observations gathered as part of long term spoil monitoring activities undertaken by *B. R. Emmerton Pty Ltd* at a range of mine sites across the Bowen Basin during the past 10-15 years has provided valuable information on the leaching and erosive behaviour of various spoil materials. Based on the amassed information of *B.R. Emmerton Pty Ltd* and *Soil Mapping and Monitoring Pty Ltd* in combination with the landscape data of Burgess (2003a, 2003b) a spoil classification for rehabilitation purposes has been developed (Emmerton and Burgess pers. comm.) to allow categorization of the spoil type present at each long term monitoring site.

iv The spoil classification recognises and groups the range of substrate materials typically exposed by coal mining activities within the Bowen Basin and describes them in a framework suited to spoil behaviour and rehabilitation outcomes. It classifies spoil materials into broad categories based on geological age, *in situ* weathering status (of the undisturbed strata), dominant lithology, known measured physical and chemical attributes and expected behavioural characteristics following exposure and weathering. It also provides a valuable guide to the infiltration and leaching characteristics, reactivity and chemistry of different spoil materials, as well as qualitative prediction regarding degree of competency and response to accelerated weathering. When the spoil classification is used in conjunction with the topsoil classification discussed in Section 1.9 they form a powerful planning tool for predicting rehabilitation response under differing scenarios. It is important to note that both the soil and spoil classifications are live documents and are under continued development (Emmerton and Burgess pers. comm.).

Erosion Assessment

142 The methodology presented outlines the techniques and measurements used to describe the state/activity, type and degree of erosion at a site and provide some simple measures to quantify the extent and severity of any erosion processes operating.

a Visual erosion assessment-immediate site area

i Visual assessment of the erosion features in the immediate site area at each site is undertaken within 5m of the lower vegetation transect peg and is centred around the central transect line. This assessment is conducted in conjunction with the description and assessment of surface soil condition and structure parameters because it is likely that surface soil behaviour and surface erosion processes are closely related. Ideally, assessment should be undertaken each time a site is censused. Typically, the visual assessment of the immediate site area involves:

- Determining the presence of sheet erosion, (percentage of the area affected, exposure of roots or depth of removal from stone/root pedestals and presence of lag gravel);
- Determining the presence of terracettes; and
- Determining the presence and depth of remaining rip lines.

b Assessment of gross erosion features – transect measurements

i The frequency and dimensions of all **rill, gully, piping, cracking and mass movement features** observed along a 50m transect line are recorded for a defined area either side of the transects centreline (i.e. typically numbers of observed features within a 50 x 2m plot centred around the erosion transects centreline). Collection of gross erosion data in this way allows calculation of erosion statistics on a per hectare basis (i.e. numbers and dimensions of rills, gullies, pipes and mass movement features per ha). Such data allows a more practical understanding of erosion status at different sites and provides a convenient platform for comparing erosion status between different rehabilitation scenarios (erosion outcomes from different soil – spoil – landform – treatment combinations).

ii **Initial selection and setup of the erosion transect** at a site involves locating the midpoint and two endpoints of the transect using a 50m tape. The lower (downslope) 10m vegetation transect peg is used as the centre point of the transect and the tape is then run out 25m in either direction at an angle effectively perpendicular to the slope (i.e. approximately on the contour). The ends of the transect are carefully positioned to ensure the three pegs are in alignment. This ensures the transect line can be accurately located during assessments using any two pegs from any point on the transect. The transect endpoints are permanently pegged and GPS locations recorded. Positioning of the transect may require modification at some sites where slope angle and site area constraints require a different alignment.

iii **Measurement of rill and gully features along the transect** requires initial assessment of rill/gully erosion features >0.05m deep that intercept the transect centre line, irrespective of whether they are active or not. Differentiation between rills and gullies is depth based, with rills being recorded for features with depths <0.3m and gullies where depths are >0.3m. At each observation point along the transect the following is recorded:

- Location and size of the rill or gully feature (width and depth);
- Activity state of the rill or gully (active, stabilised, partly stabilised);
- Gully morphology (U shaped, square, V shaped, trough or broad trough, V or broad V);
- Presence of layers which may impede or increase erosion rates (e.g. dispersive layers, rock cladding etc); and
- Degree of development/severity of the rill or gully; categories recorded include minor (isolated, linear discontinuous), moderate (linear, continuous, primary or minor drainage lines), severe (continuous or discontinuous and incorporating secondary drainage lines/multiple branches) or deeply incised.

iv **Measurement of sheet erosion and any piping or mass movement features** that may be present in a predetermined area running either side of the transect centreline is also undertaken. The width of the observation area running either side of the 50m transect can be varied to suit conditions (calculations can be presented on a per hectare basis). The width of the observation area should be set at a distance that allows easy and practical observations, but be large enough to be representative of the wider rehabilitation area being

investigated. Typical widths (either side of the centreline) range from as narrow as 0.5m where vegetative cover is very thick to wider than 5m where groundcover is extremely sparse and erosion features are easily observable.

v For **each erosion feature** observed along the transect the following is recorded:

- Type/nature of the erosion feature (sheet, rill, gully or piping/mass movement);
- Dimensions of the erosion feature (width and depth for rills/gullies, diameter and depth for piping/mass movement); and
- Severity of the erosion feature (maximum width/length/depth) to allow investigation and comparison at future monitoring events.

vi In situations where piping/cracking/mass movement are not recorded as part of the erosion transect, but are observed elsewhere within the wider monitoring site area, then estimated numbers per 1000m^2 should be recorded.

vii **Measures of erosion status** calculated from erosion transect data include:

- Piping density (pipe structures per hectare);
- Sheet erosion extent (%) along the transect; and
- Gully index. Obtained by summing gully cross sectional area in m2 (gully width (m) x gully depth (m)) over the length of the transect.

Vegetation Monitoring

143 The methodology presented outlines the techniques and measurements used to attributes of vegetation established.

a Monitoring site design

i Selection of monitoring sites should ensure the site network at the mine represents the diversity of soil, spoil and landform conditions known to occur, as well as the range of likely rehabilitation treatments to be implemented. Because temporal vegetation monitoring requires periodic repeat assessment, monitoring site design needs to ensure that:

- Any transect or quadrat layout is scientifically valid;
- Vegetation measurements and any sampling are non-destructive;
- Soil and spoil sampling is non-destructive (to the degree possible) and vegetative cover is left intact (other than some trampling around access pathways); and
- Adequate access is available to all site components to ensure each monitoring activity does not negatively impact on any other activity and that subsequent re-measurement is not influenced by previous monitoring events.

ii At each monitoring site, species identification as well as various measures of cover, density and vegetative change are measured and recorded for ground layer species and also above ground canopy species. The transect is marked by two permanent pegs 10m apart and carefully positioned at an angle to the contour and also to any rip lines or other surface treatments running through the site. Each transect is numbered and accurately located with GPS co-ordinates (local site datum) marking start and finish points. Central monitoring transects are photographed at each monitoring event. Transect photographs are typically taken from the downslope 10m central transect peg looking upslope along the transect. Photo aspect should match pre-existing records wherever possible.

b Overview of vegetation monitoring measurements

i The basic units of measurement used to determine vegetation growth and ecological characteristics at each monitoring site include groundcover measurement (%), species diversity counts, stem density (stems/ha)/basal area (m^2/ha) assessment and crown cover measurement (%). In addition, a number of calculated live groundcover parameters such as species dominance, proportional similarity and community flux are used to characterize

ecological development or change. During each rehabilitation monitoring event, the following quantifiable measurement and sampling routines are undertaken:

- ***Groundcover analysis (%)*** along the permanent central 10m transect;
- ***Species diversity counts*** within $10m^2$, $100m^2$ and $1000m^2$ permanent plots;
- ***Live groundcover parameters*** (species dominance measured as Simpsons Index (C) and effective species number);
- ***Tree density (stems/ha) and basal area (m^2/ha)*** for individual species and also summed for broader ecological groups;
- ***Crown cover (%)*** for individual species and also summed for the entire canopy.

c Groundcover analysis (%)

i Groundcover is measured as a direct percentage (%) from 100 vertical intercepts along the permanent central 10m transect during each monitoring event. Data collection in the field uses crosshair sightings from a 1.0m high vertical sighting tube every 0.1m along the length a 10m tape strung between the permanent central transect markers. Measurements are quantifiable and repeatable and provide very clear data on the components of groundcover within and between years at each location. Groundcover measurements are typically collected first at a site to avoid possible trampling from other monitoring activities. During each monitoring event ***live cover (LC), standing dry cover (SD), litter (L), fallen timber (T), surface gravel and/or rock cover (R)*** *and* ***bare ground (B)*** are measured. ***Vegetative groundcover (VGC)*** is calculated by summing all components except fallen timber, gravel/rock and bare ground, while ***total groundcover (TGC)*** includes all components except bare ground.

ii The ***abundance, size and nature of gravel and rock cover (>6mm - >2000mm)*** is routinely recorded during groundcover field data collection at all monitoring sites (the raw data is generally not presented in monitoring summaries but is available if required). This recognises the important role lag gravel and rock cover play in surface stability and erosion control at rehabilitation sites. Collection of clearer information on the effect different size fractions and abundances have on surface stability is of increasing importance as the use of rock clad landforms in rehabilitation increases. All gravel and rock data are collected in accordance with classes and standards outlined by the National Committee on Soil and Terrain (2009).

d Species (by area) diversity

i Species diversity on rehabilitated sites is typically lower than in natural situations and often reduces further over time following initial rehabilitation, as the number of coloniser species declines. Diversity is assessed on an area basis for monitoring sites and measures species counts from predefined/permanent and repeatable sampling plots of varying sizes. The area sampled for diversity increases progressively in size from an initial 10 x 1m transect ($10m^2$) to a 10 x 10m sample plot ($100m^2$) and finally a 50 x 20m sample plot ($1000m^2$); all centred around the permanent central 10m site transect. Each incremental increase in plot size incorporates the species counts from the previously sampled area and only additional species are added to the counts for larger plots. Species are identified and listed at each census event.

- The **species count for the $10m^2$ plot** is measured between the two permanent pegs of the central 10m transect, approximately 0.5m either side of the transect centreline (10m x 1m).
- The **species count for the $100m^2$ plot** is measured by adding to the previous count, additional species that are present within an area 5m either side of the permanent 10m transect centreline (10m x 10m).
- The **species count for the $1000m^2$ plot** is measured by adding to the previous count, additional species that are present within an area 10m either side of the permanent 10m transect centreline and extending 20m distant from both end pegs (50m x 20m).

e Live groundcover parameters

i Species dominance

- Species dominance is a calculated parameter derived from the relative ***proportions of one species compared with the other species present.*** Dominance is typically lowest in natural vegetation communities (i.e. where species diversity is highest) and much higher (although variable) in rehabilitation situations. Assessment of species dominance (or concentration) is based on the probability that two randomly chosen plant specimens from the central 10m groundcover transect will belong to the same species. The dominance estimate for a site is determined statistically from live cover proportions and is known as **Simpson's Index *(C).***
- It is calculated as the sum of squares of species importance values. These are proportional values for each of the live species present and are derived from live cover (%) measurements collected during the central 10m groundcover transect. Simpson's Index varies from a value of 0 (an infinite number of non-dominating species) to a maximum of 1.0 (only one species present). Essentially, the lower the index then the lower the concentration or dominance shown by individual species and the higher the heterogeneity.

ii Number of effective species (1/C)

- In most rehabilitation scenarios, total groundcover levels significantly exceed those measured in natural situations. However, measured data shows that often only a few effective live species are normally present. This compares with much higher numbers in more diverse natural situations. Because Simpson's Index (C) varies inversely with heterogeneity, its reciprocal (1/C) which is defined as the ***number of effective species,*** can be interpreted as the number of equally represented species that would account for the variation present at a particular site.
- As such, the ***number of effective species (1/C)*** is a useful tool for interpreting dominance data. For example, a Simpson's Index of 0.1 or 0.2 can be interpreted as the equivalent of 10 or 5 equally represented or effective species at a site, suggesting a very diverse groundcover layer. Conversely a Simpson's Index of 0.5 or 1.0 would mean only 2 or even just 1 equally represented or effective species was present; a result often seen in buffel grass situations.

f Tree density and basal area

i Tree density numbers (stems/ha) and basal area figures (stem cross-sectional area in m^2/ha calculated from tree girth at breast height within a known plot size) are collected as part of the vegetation monitoring suite to provide surrogate measures of tree biomass. Tree density is assessed by counting all stems irrespective of height, within a known plot size. Plants with multiple stems are counted only once. Basal area is recorded for all stems >0.1m girth at breast height within the nominated plot.

ii Typically, the measured plot covers $500m^2$ and is located 5m either side of the permanent 10m groundcover transect centreline and extends 20m distant from both central marker pegs (50m x 10m). This size plot allows representative assessment of density and basal area data at most sites, while keeping measurements relevant to the other monitoring activities being undertaken (particularly groundcover, soil characteristics and erosion measures) within close proximity of the central 10m transect at each site.

iii Whilst a $500m^2$ plot is preferable for consistency, plot size can be varied to suit particular circumstances, as final tree density and basal area data are calculated on a per ha basis. Typically, plot sizes are only varied in situations where:

- Tree densities are very low. In such cases, plot size can be increased to $1000m^2$ located 10m either side of the permanent 10m groundcover transect centreline and extending 20m distant from both central marker pegs (50 x 20m - equivalent to the largest species diversity plot); or
- Conversely, where tree densities are very high. In such cases, plot size can be reduced to $100m^2$ located 1.0m either side of the permanent 10m groundcover

transect centreline and extending 20m distant from both central marker pegs (50 x 2m).

iv **Stem density** varies from year to year, either through recruitment of seedlings or through the death of mature individuals. Species and stem height (m) (minimum of 3 typical specimens for each species) are recorded for all stems within the nominated sample area. Stem counts for individual species from either a $100m^2$, $500m^2$ or $1000m^2$ plot size are converted to stems/ha to allow comparison of data between years and across sites. Stem numbers for each species may also be summed to provide stem density data on a broad vegetation group basis or for the site as a whole.

v **Basal area** is recorded for all stems within the nominated plot where girth (m) measured 1.3m above ground level is greater than 0.1m. Girth measurements (stem circumference in m) provide a rapid and reliable surrogate for diameter at breast height (dbh). Girth values (m) are converted to a radius value (m) before calculating cross-sectional area (m^2) for each stem. Individual stem cross sectional area figures for each species either from a $100m^2$, $500m^2$ or $1000m^2$ plot size are then summed and converted to basal area figures in m^2/ha (calculations vary depending on plot size). Figures for individual species may also be summed to provide basal area data (m^2/ha) on a broad vegetation group basis or for the site as a whole.

g **Crown cover (%)**

i Crown cover (%) data for above ground canopy forming species is routinely recorded during field data collection at all monitoring sites. This recognises the importance that crown cover potentially plays in moderating rainfall impact and erosion risk and also as a component of ecosystem functionality. Collection of more detailed information on the level of canopy cover under different rehabilitation scenarios and also in comparable natural analogue situations will be important when characterising the ecosystem value of rehabilitated vegetation during future mine decommissioning and relinquishment.

ii Current methodology used in the collection of **crown cover** (**%)** data at individual sites records the extent of canopy intercepts along a 50m tape. The start and finish of each crown is recorded and summed as a total canopy distance for each individual species. Canopy intercepts are then converted to crown cover % as a simple proportion (i.e. crown cover % = total canopy distance in 50m x 2) and calculated either on an individual species basis or as a total value for the site as a whole.

iii Crown cover measurements are undertaken along the central 50m transect running through the centre of each monitoring site. This transect is permanently positioned by the 2 central 10m marker pegs (delineating the 10m groundcover transect) and extends 20m distant from each peg. It is important to recognise that the positioning of this transect has been determined by monitoring requirements other than the measurement of crown cover (%). Whilst crown cover data collected along this transect will be spatially relevant to other monitoring measures collected at the site, it may not necessarily be representative of crown sizes or crown separation ratios across the wider site area. Conversely, the advantage of measuring crown data in its current format is that it allows accurate, relocatable and repeatable measurements between census events and ensures temporal changes are observed and quantified. In addition, crown cover measurements collected in this way will be spatially relevant to other monitoring data collected at the site such as tree density, species diversity and groundcover analyses.

Monitoring Schedule

144 Monitoring programs at Minerva Mine are outlined in Table 14.

TYPE OF DISTURBANCE	TYPE OF MONITORING	SCHEDULE Going Forward
Overburden dumps	Rehabilitation monitoring as defined within the Monitoring Methods Section of the Rehabilitation Management Plan concerning; • Soil profile attributes • Vegetation establishment • Surface Stability • Surface/Soil Fertility	Every 2 years or as considered necessary for each site by 3rd Party Scientists.
Undisturbed RE areas in ML's	Bluegrass Offset Area monitoring.	Annual
Final void, Dams	Water quality.	Quarterly Dam sampling as defined by Environmental Authority EPML00668613. Monthly standing groundwater levels. Bi-annual groundwater sampling as defined by Environmental Authority EPML00668613. Annual groundwater sampling as per Water Licence requirements.
	Geotechnical stability/safety of high and low wall areas.	Ongoing pit inspections during operations. Post closure, geotechnical inspection and assessment conducted on an annual basis over a 5 year period.
Creek Diversions	<u>Vegetation Cover Assessment & Structural Stability</u> Examine the full length of diversions using high resolution aerial photogrammetry and / or detailed ground observations.	Surveillance inspections as per Water Licence requirements.
	Assess whether water quality might be adversely affected during passage through the diversion (i.e. upstream and downstream water quality sampling for key analytes including pH, EC, Sulphate, Suspended Solids and Metals).	Annual REMP monitoring process as defined by Environmental Authority EPML00668613.
Standing highwalls	Highwall geotechnical stability status. Field inspections and aerial imagery.	Ongoing pit inspections during operations. Post closure, geotechnical inspection and assessment conducted on an annual basis over a 5 year period.

Table 14 – Rehabilitation Monitoring Program

9 Rehabilitation Performance Criteria

145 Growing evidence from over 30 years of rehabilitation monitoring in the Bowen Basin indicates that direct duplication of adjoining natural ecosystems is impractical on most rehabilitated overburden spoil. The major reason being the significant differences between mine spoil and natural soils chemical and physical makeup; as well rehabilitated spoil landscapes are often more elevated with greater slope gradients. The spoil growth media is often unweathered, unconsolidated, sodic, and saline; thus is different in physical and chemical makeup than surrounding natural subsoil. However, an approach of rock mulching erosive prone dump batters followed by topsoil application that is subsequently deep ripped and seeded to a mix of Acacia and Eucalypt Species reflecting Regional Ecosystems in the area with similar slope attributes will result in the following enhanced environmental values;

- **a** Reduced potential sediment load runoff concerning downstream water quality attributes off lease;
- **b** Increased stable landform features reflecting slope and rock scree attributes of adjoining Regional Ecosystems in the area that provide reference with regard to weathering process consequences in terms of geomorphological time frames;
- **c** Increased flora biodiversity thus resulting in a wider array of fauna habitat types over the longer term.

146 The rehabilitation success criteria for mine disturbance areas must be primarily based on achieving a stable landform. Rehabilitated areas will be monitored using the selected parameters and trends tracked to demonstrate progress towards a self-sustaining vegetation cover. The natural/reference sites will facilitate develop of completion criteria as related to the rehabilitation treatments expedited.

147 General aspects for consideration in the validation of rehabilitation performance criteria include;

- **a** Geotechnical and hydrological landform stability, including final void highwall, with no mass failure of slopes;
- **b** Effective drainage structures, including creek diversions, with similar characteristics to natural waterways in the vicinity of the site;
- **c** Downstream water quality complying with conditions of the Environmental Authority (sediment, salinity values).
- **d** Externally draining areas must be stable in terms of erosion processes.

148 Table 15 outlines the performance indicators which Minerva will take into consideration when assessing the sustainability of its rehabilitation programs for each post-mining land use (PMLU) and non-use management area (NUMA). A conceptual map of PMLUs and NUMAs at closure is presented in **Appendix 2**. Performance Criteria will be updated as further characterisation and understanding of natural/reference site attributes is developed via the rehabilitation monitoring program.

Demonstration Sites

149 Rehabilitation monitoring sites which have met the performance criteria for at least 3 successive monitoring events will be proposed as demonstration sites. These sites are those deemed to have reached a desirable steady-state condition in terms of stability, soil profile and floral characteristics. These sites will continue to be monitored and will become the compliance standard for success of rehabilitation.

150 Natural Sites

- **a** Representative natural sites will continue to be monitored. The main purpose is to document the natural range of vegetative variation in grazing and bushland settings with a view to returning land which mimics it as best as can be achieved (i.e., bushland and grazing compatibility/connectivity as is possible). However as indicated, a return of rehabilitated spoil to the same native analogue function is not feasible nor is it proposed in this RMP.

Disturbance Type	PMLU/NUMA	Performance Requirements
Overburden spoil. .	Grassy open woodland	Effective rooting depth > 50cm (indicated by acceptable soil profile pH/EC, salinity or hard layers) No acid or saline seepage areas derived by inspections and interrogation of imagery at resolution of 1:5k to 1:10K Absence of active rills and gullies as evidenced from surveillance from high resolution photogrammetry and ground observation/measurement. Ground cover stable or improving. Ground cover is defined as any cover that assists in controlling erosion and may include live or dead cover and possibly rocky debris. Developing vegetative community consisting of a mixture of predominantly native trees, shrubs and grasses. Specific areas of potential contamination have been identified, remediated and monitored according to the Regulator's requirements.
Infrastructure, including ROM areas, creek diversions	Low-intensity grazing	Effective rooting depth > 50cm (indicated by acceptable soil profile pH/EC, salinity or hard layers) No acid or saline seepage areas derived by inspections and interrogation of imagery at resolution of 1:5k to 1:10K Absence of active rills and gullies as evidenced from surveillance from high resolution photogrammetry and ground observation/measurement. Ground cover stable or improving. Ground cover is defined as any cover that assists in controlling erosion and may include live or dead cover and possibly rocky debris. Specific areas of potential contamination have been identified, remediated and monitored according to the Regulator's requirements.
Final Voids	Non-Use Management Area*	No public access to highwalls/end walls (bunding/fencing as required) Closure bund installed minimum 50m from pit crest or distance equal to Factor of Safety of 1.5 (unless an alternative is justified by an appropriately qualified person). Maximum slope in competent rock 275% (70 degrees). Maximum slope in incompetent rock 65% (angle of repose). Maximum total void surface area 91ha (measured at maximum water level) Assessment report by a Registered Professional Engineer of Queensland (RPEQ) on the geotechnical stability of final voids. Surface water and groundwater quality of receiving waters meets the requirements of Schedule W of the Environmental Authority. Voids have no adverse environmental impacts on surrounding aquifers 1 in 1,000 AEP flood event in Sandhurst Creek diversion does not enter final void.
Dams	Water storage	Water quality is suitable for beef cattle drinking water (EA Table W6). Functioning bywash or spillway with adequate flow capacity provided for dams. Sign-off by post-mining landholder (for retained dams).

* Western and Southern voids as determined by Residual Void Investigation Report (5 November 2021)

Table 15 – Rehabilitation Performance Criteria

Performance Review & Corrective Actions

151 Annual review and update will include:

- **a** Ensure that any significant changes to the long term mine plan are incorporated;
- **b** Mine site disturbance is updated on mine plans and conforms with the Plan of Operations;
- **c** All environmental monitoring programs are being conducted to the required standards of the Environmental Authority and data is readily available;
- **d** Suitably qualified persons conduct reviews of all monitoring data at least every 2 years to determine data trends, coverage is adequate and methods are appropriate;
- **e** Rehabilitation performance is trending towards final completion criteria and required rehabilitation repair works are scheduled;
- **f** Spoil and topsoil chemistry characterization is current;
- **g** Topsoil records (stockpiles and spread over rehabilitation) are current;
- **h** Actual costs for rehabilitation activities conform to Plan of Operations requirements.

152 The annual review should provide direction and evidence for auditors in the verification of Performance Category for annual Plan of Operations.

10 Post Mine Land Capability

Post Mine Land Use

153 The objective of spoil reshaping is to maximise areas of higher potential suitable land which will remain stable and not impact downstream. Overriding goals are to re-contour to acceptable slopes and establish vegetation suited to the area that is compatible with established regional land use patterns. Appropriate management of particular domain areas where slope is not an attribute limitation may allow grazing activities to be sustainable for those areas.

154 If research or monitoring shows grazing to be undesirable, all areas will revert to a bushland habitat with stable self-sustaining land types being the overriding concept.

155 Proposed post mining land uses include:

- **a** Low-intensity grazing;
- **b** Grassy open woodland; and
- **c** Water storage areas (dams).

Land Suitability Assessment Process

156 The steps involved in the assessment of grazing suitability for post mine lands are summarized below.

- **a** Requirements for a grazing use were expressed as limitations, which may be measured or estimated in various ways. Assessment of limitations is based on Shields and Williams (1991) for grazing in the Kilcummin area near Clermont. The severity and relevance of certain limitations in the agricultural environment may differ to reclaimed mine lands, e.g., high salinity in the root zone of an agricultural soil may be irrelevant in certain types of mine spoil which are known to leach salts out over time.

- **b** ***Table 16*** lists the major land use requirements for grazing and limiting factors deemed relevant to rehabilitated domains.

c The various baseline data attributes used to measure or approximate the severity of limitations were then determined. Such attributes are referred to as diagnostic attributes by Land Resources Branch (1990) and are listed in Table 17.

d Critical values for each diagnostic attribute need to be determined from established standards. In the case of this Plan, the adopted standards are either that from Shields and Williams (1991), or are to be validated via forthcoming rehabilitation monitoring processes.

e Each post-mining land type is then allocated a grazing suitability class based on the most severe limitation or combination of limitations.

Grazing Use Requirement	Limitation
acceptable long term soil loss rates	erosion (e)
adequate water supply	water availability (m)
adequate nutrient supply	nutrient deficiency (n)
low levels of toxic elements	element toxicity (nt)
favourable levels of soluble salts	soil profile salinity (sa)
adequate soil aeration	soil physical factors (p)
suitable water quality	water quality in voids and spoil
adequate soil depth for plant roots	effective rooting depth (r)
favourable soil reaction	pH (pH)
surface gravel, coal and rock not excessive	rockiness (r)
minimum wet ground conditions	wetness (w),
ability to access stock or stock to graze	landscape complexity (lc)

Table 16 – Land Characteristics Requirements for Grazing

Grazing Suitability

157 The potential for a beef cattle grazing land use for rehabilitated spoil is to be assessed using the methodology of Land Resources Branch (1990) and suitability classes assigned according to Shields and Williams 1991. The five class grazing suitability classification as proposed by Shields and Williams (1991) is shown as the following Table 18.

158 Areas of rehabilitation will be identified at Minerva Mine via rehabilitation monitoring processes which demonstrates potential for grazing. Grazing land units need to be significant in size and uniform in nature such that excessive risk of degradation does not occur.

159 The best grazing potential can expected to be on the rehabilitated infrastructure domain, which have low, stable, slopes. These areas are likely to be at best class 3 grazing land which Shields and Williams (1991) considers to be; suitable land with moderate limitations which require incorporation of various management practices to maintain economic production. A low-intensity grazing post-mining land use is proposed (see Table 15 and Appendix 2). Under such low-intensity grazing conditions, the post-mining land use would be sustainable, non-polluting, stable and safe to humans, stock and wildlife.

Limitation	Diagnostic attributes
erosion (e)	slope gradient slope length use of topsoil size, frequency and stability status of gullies texture spoil type internally or externally draining
water availability (m)	spoil type and slope topsoil type and depth effective rooting depth compaction (PSA, Ca:Mg ratio on surface) clay % limit of wetting front (depth to salt layer) landscape position ESP profile vegetation types and vigour rainfall distribution gravimetric water contents at –33 , –1500KPa
nutrient deficiency (n)	topsoil or spoil type pH profile, texture Al or Fe content organic matter (not organic Carbon) cation exchange capacity fertility laboratory analysis
salinity (sa)	mean root zone salinity via EC extent of wetting front to salt accumulation
water quality	EC, pH and sulphates levels of void and spoil water bodies.
soil physical factors (p)	surface condition – texture / structure % surface gravels or coal size and frequency of gullies
wetness (w)	vegetation type period & frequency of saturation or free water depth of possible inundation
landscape complexity (lc)	size and shape of suitable land types effects of adjoining non-suitable land

Table 17 – Diagnostic attributes used to evaluate severity of limitations

160 Emmerton (2003) proposed a set of landform parameters which were considered indicative of a possible grazing use of rehabilitated domains which include;

a A maximum slope of 12%

b Cover levels maintained above 70%

c Adequate slope configurations, cation exchange capacity, salinity profiles, pH and structure.

Table 19 lists the major limiting factors which are relevant to this assessment of a potential grazing use on domains of rehabilitation.

Class	Description
1	Suitable for grazing with negligible limitations.
2	Suitable for grazing with minor limitations.
3	Suitable land with moderate limitations which require incorporation of various management practices to maintain economic production.
4	Marginal land which is presently unsuitable due to severe limitations where the long term significance of the limitations is not known. The use of this land is dependent on outcomes of additional studies.
5	Unsuitable with extreme limitations.

Table 18 – Grazing Land Suitability Classes

Rehabilitation Type	Limitations	Severity (1 – 5)	Grazing class
Spoil generally less than 12% slope with >70% cover maintained.	erosion potential rootzone salinity moisture availability nutrient availability	3 2 - 3 2 3	3
Spoil generally less than 12% slope with <70% cover maintained.	erosion potential rootzone salinity moisture availability nutrient availability	4 2-3 3 3	4
Spoil generally in the range 12% – 17% slope	erosion potential rootzone salinity moisture availability nutrient availability	5 3 3 3	5

Table 19 – Major Limiting Factors and Severity for Grazing

Grassy Open Woodland Suitability

161 The spoil domain shall be become a grassy open woodland habitat where the overriding concept is long term stability to ensure that downstream effects are minimal. Where possible, the vegetated flora will be naturally occurring local eucalypt/acacia species, however other species may also be included where they have a functional role that local species cannot fill. As previously documented, an approach of rock mulching erosive prone dump batters followed by topsoil application that is subsequently deep ripped and seeded to a mix of Acacia and eucalypt Species reflecting Regional Ecosystems in the area with similar slope attributes will result in the following enhanced environmental values;

a Reduced potential sediment load runoff concerning downstream water quality attributes off lease;

b Increased stable landform features reflecting slope and rock scree attributes of adjoining Regional Ecosystems in the area that provide reference with regard to weathering process consequences in terms of geomorphological time frames;

c Increased flora biodiversity thus resulting in a wider array of fauna habitat types over the longer term.

The rehabilitation shall be non-polluting, stable, safe to humans and wildlife and able to sustain a grassy open woodland post-mining land use.

162 In grassy open woodland rehabilitation on spoil, grass swards may become moribund in the long-term and have reduced effectiveness for erosion control. In such areas, managed infrequent low-intensity grazing and/or managed infrequent cool burning is likely to be employed in a manner which does not adversely affect long-term tree and shrub cover.

163 The assessment process of the types, composition and classification of proposed grassy open woodland habitat will be further characterised via forthcoming rehabilitation monitoring processes that will include recording species diversity, density and vigour in representative areas of rehabilitation.

Water Storages

164 Dams may be left after mine closure with the agreement of the background land holder (EA Condition F12). This is the intention when the water quality in dams is suitable to beef cattle drinking water set out in EA Table W6. Retained dams would have a functioning bywash or spillway with adequate flow capacity provided. Under such conditions, the water storages would be safe to humans and wildlife, non-polluting, stable and able to sustain an appropriate land use by providing water to stock and wildlife.

Land Management Strategies

165 Details for pre-mining land use and soils have been described by Ison *et al* (1996) indicating the land in general was capable of supporting crop and pastoral development predominantly ranging from Shallow to Deep Black Vertisols on Tertiary Basalt interspersed by Red Brown Non-Cracking Clays and Duplex soils on Permian Sediments. Summaries of this information are included in the ***EMP*** (Minerva Mining 2007).

166 The pre-mining landscape was a flat to gently rolling terrain with occasional hill features with maximum variation over the area of around 14m. Nearby to the west and south, there are a number of relic basalt flows and intrusive volcanic plugs that form steep hills and ridges up to 250m above the surrounding black soil plains. This backdrop of steep sided basalt formations forms the dominant visual character of the locality.

167 Recommended management strategies for all ML areas are described in this Section.

168 The range of requirements for all mine lease areas is included in Table 20.

Active Mining Areas

169 General principles to be applied for active mining disturbance include;

- **a** Overburden waste dumps to be constructed progressively to final landform design, such that reshaping is mitigated prior to revegetation activity;
- **b** Competent basalt resources will be managed to ensure optimised final landform surface application;
- **c** Suitable topsoil will either be stockpiled until recontoured areas are available, or respread immediately to an average depth of 10-20cm across available recontoured areas;
- **d** Contour ripping as an erosion control measure immediately after topsoil placement;
- **e** Seeding with an appropriate seed mix into the ripped seedbed;
- **f** Construction and revegetation of permanent creek diversions to mimic the natural morphological characteristics of the original watercourse; and
- **g** Final voids will be fenced and/or bunded to prevent access. Voids will then collect water from groundwater inflow, direct rainfall and runoff from the rehabilitated landform.

Visual Amenity

170 The pre-mining landscape was a flat to gently rolling terrain with occasional hill features with maximum variation over the area of around 14m. Nearby to the west and south, there are a number of relic basalt flows and intrusive volcanic plugs that form steep hills and ridges up to 250m above the surrounding black soil plains. This backdrop of steep sided basalt formations forms the dominant visual character of the locality.

171 Open cut coal mining involving deep stripping to access coal seams results in a significant change to the local landscape. Prior to rehabilitation the contrast between mined areas and surrounding undisturbed areas can be stark due to elevated spoil mounds that are visible from access roads and one or more local homesteads in vicinity of the mining operation.

172 Thus landscape disturbance represents an impact to the visual amenity for the immediate area; however this is against a backdrop of steep sided basalt formations to the west and south. This is a temporary situation until rehabilitation works have been completed. The Minerva Mine Final Landform Plan is still being developed; nonetheless the concepts have been established and are consistent with creation of a landform which will not be in stark contrast with the surrounding environment. All areas are planned to be revegetated to form a mosaic of grassland and bushland habitat. Hence the final landform should blend into the surrounding terrain provided the outcome is stable and vegetated, visual impacts will be mitigated.

Aspect	Objective	Controls
Declared plants and weeds	Identify and control such species and prevent the introduction of declared plant pests On Minerva Mine ML's, declared weeds identified are; *Parthenium hysterophorus,* ragweed *Opuntia stricta,* prickly pear *Cryptostegia grandiflora* rubber vine *Eriocereus spp*. harissa cactus *Acacia nilotica*, prickly acacia *Ziizphus mauritiana* chinee apple Other species which may occur in the region are; *Harrisia martinii, Jatropha gossypiifolia, Lantana camara* and *Bryophyllum elagoense.* *Hymenachne amplexicaulis* (water storages). *Acacia farnesiana* is seen as a potential threat by out competing other native species.	Discussions held with appropriate Shire Council Representatives regarding weed management protocols. Provision of, and requirements for vehicle wash down facilities. Wash down bays will collect seeds that are washed from the vehicles to prevent ingress to drainage lines. Appropriate grazing management is a key strategy with regard to weed control. A Paddock Authorisation process has been developed to control grazing intensity and duration.
Fauna pests	Control of Cats and rodents	Waste management and facilities to minimise food sources for introduced rodents (rats and mice) around industrial areas, offices and crib huts. Conduct ongoing cat trapping programs as required following Local Government Guidelines.
	Control feral pigs	Scheduled baiting and aerial shooting programs are expedited.
	Wild dogs	Baiting activities are coordinated with Local Government Programs.
Interfering with creeks	Preserve riparian and possible cultural heritage values.	Water course assessment as conditioned in the site Environmental Authority is required prior to any disturbance of water courses in accordance with the administering authority's *Guideline-Activities in a Watercourse, Lake or Spring associated with Mining Activities.* A Cultural Heritage Management Plan shows the locations of all known areas of significance and requirements prior to any land disturbance.
Unauthorised disturbance	Reduce vegetation removal and other disturbance to essential areas. Prevent possible cultural heritage disturbance.	Operations Planning Meeting processes include Environment Section Representatives to provide input with regard to delineation of unauthorised disturbance. This includes lighting of fires. Requirements conveyed in awareness training. A Waste Management Plan to be maintained and employees made aware.
Unauthorised fires	Prevent unnecessary environmental harm and air pollution	
waste disposal	Prevent contamination of land and health of the environment.	
Field maintenance	Prevent pollution from regulated waste including oils, chemicals and grease.	Ensure all field maintenance activities are planned, approved and follow established procedures for control of contaminated runoff as well as reporting and clean-up of spills.

Table 20 – Management Requirements for Mine Lease Lands

11 Terms & Definitions

Term	Definition
Domains	Land management units within a mine site, usually with similar geophysical characteristics
DNRM	Queensland Department of Natural Resources and Mines
Environmental Authority (EA)	Administering authority 'Licence to Operate' which mandates environmental compliance conditions, monitoring, investigation, and notification requirements.
EA Conditions	Compliance conditions of the Environmental Authority pertaining to environmentally relevant activities
EM Plan	Environmental Management Plan
Endwall	The lengthwise extremities of the pit (as opposed to the side extremities which are the highwall and lowwall).
Final void	The last mining pit and remaining ramps
FRR	Final Rehabilitation Report
Highwall	The pit wall of un-mined land
Lowwall	The spoil placed immediately adjacent to the pit in the previously mined strip and can rise to crest of a pre-strip dump.
NUMA	Non-use management area
PMLU	Post-mining land use
Pre-stripping	The operation to remove overburden with truck and shovel
RMP	Rehabilitation Management Plan
Residual void	A void remaining after mine closure
Salinity	Generally refers to the concentration of sodium chloride and other salts either in soil or water
Spoil	Overburden after removal to expose the coal seam
Topsoil	The upper layer of the soil profile removed for reuse in rehabilitation as an inoculant and growth medium.

12 References

Burgess JW (2003a). *Land Resource Assessment of the Windeyers Hill Area, Isaac – Connors and Mackenzie River Catchments, Central Queensland, Volume 1*, Department of Natural Resources and Mines, Land Resources Bulletin Series QNRM02189, Brisbane.

Burgess JW (2003b). *Land Resource Assessment of the Windeyers Hill Area, Isaac – Connors and Mackenzie River Catchments, Central Queensland, Volume 2 - Appendices*, Department of Natural Resources and Mines, Land Resources Bulletin Series QNRM02189, Brisbane.

Chamberlain, J. and Emmerton, B.R. (2014). *Minerva Mine SE Waste Dump Grazing Trial Design and Monitoring Plan*. November 2014.

EES (2004). *Assessment of flora impacts associated with proposed mining operations at Minerva deposit (Mining Lease 70145), Central Queensland*. Earthworks Environmental Services Report 04c31.

EES (2005). *Desktop assessment of fauna impacts associated with proposed mining operations at Minerva deposit (Mining Lease 70145), Central Queensland*. Earthworks Environmental Services Report 04c31b to Minerva Mining.

ESys (2005). *Assessment of soils and overburden/interburden materials available for rehabilitation after mining, Minerva Mine*. A report by ESys Consulting Pty Ltd to Sandhurst Mining Company Limited February 2005.

ESys (2007). *Assessment of soils of Minerva South*. A report by ESys Consulting Pty Ltd to Minerva Mining Company Ltd July 2007.

Ison (1996a). *Minerva Project Soil and Land Capability Assessment*. Ison Environmental Planners, May 1996.

Ison (1996b). *Minerva Project Spoil Characterisation*. Ison Environmental Planners, April 1996.

Land Resources Branch (1990). Guidelines for agricultural land evaluation in Queensland. Queensland Department of Primary Industries. Land Resources Branch.

Mckenzie NJ, Coughlan KJ and Cresswell HP (2002). *Soil Physical Measurement and Interpretation for Land Evaluation.* Australian Soil and Land Survey Handbook Series Volume 5. CSIRO Publishing, Melbourne.

Minerva Mining (2007). Environmental Management Plan. V3.070913. September 2007.

National Committee on Soil and Terrain (2009). *Australian Soil and Land Survey Field Handbook,* Third Edition. Australian Soil and Land Survey Handbook Series Volume 1. CSIRO Publishing, Melbourne.

Rayment GE and Higginson FR (1992). *Australian Laboratory Handbook of Soil and Water Chemical Methods*. Australian Soil and Land Survey Handbook Series Volume 3. Inkata Press, Melbourne.

Shields and Williams (1991). Soils and Land Suitability for the Kilcummin area, Central Queensland. Queensland Department of Primary Industries. Brisbane.

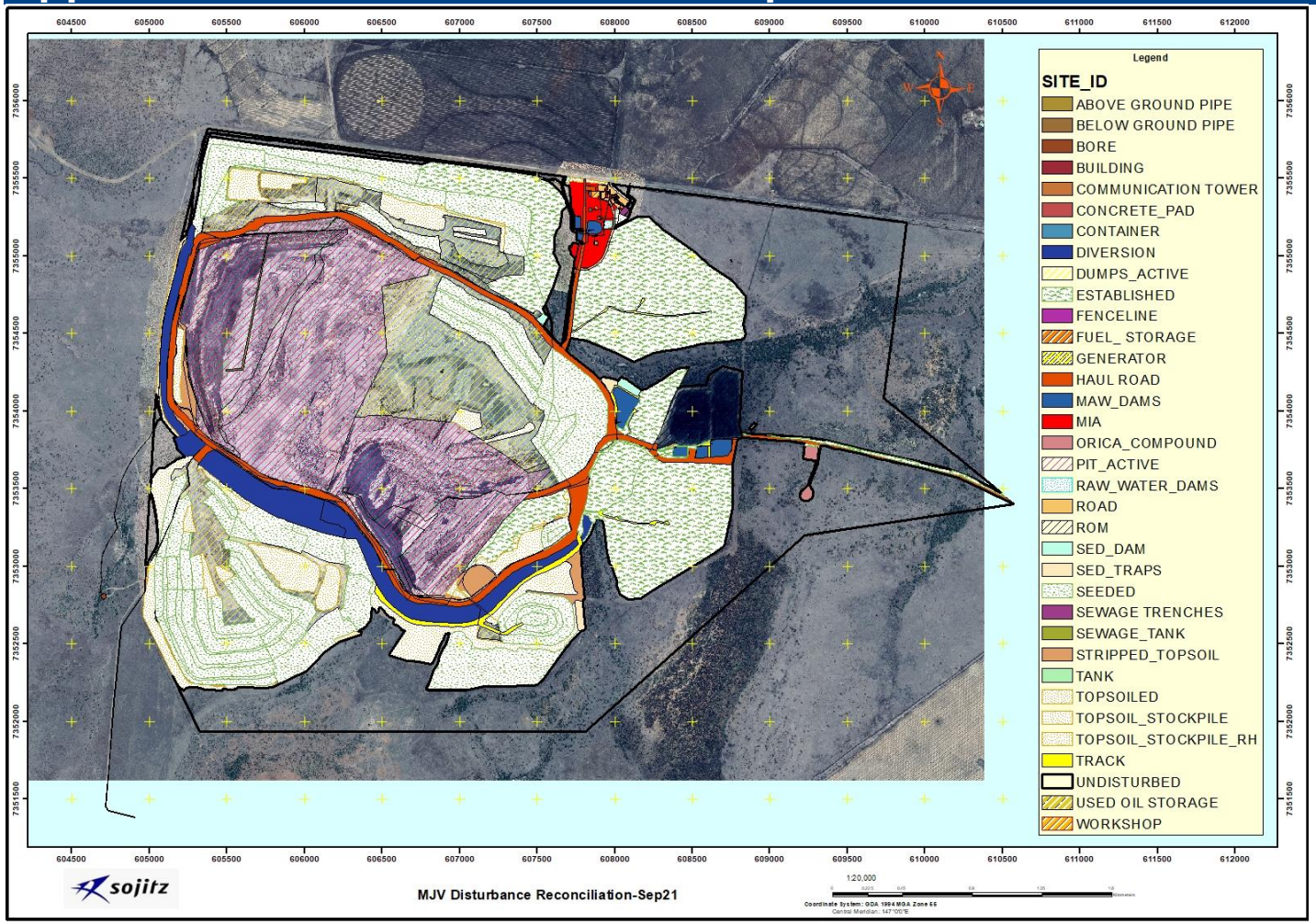
13 Version Management

Version	Details	Contributors
1.0	June 2015	MJV Environmental Superintendent (R. Gooley)
1.1	Minor revision, November 2021. Final void information updated, consistent with Residual Void Investigation Report. Updated disturbance, rehabilitation and land use information and terminology. Updated maps in Appendices.	Rehabilitation Manager (R Gooley)

14 Environmental Authority Compliance Summary

EA Requirement F4	Refer to Section
a) Rehabilitation objectives to achieve the rehabilitation goals for all disturbed areas.	3
b) Detailed rehabilitation methods for each disturbed area.	7
c) Rehabilitation indicators to measure the success of the rehabilitation against the rehabilitation objectives.	8, 9
d) Final completion criteria that will achieve the rehabilitation goals and objectives.	8, 9
e) Details of appropriate monitoring and maintenance of rehabilitation.	8, 9

Appendix 1 – Mine Disturbance – September 2021



Appendix 2 – Conceptual PMLU and NUMA Extent