



Ensham
R E S O U R C E S



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ABN 45 010 236 272
37.5%

Bowen Investment
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ABN 12 002 806 831
15.0%

PROGRESSIVE REHABILITATION AND CLOSURE PLAN

Version 3

Mining Leases

7459, 7460, 70049, 70326, 70365, 70366, 70367

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REHABILITATION PLANNING PART

This PRC Plan *Rehabilitation Planning* part includes information required by the EP Act and the guideline¹ under section 126C(1)(j) of the EP Act. It details how progressive rehabilitation and closure will be carried out over all the lands within relevant resource tenements at Ensham Mine.

Introduction

This a transitional Progressive Rehabilitation and Closure (PRC) Plan for the Ensham coal mine, located near Comet, 35 kilometres (km) northeast of Emerald in central Queensland. Ensham uses conventional open-cut strip-mining and underground bord and pillar mining methods to extract coal from the late Permian aged Rangal Coal Measures. Opencut mining commenced in 1993 and has disturbed an area of approximately 4,731.5 hectares (ha) to date. Underground mining commenced in 2012 and causes no discernible surface disturbance. At the end of 2021, Ensham had completed 1,647.4 ha of land rehabilitation. Most of that rehabilitation has a target post-mining land use (PMLU) of cattle grazing.

Ensham is operated on behalf of joint venture partners by Ensham Resources Pty Limited, a wholly owned subsidiary of Idemitsu Australia Pty Ltd (formally Idemitsu Australia Resources Pty Limited). The joint ventures partners (Idemitsu Australia Pty Ltd (IA) 47.5%, Bligh Coal Limited 37.5% and Bowen Investment (Australia) Pty Limited 15%) hold the relevant environmental authority (EA) and seven associated mining lease (ML) tenements covering 12,642.4 ha.

This PRC Plan has been developed in accordance with relevant sections 126C and 126D of the Queensland *Environmental Protection Act 1994* (EP Act) to satisfy requirements in the Queensland Government's *Guideline—Progressive rehabilitation and closure plans* (the Guideline) (DES 2019). The main purpose of the PRC Plan is to—

- Demonstrate planning for rehabilitation, including how and where environmentally relevant activities will be carried out in way that maximises the progressive rehabilitation of land to a stable condition.
- Provide for the condition to which land must be rehabilitated prior to surrender of the EA.

All areas disturbed within the relevant mining tenures will be rehabilitated to a PMLU or managed as a non-use management area (NUMA). Any undisturbed land within the relevant mining tenures is also identified as a PMLU.

Transitional arrangements.

Ensham is an existing, mine operating under an existing site-specific EA. This is a transitional PRC Plan submitted pursuant to the transition notice issued on 13 August 2020. The, transitional provisions of the EP Act operate to preserve existing outcomes, which outcomes are reflected in this PRC Plan.² Ensham has pre-approved non-use management areas (NUMAs) as detailed in land outcome document EA *EPML00732813*. As Pre-approved NUMAs are provided under the current EA, the following requirements do not apply to this PRC Plan -

- Justification of the NUMA.

¹ DES (2019), *Guideline—Progressive rehabilitation and closure plans (PRC plans)*, ESR/2019/4964, Version 2.0.

² DES (2019), *Guideline—Progressive rehabilitation and closure plans (PRC plans)*, ESR/2019/4964, Version 2.00, p47

- Evidence to support justification of the NUMA.
- Public interest evaluation.
- Compliance with the prohibition of voids located within a flood plain having to be rehabilitated to a stable condition.

This PRC Plan outlines how Ensham will manage NUMAs to achieve best practice management and minimise risks to the environment.

Land outcome documents.

Land outcome documents are defined in section 750 of the EP Act. The following land outcome documents are relevant to this PRC Plan.

Legislative requirement	Land outcome documents
land outcome document , for land, means the following documents relating to the land—	
(a) an environmental authority for a resource activity on the land;	1. EA EPML00732813, dated 3/9/2020.
(b) a document made under a condition of an environmental authority mentioned in paragraph (a), if— (i) the document relates to the management of a void within the meaning of section 126D on the land, or the rehabilitation of the land; and (ii) the document was received by the administering authority before the assent date; and (iii) the administering authority has not, within 20 business days after the assent date, given notice to the holder of the environmental authority that the document is insufficient in a material particular relevant to a matter mentioned in subparagraph (i); and (iv) before the assent date, the document had not been superseded;	
(c) a document made under a condition of an environmental authority mentioned in paragraph (a), if— (i) the document relates to the management of a void within the meaning of section 126D on the land, or the rehabilitation of the land; and (ii) the environmental authority requires the document to be given to the administering authority on a stated day that is on or after the assent date, or does not state a day when the document must be given; and (iii) the document is received by the administering authority within 3 years after the assent date; and (iv) the administering authority does not, within 20 business days after receiving the document, give the holder of the environmental authority notice that the document is insufficient in a material particular relevant to a matter mentioned in subparagraph (i);	None.
(d) a report evaluating an EIS under the State Development and Public Works Organisation Act 1971, section 34D ;	None.
(e) an EIS assessment report;	None.
(f) a written agreement between the holder of an environmental authority mentioned in paragraph (a) and the State that is in force on the assent date.	None.

Ensham notes that the land outcome document list is hierarchical. Where there is an inconsistency between these documents, on either the final outcome or details of the outcome, then the document appearing first in the list will prevail to the extent of the inconsistency³.

Accuracy.

Mining lease spatial inaccuracies.

Mining lease polygons used in this PRC Plan were downloaded from *QSpatial – Queensland Spatial Catalogue* (see <http://qldspatial.information.qld.gov.au/catalogue/custom/index.page>). We note this spatial data has inaccuracies in areas (size and extent) and boundaries (points and lines) (Figure P0-1). Inaccuracies mean the sum of each mining lease area is greater than the total area when mining leases are presented together. In this PRCP, all spatial data presented is accurate on a per mining lease basis only and cumulative totals are the sum of each tenement.

Cartesian area versus spherical area.

The QSpatial attribute area data is based on the registered survey plan. The area for survey plans is calculated as a cartesian area, which assumes a flat plane. In contrast, this PRC Plan presents all polygons as spherical area. Spherical area takes account of the curvature of the surface of the earth.

The sizes of planned versus actual rehabilitation areas will vary with level of accuracy.

There are many challenging aspects of mined land rehabilitation that will result in unavoidable mismatches between the size of predicted rehabilitation polygons or areas and the size of actual rehabilitation areas. These include design tolerances, and assumptions made on material volume losses and gains in earthworks, and the cascading effect that changes to one area have on those surrounding it. Whilst this PRC Plan reports future rehabilitation areas with a high degree of accuracy i.e., up to two decimal places, this level of accuracy is not realistic in rehabilitation earthworks. The identified rehabilitation areas are therefore subject to the following levels of accuracy:

- For discrete rehabilitation or improvement areas, the hectares presented herein are accurate to ± 15 %.
- For total areas of PMLUs and NUMAs, the hectares presented herein are accurate to ± 5 %.

³ DES (2019), *Guideline–Progressive rehabilitation and closure plans (PRC plans)*, ESR/2019/4964, Version 2.00, p48.



Figure P0-1 Example of spatial data inaccuracies in QSpatial

1 PROJECT PLANNING

In accordance with section 126C(1)(b) and (c)(ii) of the EP Act, the rehabilitation planning part of the PRC plan must include a description of:	
• each resource tenure, including the area of each tenure	Table 1-1
• the relevant activities to which the application relates	Table 1-3
• the likely duration of the relevant activities	Section 1.1
• how and where the relevant activities are to be carried out, including maps.	Section 1.1.1 & Figure 1-4 Environmentally relevant activities

1.1 Project description

Ensham is an operating opencut and underground coal mine located 35 kilometres (km) northeast of Emerald, near Comet, in central Queensland (Figure 1-1). The opencut uses a single dragline to expose coal which is removed with excavators and trucks. The underground uses five continuous miner production units to extract coal and a coal clearance system to convey coal to surface stockpiles. Ensham produces a high energy, low ash thermal coal for export via Gladstone Port and domestic electricity generation at Gladstone Power Station. The mine has operated since 1993 and supports a workforce of approximately 600 employees and contractors.

There are seven relevant resource tenements (Table 1-1, Table 1-3, and Figure 1-2). The mining operation commenced at Yongala on ML 70049 in 1993 with other mining leases added since, totalling a combined area greater than 12,000 ha. The duration of mining as a whole is planned to cease in 2037 with the completion of rehabilitation in 2043, subject to the approval of mining lease renewal where required. The term of the existing mining leases are currently authorised to continue until 2028 and a renewal of these leases to 2050 will be sought to accommodate mining the identified resource and mine rehabilitation. Primary mine features at Ensham include open-cut pits and overburden dumps, Underground infrastructure, rehabilitation, and Mine infrastructure (Figure 1-3). As this is a transitional PRC Plan, Ensham is not required to demonstrate how aspects of the mine site have been designed for closure for existing or approved disturbance.⁴

Table 1-1 Ensham mining leases

70049	Bligh Coal Ltd Idemitsu Australia Pty Ltd Bowen Investment (Australia) Pty Ltd	28/01/1993	31/01/2028	1,648.0
7459	Bligh Coal Ltd Idemitsu Australia Pty Ltd Bowen Investment (Australia) Pty Ltd	21/04/1994	31/01/2028	6,154.0
70367	Bligh Coal Ltd Idemitsu Australia Pty Ltd Bowen Investment (Australia) Pty Ltd	21/04/1994	31/01/2028	1,004.0

⁴ DES (2019), *Guideline—Progressive rehabilitation and closure plans (PRC plans)*, ESR/2019/4964, Version 2.00, p19.

7460	Bligh Coal Ltd Idemitsu Australia Pty Ltd Bowen Investment (Australia) Pty Ltd	21/04/1994	31/01/2028	774.3
70326	Bligh Coal Ltd Idemitsu Australia Pty Ltd Bowen Investment (Australia) Pty Ltd	15/09/2005	31/1/2028	25.7
70365	Bligh Coal Ltd Idemitsu Australia Pty Ltd Bowen Investment (Australia) Pty Ltd	04/11/2010	31/01/2028	2,766.0
70366	Bligh Coal Ltd Idemitsu Australia Pty Ltd Bowen Investment (Australia) Pty Ltd	04/11/2010	31/01/2028	254.3

Table 1-2 Ensham affected lands and landholders

70049	Lot 3 CP911009 Lot 2 SP165518	MD, ME, EM, JD & SM Shaw RH & RJ Simmons
7459	Lot 31 CP864573 Lot 32 RP908643 Lot 30 CP864574 Lot 33 RP864576	Bligh Coal Ltd (47.5%) Idemitsu Australia Pty Ltd (37.5%) Bowen Investment (Australia) Pty Ltd (15%)
70367	Lot 31 CP864573 Lot 32 RP908643	Bligh Coal Ltd (47.5%) Idemitsu Australia Pty Ltd (37.5%) Bowen Investment (Australia) Pty Ltd (15%)
7460	Lot 31 CP864573 Lot 32 RP908643	Bligh Coal Ltd (47.5%) Idemitsu Australia Pty Ltd (37.5%) Bowen Investment (Australia) Pty Ltd (15%)
70326	Lot 31 CP864573	Bligh Coal Ltd (47.5%) Idemitsu Australia Pty Ltd (37.5%) Bowen Investment (Australia) Pty Ltd (15%)
70365	Lot 31 CP864573 Lot 32 RP908643	Bligh Coal Ltd (47.5%) Idemitsu Australia Pty Ltd (37.5%) Bowen Investment (Australia) Pty Ltd (15%)
70366	Lot 30 CP864574	Bligh Coal Ltd (47.5%) Idemitsu Australia Pty Ltd (37.5%) Bowen Investment (Australia) Pty Ltd (15%)



Figure 1-1 Ensham location in central Queensland



Figure 1-2 Ensham resource tenements (mining leases)

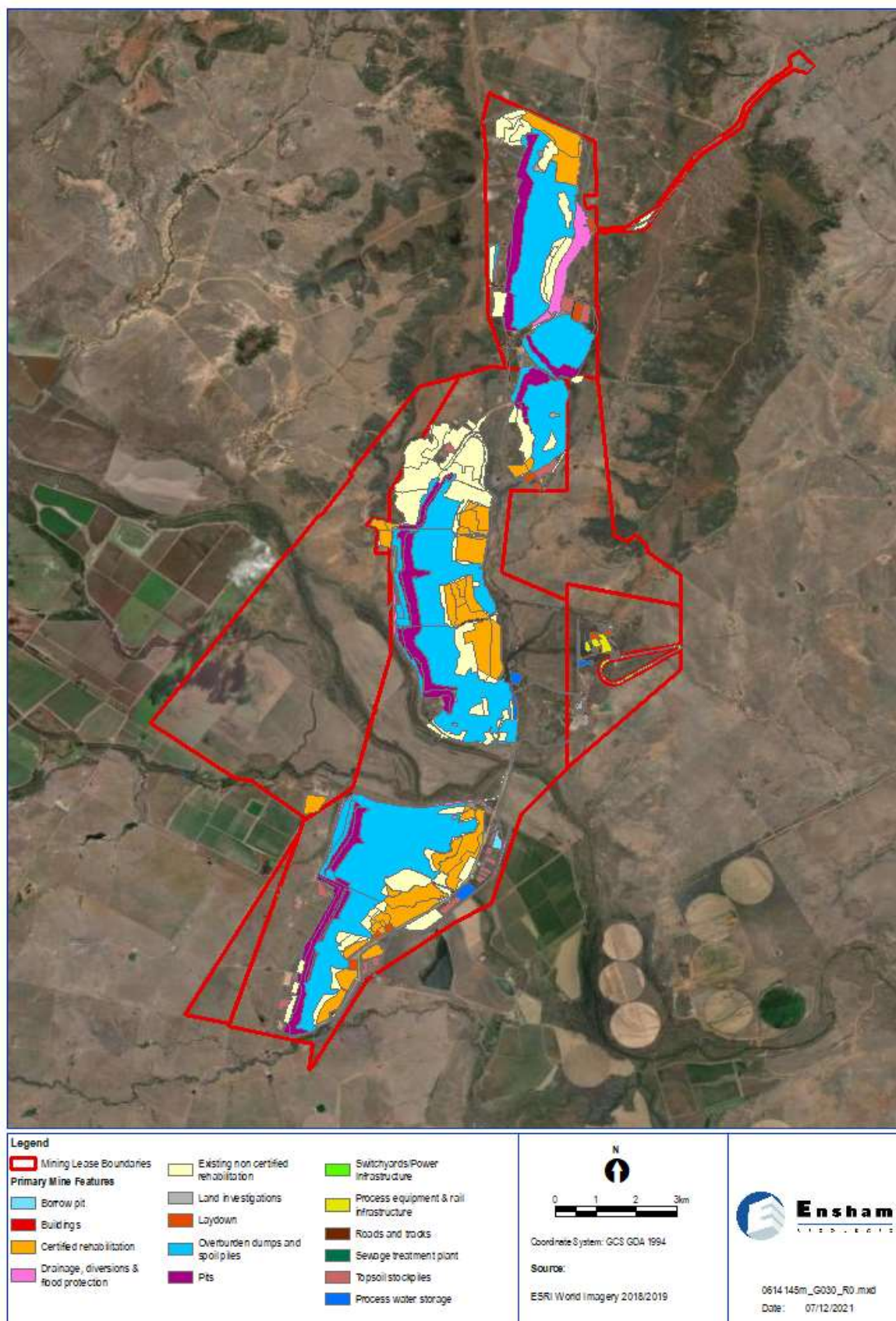


Figure 1-3 Ensham primary mine features

1.1.1 Environmentally Relevant Activities (ERA's)

Ensham's EA (EPML00732813) authorises the carrying out of the below listed ERA's. Not all ERA's currently occur in all mining leases despite that all ERA's are authorised for all mining leases. While open cut mining operations are downsizing, it is not possible to define the future commencement or locations of ERA's at Ensham specifically. A renewal is planned to be sought for all mining leases where required.

Table 1-3 Ensham environmentally relevant activities

70049	Mining black coal	1993	2028
	Extraction & screening	1993	2028
	Waste disposal	1993	2028
7459	Mining black coal	1994	2043
	Chemical storage	1994	2043
	Extraction & screening	1994	2043
	Regulated waste storage	1994	2043
	Waste disposal	1994	2043
	Sewage treatment	1994	2043
70367	Mining black coal	1994	2043
7460	Mining black coal	1994	2043
	Sewage treatment	1994	2043
70326	Mining black coal	2005	2043
70365	Mining black coal	2010	2043
70366	Mining black coal	2010	2043

It is noted that the below figure does not display the extent of ERA 13 – mining black coal, as its extent is variable in both open cut and underground operations across the mining leases. It is considered that black coal mining occurs across the mining leases as a whole.

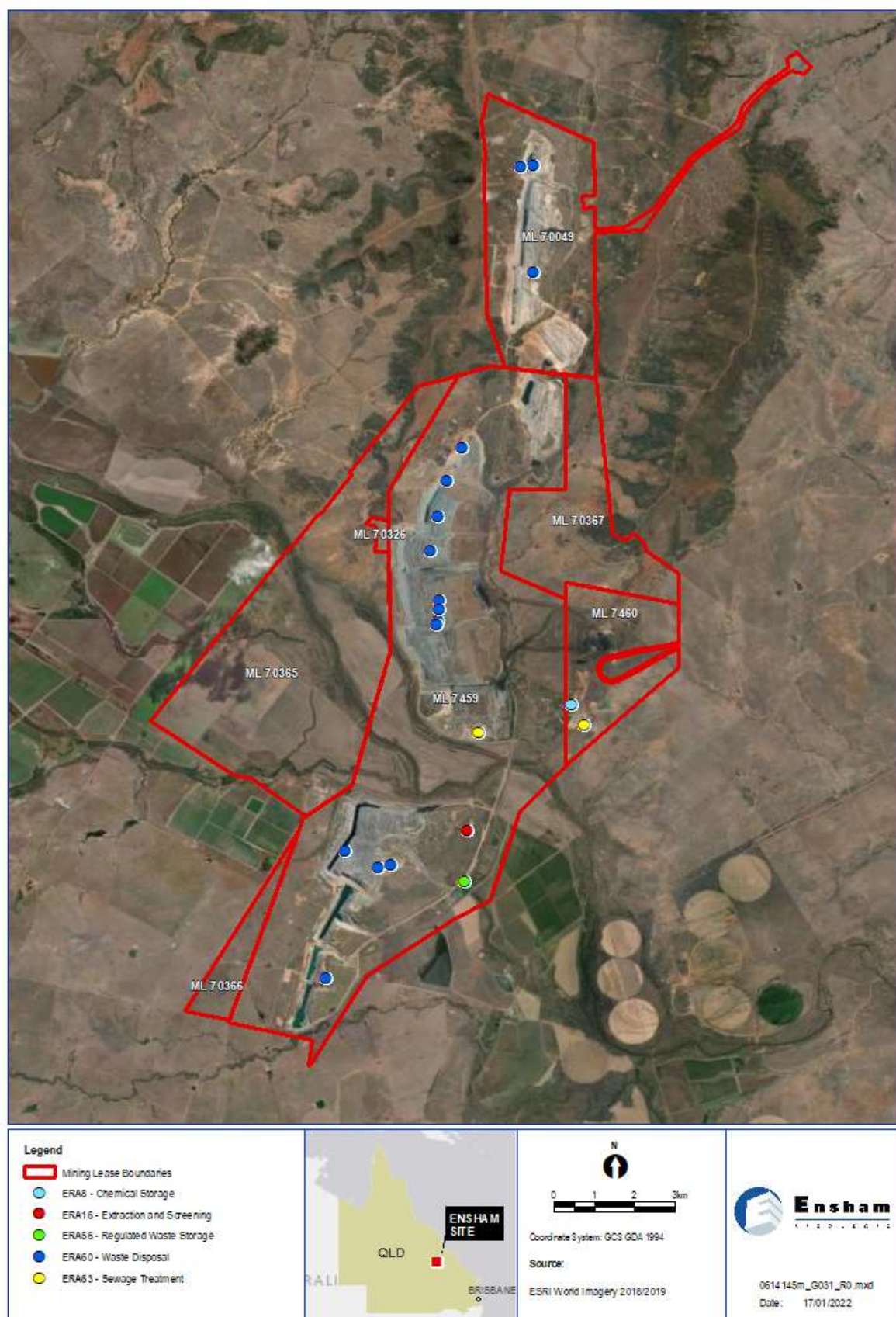


Figure 1-4 Environmentally relevant activities

1.2 Existing rehabilitation

Ensham has completed more than 1,600 ha of opencut mine rehabilitation since 2001 (Figure 1-5, Figure 1-6, Figure 1-7 and Figure 1-8). This equates to approximately one third of total mining disturbances. Most existing rehabilitation has a target PMLU of beef cattle grazing. Portions of existing rehabilitation have been approved as certified under the EP Act (Table 1-4) or not yet applied for. Following approval of the application for certification of progressive rehabilitation in 2021, Ensham has more certified opencut rehabilitation than any other opencut coal mine in Queensland.

Table 1-4 Ensham existing rehabilitation

Certified (2018)	97.2
Certified (2021)	565.63
Not yet applied for or certified	984.6
TOTAL	1647.4



Figure 1-5 Existing rehabilitation at AB Pit (ML7459)

These areas are currently used for beef cattle grazing.



Figure 1-6 Existing rehabilitation at CDE Pit (ML7459)



Figure 1-7 Existing rehabilitation at Y Pit (ML70049)

This area was certified in 2019 and is currently used for beef cattle grazing.

1.3 Progressive rehabilitation

Ensham have specified areas of progressive rehabilitation of the remainder life of the Ensham mine, as incorporated into the PRCP schedules provided as Appendix 9.1. It is further noted that the spatial information provided to accompany this document meets the minimum 10-year period.

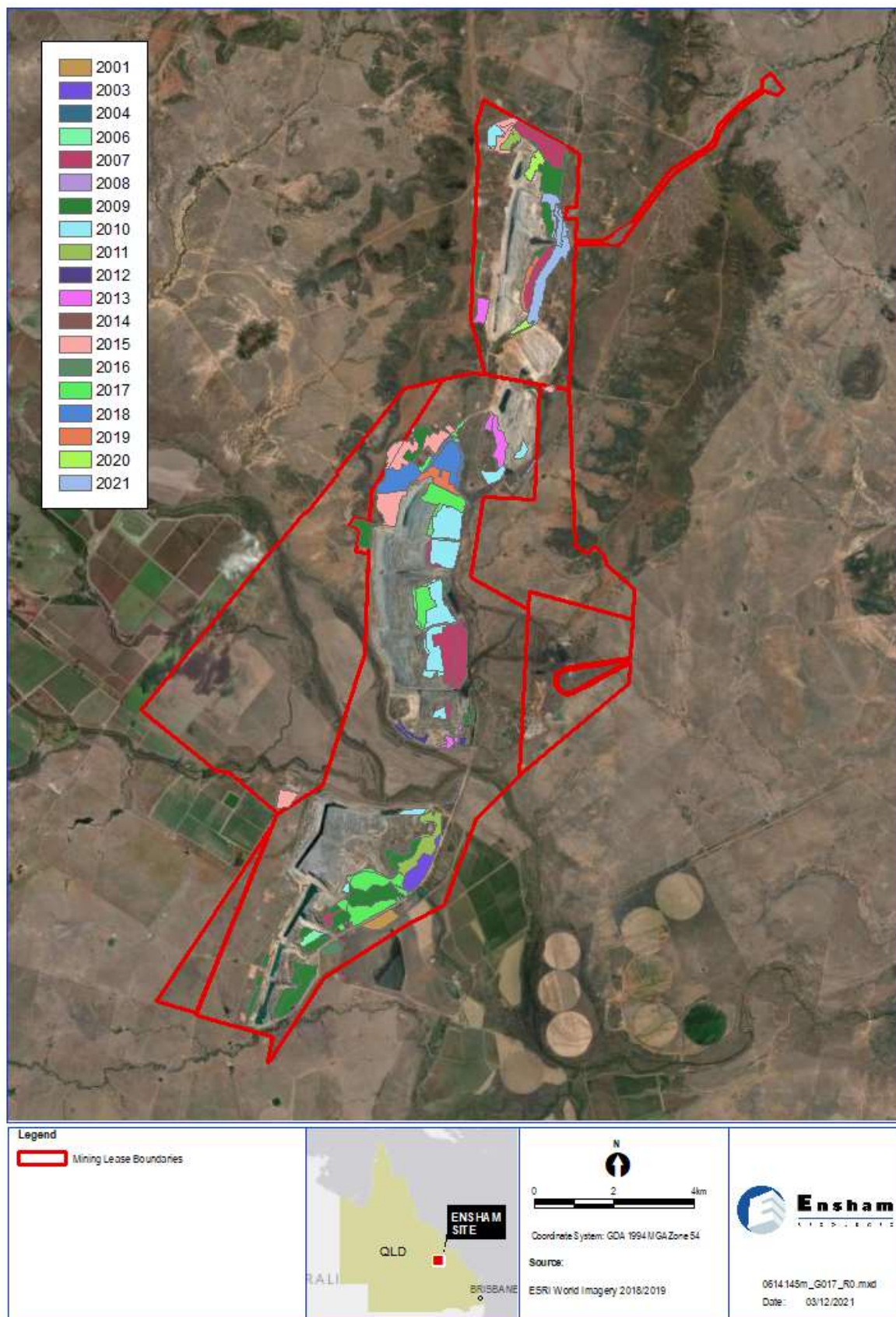


Figure 1-8 Ensham existing rehabilitation

1.4 Baseline Information

1.4.1 Site topography

The pre-mining topography at Ensham (Figure 1-9) is described as follows:

- Terrain in the northern half of the mine comprises mainly mildly dissected gently to moderately sloping and undulating lands, which form slopes and outwash plains flanking Boggy Creek. Erosion has occurred below the elevated plateau remnants that occur in the north. Plateau remnants feature steep escarpments, with slopes in the order of 33% to 66% gradient or more, with local relief up to 50 m between plateau crests and adjacent escarpment foot slopes.
- In the southern half, terrain is essentially gently sloping. This encompasses the extensive floodplain area of the Nogoia River and its major tributaries which flow through the area in a south-easterly direction within a broad alluvial tract approximately 4 km wide.

Key post-mining landform design parameters for rehabilitation are within the natural range of geometries of local landforms e.g., slope gradients and lengths.

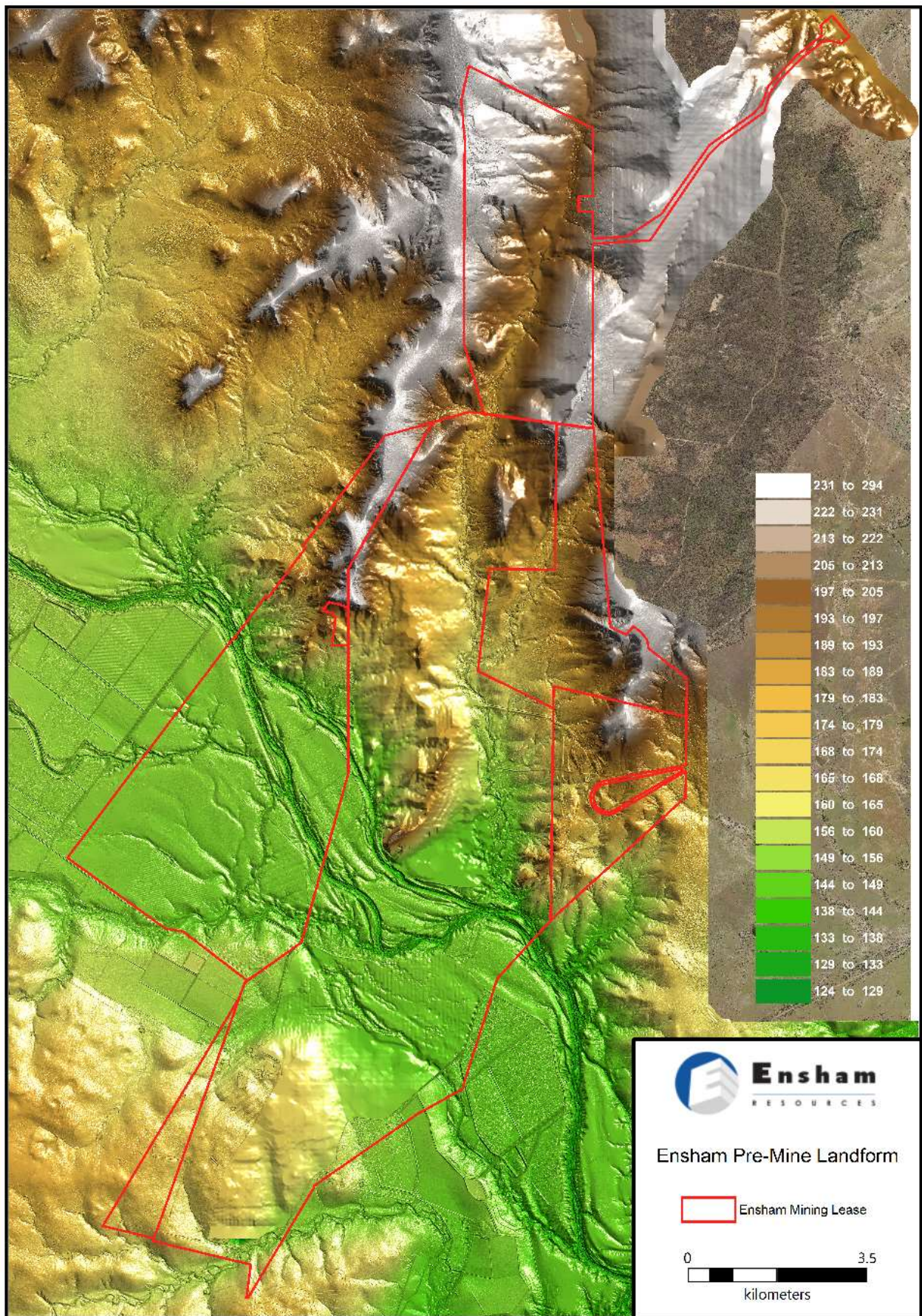


Figure 1-9 Ensham pre-mining topography

1.4.2 Climate

1.4.2.1 General

Ensham is in the Central Highlands Region which has a sub-tropical climate characterised by high variability in rainfall, temperature, and evaporation. Drought, flood, heatwaves, and frost are features of the climate. In general, winter days are warm and nights are cool, while summer days are hot and nights are warm. Rainfall is summer dominant with almost half falling between December to February, often as high intensity thunderstorms.

According to CSIRO (2016), long term climatic modelling for Eastern Australia has predicted with very high confidence an increase in average minimum and maximum temperatures, the intensity of extreme rainfall events and the projection of droughts. A medium confidence prediction also indicates that there will be a decrease in average rainfall during winter and spring.

The closest Bureau of Meteorology (BoM) stations are Comet Post Office and Emerald Post Office.

1.4.2.2 Temperature, rainfall, and evaporation

December and January are the warmest months, reaching average high temperatures of 34.6 degrees Celsius (°C) (Table 2-1). June and July are the coolest months. Humidity is fairly consistent throughout the year with morning ranging from 55 – 69 % and afternoons ranging from 33 – 47 %, with spring months drier than the rest of the year.

Average monthly rainfall approximately 17 mm in July to almost 90 mm in February. The average rainfall is received in about 60 rainy days. Almost half of annual rainfall occurs in summer, between December and February.

**Table 1-5 Average temperatures rainfall and evaporation Emerald Airport from 1992 to 2020
(BoM 2020a)**

Month	Temperature (°c)		Rainfall (mm)
	Min	Max	
January	22.3	34.6	84.2
February	22.1	33.8	87.6
March	20.5	32.8	59.7
April	17.0	30.0	28.9
May	13.1	26.4	18.0
June	10.3	23.4	30.4
July	9.1	23.4	17.2
August	10.0	25.5	20.3
September	13.6	29.2	25.6
October	17.1	31.8	44.2
November	19.5	33.5	50.4
December	21.4	34.5	81.5

Evaporation exceeds rainfall in all months (Table 1-6). Unremarkably, the highest deficits occur in the warmer months. The annual average moisture deficit is approximately 1,500 mm.

Table 1-6 Evaporation and moisture deficits (BoM 2020b)

Month	Rainfall (mm)	Evaporation (mm)	Moisture deficit (mm)
January	124.8	229.5	104.7
February	161.8	182	20.2
March	45.4	180.2	134.8
April	6.6	162.8	156.2
May	9.8	121	111.2
June	17.2	102.2	85
July	11.8	104.9	93.1
August	13.6	152.8	139.2
September	6.2	162.7	156.5
October	89	206.2	117.2
November	38.4	249.5	211.1
December	42.6	223.9	181.3
Total	567.2	2077.7	1510.5

1.4.3 Geological setting

Ensham mine is located within the western Bowen Basin. The stratigraphic sequence across the mining lease is comprised of unconsolidated Quaternary sediments overlying consolidated Permian and Triassic materials (Table 1-7). The Permian and Triassic strata form regular layered fluvio-deltaic sedimentary sequences, while the Quaternary sediments are more complex and irregular (Ensham Resources 2018).

The coal deposits targeted for mining are located within the Rangal Coal Measures, the uppermost Permian unit (Figure 1-10). The Rangal Coal Measures are 100 m thick, and subcrop over a strike length of approximately 80 km around the northern and eastern limits of the mine. The coal seams which occur at Ensham include the following:

- The Aries seam (A1),
- The Aries 2-Castor seam (A2C), 4.3m thick,
- The Castor Seam Lower Split (C22), between 0.2 and 0.4 m thick,
- The Pollux Seam (P), present 6 to 12 m below the C22 Seam (Figure 1-11),
- The Orion Seam (Q)*, and
- The Virgo Seam (V)*.

*these seams are not mined at Ensham

Table 1-7 Ensham stratigraphic summary

Age	Unit	Description
Quaternary	-	Alluvium, comprising soil, silt, clay, sand, and gravel.
Tertiary	Emerald Formation	Mudstone, sandstone, conglomerate, siltstone sediments, weekly consolidated in parts. Tertiary volcanics (basalt) are also mapped as being present over 10 km to the west of the mine.
Triassic	Rewan Group	Mudstone with lithic sandstone interbeds.
Permian	Rangal Coal Measures	Feldspathic and lithic sandstone, carbonaceous mudstone, siltstone, tuff and coal seams. Coal seams include the Aries, Castor, Pollux and Orion

	seams. The main economic seams at Ensham are the Aries 2 and Castor seams.
Burngrove Formation	Sandstones, siltstones and mudstones, and banded coal seams frequently interbedded with tuff and tuffaceous mudstones - coal seams include the Virgo and Leo seams.
Fair Hill Formation	Lithic and feldspathic labile sandstone, siltstone, mudstone and conglomerate.
Macmillian Formation	Lithic and feldspathic sublabile mudstone, siltstone and sandstone.

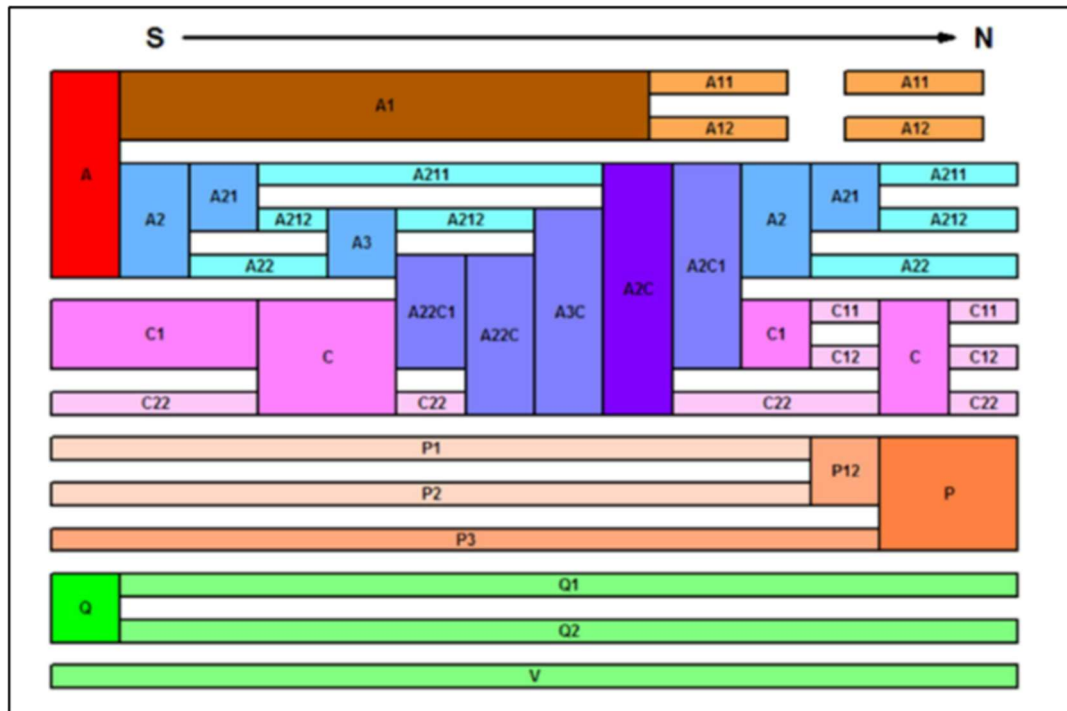


Figure 1-10 Rangal coal measures at Ensham

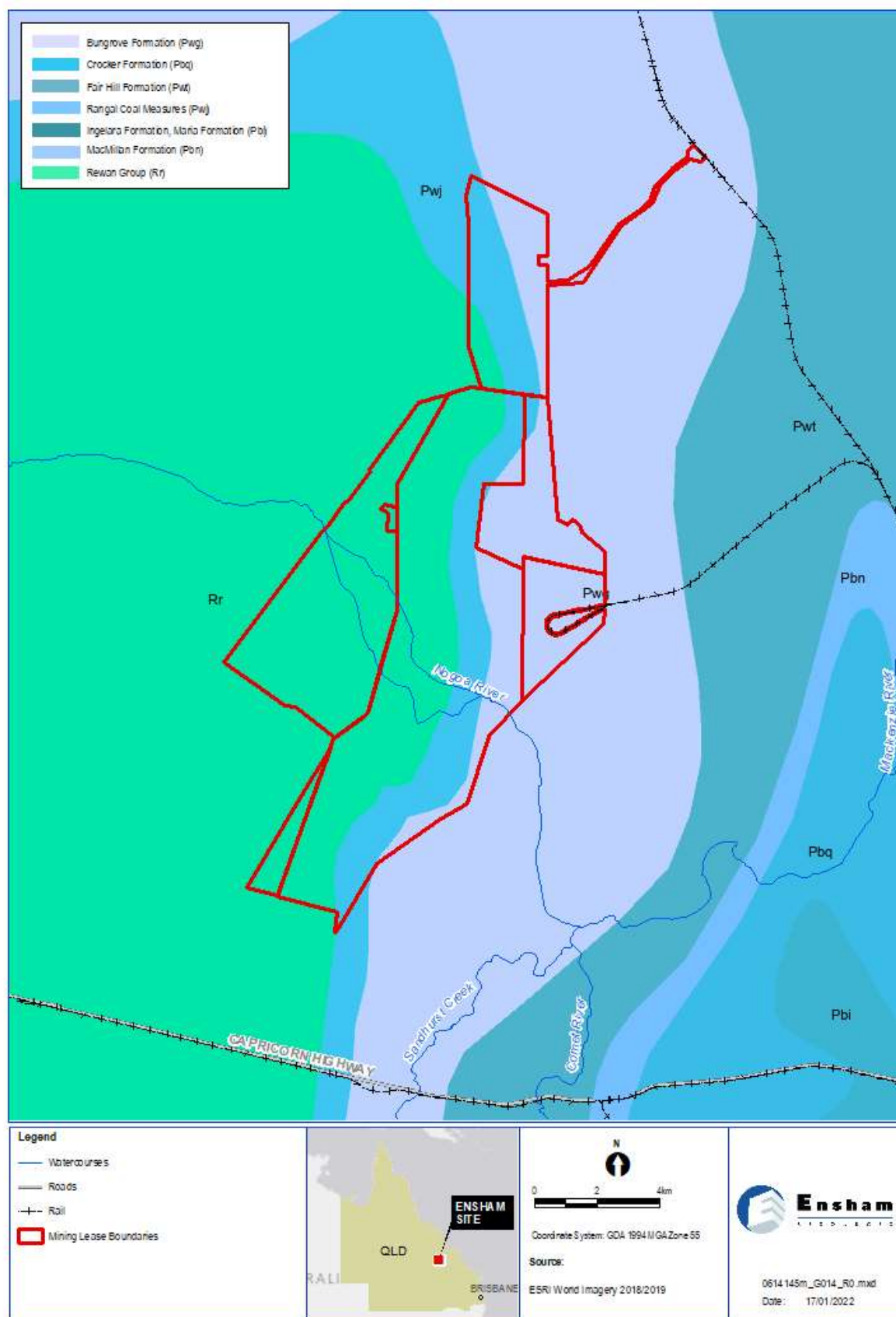


Figure 1-11 Geological units at Ensham

1.4.4 Site hydrology and fluvial units

Ensham is located approximately 10 km upstream of the confluence of the Nogoa and Comet Rivers and encompasses parts of the northern and southern floodplains of the Nogoa River. Boggy Creek is a smaller ephemeral tributary of the river which flows from the north, parallel to the existing mine. Winton Creek is another ephemeral tributary which traverses the mine site on the south side of the river.

The Nogoa River forms part of the headwaters of the Fitzroy River Basin and includes the major tributary of Theresa Creek. The Nogoa and Comet Rivers combine to form the McKenzie River, which further downstream joins the Dawson River to become the Fitzroy River. The Fitzroy River flows to the Coral Sea at Rockhampton and is one of eastern Australia's largest river catchment systems.

Key features of fluvial networks at Ensham are as follows:

- The Nogoa River dissects the mine (Figure 1-12). The flood plain has been temporarily restricted to 1,600 m width by flood protection levees. PMLU – Flood Protection Landform will ultimately re-establish a minimum floodplain width of 2,000 m.
- Ephemeral tributaries of the Nogoa River that flow across the mining leases are Boggy and Winton Creeks.
- Corkscrew Creek, an ephemeral tributary of the Comet River, flows through the southern corner of ML 7459.
- A licenced diversion exists on Boggy Creek. Rehabilitation of this diversion to re-establish comparative up- and down-stream geomorphological characteristics commenced in 2020 and landform development was completed during 2021. This is PMLU – Boggy Creek Diversion.

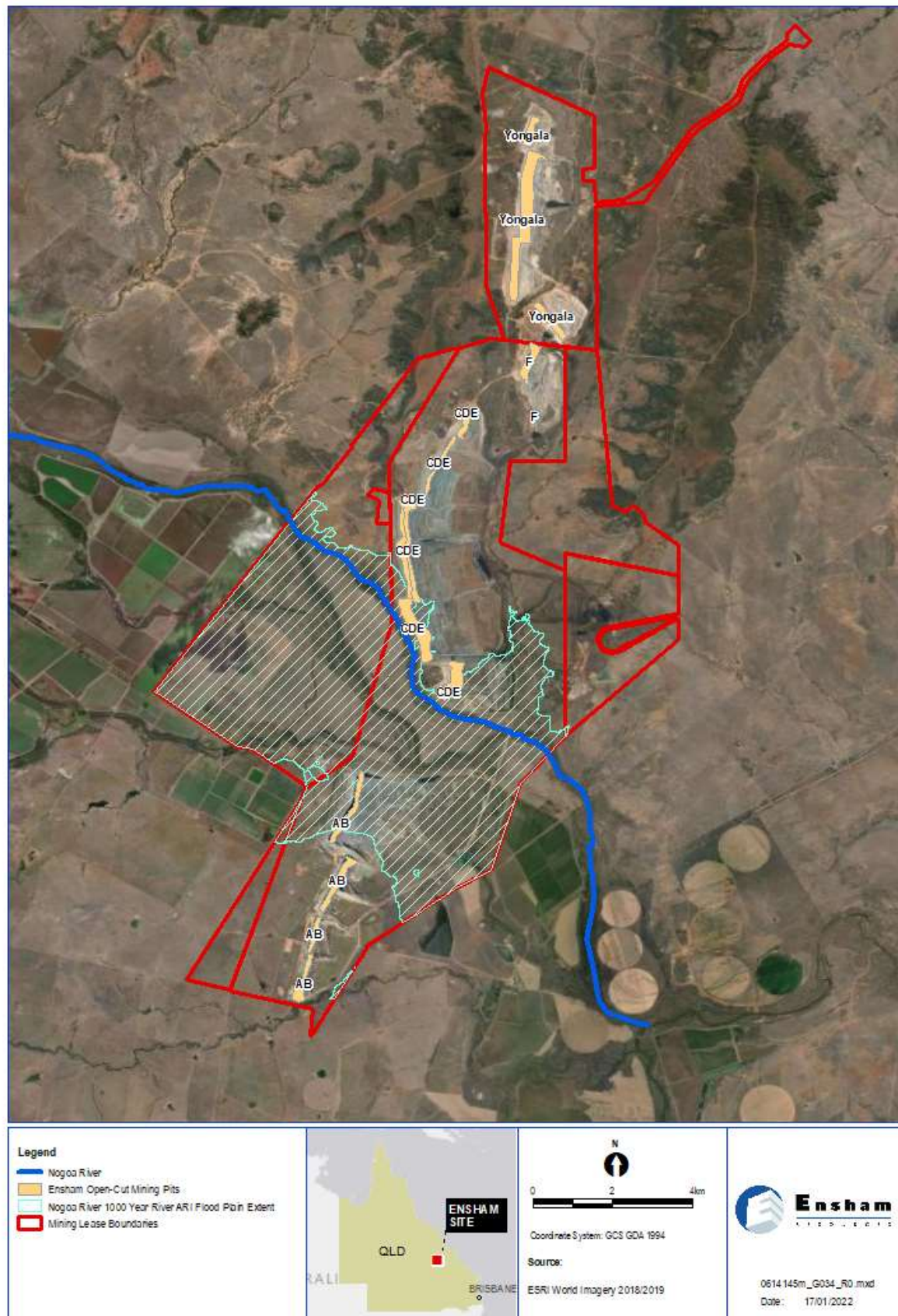


Figure 1-12 Nogoa River pre-mining floodplain extents

1.4.5 Groundwater

There are two main groundwater bearing units at Ensham, namely the shallow alluvium (Quaternary aged sediments) association with the Nogoa River floodplain and the much deeper Permian aged Rangal Coal Measures. These units are not hydraulically connected and are separated by a low permeability unit.

The alluvium is an unconfined system recharged by rainfall and irrigation practices. Its water is generally very saline and unsuitable for uses such as stock watering or irrigation. The alluvium is not well connected with the Nogoa River (Figure 1-13). Notwithstanding, groundwater monitoring by Ensham indicates standing water levels are influenced by rainfall and large flooding events (Figure 1-14). This creates large fluctuations in water level and quality.

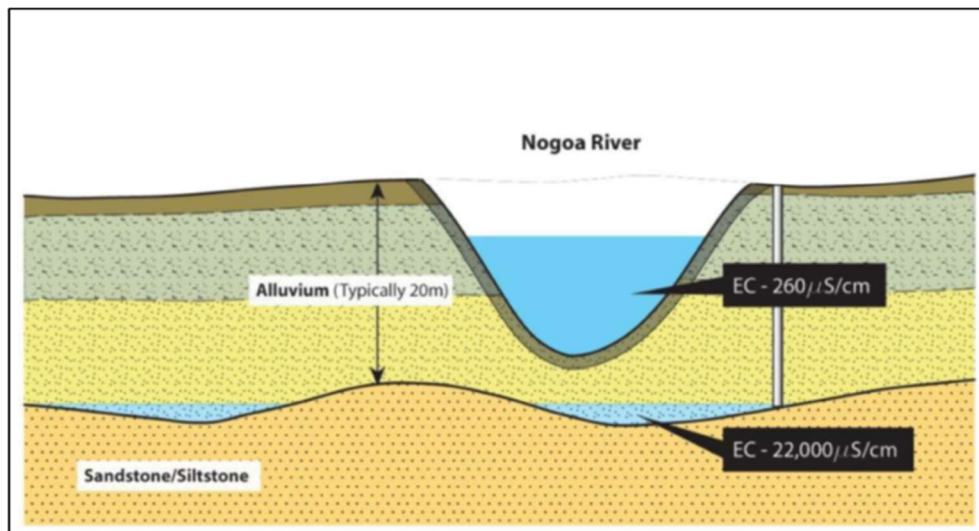


Figure 1-13 Conceptual cross-section of the Nogoa River floodplain and Quaternary alluvium aquifer (AGE 2006)

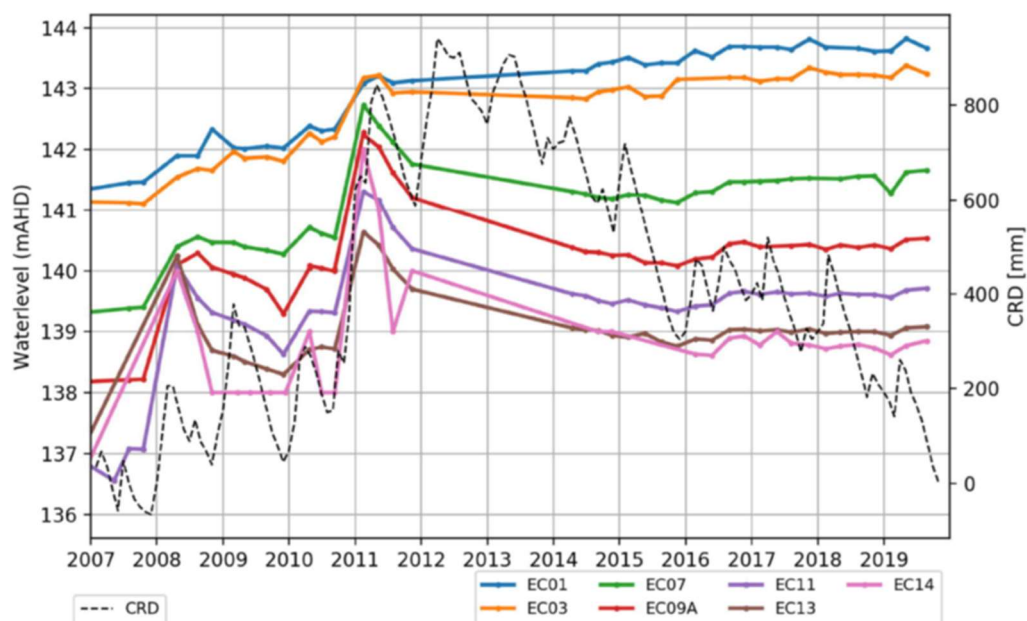


Figure 1-14 Standing water levels in Quaternary alluvium monitoring bores and cumulative rainfall departure (CRD) (SLR Consulting 2020)

Groundwater in the coal seams is also saline and not suitable for stock water supply or irrigation. These aquifers are confined by overlying and underlying shale and mudstones and exhibit relatively low transmissivity and recharge rates. Storage and movement of groundwater occurs within the coal seams, primarily along cleats and fissures and occasionally within minor fault zones. Groundwater quality is variable but typically very poor within this aquifer due to high salinity.

1.4.6 Soils

Story *et al.* (1967) describe several land systems and associated soil groups at Ensham (Table 1-8 and Figure 1-15). There are six major soil groups present, each with one or more soil type variants (

Table 1-9). Soils are generally highly weathered and chemically and physically poor, with salinity and sodicity limiting productivity at depth i.e., saline and sodic subsoils.

Table 1-8 Land systems at Ensham

Land system	Description	Approximate area within mining lease boundaries (ha)
Humboldt	Blackbutt and brigalow on weathered clay plains occurring in most parts of the area; texture contrast and cracking clay soils.	3208.8
Monteagle	Lowlands with box and texture-contrast soils on undissected Tertiary land surface throughout the area except in the extreme south and north-east.	1308.7
Blackwater	Characterized by brigalow plains and cracking clay soils on weathered tertiary clay and older rocks along the central axis of the area.	1923.6
Comet	Alluvial plains with brigalow and cracking clay soils, often flooded, along major streams.	3834.4
Durandella	Hills with lancewood and narrow-leaved ironbark on weathered Tertiary and Permian rocks in the north-west, center, and south-east; shallow rocky soils.	1922.9
Girrah	Lowlands with downs and brigalow and cracking clay soils on unweathered Permian shale and lithic sandstone in the north and center.	414.7

Table 1-9 Soil groups at Ensham (from Hansen 2006)

Major soil group	Soil type	Soil classification	Soil description
1 - Shallow Rocky Soils	1	Leptic Rudosols	Soil type 1 occurs on low rocky hills and steep escarpment slopes and eroded plateau remnants. These soils are shallow (<0.5m), exhibit very little profile development and contain gravel and rock cobbles from various geological formations.
2 – Moderately Shallow Gravelly Sands, Loams or Clay Soils	2.1	Colluvic Clastic Rudosols	This soil group occurs on eroded middle and lower slopes and broad low gravelly rises. These soils are shallow to medium depth and comprise uniform or weakly gradational sands, loamy sands or sandy loams, loams or clayey soils with varying amounts of ferruginous and siliceous gravel or stone. These soils exhibit low soil fertility and water storage capacity.
	2.2	Regolithic Chemic Tenosols	
	2.3	Acidic Brown Clastic-Leptic Rudosols	
3 – Gradational Red and Yellow Earth Soils	3.1	Petroferric Red Kandosols-Tenosols	These soils are present on the elevated dissected and eroded Tertiary plateau remnants and undulating plains associated with the Tertiary Emerald Formation. These soils include sandy, sandy loam or loamy surface soils grading to red, reddish brown or yellowish-brown sandy loam to light to medium massive or structured clay subsoils often with appreciable amounts of ferruginous gravel.
	3.2	Acidic Mesotrophic Red Kandosols	
	3.3	Haplic Mesotrophic Red Ferrosols	
4 – Texture Contrast (Duplex) Soils	4.1	Subnatric Brown Sodosol	Group 4 soil types have formed on Permo- Triassic sedimentary rocks, on gently inclined slopes, dissection slope interfluvies, broad low rises and plains and on alluvial terraces and drainage flats. These soils are sandy, silty or loamy on the surface with a clear to abrupt change to a clayey subsoil horizon.
	4.2	Eutrophic Mesonatric Brown Sodosols	
	4.3	Eutrophic Subnatric Yellow Sodosols	
5 – Uniform Fine-textured (Non-cracking) Clay Soils	5.1	Sodic Pedaric Brown Dermosols	These soil types are present on erosional plains, levees and high terraces along stream systems, undulating alluvial plains and associated with cracking clays of Soil Group 6. These soils exhibit uniform profiles or weakly gradational profiles where clay content may increase slightly with depth.
	5.2	Sodic Pedaric Brown Dermosols	
	5.3	Sodic Pedaric Brown Dermosols	
6 – Cracking Clay Soils	6.1	Epipedal Black, Grey or Black Vertosols	Group 6 soil types form the dominant soil type within the alluvial plains associated with the Nogoa River and its tributaries. These soils have uniform medium to high clay content, pronounced swelling and shrinkage properties and commonly feature gilgai.
	6.2	Endohypersodic, Epipedal Black, Grey or Brown Vertisols	

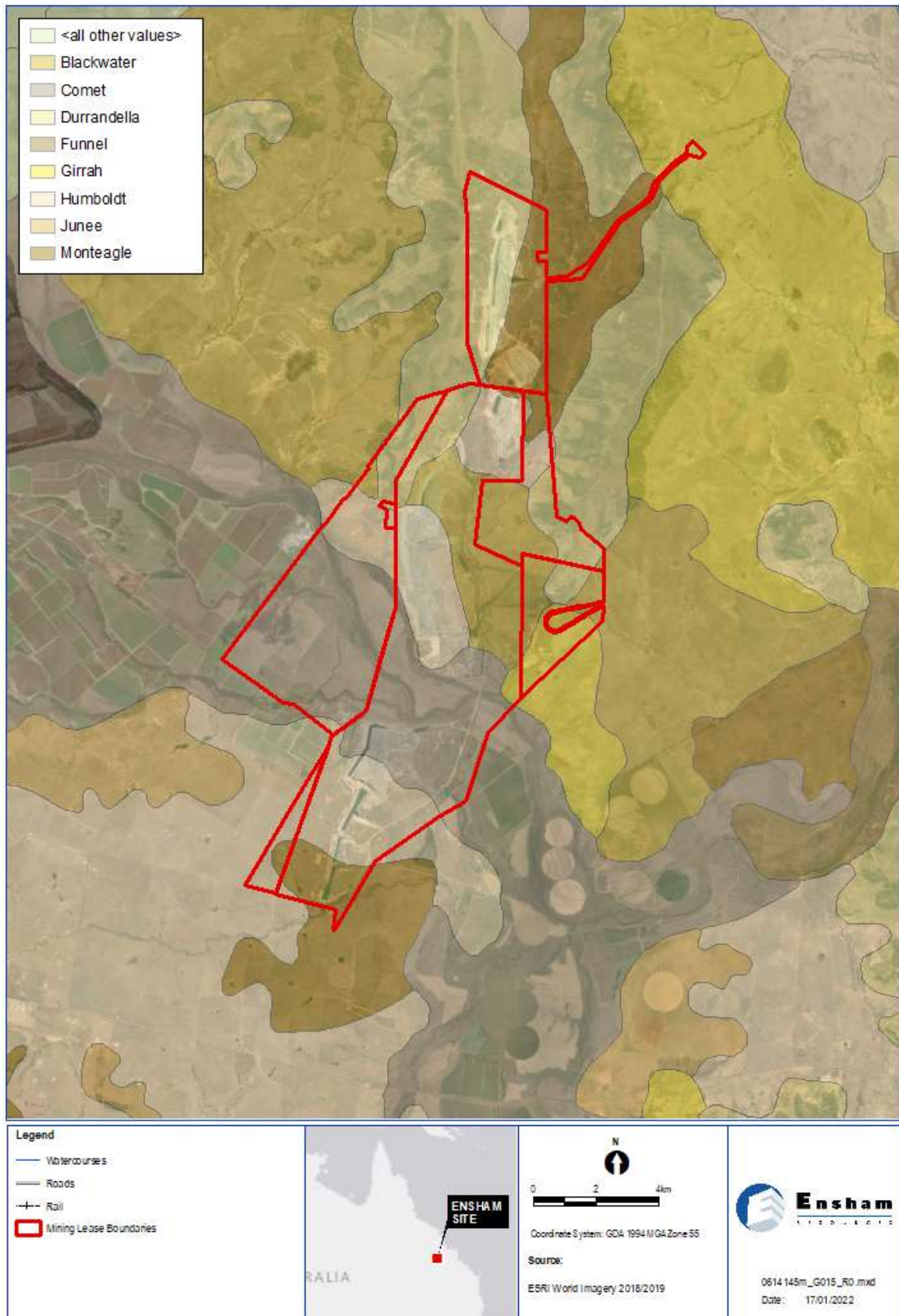


Figure 1-15 Land systems at Ensham

1.4.7 Land stability

Many land systems and associated soils found in the northern part of Ensham have moderate to high erosion potential and are unsuitable for clearing and agricultural development. The initial EIS found soil stability was variable (Hollingsworth, Dames and Moore (1990) and noted the following:

“Overall, the Yongala property, which comprises the major part of the study area, is currently in a moderately to in places severely degraded condition.....those areas which are potential susceptible to degradation due to landform, soil type and drainage conditions, already reflect a substantial level of degradation.

In places, very deep erosion gullies have developed in many of the depressional drainageways within the property...The size and severity of gullying is attributable to the generally dispersive nature of the soils and substrate materials within those land units and uncontrolled surface water runoff.”

A more recent assessment over the central parts of Ensham found soils were variably affected by an accumulation of salts which affected structural stability (Hansen 2006). For example, major soil groups 2, 4, 5 and 6 are moderately to highly saline (refer to

Table 1-9). This study concluded that due to accumulated salts, soils will generally have low infiltration and hydraulic conductivity and be prone to dispersion and excessive erosion if exposed to runoff.

1.4.8 Vegetation

Much of the land at Ensham had been cleared of vegetation for agricultural development prior to mining. Vegetation mapping shows there are 13 regional ecosystems within the mining leases (Table 1-10 and Figure 1-16). There are four Threatened Ecological Communities identified as potentially occurring (Table 1-11).

Table 1-10 Regional ecosystems at Ensham

Regional ecosystem	Description	Biodiversity status	VM Act class ¹
11.3.1	<i>Acacia harpophylla</i> and/or <i>Casuarina cristata</i> open forest on alluvial plains	Endangered	Endangered
11.3.25e	<i>Eucalyptus tereticornis</i> or <i>E. camaldulensis</i> woodland fringing drainage lines	Of concern	Least concern
11.4.9a	<i>Acacia harpophylla</i> shrubby woodland with <i>Terminalia oblongata</i> on Cainozoic clay plains	Endangered	Endangered
11.3.3	<i>Eucalyptus coolabah</i> woodland on alluvial plains	Of concern	Of concern
11.7.1	<i>Acacia harpophylla</i> and/or <i>Casuarina cristata</i> and <i>Eucalyptus thozetiana</i> or <i>E. microcarpa</i> woodland on lower scarp slopes on Cainozoic lateritic duricrust	Of concern	Least concern
11.7.2	<i>Acacia</i> spp. woodland on Cainozoic lateritic duricrust. Scarp retreat zone	No concern at present	Least concern
11.4.8	<i>Eucalyptus cambageana</i> woodland to open forest with <i>Acacia harpophylla</i> or <i>A. argyrodendron</i> on Cainozoic clay plains	Endangered	Endangered
11.7.4	<i>Eucalyptus decorticans</i> and/or <i>Eucalyptus</i> spp., <i>Corymbia</i> spp., <i>Acacia</i> spp., <i>Lysicarpus angustifolius</i> woodland on Cainozoic lateritic duricrust	No concern at present	Least concern
11.5.9b	<i>Eucalyptus crebra</i> and other <i>Eucalyptus</i> spp. and <i>Corymbia</i> spp. woodland on Cainozoic sand plains and/or remnant surfaces	No concern at present	Least concern
11.7.1/11.7.2	<i>Acacia harpophylla</i> and/or <i>Casuarina cristata</i> and <i>Eucalyptus thozetiana</i> or <i>E. microcarpa</i> woodland on lower scarp slopes on Cainozoic lateritic duricrust and <i>Acacia</i> spp. woodland on Cainozoic lateritic duricrust. Scarp retreat zone.	Of concern/least concern	Least concern
11.9.2	<i>Eucalyptus melanophloia</i> +/- <i>E. orgadophila</i> woodland on fine-grained sedimentary rocks	No concern at present	Least concern
11.7.4/11.7.2	<i>Eucalyptus decorticans</i> and/or <i>Eucalyptus</i> spp., <i>Corymbia</i> spp., <i>Acacia</i> spp., <i>Lysicarpus angustifolius</i> woodland on Cainozoic lateritic duricrust and <i>Acacia</i>	No Concern/no concern	Least concern

Regional ecosystem	Description	Biodiversity status	VM Act class ¹
	<i>spp.</i> woodland on Cainozoic lateritic duricrust. Scarp retreat zone.		
11.3.1/11.3.25	<i>Acacia harpophylla</i> and/or <i>Casuarina cristata</i> open forest on alluvial plains and <i>Eucalyptus tereticornis</i> or <i>E. camaldulensis</i> woodland fringing drainage lines.	Endangered/of concern	Endangered
11.3.25e/11.3.3	<i>Eucalyptus tereticornis</i> or <i>E. camaldulensis</i> woodland fringing drainage lines and <i>Eucalyptus coolabah</i> woodland on alluvial plains.	Of concern/of concern	Least concern
11.3.1/11.3.3/ 11.3.37/11.3.2	<i>Acacia harpophylla</i> and/or <i>Casuarina cristata</i> open forest on alluvial plains, <i>Eucalyptus coolabah</i> woodland on alluvial plains, <i>Eucalyptus coolabah</i> fringing woodland on alluvial plains and <i>Eucalyptus populnea</i> woodland on alluvial plains.	Endangered/of concern/ no concern/of concern	Endangered
11.3.25/11.3.3/ 11.3.3c	<i>Eucalyptus tereticornis</i> or <i>E. camaldulensis</i> woodland fringing drainage lines and <i>Eucalyptus coolabah</i> woodland on alluvial plains	Of concern/of concern	Least concern
11.7.2/11.7.4	<i>Acacia spp.</i> woodland on Cainozoic lateritic duricrust. Scarp retreat zone and <i>Eucalyptus decorticans</i> and/or <i>Eucalyptus spp.</i> , <i>Corymbia spp.</i> , <i>Acacia spp.</i> , <i>Lysicarpus angustifolius</i> woodland on Cainozoic lateritic duricrust.	No concern/ no concern	Least concern
11.7.2/11.7.1	<i>Acacia spp.</i> woodland on Cainozoic lateritic duricrust. Scarp retreat zone and <i>Acacia harpophylla</i> and/or <i>Casuarina cristata</i> and <i>Eucalyptus thozetiana</i> or <i>E. microcarpa</i> woodland on lower scarp slope on Cainozoic lateritic duricrust.	No concern / least concern	Least concern
11.4.9/11.4.9b/ 11.4.8	<i>Acacia harpophylla</i> shrubby woodland with <i>Terminalia oblongata</i> on Cainozoic clay plains and <i>Eucalyptus cambageana</i> woodland to open forest with <i>Acacia harpophylla</i> or <i>A. argyrodendron</i> on Cainozoic clay plains.	Endangered/endangered	Endangered
11.9.2/11.9.1	<i>Eucalyptus melanophloia</i> +/- <i>E. orgadophila</i> woodland on fine-grained sedimentary rocks and <i>Acacia harpophylla</i> - <i>Eucalyptus cambageana</i> woodland to open forest on fine-grained sedimentary rocks	No concern/endangered	Least concern

Table 1-11 Threatened ecological communities potentially occurring at Ensham (DAWE 2021)

Name	Status	Type of presence
Brigalow (<i>Acacia harpophylla</i> dominant and co-dominant)	Endangered	Community known to occur within area

Natural grasslands of the Queensland Central Highlands and norther Fitzroy Basin	Endangered	Community likely to occur within area
Poplar Box grassy woodland on Alluvial plains	Endangered	Community likely to occur within area
Weeping Myall woodlands	Endangered	Community likely to occur within area

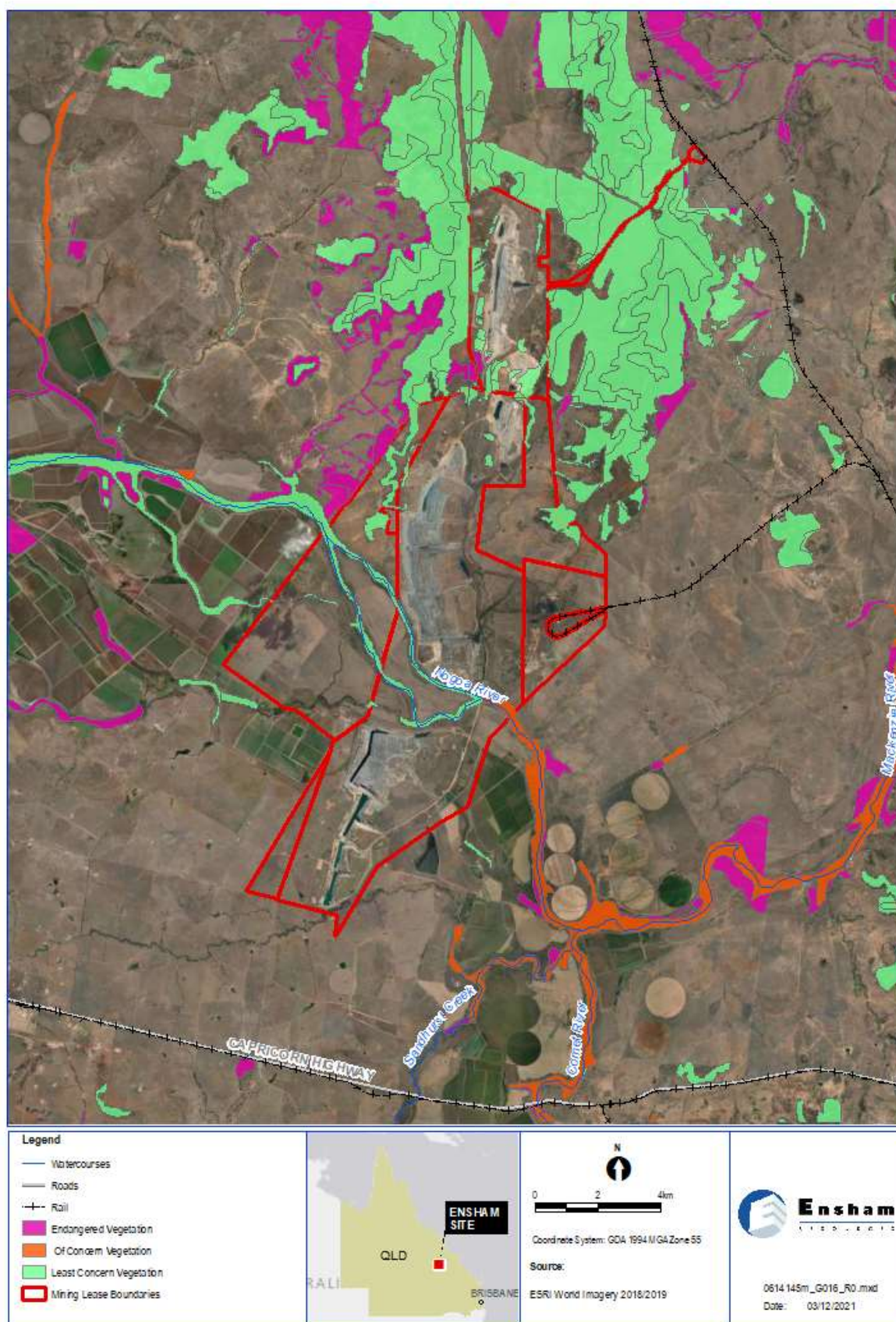


Figure 1-16 Regional ecosystems mapped at Ensham

1.4.9 Fauna

Desktop review indicates that 504 species have been recorded within a 50 km radius of Ensham (Queensland Government 2021). The species includes 22 amphibians, 103 reptiles, 27 ray-finned fish, 69 mammals, 14 insects and 269 birds. Of these, 23 species are identified as Matters of National Environmental Significance (MNES) as threatened species (Table 1-12). Field surveys conducted by Hansen Consulting (2006) recorded 193 terrestrial vertebrate species were recorded during two survey, including 22 mammals, 140 birds, 21 reptiles, and 10 amphibian species. None of the macroinvertebrates or fish species recorded are of conservation significance.

Table 1-12 Threatened species potentially occurring within 50 km of Ensham

Species name	EPBC Act 1999 listing status
<u>Birds</u>	
<i>Calidris ferruginea</i> Curlew sandpiper	Critically endangered
<i>Erythrotriorchis radiatus</i> red goshawk	Vulnerable
<i>Falco hypoleucos</i> Grey falcon	Vulnerable
<i>Geophaps scripta</i> Squatter pigeon (southern)	Vulnerable
<i>Grantiella picta</i> Painted honeyeater	Vulnerable
<i>Neochmia ruficauda</i> Star finch (eastern, Star finch (southern)	Endangered
<i>Poephila cincta</i> Southern black-throated finch	Endangered
<i>Rostratula australis</i> (Australian painted snipe)	Endangered
<u>Mammals</u>	
<i>Chalinolobus dwyeri</i> Large-eared Pied Bat, Large Pied Bat	Vulnerable
<i>Dasyurus hallucatus</i> Northern quoll	Endangered
<i>Macroderma gigas</i> Ghost bat	Vulnerable
<i>Nyctophilus corbeni</i> Corbens's long-eared bat	Vulnerable
<i>Onychogalea fraenata</i> Bridled nail-tail wallaby	Endangered
<i>Petauroides volans</i> Greater glider	Vulnerable
<i>Phascolarctos cinereus</i> Koala	Vulnerable
<i>Pteropus poliocephalus</i> Grey-headed flying fox	Vulnerable
<u>Reptiles</u>	
<i>Delma torquata</i> Adorned delma	Vulnerable
<i>Denisonia maculata</i> Ornamental snake	Vulnerable
<i>Egernia rugosa</i> Yakka skink	Vulnerable
<i>Elseya albagula</i> Southern snapping turtle	Critically endangered
<i>Furina dunmalli</i> Dunmall's snake	Vulnerable
<i>Lerista allanae</i> Allan's Lerista	Endangered
<i>Rheodytes leukops</i> Fitzroy River turtle	Vulnerable

1.4.10 Pre-mining land uses

Prior to mining, the land was used for agricultural purposes, predominantly cattle grazing, but also irrigated and non-irrigated farming. Cultivation was restricted to land within the floodplain of the Nogoa River, most of which has not been disturbed by opencut mining.

The 1992 Environmental Management Overview Strategy (EMOS) for the Yongala property, the first granted mining lease at Ensham Mine (ML70049), described the property by noting the following comments:

"The only current land use within the study area is beef cattle grazing on predominantly native pastures of low to moderate productivity with some areas of introduced pasture species, mainly Buffel grass. The Yongala property which comprises the major part of the area of interest for the mining project is currently in a moderately to severely degraded condition. The rating of "Erosion Status" in Table A3.1 in Appendix 3 largely reflects the current condition of the land in that those areas which are potentially susceptible to land degradation due to the existing soil types and drainage conditions, are already in a substantially degraded condition.

In places deep erosion gullies have developed along many of the gently inclined natural drainage ways (see Figure 6) within the property. The size and severity of gullying is largely attributable to the occurrence and generally dispersive nature of the surficial soils and substrate materials in those areas, exacerbated by the effects of uncontrolled surface water runoff resulting from high intensity storms. Quite commonly, the initiation of these "badlands" type of erosion features can result from overgrazing by stock and other animals, or may be due to local soil/drainage effects. Whatever the cause, once developed to an advanced state, these types of erosion features are difficult and expensive to contain and rehabilitate successfully.

Elsewhere on the property, mainly on the gently inclined mid-slopes below the red (lateritic) soil crestal plains, frequent small to locally quite extensive occurrences of surface scalding (bare areas) are evident. These areas may also reflect local soil/drainage effects, such as downslope subsurface drainage discharge zones with possible increased salinity or even higher nutrient levels which pre-dispose those areas to concentrated grazing by cattle. Irrespective of the origin of these features, once the areas become devoid of surface vegetative cover they are susceptible initially to sheet erosion and to the subsequent development of increasing levels of gully erosion."

Whereas, the 1993 EMOS for the addition of ML7459, ML70367 and ML7460 notes:

"The area has been used for farming for many years and at least 90 percent of the lease area has been cleared including the land over the sites of the mine pits and the industrial area. The former owner of the Ensham property used it for beef cattle grazing, mainly on natural pastures but with some areas improved by deep ploughing and seeding with Buffel grass. The Duckponds property was mainly used for agricultural purposes, grain production, on the flood plain areas. The southern end of the lease was used primarily for improved pastures for beef cattle grazing."

As per the above commentary, the pre-mining land condition varied across what is now Ensham Mine. Pre-mining imagery is displayed in Figure 1-17 below. The topography of this area (pre-mining) has been previously displayed in Section 1.4.1 (Figure 1-9).

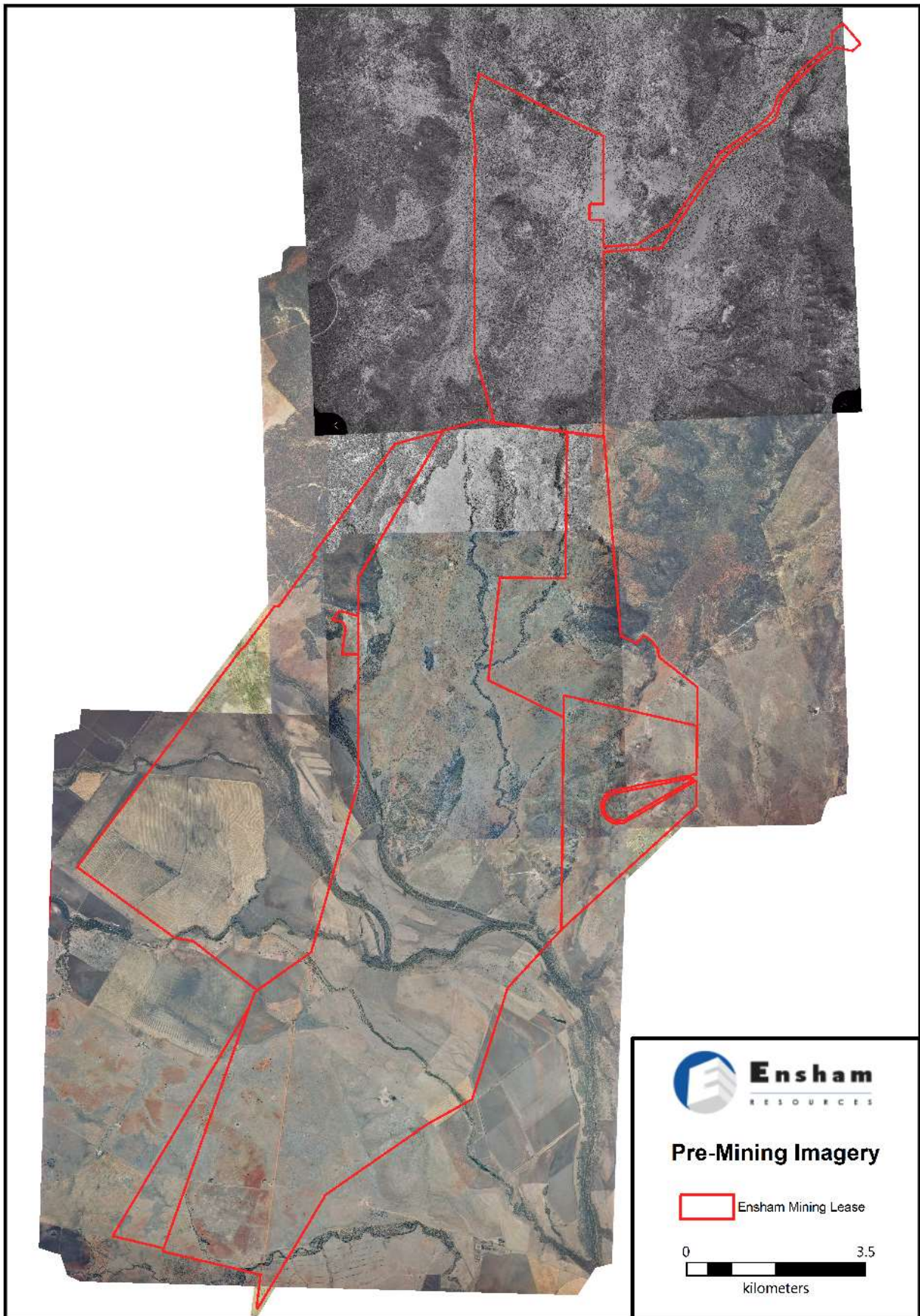


Figure 1-17 Ensham Pre-Mining Land Condition

1.4.11 Underlying landholders

Underlying landholders have been identified in Table 1-2 in Section 1.1 of this report.

2 COMMUNITY CONSULTATION

In accordance with section 126C(1)(c)(iii) and (iv) of the EP Act, the rehabilitation planning part of the PRC plan must include:	
• details of the consultation undertaken by the applicant in developing the proposed PRC plan, and	Section 2.2
• details of how the applicant will undertake ongoing consultation in relation to the rehabilitation to be carried out under the plan	Section 2.3

2.1 Engaging the community

Ensham has a long history of meaningful engagement with the community on all matters, including progressive rehabilitation. The enduring objectives of community consultation are to:

1. Identify stakeholders and their issues regarding rehabilitation and closure of the mine,
2. Ensure that Ensham addresses and responds to stakeholder issues and keeps the community informed on progressive rehabilitation and steps towards mine closure.

Community consultation was undertaken for the land outcome in the RVP including a Social Impact Assessment (SIA) of the outcome for the voids. The SIA involved an assessment of the social impacts of the proposed landform designs including flood related and water quality impacts on the health and community wellbeing. As identified in the SIA, the retention of levees and the associated flood protection for downstream landholders was a significant issue in determining the final landform design. In addition to the consultation with the community and the administering authority, a further informal notification to members of the public in respect of the proposed landforms was undertaken pursuant to section 316Q of the Environmental Protection Act 1994. As a result of this process, the most suitable outcome for the residual voids was assessed consistently with the outcome of the consultation. In order to return the width of the flood plain more toward pre-mine levels, but still protecting downstream landholders, the widening of the existing flood plain will happen on the northern side as defined in Appendix 5 of the EA. This outcome was deemed acceptable in the EA amendment which outcome has been adopted in this PRCP.

Additionally:

- Ensham is a 30-year-old coal mine that has engaged with the community for 3 decades.
- Nominated PMLUs are transitioned from land outcome document EA *EPML00732813*.
- The largest PMLU in rehabilitation at Ensham is beef cattle grazing, which is:
 - Re-establishing the pre-mining land use; and
 - For the most part, consistent with surrounding land uses,
 - Being actively used as part of grazing operations.

- Ensham has received certification of 565.3 ha of rehabilitation with a beef cattle grazing PMLU during 2021.

2.2 Stakeholder consultations – PMLU & NUMA

Ensham has conducted considerable stakeholder consultations about rehabilitation over the past 30 years. The matters collectively discussed with the community during these stakeholder consultations have informed and are the basis upon which the PRC plan has been developed. The outcomes in the PRC Plan are informed by these consultations. Over these years, formal stakeholder consultations have been undertaken inclusive of the following.

2.2.1 Environmental Impact Statements (EIS) (1990, 2009 & underway)

Stakeholder consultation programs for EIS' have engaged with neighbouring landholders, local, state and federal governments, industry bodies, community groups and other interested parties. These programs identified a wide range of stakeholder issues, including mined land rehabilitation, that were subsequently addressed in EIS processes.

- Ensham Coal Project, impact assessment study (Hollingsworth et al. 1990).
- Revised Ensham Central Project, environmental impact statement including the outcomes of stakeholder engagements (Hansen Consulting 2006).
- Ensham Life of Mine Extension Project, environmental and social impact assessments are currently underway.

2.2.2 Ensham Residual Void (RV) Project (2017-2020)

The focus of this project was to provide a platform to discuss rehabilitation options and rehabilitation success criteria for residual voids at the Ensham mine. The RV Project was primarily concerned with the location, extent, and potential environmental and social impacts of final voids, which are comprised in part of NUMAs, i.e., Groundwater daylighting water areas and Highwalls. As part of the RV project, the following engagement occurred:

2.2.2.1 Community Reference Group.

In the early phases of the Project (November 2017), a Community Reference Group (CRG) was established to work with the company and its relevant consultants in relation to the Project. The CRG consists of 11 members, including an Independent Chair, that includes representation from nearby neighbours (3), mining area landholder (1), Central Highlands Council (2), CCHRUP (1), Fitzroy Partnership for River Health (1), Sunwater (1), Cotton Growers and Irrigators Association (1) and community (1).

The CRG has been established to:

- Establish good working relationships and promote information sharing between Ensham Mine, the local community and stakeholder groups on the Ensham RVP.
- Allow community members, and or their representatives, to seek information from Ensham Mine and provide feedback on the study to assist with the delivery of balanced social, environmental and economic outcomes for the community.
- Enable Ensham Mine representatives to keep the community informed about the project.

- Allow Ensham Mine to seek community views on the study and respond to matters raised by the community.
- Discuss the RV Project and raise any concerns associated with the Preferred Options and Final Option.
- Review the reports and studies undertaken for the RV Project.
- Provide comments on the reports and studies undertaken for the RV Project.
- Discuss community concerns with the RV Project, Preferred Options and Final Option.

CRG members were provided with all technical reports for review and comment and were briefed on the SIA approach and stakeholders to be engaged as part of the SIA program.

- i. Social impact assessment (Umwelt 2019).
- ii. Hydrology (Hydro Engineering and Consulting Pty Ltd 2019).
- iii. Groundwater (Hydrosimulations 2019).
- iv. Geochemistry (RGS 2019).
- v. Water solute and balance (Hydro Engineering and Consulting Pty Ltd 2019b).
- vi. Geotechnical stability (WSP 2019).
- vii. Geomorphology (WRM 2019).
- viii. Ecology (Umwelt 2019b).

2.2.2.2 Social impact report (Umwelt 2019).

This social impact assessment engaged with 48 stakeholders including neighbouring landholders, water catchment groups, local government, indigenous (Traditional Owners) groups and industry and business.

During the SIA engagement process, there were five key themes that were identified by stakeholders across the three options presented. These included: Flood, Water Quality, Option Management, Community Use and Landform Design.

This section provides further detail on the social impact themes identified drawing, where relevant, on engagement and social baseline data collected in the profiling and scoping phases of the SIA.

2.2.2.2.1 Flood

Flood was repeatedly identified by stakeholders as an impact across the options being assessed and is directly related to the Ensham Mine site being located on a flood plain of the Nogoa River. In 2008 and 2010, major flood events occurred in the region. The 2008 flood event saw the Ensham Mine inundated with water because of a levee failure and flood water flowing into the operational pits. The failure of the levee, and the perceived ramifications for nearby neighbours and community, resulted in reengineering and construction of levees to protect it from a flood, with an average recurrence interval of 1000 years in the Nogoa River (Queensland Floods Commission of Inquiry, 2012); subsequently approved by the Coordinator-General in 2009. These relatively recent flood events have raised concerns in the community regarding the management of existing voids, given imminent closure, and subsequent impacts on upstream and downstream landholders.

The Ensham Mine is surrounded by cotton farmers both upstream and downstream of the site and more broadly the Central Highlands region is heavily populated by farmers reliant on the availability of quality water to support their crops. As such, flood events have an intrinsic effect on the livelihoods of farmers; with some farmers reliant on smaller more regular flood events to maintain water security in the region. Conversely, large flood events pose the risk of negatively impacting farmers by damaging property, destroying crops and reducing yield. For example, in 2010-11, floods destroyed cotton crops in central Queensland with water logging reducing yield by approximately 10-15 per cent, resulting in significant financial implications for cotton growers (Australian Government, 2011). In 2013, Agforce estimated that about 30% of the Emerald cotton crop was inundated with a loss of 62,000 bales and a value in the order of \$31m (Regional Australia Institute, 2013). These effects were reflected by landholders and other key stakeholders in the comments and concerns that arose during the engagement phases of the SIA. The ability to mitigate against major flood events has the potential to protect the economic and infrastructure strengths that exist in the CHRC area.

Major flood events have the added risk of affecting the health and wellbeing of residents, particularly psychosocial impacts such as stress. Adults of working age and residents of regional and remote areas in Queensland were more likely to report emotional impacts caused by the 2010 floods such as distress, feeling terrified, helplessness or hopelessness, and stresses associated with having reduced incomes. Mental health issues were the largest impact of the floods in 2010 with an estimated lifetime cost of approximately \$5.9 billion (Australian Business Roundtable (ABR), 2016). Mental health-related behaviours such as substance use (alcohol and smoking) have been documented following natural disasters (ABR 2016), in Emerald there was anecdotal evidence of a significant increase in alcohol related problems and domestic violence post the 2010 flood event (QCOSS, 2011). It is reasonable to expect that the mental health of residents in Emerald and its surrounding regions was affected having experienced major flood events in both 2008 and 2010.

With Ensham Mine being located on a floodplain in proximity to the Nogoa River, Comet River and Winton Creek, there is a perception in the community that there is a high risk of contamination should seepage occur, with effects likely to be felt broadly across the Central Highlands region. Scientific studies show that seepage will not be an issue to either the river or groundwater, as further detailed in Appendix 9.4 – Hydrogeology summary report. The angst among stakeholders regarding the potential for seepage to the river system was evident during the SIA engagement process.

In 2013, farmers told the ABC that the Dee River was an unnatural shade of blue-green and that birds and fish were dying with contamination anecdotally reported to be occurring 55kms downstream from the Mount Morgan Mine. The high profile nature of the problems at Mount Morgan, in relation to groundwater seepage and contamination of the waterways, contributes to the level of concern in the Emerald and Comet communities given their heavy reliance on water for a range of purposes. The sentiment was further exacerbated by the breaching of the levees that occurred in the 2008 flood event. It was iterated by downstream landholders during stakeholder meetings that removal of the current levee system would have detrimental impacts on their properties and infrastructure. The flood protection landform position on the southern side of the Nogoa River maintains the current protection for downstream landholders, while the floodplain widening on the northern side of the Nogoa River removes any upstream impacts.

2.2.2.2.2 Water Quality

Water security is critical to support industry and liveability of communities in the Fitzroy Basin. As with many parts of Australia, in the Fitzroy Basin there are multiple users of water, the coal industry and the agricultural industry are the two largest industries, raising concerns for: security of water supply; flood and drought impacts; the management of surface and underground water; and environmental flow and water quality (KPMG, 2018). The Central Highlands region has extensive water infrastructure, serviced by the Fairbairn Dam, a number of smaller weirs and a comprehensive irrigation network. Generally, water security is considered relatively strong; however, minimising water loss, unlocking future capacity and optimising water use and flexibility are ongoing challenges for the Central Highlands (KPMG, 2017).

Agriculture is the major industry across the Central Highlands region accounting for approximately 12 per cent of all employment in the region. Surrounding the Ensham Mine are primarily cropping farms (mostly cotton) and some cattle grazing, including Nogoa Pastoral that runs cattle within the boundaries of the land owned by the Ensham Joint Venture. The Nogoa Pastoral Company operates on land within all mining tenures except ML 70049. The underlying landowner undertakes grazing activities on rehabilitated land within ML 70049.

As at 31 July 2018, there were 1,971 head of cattle comprising 787 steers, 1,127 females and 37 bulls. The Nogoa River runs between Pit B and Pit C, connecting to the Fairbairn Dam and an intricate water system that provides water to the mines grazing operations, the mine itself and to the townships of Comet and Emerald and the region more broadly. As previously noted, water quality in the Central Highlands region is paramount to ensure it is usable for cropping and to support the current agricultural industry, as well as regional economic growth aspirations. Ensham also extract raw water for drinking supply from downstream of mining operations. Mining activities taking place on and around a floodplain, with the perception that there is potential for seepage to the river system, creates what is perceived to be a high risk scenario for the Central Highlands Region. With Mount Morgan, also situated in the Fitzroy catchment, the fear of contamination from groundwater seepage is evident amongst stakeholders concerned for their livelihoods and the safety of their community. The largest social risk identified by participants related to water quality, as a result of the Ensham Mine, relates to salinity, or salt content and the effects that this would have on landholders and the agricultural industry. The stronger the conductivity levels of water, the higher the salt content. Table 7.2 shows the conductivity of water levels mapped to the salinity class for irrigation water.

2.2.2.2.3 Community Use

Increasing the availability of land for future grazing and or cropping would be deemed as high value in a region such as the Central Highlands. Comet, where the Ensham Mine site is located near, has agriculture as the largest employer making the potential for use of the land a valuable asset. The use of any rehabilitated land would not be able to occur until the rehabilitated areas are deemed safe, stable and non-polluting and able to sustain appropriate land use after rehabilitation (Queensland Government, 2014). Significant areas of rehabilitation are incorporated into the grazing operations of Nogoa Pastoral Company

2.2.2.2.4 Landform Design

Design refers to the impacts that directly relate to the landform design features of each of the options. A number of design changes have been made between round one and two SIA engagement phases. The most significant changes were made to Preferred Option 1 – Landform Levee, as a result of community feedback and preliminary findings from scientific studies. This resulted in a decision being made to: maintain landform to a 1:1000 level, negating the need to realign the anabranch; raise the floor of the pits to minimise groundwater interactions; and introduce a biodiversity corridor (treed corridor) along the highwalls of all pits.

Preferred Option 2 Flood Mitigation and Beneficial Use and Preferred Option 3 Backfill to PMF also saw changes to design with landform redesign to minimise geomorphological risks and the inclusion of the biodiversity corridor (treed corridor) along the western aspect of the rehabilitated landform between Corkscrew Creek and the Nogoia River. This would add to existing values in the natural landscape of the CHRC area that already contribute to a range of features and services that attract tourists to the region. The largest design related social risks for this project relate to the potential visual impacts of the voids for those living in the vicinity of the mine site.

Across all stakeholder groups consulted (key stakeholders, local and regional community residents and Ensham employees), Preferred Option 2 emerged as the key option preference (92), followed by Preferred Option 3 (29) and Preferred Option 1 (12). Key stakeholders consulted were more divided in their option preferences between Preferred Option 2 – Beneficial Use (16) and Preferred Option 3 – Backfill to PMF (19); whereas, both local and regional community residents (42) and Ensham employees (34) were more likely to demonstrate a clear preference for Preferred Option 2.

Option 2 was not supported by DAF, DNRME and DES. The outcome was a modified Option 1 with the retention of high walls to maximise the area of land suitable for grazing on the low walls. There is no potential for future beneficial use of the residual voids as water storages.

2.2.3 Background landholder/s

Ensham meets and communicates frequently with the background landholders to ML 70049 covering Lot 3 CP911009 and Lot 2 SP165518. These meetings have including detailed discussions about rehabilitation practices and outcomes at the Yongala and Boggy Creek properties.

2.2.4 DES Interactions

The following key communications were made with the administering authority during the community consultation process.

- Staged meetings with the Administering Authority, which included submission and discussion of the technical studies and the outcomes of stakeholder consultation.
- Application for amendment of EA EPML00732813 to include outcomes of the RV Project.

2.3 Community consultation plan

A community consultation plan has been developed to detail Ensham's community engagement. This plan here on referenced as the Stakeholder Engagement Plan and is included as an attached reference document for the PRC plan.

2.4 Community consultation register

Ensham maintains a community consultation register that complies with section 126C(1)(c)(iii) of the EP Act. The details of all engagements with key stakeholders are recorded in the register. An extract of this register is included within a Figure in the Stakeholder Engagement Plan mentioned above.

3 POST MINING LAND USE

In accordance with section 126C(1)(d) of the EP Act, the rehabilitation planning part of the PRC plan must state the extent to which each post-mining land use for land identified in the PRCP schedule for the plan is consistent with:	
a) the outcome of consultation with the community in developing the plan, and	Section 2.2
b) any strategies or plans for the land of a local government, the State or the Commonwealth.	Section 3.2

3.1 Ensham PMLUs

Following are summary descriptions of rehabilitation PMLUs at Ensham. These PMLUs are translated into this transitional PRC Plan from, and are consistent with, land outcome document EA *EPML00732813*, meaning that determination and justifications of PMLU's are not required for this PRCP.

Each listed PMLU can be rehabilitated to a stable condition⁵, whereby:

- The land is safe and structurally stable, and
- There is no environmental harm being caused by anything on or in the land, and
- The land can sustain a PMLU.

As this is a transitional PRC Plan, Ensham is not required to complete the information requirements under section 126C(1)(j) of the EP Act⁶.

3.1.1 Cattle grazing on overburden / infrastructure areas

Beef cattle grazing is the largest land use in the Fitzroy Natural Resource Management (NRM) Region (ABARES 2015) occupying 12 million ha or 78 % of the total area. There are major beef cattle breeding, growing, and finishing operations and sale and processing facilities in the NRM region.

Rehabilitation that will be used for beef cattle grazing will have slope gradients not greater than 25 % in accordance with Table 9-5 and will be sown to a mix of 3P (perennial, palatable and persistent) grasses and legumes. This rehabilitation will be land suitability class 1 (suitable) to class 4 (marginally suitable) according to the 2013 guidelines for agricultural land evaluation in Queensland (Queensland Government 2013b). Though not a criterion in land suitability assessment, cattle have grazed rehabilitated pastures at Ensham since 2012 and currently have access to about 600 ha of rehabilitated land.

⁵ DES (2019), *Guideline–Progressive rehabilitation and closure plans (PRC plans)*, ESR/2019/4964, Version 2.00, p21.

⁶ DES (2019), *Guideline–Progressive rehabilitation and closure plans (PRC plans)*, ESR/2019/4964, Version 2.0, p19.

The Supplementary Landform Report (p 20):

The design of the grazing domain will deliver a significantly better post mining land suitability for grazing than pre-mining for this area. This is supported by land mapping completed prior to mining in 1992 and undertaken as part of the Ensham Mine Environmental Management Overview Strategy (EMOS). This mapping shows significant amounts of the northern mining areas as being Land Suitability Class 5. Land Suitability Class 5 describes land with extreme limitations that preclude any possibility of successful sustained use of the land in the proposed manner eg grazing (Guidelines for Agricultural Land Evaluation in Queensland 2013). The Completion Criteria contained in the submitted Rehabilitation Management Plan identifies that the areas that were Class 5 areas will now be equal to or greater than Class 4 (as defined in Appendix A: Land use limitation subclass threshold limits of the submitted Rehabilitation Management Plan) .

The reinstatement of the grazing PMLU for the inward facing low wall slopes in the rehabilitated open cut mining areas is consistent with the pre mining land use (Hollingsworth, Dames and Moore ECP IAS 1990 p92) and aligned with Hierarchy no: 4 - reinstate previous land use (e.g. grazing or cropping). Additionally, the inclusion of the 675ha's into the grazing PMLU connects the grazing areas lower in the rehabilitated open cut mining areas with the grazing areas on the upper and outward facing slopes.

This complements the existing approved grazing domain area currently approved in the Ensham Mine Environmental Authority, delivering additional income producing land for the landowner which would assist with maintenance and upkeep of the rehabilitated land. Grazing has been, and continues to remain, a key industry for the Central Highlands (Central Highlands Economic Master Plan, 2017).

According to land outcome document EA EPML00732813, this PMLU will incorporate the following characteristics.

- All outward facing overburden slopes would achieve 0 to 10% slopes for tertiary materials, and 0 to 15% slopes for Permian materials.
- At least 90% of the inward facing slopes within this PMLU would achieve 0 to 10% slopes for tertiary materials, and 0 to 15% slopes for Permian materials.
- Up to 10% of inward facing slopes may exist between 15% to 25%, and would be fully contained within the areas of 0 to 15% slopes.
- Minimum factor of safety of 1.5.

These slopes would be topsoiled and seeded, hay mulched or other suitable treatment applied to further reduce erosion risk potential. Benches within the spoil rehabilitation are not topsoiled to allow germination of tree seed as part of cattle shelterbelts and visual amenity. It is noted that this practice occurs on areas of relatively flat ground (benches are typically constructed with very little slope) and has been demonstrated through progressive rehabilitation to be effective. Further detail is provided in Appendix 9.2 PMLU context report and Appendix 9.3 – Monitoring summary report.

Rehabilitated spoil with up to 10% of slopes at between 15% and 25% will be comparable with the slopes in some of the adjoining current grazing paddocks.

The below table and figure details the slope percentages of existing cattle grazing paddocks surrounding Ensham's mining and rehabilitation areas. Table 3-1 describes the percentage of area categorised within each slope percentage interval, eg. 63% of the area of No Man's Land Paddock has a slope of between 0-10%.

Table 3-1 Slope of existing grazing paddocks

Paddock	Area (ha)	0 – 10%	10 – 15%	15 – 20%	20 – 25%	25 – 100%	> 100%
No Mans Land Paddock (part)	544	63%	17.6%	8.1%	4.1%	7.6%	0.1%
Boundary Paddock	207	51.4%	23.8%	12.4%	5.8%	6.4%	0.1%
Annabranh Paddock	895	57.9%	17.3%	8.7%	4.7%	11.2%	0.2%
Long Paddock	347	98.7%	0.9%	0.3%	0.1%	0.1%	0%
Boggy Creek Paddock	329	94.7%	2.4%	1.2%	0.7%	1.1%	0%
Adrians Paddock	356	84.9%	9.5%	2.7%	1.3%	1.6%	0%

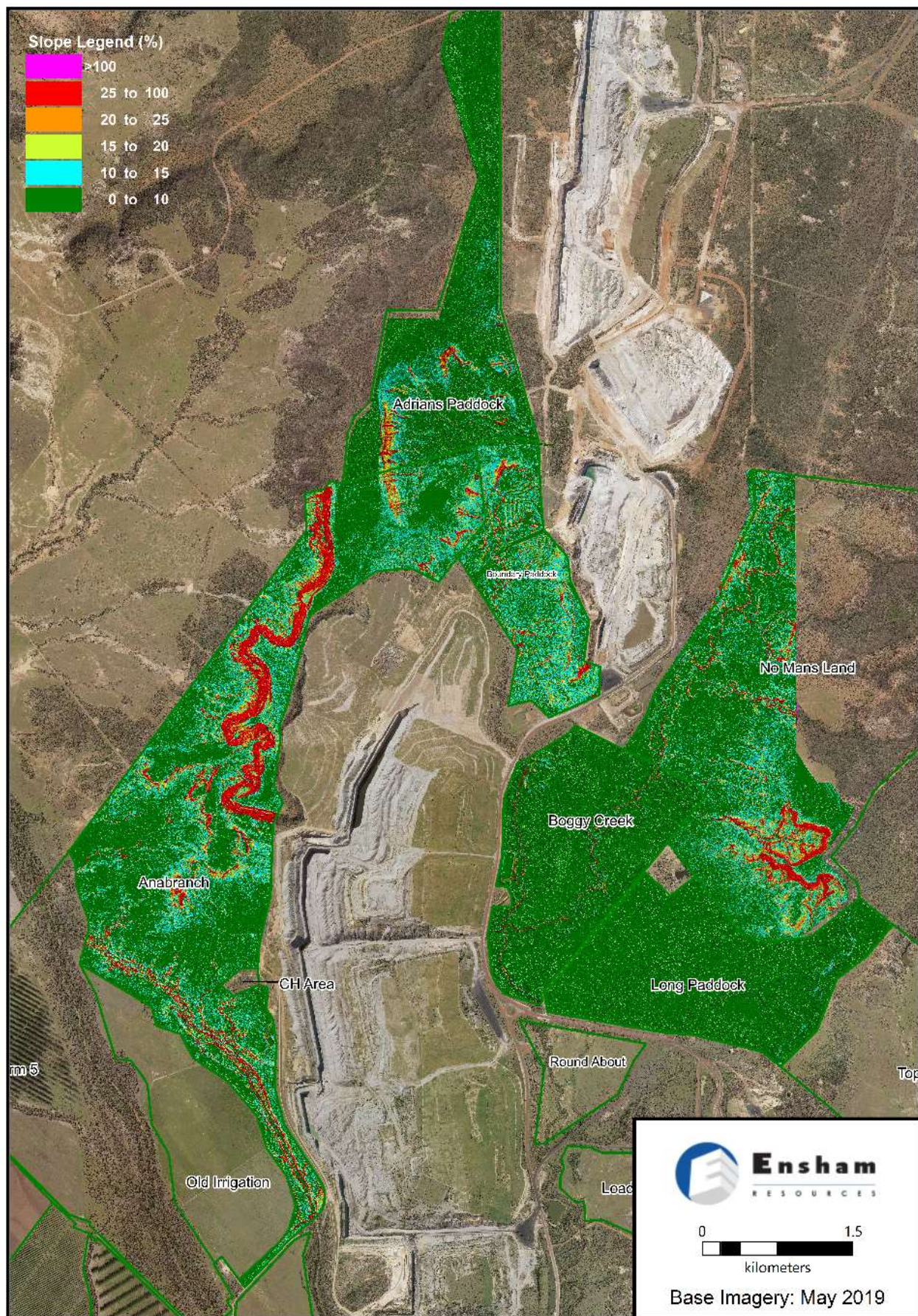


Figure 3-1 Slopes of existing grazing paddocks

3.1.2 Landholder retained infrastructure

As per the written agreements, some mining infrastructure will be retained by the background landholders. This includes roads, dams, pipelines, bridges and electrical reticulation to assist in meeting ongoing land management requirements. Though important to facilitating other PMLUs, landholder retained infrastructure will be a minor component of rehabilitation at Ensham of all PMLUs at the mine.

Landholder retained infrastructure will include the following.

- The main power supply line into the mine is also used for power supply to a rural switchyard which then provides power to the homestead and property infrastructure such as a river pump and a bore. The 66KV line to the rural switchyard and lines to property infrastructure are to be retained.
- Water is pumped from the river using a Water Licence allocation to 2 dams, Clear Water Dam and Sailors Dam. It is pumped firstly to Clear Water Dam and then pumped again to Sailors Dam. The water from both dams is used within the mining operation as raw water. Water from Sailors Dam is further pumped as part of the grazing property infrastructure to tanks and troughs. Currently Sailors Dam is the only permanent water supply to the eastern grazing paddocks. The dams and accompanying pipelines are to be retained as part of the grazing infrastructure.
- The access road commences from the gazetted road into Currimundi property. It is the main access used for transport of stock arriving or departing from the main cattle yards by road train. Access across to the northern side of the river is achieved via the main access road, which is capable of transporting heavy machinery such as dozers used for fire breaks and vegetation management. In the event of flooding a light vehicle bridge provides access to the northern portion of the property.
- The access road continues north of the river and provides access to the stock watering infrastructure at Sailors Dam. It is proposed to retain this infrastructure as part of the grazing operation.
- Boundary paddock has been used as part of the cattle grazing operation of Duckponds for at least the last 5 years. A sediment dam was installed when out of pit spoil was being rehabilitated within this paddock. The rehabilitation is certified but the sediment dam has been left as a valuable stock watering point. It is proposed to be retained in its current configuration as it provides permanent stock water.
- The section of Yongala Haul Road existing over the Simmon's property "Boggy Creek" has been requested to be retained as is.

3.1.3 Boggy Creek diversion

Excavation, reshaping, topsoiling and seeding of the Boggy Creek diversion has been completed in 2021. Adjoining areas and finalisation of drainage works are currently being undertaken. This rehabilitation will re-establish required geomorphological functionality to the watercourse, including suitable riparian vegetation. Like Native Bushland Corridor, this PMLU provides important habitat and ecosystem services, and links upstream and downstream remnant regional ecosystems, including those associated with the Nogoa River.

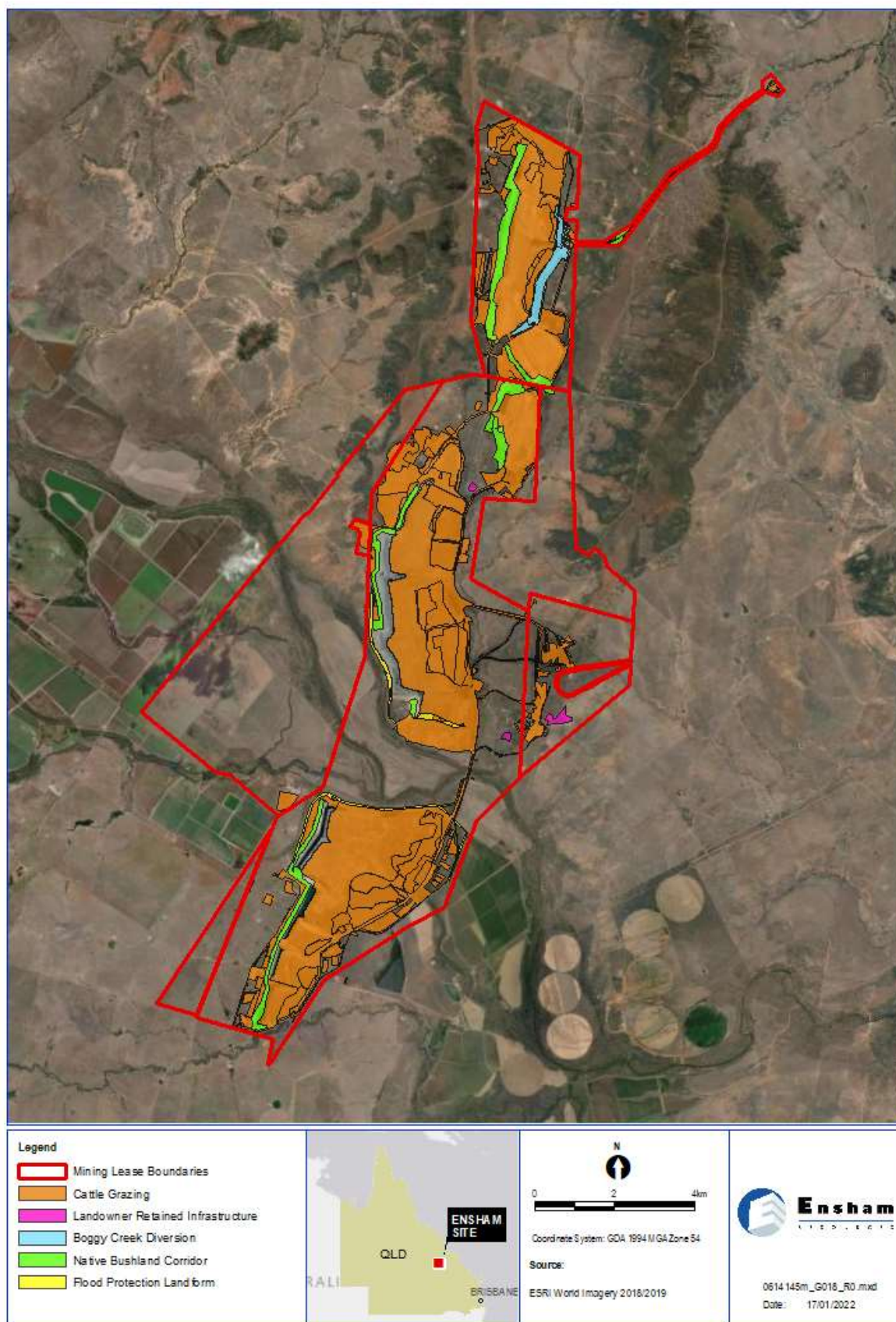


Figure 3-2 Locations and extents of PMLUs

3.1.4 Native bushland corridor

Regional ecosystems in the Brigalow Belt Bioregion have been extensively cleared for agriculture and within the Fitzroy NRM Region protected, conservation and minimum use areas occupy just 7.8 % of land (ABARES 2015). Native bushland corridor rehabilitation at Ensham will provide important habitat for a variety of native animals and plants, with linkages to existing remnant regional ecosystems associated with the Nogoa River.

Native Bushland Corridor PMLU is located on the western side of the rehabilitated open cut mining areas, connecting Corkscrew Creek with the Nogoa River floodplain and the escarpment country. The corridor also connects with Boggy Creek.

According to land outcome document EA *EPML00732813*, this PMLU will incorporate the following characteristics.

- $\geq 50\%$ established and persistent vegetative groundcover for all slopes from 0-20%.
- $\geq 80\%$ established and persistent cover (vegetative and/or rock mulch if required) for slopes from 20% to 25%.
- Species richness ≥ 2 tree species, ≥ 3 shrub species, ≥ 5 groundcover species.
- Maximum 25% slope
- Areas $> 15\%$ to be certified by a suitably qualified person as being stable long term, with rock mulch applied as required.

This PMLU has three broad functions, viz.

- It will provide corridors which will increase the available vegetation cover and associated foraging opportunities in the locality and is anticipated to be beneficial for a variety of native fauna species as well as increasing fauna movement opportunities in this landscape.
- It will also prohibit vehicle access onto the rehabilitated highwall slopes. This sustainable control is seen as better practice than the conventional practice that includes constructing a berm and fencing of the highwall.
- It will also reduce any visual impacts that may be associated with the rehabilitated opencut mining areas. The rehabilitated open cut mining areas are designed to be consistent with, and blend with, the regional escarpment landscape. As such, the rehabilitated open cut mining areas are not expected to have any significant impact on the visual amenity of the area. The selection of the flora species will be determined closer to time of rehabilitation, utilizing tree shrub, and groundcover BioCondition benchmarks for relevant regional ecosystems.

3.1.5 Flood protection landform

The purpose of this rehabilitation is to prevent flood inundation of other rehabilitation areas. This PMLU replaces existing flood protection levees. Therefore, a key indicator is the design level of the landform crest, which must be at least 1 m above the estimated 1 in 1,000-year annual recurrence interval (ARI) flood event.

3.2 Relevant strategies and plans of the local, and State or Commonwealth governments

To the extent relevant, Ensham is on land affected by the following government plans.

- 1) Central Highlands Regional Council (CHRC)
 - a) *Central Highlands Regional Council Planning Scheme 2016* (CHRC 2016).
- 2) Queensland Government
 - a) *Central Queensland Regional Plan* (Queensland Government 2013).

3.2.1 CHRC planning scheme 2016

The *Central Highlands Regional Council Planning Scheme 2016*, adopted by Council on 24 February 2016, superseded the four Planning Schemes and associated planning scheme policies of the former Emerald, Duaringa, Bauhinia and Peak Downs Shires. Under the planning scheme, the Ensham mine is located in the rural zone. The following highlighted provisions are from *Part 3 Strategic Framework* and show the PMLUs at Ensham are strongly aligned with the planning scheme, as further described in Section .3.1.

3.5 Natural resources and landscape theme

3.5.1 Strategic outcomes

The strategic outcomes for the natural resources and landscape theme are the following:

- b. Natural and rural landscape features are appropriately managed, utilised and protected to ensure that the Central Highlands maintains its unique character and identity whilst also allowing its natural resources, such as mineral and agricultural assets, to be sustainably used and managed.*
- c. Management and development practices reflect best practice methods for the sustainable use of the rich deposits of natural resources within the region, while encouraging new renewable and cleaner natural resources development.*
- d. Key natural resources including biological, energy, extractive, land, air and water resources are protected and sustainably managed to allow communities to meet present needs while not compromising the ability of future generations to meet their needs.*
- e. Use of land and its natural resources is undertaken in a way that does not cause an adverse impact on the environment.*
- f. Natural ecosystems and water resources are protected and conserved as critical elements to the sustainability of all activities in the Central Highlands region.*
- g. Development in and adjacent to natural resource areas within Central Highlands is managed to facilitate co-existence between traditional rural and agricultural pursuits and resource activities and avoid or otherwise mitigate negative impacts on the continued and future use of these resource areas.*

3.5.3 Element 2 – Natural resource management

3.5.3.1 Specific outcomes

Mineral and extractive resources

- d. *The economic benefits of extracting deposits of non-renewable resources and minerals from within the region are balanced against:*
 - i. *socio-economic and environmental impacts; and*
 - ii. *the long-term sustainable use of the land for non-extractive renewable activities and agricultural or pastoral uses.*
- e. *Development within the Bowen Basin, as identified on [Strategic Framework Map SFM-003](#), is appropriately designed and located to maximise opportunities for co-existence between mineral, petroleum and coal resource development and other land uses and sensitive environments.*

3.2.2 Central Queensland Regional Plan 2013

The purpose of this plan is to identify the State's interests in land use planning in the central Queensland region. A large portion of Ensham Mine is located within a priority agricultural area, with current areas within the Ensham MLs (in proximity to the floodplain area, and overlying areas where underground mining is and has occurred) being utilised for cropping land now. Protecting priority agricultural land uses while supporting co-existence opportunities for the resource sector is a key regional policy (Figure B2-3). In addition, cattle current graze on rehabilitated land at Ensham and rehabilitation is primarily directed towards this beef cattle grazing as a PMLU, demonstrating rehabilitation is strongly aligned with the plan.



Figure 3-3 Regional outcome for priority agricultural land (from Queensland Government 2013)

4 NON-USE MANAGEMENT AREAS

In accordance with sections 126C(1)(d), (g) and (h) of the EP Act, for each proposed non-use management area, the rehabilitation planning part of the PRC plan must:	
state the reasons the applicant considers the area cannot be rehabilitated to a stable condition	s126C(1)(g) of the EP Act is not applicable to this transitional PRC Plan
include copies of reports or other evidence relied on by the applicant for each proposed non-use management area	S126(1)(h) of the EP Act is not applicable to this transitional PRC Plan
state the extent to which the proposed non-use management area is consistent with the outcome of consultation with the community in developing the plan, and	Section 2.2
state the extent to which the non-use management area is consistent with any strategies or plans for the land of a local government, the State or the Commonwealth.	Section 4.2

4.1 Ensham NUMAs

Following are summary descriptions of rehabilitation NUMAs at Ensham. These pre-approved NUMAs are translated into this transitional PRC Plan from land outcome documents EA *EPML00732813*. On this basis, Ensham is not required to:

- Justify NUMAs.
- Provide evidence to support the justification of NUMAs.
- Go through the public interest evaluation process.
- Comply with the prohibition of voids located within a flood plain having to be rehabilitated to a stable condition.

The land outcome document (EA) sets out the criteria to be met for the high walls and groundwater daylighting water areas are to be safe, stable and non-polluting. They do not have a nominated land use.

It is noted that the EA outlines that the approximate area to be retained as Groundwater Daylighting Water Areas is a maximum of 192ha. However, it is noted, in Section 4.1.3, that the anticipated area is less than authorised in the EA.

4.1.1 Groundwater daylighting water areas

Regionally significant water storages, dams and reservoirs occupy less than 1.5 % of land within the NRM region (ABARES 2015). At a local level, minor water storages are important for stock and domestic supplies and assist native animals, particularly in times of drought. Groundwater daylighting water areas will be a minor component of rehabilitation at Ensham (Figure 4-1 and Table 4-1).

These areas will be fenced either prior to relinquishment, or, when water daylights (whichever is the sooner) to prevent cattle accessing these areas. It is anticipated that aquatic bird life will reside in these areas similar to current site water bodies which support large numbers of aquatic bird life that would not exist on site otherwise.

Table 4-1 Maximum final water levels, volumes and water areas (as authorised by EA EPML00732813)

Pit	Surface water level	Regional groundwater level	Water storage volume (GL)	Water area (ha)	Approximate time for groundwater to daylight	Approximate year of equilibrium
A south	Groundwater does not daylight					
A central	133	144	0.5	3	50 years	2140
A north	133	144	1.2	16		
B	123	142	3.1	33	55 years	2200
C	125	142	22.1	65		
D				75		
E	Groundwater does not daylight					
F						
Y						
Total			26.9	192		

4.1.2 Highwalls

Highwalls is a relatively minor component of the rehabilitated landscape at Ensham as shown in Figure 4-1. Highwalls will have sufficient improvements to ensure safety, structural stability, and minimisation of environmental harm.

1) Improvements for safety.

- Safety bund constructed at ≥ 2 m high, base width of ≥ 5 m and crest width of ≤ 2 m.
- Safety bund positioned a distance not less than the total of the width of the *potentially unstable pit edge zone* plus an additional 10 m away from the existing pit edge. The width of the potentially unstable pit edge zone is defined by the distance between the existing pit edge and a point on the ground surface representing the intercept of a 45° plane projected from the slope toe.
- Fencing erected along extent of former highwalls.
- Fence position to be an additional 10 m away from the bund (in a direction away from the highwall edge).
- Warning signage posted every 500 m of the animal exclusion fence.

2) Improvements for structural stability.

- Slope gradients achieved as follows-
 - Maximum of 275 % slopes for competent high walls.
 - Maximum of 50 % slopes for incompetent material

- iii) A south pit, F Pits and Y Pits highwall must be reshaped to a maximum of 25 % slopes.
 - iv) Northern Endwall of B Pit maximum 15 % slope
 - b) Landforms are assessed as geotechnically stable with a factor of safety ≥ 1.5 .
 - c) Water run-off from above the highwall is channelled to the groundwater daylighting water areas PMLU through design pathways.
- 3) Improvements to ensure minimisation of environmental harm.
- a) Regional groundwater aquifers maintain their current water quality and groundwater monitoring bores do not exceed the water quality limits detailed in Table C11 – Groundwater quality limits in the relevant EA as a result of mining activities.

4.1.3 NUMA summaries

The total area and locations of each NUMA are provided for each mining tenement (Table 4-2).

Table 4-2 Planned location and extent of NUMAs at Ensham

NUMA	ML7459	ML7460	ML70365	ML70366	ML70367	ML70049	ML70326
Highwalls	83.1	0.0	0.0	0.0	0.0	0.0	0.0
Groundwater daylighting water areas	145.8	0.0	0.0	0.0	0.0	0.0	0.0

It is highlighted (as detailed in Table 4-1) that the maximum water area authorised for Ensham (as per Appendix 3 of EA EPML00732813 EPML) equates to a total of 192ha. However, as shown in Table 4-2 above, the actual area anticipated to be contained as 'Groundwater daylighting areas NUMA' is less than this, with a total of only 145.8ha. It is highlighted that Ensham are not planning for the full area authorised to be retained, as the landform design process has successfully sought to minimise the area to be retained as NUMA.

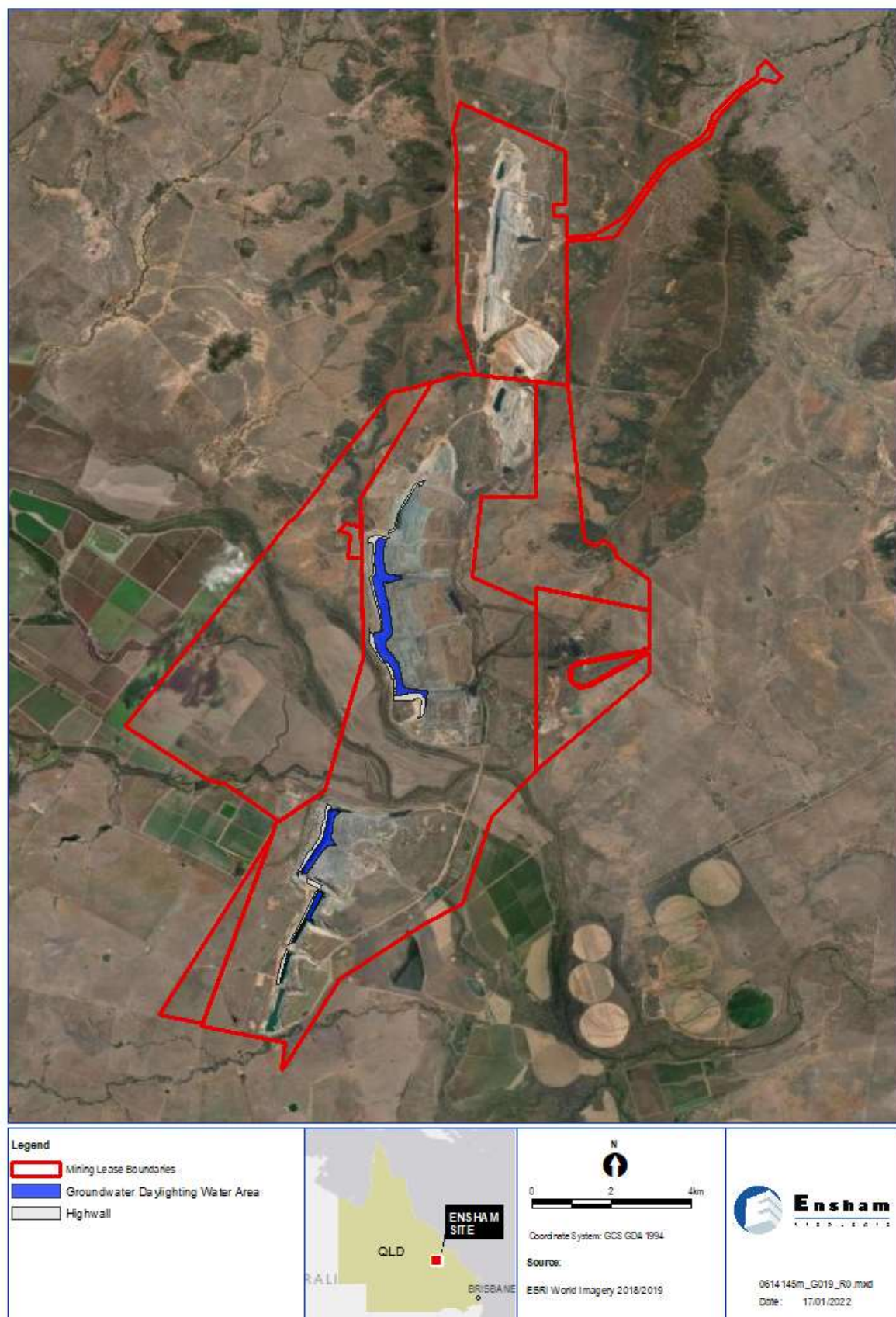


Figure 4-1 Location and extent of NUMAs

4.2 Relevant strategies and plans of the local, and State or Commonwealth governments

The existence of NUMAs in the post-mining landscape at Ensham is an inevitable consequence of the approved mining activities. Despite being pre-approved in land outcome documents, the area of NUMAs has been minimised and represents less than 5 % of all disturbed lands. The strategic outcome of protecting natural resources is supported by minimising the area of groundwater daylighting and the design which means that the residual areas are groundwater sinks not sources. Conversely, Ensham has sought to maximise the area of grazing PMLUs in the post-mining landscape. Therefore, to the extent possible, Ensham has complied with the local (CHRC 2016) and regional (Queensland Government 2013) planning instruments, particularly as these relate to resource and agricultural land use co-existence and sustainability.

4.3 Voids in floodplains

In accordance with section 126D(3) of the EP Act, if land the subject of the proposed PRCP schedule will contain a void situated wholly or partly in a flood plain, the schedule must provide for the rehabilitation of the land to a stable condition.
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As NUMAs at Ensham have already been identified in a land outcome document, i.e., EA *EPML00732813*, this PRC Plan is not required to comply with sections 126C(1)(g) or (h) or 126(D)(2) or (3) of the EP Act.⁷

As the pre-approved NUMA locations have been specified in the EA and are shown in Figure 4-1, Ensham is not required to undertake floodplain modelling as part of this plan; however, references and information relating to flood modelling previously carried out have been included.

⁷ DES (2019), *Guideline–Progressive rehabilitation and closure plans (PRC plans)*, ESR/2019/4964, Version 2.0, p23.

⁸ DES (2019), *Guideline–Progressive rehabilitation and closure plans (PRC plans)*, ESR/2019/4964, Version 2.00, p26

5 REHABILITATION MANAGEMENT METHODOLOGY

In accordance with section 126C(1)(e) and (i), the rehabilitation planning part of the PRC plan must:	
For each proposed post-mining land use for land, state the proposed methods or techniques for rehabilitating the land to a stable condition in a way that supports the rehabilitation milestones under the proposed PRCP schedule.	Sections 5.2, 5.3, 5.5, 5.8, 5.9, 5.10, 5.12, 5.13 & 5.14
For each proposed non-use management area, state the proposed methodology for achieving best practice management of the area to support the management milestones under the proposed PRCP schedule for the area.	Sections 5.1 and 5.11.

Following is a general description of the proven rehabilitation practices at Ensham and the significant drivers that have shaped development of those practices. General rehabilitation practices at Ensham are efficient and effective. To date, most rehabilitation has focussed on inter-ramp, outward facing slopes of 10 – 15 % gradient for cattle grazing PMLU.

Detailed information has been provided as to the proposed methods and techniques for rehabilitating the land to a stable condition for each proposed PMLU in Section 3.1 above, Section 5.14 as well as Appendices 9.3 and 9.6. This information has also informed rehabilitation milestones identified in Section 9.1.3.2 for the PRCP Schedule.

5.1 Hydrogeology

A detailed description of the hydrogeological systems of relevance to Ensham is provided in Appendix 9.4 – Hydrogeology summary report. The Appendix summarises relevant historical information and presents a summary of the hydrogeology of the site and all connected strata. Detail of a conceptual model has also been included to illustrate the mine site's groundwater systems.

The Bowen Basin is the largest productive coal basin in the country. The Bowen Basin stretches from Townsville to south of the Queensland-New South Wales border in a north to south direction. In the southern parts, the extent of the Bowen Basin and the hydrogeological Great Artesian Basin (GAB) overlap.

5.1.1 Groundwater overview

The Rewan Formation is recognised as the base aquitard of the GAB (Habermehl, 1980 and 1998).

At Ensham, the Rewan Group is present at subcrop. The Clematis Sandstone, an aquifer of the GAB is not present. The closest intake area (i.e. outcrop of the Clematis Sandstone) is located 50 km southeast of the mine area. The surface geology of the Project Area is dominated by the Nogoia River alluvium to the south and the Tertiary Sediment to the south and the north.

5.1.2 Occurrence and nature of groundwater at Ensham

The stratigraphic sequence comprises unconsolidated Quaternary aged sediments unconformably overlying consolidated Permian and Triassic aged sequences. The Triassic age Rewan Group overlies the Permian coal measures and occurs as in-fill material, thickening to the west with the dip of the coal measures and thin to the east. The Permian and Triassic strata form regular layered fluvio-deltaic sedimentary sequences, while the Quaternary sediments are more complex and irregular.

The coal deposits mined at Ensham Mine are found within the Rangal Coal Measures, which is the uppermost Permian unit. The Rangal Coal Measures consist of interbedded sandstone, siltstone, mudstone, and coal with tuff (towards the base) and have a thickness of up to 100 m.

Further detail of the groundwater units and occurrence at Ensham is provided in Appendix 9.4.

Hydrogeological assessments (Cote, 2020; Hydrosimulations 2020) for Ensham describe that the main groundwater bearing units as the alluvium (quaternary sediments) and the Permian aged Rangal Coal Measures. The alluvium is an unconfined system recharged by rainfall and irrigation practices. These groundwater bearing units are referred to as the “regional groundwater system”.

The data indicates that groundwater from the coal seams flows primarily towards underground workings. When underground workings are in close proximity to rehabilitated open cut mining areas, there can also be pathways with relatively high hydraulic conductivity that convey water from the rehabilitated open cut mining areas to the underground workings.

Figure 5-1 below shows a selected long-section of Ensham mine, and illustrates a conceptual understanding of the nature and occurrence of the groundwater systems as well as all surface to underground interactions. This long-section has been selected as an illustration of the patterns and processes at play, and further sections are available within Appendix 9.4 to show all parts of the Ensham site.

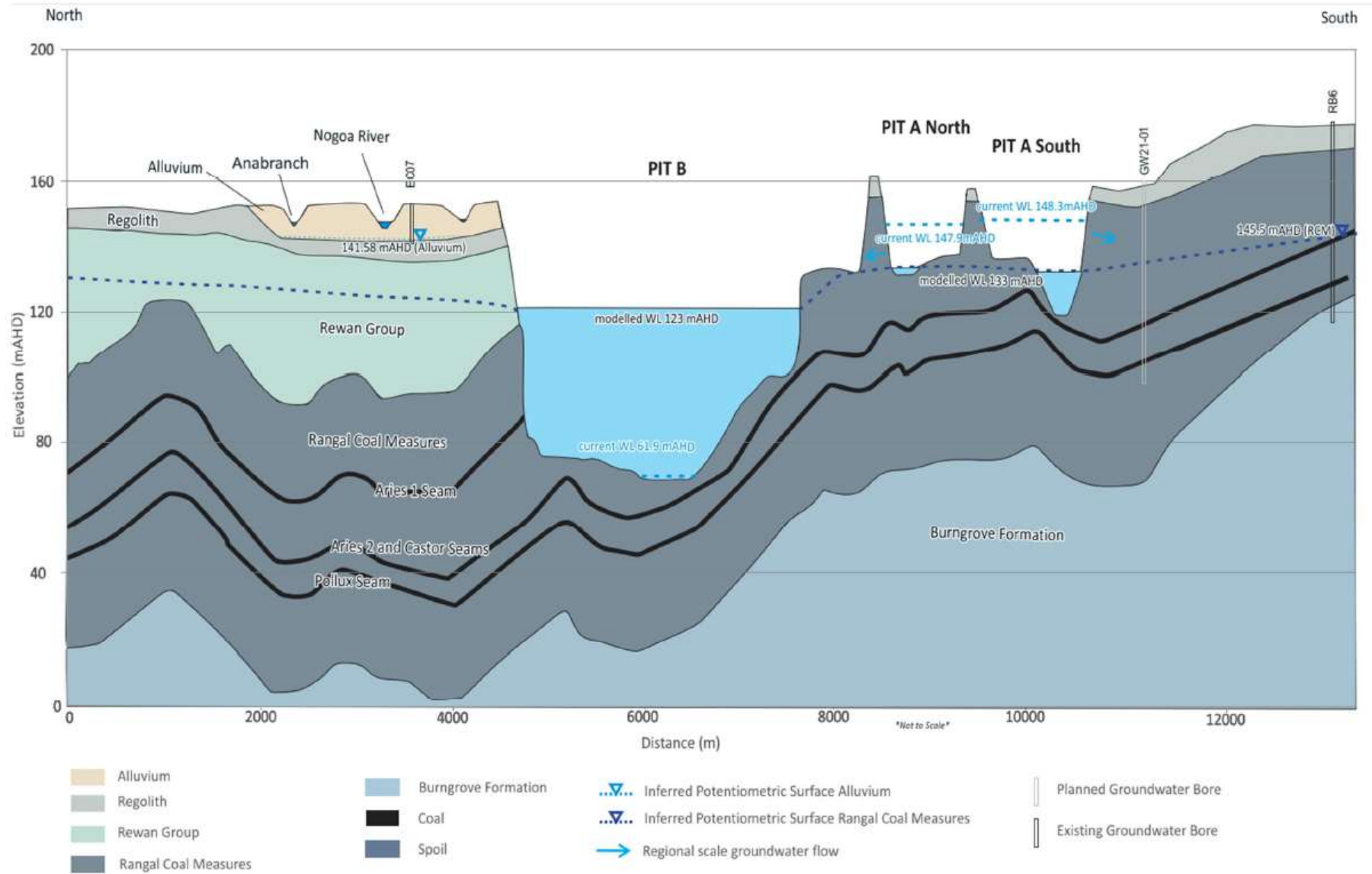


Figure 5-1 Cross section of Nogoia River and Pits A and B (north to south)

5.1.3 Water levels and flow characteristics

Groundwater level and flow in the alluvium is highly variable with thin saturated zones of poor-quality water in deeper sections of an otherwise largely unsaturated formation (SLR, 2020). Hydraulic testing also indicates the conductivities are variable. The primary driver of groundwater flow in the alluvium aquifer is the topographic gradient, and groundwater following the direction of the Nogoa River from north-west to south-east.

Groundwater in the Rangel Coal Measures flows primarily towards the Ensham underground mine area due to the dewatering and depressurisation associated with underground mine development. Recharge occurs primarily from rainfall infiltration on exposed outcrop. The coal measures also subcrop in localised zones beneath alluvium associated with the Nogoa River, where the unit may be recharged by downward seepage where there is an absence of clay and silt layers. Limited recharge may also occur via downward leakage from the Triassic age Rewan Group and Tertiary sediments, as well as from areas of site surface water storage (i.e. in-pit water storages from open-cut mining at the Ensham Mine). The coal seams are connected with the open-cut pits (which are the mined-out areas of the outcropping coal seams). If the pit voids fill up with water, this can create flow into the coal seams. Hydraulic conductivities within the Rangel Coal Measures interburden have also been measured to vary significantly (SLR, 2020).

Potentiometric mapping for both of the main aquifers has been provided within Appendix 9.4.

5.1.4 Water quality

There are two main groundwater units of relevance, the shallow Quaternary Alluvium as associated with the Nogoa River floodplain, and the much deeper Permian aged Rangel Coal Measures. These units are not hydraulically connected and are separated by a low permeability unit, and thus their chemistry is unique.

The alluvium is an unconfined system recharged by rainfall, flooding and irrigation practices. Water quality is highly variability but also exhibits high salinity and is therefore unsuitable for stock watering and irrigation. The majority of bores screened in the alluvium are of sodium-chloride (Na-Cl) water type dominance. Water pH is neutral with a median value of 7.1. Most of the alluvium is hydraulically isolated from the Nogoa River, resulting in brackish to highly saline conditions.

Groundwater in the Rangel Coal Measures is saline and not suitable for stock water supply or irrigation, with variable quality, but typically considered to be poor due to high salinity. Bores monitoring the Rangel Coal Measures are Na-Cl dominant. Water pH is neutral with a median value of 7.7.

Water infiltrating through the spoil material associated with the mine can mobilise solutes or metals that influence final void water quality. RGS (2019) suggest salts in overburden will be immediately soluble and mobilised by water flow, and will decline over time.

5.1.5 Drawdown, recharge and discharge

Groundwater models have been used at site to predict long-term drawdown, recharge and discharge. Model development and refinement has been an evolutionary process with a number of models completed and updated by various parties, most recently by SLR in 2020. Further detail is provided in Appendix 9.4.

The groundwater level recovery (or rebound) indicates some permanent reduction in water levels is predicted for the water levels in the target coal seams, with water levels in the Rangel Coal Measures predicted to recover slowly to around 10 m lower than in the surrounds. However, the water levels in the alluvium, the shallow groundwater system, are predicted to fully recover to pre-mining conditions.

The limited Rangal Coal Measures water level rebound is related to the influence of the Ensham Mine final voids, which will continue to act as a localised groundwater “sink”. Considering the potential for groundwater interactions with the residual voids, the final landform for Ensham has a pre-approved NUMA to encompass these Groundwater daylighting water areas.

Cote (2020) noted that groundwater from the coal seams flows primarily towards underground workings. When underground workings are in close proximity to rehabilitated and/or open cut mining areas, there can also be pathways with relatively high hydraulic conductivity that convey water from the rehabilitated and/or open cut mining areas to the underground workings. This impacts on the water levels in the rehabilitated and/or open cut mining areas, which will likely only stabilise after closure. Initially the underground workings will fill with water after mining activities have ceased, and after this time, this groundwater will daylight to any residual voids in proximity. As a result, a pit lake will start to form in some voids, as described in Section 4.1.1. These areas as referred to as the Groundwater daylighting water areas NUMA.

As detailed in Table 4-1, it is anticipated for this to occur in Pits A (central and north), B, C and D. No daylighting of groundwater is expected for Pit A (south), nor with Pits E, F and Y (Yongala) due to backfilling above the modelled groundwater levels.

5.1.6 Uses of groundwater

Ensham is within by the Highlands Groundwater Management Area under the Fitzroy Water plan, and is located in the lower Nogoia Groundwaters of the Fitzroy Groundwater plan. Environmental values for the area that are pertinent to groundwater in the vicinity of Ensham include aquatic ecosystems, irrigation, farm supply/ use and stock water supply. Groundwater from the coal measures is not used for primary recreation or drinking water as the quality for Ensham is not suitable for drinking. Thus, it is mostly used for stock use. The alluvium aquifer is utilised in a similar manner.

5.1.7 Modelled results

Cote (2020) determined that some of the rehabilitated open cut mining areas will maintain a permanent water body with a water level that will fluctuate around a steady state ‘equilibrium’ level in response to climate variations. Equilibrium level is predicted to be reached after 50 years at A Pit, 100 years for the B Pit area, 150 years for the CD Pits rehabilitated open cut mining areas. These results are detailed in HEC (2020).

All predicted long-term average water levels are below the external “spill” level, the level at which water would overflow out of the rehabilitated open cut mining area. There will be no export of water from the rehabilitated open cut mining areas to surface water in the receiving environment. Further, all predicted water levels in the rehabilitated open cut mining areas are beneath the regional groundwater levels. Groundwater will flow from the regional system to the rehabilitated open cut mining areas. There will be no flow from the rehabilitated open cut mining areas to the regional groundwater system.

Regarding salt and long-term water quality, in the rehabilitated opencut mining area at A Pit, concentrations reach an equilibrium of approximately 12,500 $\mu\text{S}/\text{cm}$ after about 20 years. This is because there is flow through the porous medium from A Pit to B Pit. There is a balance between the inputs and outputs of solutes so that concentrations remain around a stable value.

For rehabilitated open-cut mining areas at AB Pits, and CD Pits, concentrations are predicted to keep increasing. This is because the only outflow from these areas is via evaporation, which does not contain solutes. There is no output of solutes and concentrations increase with time. Given that the water held in the rehabilitated open cut mining areas does not reach levels that result in overflow to surface water or

groundwater, this does not pose a threat to the receiving environment. In addition, it is not proposed to use the water for any PMLU. For these reasons, Cote (2020) concluded that all rehabilitated open cut mining areas are predicted to be non-polluting.

The modelling has informed which void areas will be partially backfilled above groundwater levels and which despite partial backfilling will eventually become groundwater daylighting areas, with a pit lake forming, as described in Section 4.1. These areas are referred to as Groundwater daylighting water areas and are consistent with the previously approved rehabilitation outcomes for the Ensham Coal Mine, as detailed in the EA (EPML00732813).

5.2 Flooding

Ensham is located within the Nogoa River catchment, and flooding interactions and impacts are an important consideration for the site. The susceptibility of the mine site to flooding, and potential influence of flood interactions in the long-term, has been extensively investigated. Reference is made to the Residual Void project completed by Ensham, which was required by the conditions of the previous EA.

This project saw the development of a wide-ranging body of work to understand potential long-term social and environmental interactions and aspects relevant to residual mining voids being retained for the site, as well as considering a number of long-term landform and void design concepts for the site. The project sought to initially establish a foundation of knowledge upon which landform and rehabilitation design concepts were explored, options assessed and consulted with stakeholders. The end result was to establish a landform design concept and a number of PMLUs and NUMAs for the site that are now reflected in the current EA for Ensham.

Based on the body of knowledge from these studies a high level of understanding exists to inform not only the flooding aspects of the site but also a wide range of environmental constraints. A summary is provided below.

5.2.1 Location of flood interaction areas

Ensham extends to the south and north of the Nogoa River floodplain. The following discussion about flooding summarises the analysis in WRM (2019) unless otherwise cited. This report has been provided by Ensham along with a number of other key studies, including but not limited to Umwelt (2019), Cote (2020), HEC (2020) and SLR (2021).

The Nogoa River consists of a well-defined 10 m deep channel that is carved through a relatively flat floodplain area. Flood slopes vary from 0.03 % to 0.05 %. The 0.1% AEP floodplain varies in width from about 4 km at the location of the mine (historically narrowed to 1.5 km by operational mine levees) to about 13 km near the Crinum Creek confluence. The historical floodplain was naturally restricted pre-mining to a distance of 2.6 km by Red Hill on the northern side of the anabranch and higher ground on the southern side of the Nogoa River where the present Duckponds homestead is located. The Duckponds homestead location has not been flooded by any of the floods during the time of Ensham Mine.

The floodplain consists of quaternary alluvium and lacustrine deposits of a mix of sand, silt, clay and gravel. Hansen Consulting (2006) characterised the alluvium as a strongly structured alkaline heavy (cracking) clay soil classified as a grey or brown Vertosol soil.

Flood interactions occur primarily for the southern and central Pits from A to E, and are particularly relevant to areas where voids will be retained, again as described in Section 4.1.1. Flood modelling has been conducted to ensure all voids located within flood plain areas will be rehabilitated to a stable condition, with the exception

of any areas designated as NUMA. The extent of the floodplain is as shown on the Final site design map (as required by the PRCP guidelines), provided as Figure 9.1.

5.2.2 Alteration of catchment flows

Catchment flows have already altered for the existing operation and existing approvals are in place to licence all diversion structures as well as other features, which have resulted in alteration of flooding behaviour and catchment flows in particular.

Several anabranch flood channels cross the floodplain, with the most prominent located adjacent to C Pit. The anabranch receives flow every year on average and conveys 36% of the 10% AEP event. Other flood channels receive Nogoa River floodwater only for larger floods but convey a greater proportion of the flow during these large flood events. These channels may be parts of decaying or developing anabranch channels, varying through time. B Pit has been constructed across one of the flood channels called Old Winton Creek. Prior to mining, Old Winton Creek conveyed 6 % of the 10 % AEP flow and 34% of the 1% AEP flow.

Considering post-mining alteration of catchment flows, it is recognised that no licenced diversion or levee structures can remain once the Ensham site has been rehabilitated. As such, a permanent levee structure will be incorporated into a final landform, providing long-term stability. These have been described as a discrete PMLU within Section 3.1.5, as 'Flood protection landform'. Design and construction of this landform will provide immunity to a 0.1% (1:1000) AEP year flood event.

The hydrology surrounding Ensham will be largely unchanged from the current active mining regime, if slightly improved as a result of an adequate floodplain width being maintained. Contributing catchments upstream of the mine are not expected to be affected during closure and the resulting response to rainfall events will remain similar. As part of the residual void project, commitments were made to:

- ensure a permanent flood protection structure is in place at closure; and
- reinstate a minimum of 2km floodplain width between the northern section of Pit B and the southern section of Pit C.

These requirements are incorporated into Appendix 5 (Floodplain Widening) of the Ensham EA, and have subsequently been transitioned across to milestone criteria for this PMLU (provided as RM11).

5.2.3 Modelled flood levels

Development of hydrologic modelling has occurred for all relevant catchments for all parts of the Ensham site, as well as hydraulic modelling to understand the nature of interactions with mining areas. Modelling has considered likely flood extents for a range of design storm events, up to and including probable maximum flood (PMF) levels. All modelled outputs have been made available to DES, and modelling work completed as part of the Residual Void project has also been subject to independent review and critique. It is considered fit for purpose and utilises contemporary flood modelling techniques.

Flood modelling of pre-mining conditions shows flood velocities are generally low with median channel velocities between 1.1 m/s and 1.3 m/s. Overbank velocities in the flood channels are much lower with median values between 0.2 m/s and 0.8 m/s. Observations of the Nogoa River channel and floodplain taken after the January 2008 and January 2011 floods, which were both very large events, found that the soils and vegetation characteristics at the time were capable of resisting channel bank and overbank sheet erosion, although minor localised erosion was encountered.

An indication of this is that the current anabranch of the Nogoa River through the mine was originally the main channel and the present main channel was the anabranch. Many government maps and databases reflect the original position and naming.

As an outcome of the Residual Void project, a landform design concept was adopted that prevents floodwater from inundating residual voids and grazing areas on the former floodplain, providing flood immunity up to the 0.1 % or 1 in 1,000 annual exceedance probability (AEP) flood event plus 0.5 m. It will permanently confine the floodplain to a minimum of 2 km width between the northern section of B Pit and the southern section of C Pit, as defined in land outcome document EA *EPML00732813*. The final landform design at Ensham includes a flood protection landform PMLU which relates to the permanent flood protection structure.

This will have an insignificant impact on flooding characteristics because flood modelling of the current levee alignment, which restricts the floodplain at Ensham to 1.5 km width, shows that compared to pre-mining conditions:

- There would be no change in peak velocities and shear stresses from pre-mine conditions for the 10% AEP flood;
- The differences between pre-mine and current flood velocities and shear stresses for the 1% AEP event are minor;
- Where increases from pre-mine conditions occur for the 1% AEP event, the predicted velocities and shear stresses are no greater than pre-mine velocities and shear stress along the upstream reach of the river for the same event; and
- the extreme event (adopted as 1.5 x the 0.1% AEP event) would increase velocities and shear stresses along the Nogoa River channel and the adjacent floodplain for about 7 km. Again, the increased velocities and shear stresses are no greater than pre-mine velocities and shear stress along the upstream reach of the river for the same event.

For each of these reasons, rehabilitation at Ensham is not expected to have a significant impact on the morphology of the Nogoa River in the long term.

5.2.4 Flooding risk profile

The final landform design at Ensham includes a flood protection landform PMLU to prevent floodwater from inundating residual voids on the former floodplain, providing flood immunity to Ensham up to the 0.1 % AEP flood event plus a minimum of 0.5 m. For each of these reasons, the flood risk at Ensham is considered to be low, through the application of landform design associated with pre-approved land outcomes.

5.3 Soil Assessment

Natural soils have horizons or layers, approximately parallel to the land surface, with morphological properties different from layers below and/or above it (National Committee on Soil and Terrain 2009). Horizon notation is deduced from profile descriptions, usually colour and texture, and sometimes laboratory data. Typical horizon notations are A horizons of darker, organic rich surface materials, B horizons of mineral soil layers with distinct colours, and C horizons of partly weathered parent materials beneath the solum (AB profile).

Most rehabilitation at Ensham requires creation of new soil profiles with A, B and C horizons. These new soil profiles are called Anthroposols (Isbell and National Committee on Soil and Terrain, 2016). To date, most

rehabilitation at Ensham has been completed by placing a thin A horizon of topsoil over B and C horizons of overburden –

- A horizon (0 – 15 cm depth) of topsoil
- B horizon (15 – 90 cm depth) of overburden; and
- C horizon (>90 cm depth) of overburden.

The new solum i.e., A and B horizons, has an assumed depth of 90 cm as most plant roots, plant-available nutrients and accessible water, other plant-soil interactions and soil fauna, are contained within this depth.

5.3.1 Quality of available resources

Soils at Ensham have been characterised and summarised into six major soil groups. Most soils are highly weathered, chemically and physically 'poor', and can be saline and sodic at depth. Some of the mine spoils (overburden) can also be highly dispersive and /or saline in nature.

5.3.1.1 Topsoil/ Soil groups

Soils at Ensham have been comprehensively characterised, as described in Appendix 9.5 – Soil assessment report. Essentially, there are 6 major soil groups on site, which are:

- **Soil Group (1) – Shallow Rocky Soils (Rudosols)** that occur on low rocky hills and steep escarpment slopes and eroded plateau remnants. These soils are shallow (<0.5m), exhibit very little profile development and contain gravel and rock cobbles from various geological formations. Apart from the surface (A horizon) soil, this material is not considered suitable for use as topsoil due to the predominantly coarse texture, stoniness and lower water storage capacity.
- **Soil Group (2) – Moderately Shallow Gravelly Sands, Loams and Clay Soils (Rudosols and Tenosols)** that occur on eroded middle and lower slopes and broad low gravelly rises. These soils are shallow to medium depth and comprise uniform or weakly gradational sands, loamy sands or sandy loams, loams or clayey soils with varying amounts of ferruginous and siliceous gravel or stone. These soils exhibit low soil fertility and water storage capacity and are not considered suitable for use as topsoil (apart from A horizon materials).
- **Soil Group (3) – Gradational Red and Yellow Earth Soils (Kandosols-Tenosols, Kandosols and Ferrosols)** present on the elevated dissected and eroded Tertiary plateau remnants and undulating plains associated with the Tertiary Emerald Formation. These soils include sandy, sandy loam or loamy surface soils grading to red, reddish brown or yellowish-brown sandy loam to light to medium massive or structured clay subsoils often with appreciable amounts of ferruginous gravel. The low nutrient status of this soil requires addition of suitable fertiliser, and in places tends to be moderately strongly acidic.
- **Soil Group (4) – Texture Contrast (Duplex) Soils (Sodosols)** that have formed on Permo- Triassic sedimentary rocks, on gently inclined slopes, dissection slope interfluvies, broad low rises and plains and on alluvial terraces and drainage flats. These soils are sandy, silty or loamy on the surface with a clear to abrupt change to a clayey subsoil horizon. In places, this soil type can be mildly dispersive, and sampling prior to use is recommended.
- **Soil Group (5) – Uniform Fine-textured (non-cracking) Clay Soils (Dermosols)** present on erosional plains, levees and high terraces along stream systems, undulating alluvial plains and associated with cracking clays of Soil Group 6. These soils exhibit uniform profiles or weakly

gradational profiles where clay content may increase slightly with depth, and are considered the most suitable in terms of soil physical and chemical properties.

- **Soil Group (6) – Cracking Clay Soils (Vertosols)** that form the dominant soil type within the alluvial plains associated with the Nogoa River and its tributaries. These soils have uniform medium to high clay content, pronounced swelling and shrinkage properties and commonly feature gilgai, and in places are unsuitable for use as topsoil due to increasing alkalinity, sodicity and adverse soil structure.

Most soils are highly weathered, chemically, and physically poor, and can be saline and sodic at depth.

5.3.1.2 Quality factors

5.3.1.2.1 Soil pH

Soil acidity/alkalinity affects the availability of various nutrients, toxic elements and chemical species present in soil solution and available to plant roots (Hazelton and Murphy 2007). Strong soil alkalinity reduces the plant-availability of both macro- and micro-nutrients in soils regardless of total concentration (Table 5-1). In very strongly alkaline conditions, where $\text{pH} \geq 9.0$, the availability of 8 of the 13 essential plant nutrients is reduced.

Table 5-1 Influence of soil pH on nutrient availability (from Hazelton and Murphy 2007)

Nutrient		pH _{WATER} at which nutrient availability is reduced
Macro-	N	>9.0
	P	>8.5
Micro-	Ca	>9.0
	Mg	>9.0
	Mn	>8.0
	B	>7.5
	Cu	>8.0
	Zn	>8.0

The availability of soil nutrients is a major limitation to plant production in central Queensland (Shields and Williams 1991) and P deficiency is widespread. Unlike soil N, which can be 'fixed' from the atmosphere by rhizobium bacteria in symbiotic relationships with plant roots, all soil P is derived from soil parent materials and fertilisers, if applied. Plants require relatively large amounts of available P for normal, productive growth.

Given that soil available for use in rehabilitation in Central Queensland are typically strongly alkaline, a practical approach is proposed to decide soil suitability based on pH (Table 5-2). Marginally suitable soils, with pH 8.5 – 8.9, should be with the use of ameliorants.

Table 5-2 Soil suitability based on alkalinity as pH

Soil pH	Suitability
<8.5	Suitable
8.5 – 8.9	Marginally suitable but requires amelioration
≥ 9.0	Not suitable without amelioration

5.3.1.2.2 Salinity

For mined land rehabilitation in central Queensland, topsoil with an $EC_{SAT} \leq 4$ dS/m is considered suitable. The growth of most plants is affected at higher salinities (Hazelton and Murphy 2007).

5.3.1.2.3 Sodicity

Topsoils with low sodicity are preferred for mined land rehabilitation in central Queensland. Generally, topsoils with an ESP < 6 % are suitable, while topsoils with ESP $> 6 - 14$ % are marginally suitable and typically require amelioration with gypsum to ensure aggregate stability.

5.3.1.3 Suitability of materials

Suitable topsoils for rehabilitation will have the following characteristics:

- pH < 8.5 preferably and $8.5 - 9.0$ if no other soil resources are available.
- $EC_{SAT} \leq 4$ dS/m; and
- ESP < 6 preferably and ESP ≤ 14 % with amelioration if no other soil resources are available.

Several assessments have also considered the suitability of overburden material to support the rehabilitation, effectively being placed as an alternate growth media with a view that these materials will be remediated into a topsoil over time. Previous waste material characterisation assessments include CMLR (2005), Loch (2015), URS (2005), URS (2015), and RGS (2018). In summary, the assessments demonstrate that the spoils and soils are typically sodic and saline to varying extents, and non-acid forming (Ensham Resources 2021).

The Permian spoil materials are generally non-saline to saline and sodic, and thus has some potential for use as a growth media surrogate.

5.3.2 Quantity of available resources

Table 5-3 below shows the latest inventory of the topsoil stockpiles available in Ensham. The majority of the stockpiles are Class 1 and Class 2 in quality. No further surface disturbance is planned for Ensham mine and therefore the inventory represents the total volume of topsoil available for rehabilitation use.

Table 5-3 Inventory of topsoil materials available

Location	1 – Very Good	2 – Good	3 – Marginal	4 – Poor	Total (m ³)
Total	1,211,719	987,776	577,153	21,129	2,797,777

From Table 5-3, a total of 2,199,495m³ of good / very good topsoil is available, with a further 577,153m³ considered to be of marginal, but usable, quality. Poor quality topsoil will require amelioration to be used. It is noted that Ensham frequently complete topsoil inventory updates, and this inventory reflect the latest understanding of topsoil resources available for the site (as at the end of 2021).

Table 5-4, below provides a summary of the disturbance to be rehabilitated for the Ensham site, and identifies the volume of topsoil resource required by area and type of disturbance footprint.

Table 5-4 Demand for topsoil materials, by area

Location	Topsoil volume available (m ³)	Type of disturbance	Area (ha)	~Volume required @ 150mm re-spread (m ³)
Pit AB	2,740,608	Spoil emplacement	1,755	2,632,500
Pit CDE		Borrow pits	6	9,000
Pit F		Cleared and topsoil stripped	108	162,000

Yongala		Haul road	134	201,000
		Access tracks	66	99,000
		Camp	13	19,500
		Laydown area	75	112,500
Infrastructure	57,169	Water storages	12	18,000
		Process plant	15	22,500
		Process water storage	27	40,500
Total			2,212	3,317,765

From a comparison between Table 5-3 and Table 5-4, Ensham do not have sufficient suitable material to re-spread 150mm across all areas. There is a shortfall of approximately 519,588m³ of material. This is equal to a shortfall of approximately 347 ha.

Given the magnitude of this shortfall, this is not considered to be of critical concern to the success of rehabilitation at Ensham, however the risk assessment (provided as Section 6 of this PRCP) considered the unmitigated risk associated to be high. Several actions and initiatives are proposed or underway to address this deficit and mitigate the risk. This includes the following:

- amelioration of poor topsoils and/or amelioration of spoil to create a suitable growth media, with early indications from the METS trials (detailed in Appendix 9.4) showing significant promise; and
- completion of a benchmarking exercise to understand the rehabilitation performance of other mine locations in central Queensland where 100mm of topsoil material has been applied. It is noted that, particularly for areas of 'virgin' ground such as infrastructure or disturbed areas that have been cleared and stripped, this is a common practice. It is also of note that if Ensham were to adopt an approach of applying 100mm to such areas, there would be sufficient material in inventory to meet demand.

5.3.3 Location and accessibility of resources

The haul distances described below and within the ERC are derived utilising the Spry Model, in conjunction to various site-based inputs. The Spry model simulates hauling topsoil from the stockpiles to the destination (rehabilitation) areas, recording information about the haulage including truck hours, total haul distance, etc. The Spry model uses a set of defined haul paths, and chooses the best route. By identifying the best route, this therefore identifies the haul distances for the topsoil.

Table 5-5 Topsoil haul distances derived by the Spry Model

Topsoil Location	Haul Distance
A Pit	>1000 m to <=1500 m
B Pit	>3000 m to <=4000 m
C Pit	>5000 m to <=6000 m
D Pit	> 6000 m
E Pit	>3000 m to <=4000 m
F Pit South	>1500 m to <=2000 m
F Pit North	>1000 m to <=1500 m
Y Pit	>1500 m to <=2000 m

5.3.4 Need for ameliorants and fertilisers

Most rehabilitation areas (where topsoil reapplication will occur) will require amelioration or fertiliser application at Ensham. This is due to the dispersive and/or saline nature of mine spoil, limited topsoil resources and the scale of rehabilitation works required, which requires some amelioration to support the creation of new soil profiles. Sampling of stockpiled material will occur prior to use to guide exact application rates, as well as selection and specifications of ameliorants and fertilisers.

Addressing soil limitations within Ensham soils has historically included the application of fertiliser, hay-mulch and, more recently, gypsum where needed. Past detailed amelioration and fertiliser assessment have informed the following sections. Application rates of each type of ameliorant and fertiliser are further discussed in Appendix 9.5 – Soil assessment report.

5.3.5 Suitability of soils to support PMLU outcomes

Given the limiting factors of topsoil quality and quantity at Ensham, the revegetation prescriptions are greatly influenced by land systems and soil types, ensuring the soil and spoil materials will suit the PMLU criteria and outcomes.

The extent and location of the PMLUs at Ensham which are relevant to the soil assessment, includes the following areas:

- Cattle grazing on overburden / infrastructure areas; and
- Native bushland corridor

It is notable that the majority of rehabilitation (90%) by area at Ensham has a target PMLU of beef cattle grazing. Rehabilitation suitability requires evaluation of soil and landform attributes based on the requirements for the specific PMLUs by using current technology and management.

Further, a long history of rehabilitation monitoring has demonstrated that the current rehabilitation methodology at Ensham, including treatment and use of soils, will result in successful achievement of milestone criteria for the relevant PMLUs.

Further discussion regarding to this can be found in the Appendix 9.5 – Soil assessment report, as well as Appendix 9.3 - Monitoring summary report and Appendix 9.2 – PMLU context document.

5.3.5.1.1 Use of spoil material for remediated soils

New B/C horizons provide anchorage for plants and contribute to soil nutrition; however, the principal role of subsoil is to store moisture for plant use. Understanding spoil characteristics and potential subsoil limitations that restrict root proliferation and access to stored water is essential in achieving satisfactory rehabilitation. Common limitations at Ensham that require amelioration are subsoil salinity and sodicity.

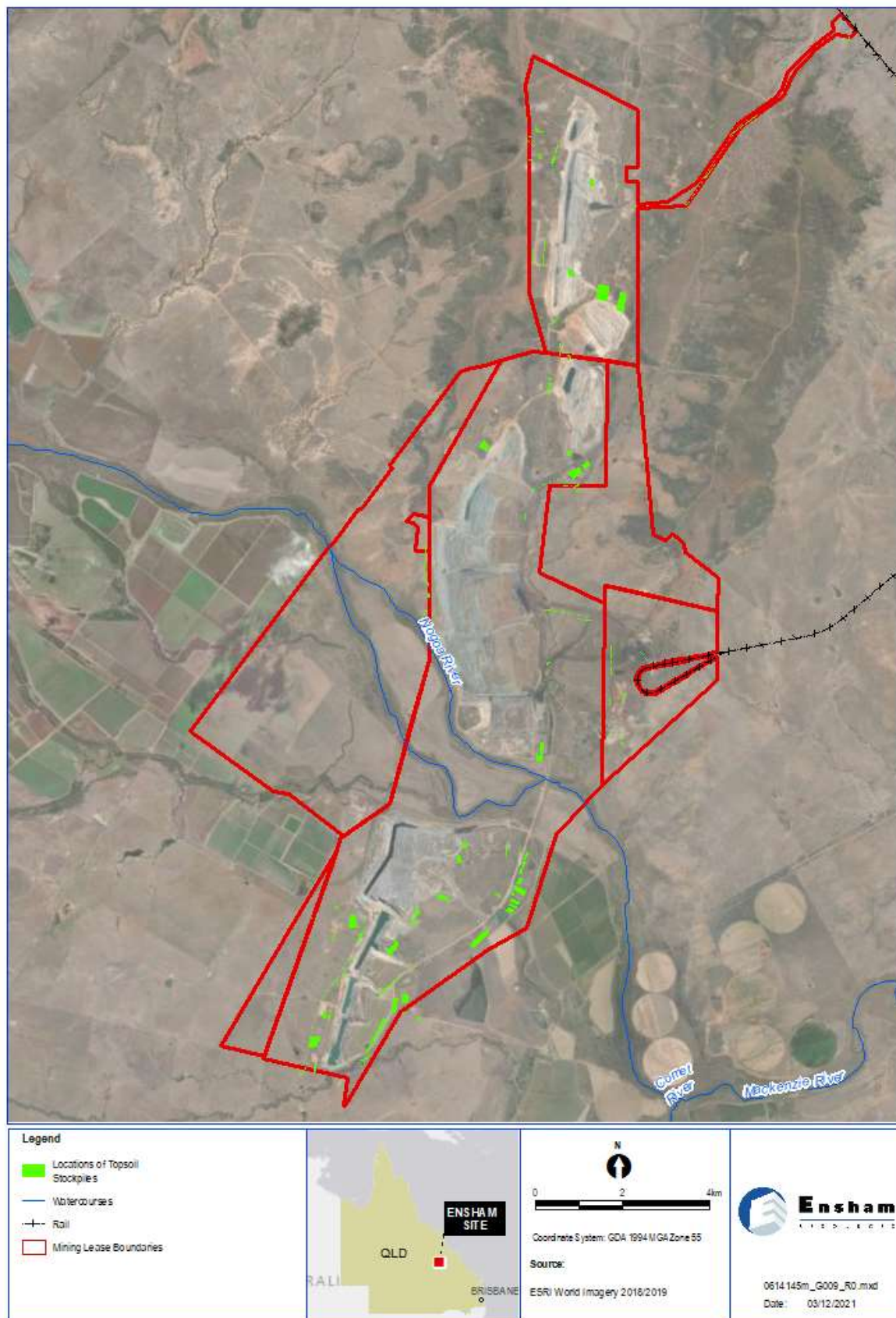


Figure 5-2 Locations of soil stockpiles at Ensham

5.4 Waste characterisation

An understanding of the geochemical characterisation of overburden materials has informed the selection of rehabilitation strategies, and appropriate PMLUs for Ensham. Geochemical hazards have been identified to investigate the character of waste rock and coal units, highlighting contaminants that pose a risk to the environment. This includes that associated with acid mine drainage (AMD), neutral mine drainage (NMD) and saline mine drainage. Adopted waste classification criteria are described as relevant and adopted by Ensham.

5.4.1 Review of sampling regime

Overburden materials at Ensham have been comprehensively characterised. To determine appropriate rehabilitated area design parameters for rehabilitation, it is crucial to understand material characteristics. Several reports have described materials at Ensham to varying extents, e.g., URS (2005), CMLR (2005), URS (2006), Loch (2015), URS (2015), and RGS (2019 and 2020) as well as RGS (2021), and each contain some useful information.

This knowledge base has covered the range of lithologies and waste materials commonly encountered at the mine. Reports demonstrate that spoils and soils are typically sodic and saline, and non-acid forming (RGS, 2018). The sampling regime meets leading practice standards in terms of sampling resolutions and coverage. It is also spatially representative of all material being mined as well as waste rock structures created, and is representative of all lithologies.

A range of analytical techniques have been applied to the sampling of waste materials, and is considered to meet and exceed the requirements of the PRCP guideline. In addition, reviews have also been conducted of downstream and surrounding surface and groundwater water quality for the site, with no evidence of AMD or NMD impacts (RGS 2019, 2020).

5.4.2 Summary of waste streams

Ensham removed Quaternary, Tertiary and Permian stratigraphic units and then mined the upper coal seam within the A, B, C, D, E, F and Y open pits. The geology of the area modelled comprises of Cenozoic sediments (alluvium, gravel, sand silt, and clay), and sedimentary rock units including sandstone, siltstone and claystone, and Triassic/Permian sedimentary units, including sandstone, siltstone, carbonaceous mudstone and siltstone and coal, as detailed in Table 5-6. The Cenozoic sediments and sedimentary units have been subdivided into Quaternary sediments and Tertiary sedimentary units when modelled. The major sedimentary rock units are primarily interbedded siltstone and sandstone with laterally continuous coal seams and some non-coal carbonaceous material, mostly mudstone.

Table 5-6 Percentage of lithological units present on pit high walls

Lithology	Pits A & B Volume (%)	Pits C, D & E Volume (%)	Pit F Volume (%)	Pit Y Volume (%)
Alluvium	1.27			
Carbonaceous Mudstone	0.37	0.38	1.01	2.63
Carbonaceous Siltstone		4.48		0.42
Clay	10.15	2.28	14.33	14.71
Claystone	5.88	0.49	6.67	0.56
Coal	0.59	5.12	7.02	7.88
Coaly Claystone			0.01	
Coaly Mudstone				0.02
Gravel	3.05			
Sand	6.96	0.67		1.38

Lithology	Pits A & B Volume (%)	Pits C, D & E Volume (%)	Pit F Volume (%)	Pit Y Volume (%)
Sandstone	28.32	54.4	33.66	42.53
Silcrete			3.21	0.07
Silt	0.27			
Siltstone	39.74	31.67	33.40	30.33
Soil	3.39	0.52	0.58	0.11
Sooty Coal			0.11	

The geological logs were used to derive inferred pre-mine volumes for the Quaternary Sediments, Tertiary Sediments and Permian Sediments. The pre-mine topography was calculated using a linear method from the crest of the highwall to the eastern edge of the deepest mined surface. The dip, and dip direction of Permian and Tertiary units was taken to be consistent and the Quaternary sediments were taken to be parallel to the predicted surface. These in-pit volumes can then be used to derive the relative proportion of these strata in the backfilled pits, as detailed in Table 5-7.

Table 5-7 Percentage of Quaternary, Tertiary and Permian by Pit(s)

Pit	Lithology Age	% of Pit	Overburden Movement (Mm ³)
Pit A and B	Permian	83.8	41.4
	Quaternary / Tertiary	16.2	
Pit C, D and E	Permian	97.8	41.0
	Quaternary / Tertiary	2.2	
Pit F	Permian	87.7	15.8
	Quaternary / Tertiary	12.3	
Pit Y	Permian	74.3	19.8
	Quaternary / Tertiary	25.7	

The result of the modelling of the type and nature of waste that comprises Ensham waste material, the following is highlighted:

- All pits are modelled as comprising a majority of Permian over/interburden, with the minor presence of Quaternary and Tertiary materials.
- Cenozoic sediments occur to varying depths from north to south.
- The geological model of all pits extends to the bottom of the relevant floor seam (namely Aries 1, Castor, and Pollux seams from north to south), between 90 – 125 m below ground level (bgl).
- The floor seams (Aries, Castor and Pollux) dips westward from approximately 2° – 6° and this dip and dip direction is roughly consistent through the model.

5.4.3 Contaminants of concern

URS (2015) found that materials represented by overburden and coal samples had low sulfur concentrations (< 0.05 %S) and contained up to two orders of magnitude more acid neutralising capacity compared to acid generating capacity. The overwhelming majority of samples were classified as non-acid forming (NAF) or Acid Consuming (AC) and the bulk mine waste materials had negligible risk of acid generation and a very high factor of safety in terms of their potential to generate acid.

Total metal/metalloid concentrations in the overburden and coal materials were low compared to un-mineralised soil materials. Leachate from these mining materials was generally pH neutral to slightly alkaline and had low levels of salinity. Dissolved metal/metalloid concentrations were below the majority of applied water quality guideline concentrations. There is the potential for saline drainage from spoil materials and dispersion due to elevated sodicity.

The depositional environment of the coal in the Ensham stratigraphic sequence was an alluvial environment with negligible marine influences at a regional level, therefore the magnitude of any potential for AMD generation is expected to be limited, compared to coal formed in marine influenced strata.

Surface water quality monitoring data collected over the past decade (2010 – 2021) is well aligned with the groundwater data and overall statistics show that at surface water quality is typically pH neutral with low concentrations of dissolved parameters such as metals/metalloids (RGS, 2021). Salinity in surface runoff collected from rehabilitated areas is also low and generally reflects predicted levels in pits and dams containing un-rehabilitated spoil runoff and water pumped from underground (RGS, 2021). Runoff quality, collected from rehabilitated landforms, comply with completion criteria for Electrical Conductivity, Sulphate and specified metals.

5.4.4 Classification of waste materials

CMLR (2005) provides a simple and practical classification of overburdens based on geology and measured physical and chemical parameters. Four distinct spoils were identified, described and mapped throughout the mine (Table 5-8). The geochemistry of these spoils is well understood and, as a result, there has been a focus on understanding and managing salinity and sodicity as the principal limitations to plant growth and stability in rehabilitation.

Soil salinity is the concentration of dissolved salts in soil solution. These are mainly Na⁺ but also K⁺, Ca²⁺ and Mg²⁺ which may be chlorides, sulphates, or carbonates. Excess salt in soil solution, i.e., high salinity, inhibits osmotic processes that enable plant roots to absorb soil moisture. Salinity is measured as electrical conductivity (EC) in a 1:5 soil/water suspension (EC_{1:5} or EC_{WATER} dS/m). This is converted to saturated EC (EC_{SAT} dS/m) by accounting for the moisture holding capacity of the soil, i.e., clay content. EC_{SAT} is preferred as it better approximates the salinity of soil solutions experienced by plant roots.

Table 5-8 Spoil types and distributions at Ensham (adapted from CMLR 2005)

Era	Period	Group	Description	Ensham pit							
				A	B	C	D	E	F	Y	
Cainozoic	Quaternary	n/a	Alluvial sands, silt gravel	Q							
	Tertiary	n/a	Sandstone, siltstone, claystone		T2				T2		
				T1							

Palaeozoic	Upper Permian	Blackwater	Rangal coal measures	P
				COAL

Sodicity occurs when the exchangeable Na^+ on the cation exchange complex leads to clay dispersion in soil. Sodic soils have the following issues.

- Surface crusting
- Low infiltration and hydraulic conductivity
- Hard, dense subsoils; and
- Tunnel and gully erosion.

The level of exchangeable Na^+ is determined by measuring the concentration of all the exchangeable cations in the soil and expressing the amount of exchangeable sodium as a proportion of the sum of all the exchangeable cations, known as the cation exchange capacity (CEC) (Hazelton and Murphy 2007). This proportion is called the exchangeable sodium percentage (ESP).

A description of each of the four spoils at Ensham follows.

5.4.4.1 Quaternary spoil (Q)

Pale brown to yellow alluvial sands and gravels (Figure 5-3). Low clay content means material has little water or nutrient holding capacity. Non-saline but sodic with low surface cohesion, this overburden is highly dispersive and prone to excessive erosion when exposed to rainfall.



Figure 5-3 Quaternary spoil in B Pit is screened for gravel and sand for use around site (left) and erosion in situ Quaternary spoil in B Pit endwall (right)

5.4.4.2 Tertiary spoil (T2)

This overburden is Tertiary age material that appears above T1 overburden in B, C, F and Y pits. It is distinguishable from T1 by its darker colour but is otherwise physically and chemically similar.

5.4.4.3 Tertiary spoil (T1)

Overlying the Permian overburden, this material is derived from Tertiary age alluvium or colluvium (Figure 5-4). It is consistently saline to extremely saline, with chloride levels toxic to plants at Y Pit, and consistently sodic to extremely sodic. This material is extremely dispersive.



Figure 5-4 Tertiary spoil overlying Permian spoil in Y Pit (left) and F Pit (right)

5.4.4.3.1 Permian spoil (P)

Easily distinguished by its bluish grey colour, consisting of rapidly weathering mudstones and siltstones, with orange/yellow resistant sandstone fragments (Figure 5-5). Derived from Permian sedimentary rocks of the Blackwater Group, it is generally non-saline to saline and sodic.



Figure 5-5 Permian spoil in D Pit emplacement (left) and E Pit highwall (right)

5.4.4.4 Waste management and placement strategies

At Ensham, conservative slope gradients have been adopted as a key management strategy to control erosion of Tertiary overburden materials. The common approach is to limit slope gradients, with the majority of slopes on site (and constructed using these materials) not more than 10%.

Key additional practices that are adopted include ensuring slope lengths do not exceed 200 m, not using contour banks or rock lined waterways, and applying surface treatment for erosion control at the time of seed sowing (hay mulch). Further information is provided as to landform design controls in Section 5.5.

Permian spoil materials are considered to be relatively benign, and it is about 50% less saline and sodic than the Tertiary overburden. Thus, it is favoured for use as a surrogate growth media material in rehabilitation because it is less hostile to plant establishment and growth, and more erosion resistant, due in part to its variable content of coarse sandstone fragments.

5.4.4.4.1 Effects of sodicity and salinity

Salinity and sodicity are opposing forces in soil / overburden aggregate stability: salinity is aggregating while sodicity is dispersing. Salinity and sodicity often occur together and salt affected materials have historically

been grouped as saline, non-saline and sodic, or saline and sodic, depending on the relative composition of the salts present. Using available data, Ensham overburdens and soils can be grouped into these categories (Figure 5-6 and Figure 5-7). Here, a saturated electrical conductivity (EC_e) >4 (dS/m) and an exchangeable sodium percentage (ESP) >6 are the generally accepted threshold limits for salinity impacts on plants and sodicity impacts on soil structure. For regional context, the 32 central Queensland soils and overburdens assessed by (So et al. 1998) in ACARP Project C4011 are included.

However, for a given sodicity value, as EC increases soil dispersion decreases. Conversely, very low EC values mean that a soil may become dispersive where the ESP is very low, e.g., ESP of 2. The relationship between salinity and sodicity is the electrochemical stability index (ESI). ESI is determined by calculating the ratio of EC to ESP, i.e., $ESI = EC_{1:5}/ESP$. The adopted critical ESI value for Australian soils is 0.05 (McKenzie 1998). Materials with an ESI less than the critical value will be prone to dispersion. Most of the Ensham overburdens and soils are highly dispersive.

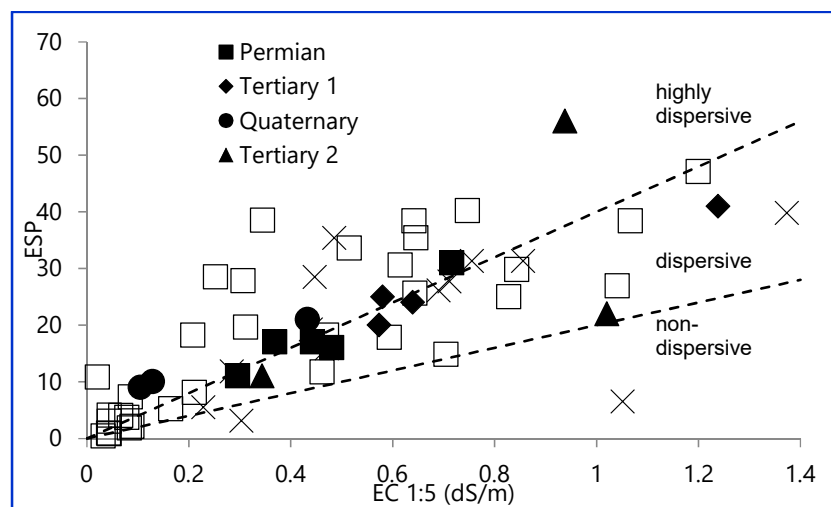


Figure 5-6 Classification of dispersive materials showing Ensham overburdens (after CMLR 2005), 16 central Queensland overburdens by ACARP C4011 (So et al 1998) and 40 central Queensland overburdens by ACARP C12031 (Henderson 2004)

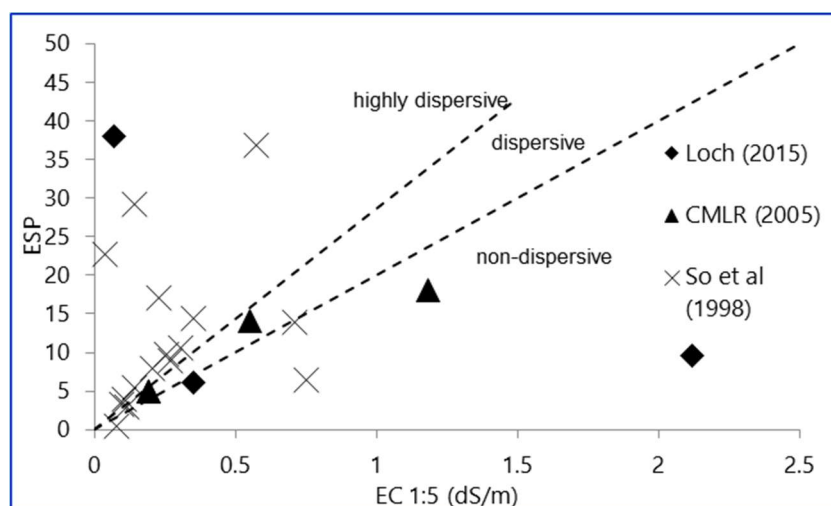


Figure 5-7 Classification of dispersive materials showing Ensham soils (after CMLR 2005 and Loch 2015) and 16 soils by ACARP C4011 (So et al 1998)

ESI explains the extremely dispersive nature of some overburdens, particularly Tertiary age materials. Although also highly saline, this salinity is insufficient to counter the effects of extreme sodicity, and the material disperses readily and is prone to excessive erosion. Ensham overburdens can be ranked in terms of salinity, sodicity and dispersivity (Figure 5-8).

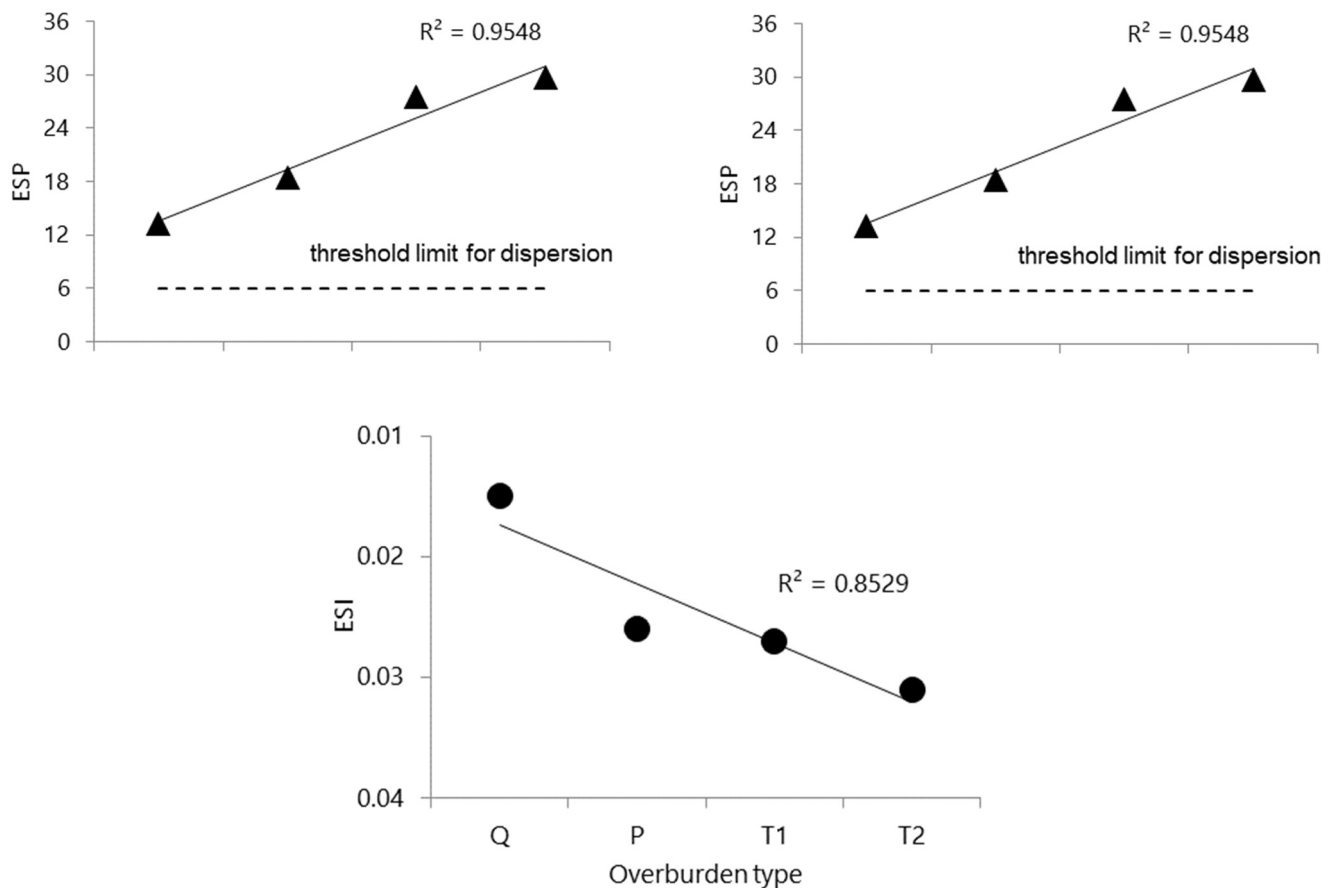


Figure 5-8 Relative salinity (a), sodicity (b) and dispersivity (c) of Ensham overburdens (after CMLR 2005)

This analysis shows that:

- Quaternary overburden is the most dispersive, but Tertiary overburdens are the most saline and most sodic;
- Tertiary overburdens are about twice as saline as Permian overburdens; and
- All overburdens are highly dispersive.

5.4.4.4.2 Quaternary spoil (Q)

Quaternary overburden is the most dispersive and least cohesive overburden at Ensham, making it prone to excessive tunnel and gully erosion. This material will be selectively placed and buried beneath other material to ensure it does not present at or near the surface of final landforms. It is not suitable for topsoil application and rehabilitation.

5.4.4.4.3 Tertiary spoils (T1 and T2)

Tertiary overburdens are the most saline and sodic, are prone to excessive dispersion and erosion, and occur in every pit at Ensham. Common throughout central Queensland mines, Tertiary overburdens have been extensively studied by ACARP and other industry-led research. For example, ACARP C12031 *Rehabilitation of Dispersive Tertiary Spoil in the Bowen Basin* by Henderson (2004) made the following recommendations in ascending order of risk of poor outcome, i.e., decreasing hazard control effectiveness.

- Bury under another spoil type.
- Cover with at least a metre of rocky spoil to create a 'store and release' cover system.
- Topsoil and grass cover at slope angles that avoid sliding failure along the soil/spoil interface when wet. Provide measures to assist erosion control until grass is established.

Practice at Ensham and other mines in central Queensland shows that conservative slope gradients are required to control erosion of Tertiary overburden. The common approach is to limit slope gradients to not more than 10%. Ensham can demonstrate appropriate hazard control effectiveness with respect to dispersion and erosion risks when:

- Slope gradients of Tertiary overburden do not exceed 10% maximum gradient
- Slope lengths do not exceed 200 m
- Contour banks and rock-lined waterways are not used; and
- Hay mulch is applied at the time of sowing.

5.4.4.4.4 Permian spoil (P)

Permian overburden is about 50% less saline and 50% less sodic than Tertiary overburdens. Though similarly dispersive, the material is favoured for rehabilitation because it is:

- Less hostile to the establishment and growth of plants; and
- More erosion resistant, due in part to its variable content of coarse sandstone fragments.

5.5 Landform design at Ensham

5.5.1 Development of design concept

Development of the landform design concept for Ensham commenced with collation of design criteria and literature review of regulatory publications, best practice guidelines, ACARP research reports, site documentation and historical information and previous landform studies completed. Relevant information on rehabilitation and landform designs from similar mine sites in Central Queensland was also utilised where available; and coupled with understanding and review of site conditions. This process developed a range of landform and residual void design options which were subsequently investigated.

A previous version of the EA required for a detailed residual void study to be completed to inform the strategy around retained voids, and by extension, surface landforms to be retained at the end of mine life for Ensham. The current EA (*EPML00732813*) is representative of the agreed outcomes from this Residual Void project.

Further discussion of the landform development process is provided in Appendix 9.6 – Landform design report.

5.5.2 Key factors of relevance to design concept

The Ensham EA requires all surface areas significantly disturbed by mining activities to be rehabilitated to a safe, stable and non-polluting landform, with self-sustaining vegetation cover. 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. These requirements, have been incorporated into the landform design concept as appropriate.

Development of the landform design has further required the synthesis of a wide range of technical and environmental factors and constraints, into the design concept. This concept has addressed any underlying factors through design, but also responds to the specific requirements present for Ensham to ensure long-term environmental control and adequate performance.

The environmental factors have typically driven the design concept outcomes, as with the following considerations:

- spoil type
- appropriate slope criteria for each spoil type
- disturbed material and land
- the location and performance of adjacent watercourse
- floodplain interactions and protection
- rehabilitation drainage

The key environmental factor of relevance to Ensham relates to the erosive potential of materials, and by extension, the erosive stability of the landforms. This has formed a primary driver of the landform design concept as well as the overall rehabilitation approach for Ensham. A further secondary factor that has driven the landform design relates to the PMLU of cattle grazing, and ensuring the land suitability requirements are provided to support these land outcomes.

5.5.2.1 Achieving sustainable rates of soil loss (erosion)

Erosion is the greatest risk to any post-mining landscape in central Queensland. Though historical rates of soil loss up to 40 t/ha/y were considered acceptable, the contemporary view is that erosion rates from rehabilitated landforms should be analogous to surrounding unmined areas. Williams (2000) summarised various soil losses and found for mixed pasture and woodlands, rates have a maximum of around 4 t/ha/y. Coincidentally, Grigg *et al.* (2001) conclude the rate of soil loss in mine rehabilitation should not exceed the rate of soil renewal, which is less than 4 t/ha/y.

It is well established that high vegetation percentages reduce erosion in rehabilitation, even on steep slopes (Carroll *et al.* 2000; Loch 2000). Under vegetation, infiltration capacities increase greatly, soil structure is improved, and erosion can be greatly reduced. So *et al.* (1998) suggest 30 to 40 % vegetation cover will be required to reduce erosion to acceptable levels. For sloping rehabilitation, rates higher than 50% were recommended by Grigg *et al.* (2001).

With consideration to material characteristics (as further detailed in Section 5.4) and more than 40 years of industry-led research and practice, Ensham has determined the following typical design objectives for slopes.

1. Tertiary overburden slopes, regardless of soil type, will typically have:

- Gradients $\leq 10\%$, and
 - Lengths $\leq 200\text{m}$, variable depending on the size of the contributing upper catchment.
2. Permian overburden slopes, regardless of soil type, will typically have:
- Gradients $\leq 15\%$, and
 - Lengths $\leq 100\text{m}$, variable depending on the size of the contributing upper catchment.

The above landform design criteria have been modelled to demonstrate they result in rehabilitation which is erosionally stable over the long term (as per Appendix 9.6 Landform design report), and is reinforced by practical examples of 20 year old rehabilitation demonstrating success. The gentle slope angles allow for longer slope lengths without resulting in unacceptable stability concerns.

5.5.2.2 Land suitability requirements for beef cattle grazing PMLU

More than 90 % of rehabilitation at Ensham has a target PMLU of beef cattle grazing. Determination of rehabilitation suitability requires evaluation of soil and landform attributes based on the requirements for beef cattle grazing land outcomes.

Five land suitability classes are defined for use in Queensland, with land suitability decreasing progressively from class 1 to class 5. Land is considered less suitable as the severity of limitations for a specified land use increase. The five land suitability classes are summarised below:

- Class 1 - Suitable land with negligible limitations.
- Class 2 - Suitable land with minor limitations.
- Class 3 - Suitable land with moderate limitations.
- Class 4 - Marginally suitable land with severe limitations.
- Class 5 - Unsuitable land with extreme limitations.

Suitability classification evaluates rehabilitation in terms of the potential to graze and finish cattle on improved pastures. The evaluation applies a strict set of rules to determine suitability and is based on frameworks developed and applied previously to unmined land in the region, e.g., Shields and Williams (1991), and is further described in Appendix 9.2- PMLU context report. Within this evaluation, there are certain landform aspects that have been considered and incorporated into the design concept.

5.5.3 Ensham final landform

Guided by the abovementioned principles and criteria, Ensham have designed a final landform in adherence to the objectives, PMLUs and the indicative plan in the land outcome document (EA). Development of the landform was undertaken through use of a modelling software that took into consideration limitations, criteria and rehabilitation strategies to enable the development of successful rehabilitation.

Key parameters were input into the modelling software, there are inclusive (but not limited to) the following:

- Identification of spoil type,
- Retaining maximum slope criteria for each spoil type dictated in the EA,
- Accounting for all disturbed material and land,
- Pertaining to the limitations dictated in the EA including, but not limited to:

- Tertiary slopes 0-10%
- Permian slopes 0-15% slopes
- Maximum of 10% inward facing slopes in the Cattle grazing PMLU between 15-25% slopes (and encased by slopes 0-15%)
- NBC maximum slope 25%
- Maximum dimensions for groundwater daylighting areas
- Competent highwalls maximum slope of 275%, incompetent maximum 50% slopes.
 - A South, F & Y pit $\leq 25\%$
 - B Pit Endwall $\leq 15\%$
- Watercourse facing slopes $\leq 15\%$
- Void facing slopes within the Highwalls NUMAs reduced to $\leq 25\%$ under exempt conditions.
- Installation of benches into rehabilitation slopes
- Minimum of 2km width in the floodplain (between B & C pit)
- Retain permanent flood structure 0.1%AEP + minimum 0.5m freeboard
- Planned drainage, particularly from highwalls to groundwater daylighting areas
- Consideration that the final landform will be able meet success criteria (safe, stable, non-polluting, land use) and will not cause environmental harm.

The resulting final landform is displayed in the below 3D LiDAR figure (Figure 5-9). For reference, a pre-mining landform figure is located in Section 1.4.1.

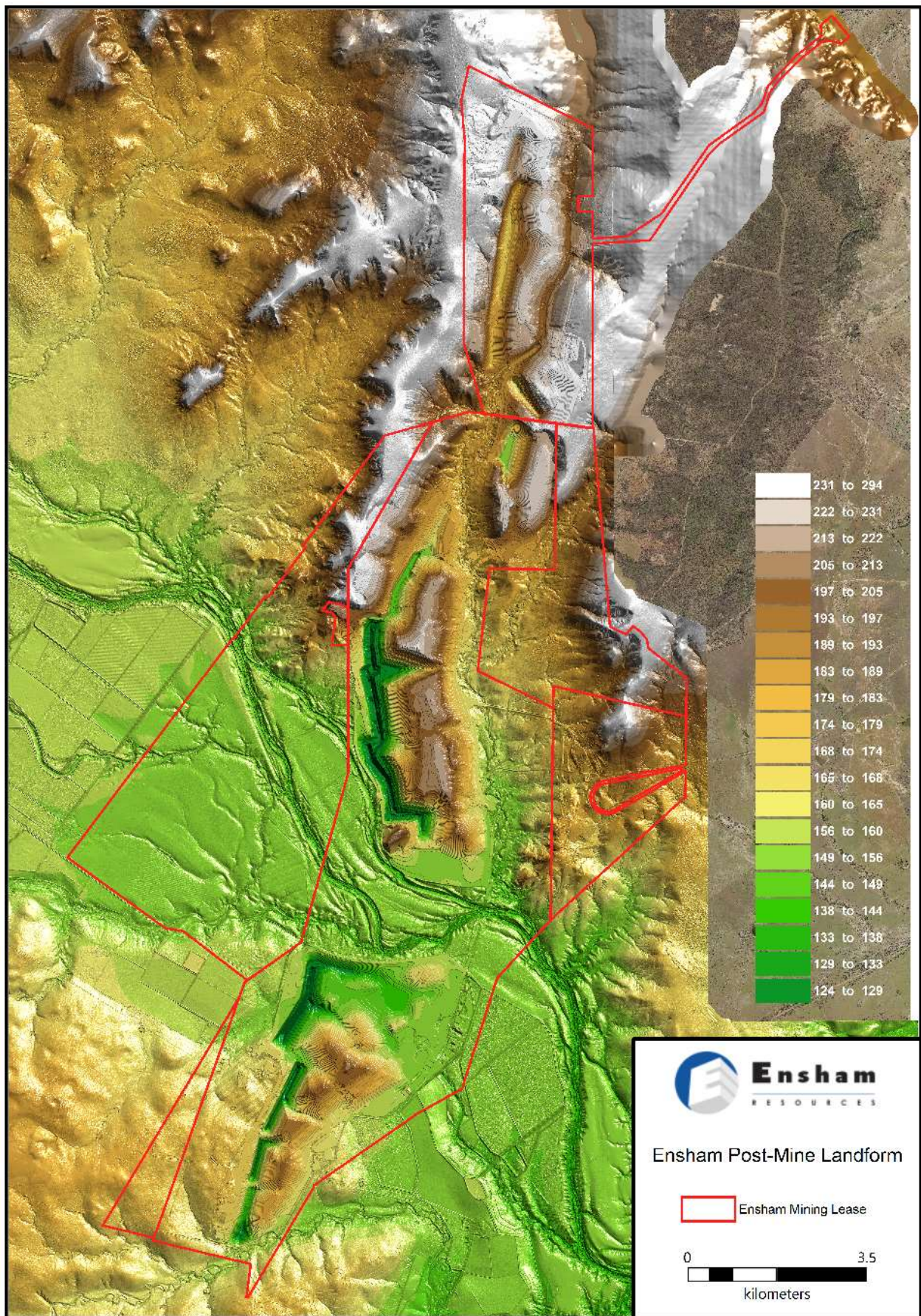


Figure 5-9 Ensham Final Landform

5.5.4 Assessment of long-term landform stability

A geotechnical investigation was undertaken as part of the Residual Void project to explore stability requirements for the final landform design in terms of void geometry. Geotechnical stability considers sudden and catastrophic surface failures such as gross rock failures, major landslips and highwall collapses. Key recommendations were made in relation to the maximum slope gradients that would be stable for the site over the long-term. This has subsequently informed the landform design concept.

In addition to geotechnical stability, the landform was also assessed against longer term, more gradual erosion, with landform evolution modelling completed. Slope angle, length of slope, and vegetation cover are important factors in the control of erosion, and can be incorporated in landform design to manage erosion characteristics of the final landform. Site practices for spoil rehabilitation have been developed over years considering the erosional stability of rehabilitated areas.

Modelling was completed for a 500-year period, and a benchmark range between 5 – 10 t/ha/yr is deemed to be appropriate, based on a literature review. Results showed that the erosion rates of the Ensham landform batter slopes are acceptable, and within this range. Further discussion of the assessment is presented in Appendix 9.6 – Landform design report.

Ensham has also had success rehabilitating Tertiary spoil dumps with 10% slope regrades, coupled with maximum slope lengths of 200m and 10m wide benches as slope breaks. Permian spoil has been found to be erosionally stable at regraded slopes of 15% with 100m slope lengths. Rehabilitation construction practices were consistent with current approaches, including topsoiling, deep ripping, grass seeding, and hay mulching. Benches are not topsoiled, but are populated with trees, as the absence of soil reduces competition between fast establishing grasses and the desired tree/shrub community.

5.5.5 Landform rehabilitation process

Ensham has a long history of completing successful rehabilitation and the following construction process has been developed from the proven methodologies. The key steps for the completion of rehabilitation for all PMLU areas, is as described within Section 5.14 of this PRCP.

The construction methodology has been prescribed based on the material availability and meeting PMLU land outcomes. A key requirements for achieving PMLU outcomes for areas of rehabilitation require the achievement of a stable landform, and therefore carefully adhering to the key landform construction process is of high importance to ensuring successful rehabilitation and land outcomes. Further discussion of the construction methodology is presented within Appendix 9.6 – Landform design report.

5.5.5.1 QA/QC processes

Ensham adopt a number of QA/QC processes to ensure rehabilitation outcomes are successfully met and rehabilitation meets quality requirements. This consists of 'conformance to design' processes, annual rehabilitation inspections and monitoring and rehabilitation performance reporting.

5.5.5.2 Trials

Ensham has a strong operational history of completing rehabilitation (with over 1,500 ha of progressive rehabilitation completed) and producing high quality rehabilitation areas. Trials and reviews have been conducted at Ensham, with review of tree and shrub species, a variety of soil arrangements, fire treatment assessment and investigation of grazing impacts within rehabilitation areas. Rehabilitation progress is reviewed annually and Ensham modifies the rehabilitation practices as needed to carefully improve rehabilitation outcomes.

5.5.5.3 Limitations and assumptions

Key assumptions and limitations of the Ensham landform design concept have been identified in Appendix 9.6 – Landform design report.

5.6 Cover design

A cover system is typically required for circumstances where the surface treatment of a mine landform or other waste material is needed to manage the exposure of waste materials that may be reactive (e.g. AMD, NMD or saline drainage). Where cover systems are required, it is in order to ensure that such contaminants are not released to the receiving environment, create legacy concerns or directly impact on the success of rehabilitation.

Most of the materials in Ensham are classified as NAF, with low potential for acid drainage. The materials also have a low potential to produce drainage with elevated metal or metalloid concentrations. Testing undertaken over the life of the mine to date have not identified any elevated levels of metals or metalloids. However, Ensham spoil material is of concern from the perspective of salinity and dispersivity.

For these materials, the preferential waste handling strategy employed for the site is that the more dispersive materials are placed under a cover of less dispersive material. Where this is not possible, the slope is reduced, as defined in Section 5.5.3

As such, no engineered covers will be installed, and therefore, the remaining requirements for cover design are not relevant.

5.7 Water management

Management of surface and groundwater is a key consideration in achieving long-term rehabilitation success, with surface water features being a primary consideration for rehabilitation at Ensham. Post-mining landforms at Ensham are designed to not concentrate overland flow and therefore, do not require contour banks or rock-lined waterways to transport overland flow downslope and off rehabilitation.

Rather, landform design is sympathetic to natural geo-fluvial processes. Slope lengths are broken by wide, flat benches to slow runoff velocities without concentrating flow and to encourage infiltration and soil profile wetting. This limits the volume and velocity of runoff and encourages revegetation. The existing water management plan will continue to be the basis of water management across site until end of mine life.

5.7.1 Contaminants of concern

Most of the contaminants of concern relevant to the completion of rehabilitation and closure relate to salinity and the transport of salts due to the water infiltration through the spoil materials. These issues have been considered with the design of the rehabilitation strategy for Ensham.

There may be other contaminants, such as metals or other chemicals utilised for mining activities. The risk posed by all contaminants is explored below, with the source, pathway and fate of contaminants detailed.

5.7.2 Source, pathway and fate of contaminants

A primary source of contaminants for Ensham is the spoil material that comprises the overburden dumps, and has been used to backfill in-pit voids. Both Quaternary and Tertiary materials can represent a source of salinity, as detailed in Section 5.4. It is noted that a wide range of management measures have been employed to

address the risks posed by these materials, which primarily relate to potential for erosivity and saline drainage. Table 5-9 summarises the source, pathway and fate connections for contaminants relevant to Ensham.

Table 5-9 Contaminants of concern by source-pathway-receptor interactions

SPR	Potential contaminant and issue	Potential for environmental harm	Key interventions and management strategies
Source	Waste material encapsulated in WRD	Interaction of waste material with water resulting in mobilisation of salinity, sediment and other contaminants	• Placement strategy for waste materials • Adoption of appropriate landform design criteria to ensure erosionally stable land outcomes
	Point source contaminants from all areas	Mobilisation of sediment, salinity or other contaminants	• Records of contaminants placement on site • Adoption of an appropriate remediation process at closure
	Airborne dust and odour from WRD surface	Mobilisation of other contaminants and particulates	• Dust control during operations and rehabilitation activities • Rapid stabilisation of rehabilitation areas through revegetation
Pathway	Runoff into surface water drainage features	Mobilisation of sediment, salinity or other contaminants	• Direct WRD areas internally into voids • Adoption of appropriate landform design criteria to ensure erosionally stable land outcomes • Adoption of water features such as benches to prevent sediment laden runoff • Monitor WQ in receiving environment and manage if required
	Seepage passing from daylighting areas into groundwater systems	Interactions between daylighting locations and surrounding groundwater environment	• Modelling has indicated the groundwater will act as a permanent sink due to presence of void daylighting areas as per the EA, • Monitor for seepage locations and manage if required • Monitor WQ in groundwater systems
	Airborne particulates that are then deposited	Transport as airborne particulates	• Dust control during operations • Rehabilitate as soon as available to stabilise surface
Receptor	Groundwater daylighting water areas (NUMA)	N/A	N/A
	Receiving surface water environment	Impact to sensitive receptors – human or animal, or aquatic ecosystems Undesirable modification to WQ within downstream surface water catchments	• Monitor receiving environment and apply EA WQ criteria

SPR	Potential contaminant and issue	Potential for environmental harm	Key interventions and management strategies
	Surrounding groundwater system	Impacts to sensitive receptors – human or animal Undesirable modification to WQ within groundwater systems	Monitor receiving groundwater systems and apply EA GW quality criteria
	Surrounding surface areas and dwellings	Impacts to sensitive receptors – human or animal Undesirable modification to surface systems, such as vegetation	Monitor sensitive receptors and dust deposition levels

5.7.3 Infiltration and seepage intervention and collection

There are no areas or features where infiltration or seepage occur which would require intervention or collection. If any patterns of seepage change over time, further consideration may be required of the need for seepage intervention and collection systems. This is considered a low contamination risk, given the lack of current seepage, the landform design arrangement and the between source and potential receptors.

5.7.4 Current water management requirements

5.7.4.1 Management of Mine Affected Water (MAW)

MAW is pumped from mining areas and stored on site in mine water storages and in certain mining pits. The storage water levels are maintained with sufficient freeboard to prevent overtopping in design rainfall events, and in most cases are not affected by external catchments. The mine water system is able to discharge waters in a controlled manner from a number of storages to the Nogoia River, in accordance with EA release conditions (which include minimum flow requirements and maximum salinity levels). The EA conditions detail a variety of contaminants required to be sampled to identify the risk they post to the environmental values of the receiving environment.

5.7.4.2 Management of Surface Water Runoff

In order to collect the suspended sediments entrained in runoff from disturbed areas, catch drains direct the runoff to sediment mitigation areas such as sediment dams. Sediments are settled out or deposited before reaching receiving waters. Deposited sediments are excavated periodically to maintain the capacity of the dams. Alongside this, rainfall runoff samples are collected rehabilitated areas to demonstrate the compliance of the surface water runoff to EA quality characteristics as part of the certification process.

5.7.4.3 Management of Runoff from Infrastructure Areas

Industrial Area runoff is also collected in catch drains and directed to sediment dams. Areas which are known to produce oil or chemical-affected runoff are banded to separate contaminants from cleaner flows, and directed to storage dams, with the water being recycled for use in the process.

5.7.4.4 Management of Sewage Effluent

Sewage effluent is produced at the sewage treatment plant and is stored in large secure tanks. The effluent is sampled regularly to demonstrate compliance, then enabling the effluent to be irrigated through a series of pipework into a low traffic area of irrigated trees.

5.7.5 Long term water management requirements

5.7.5.1 Drainage and Catchments

Ensham's Erosion and Sediment Control Plan details the specifics of Ensham's catchments and drainage strategies. As a summary, Ensham targets drainage to minimise the creation of MAW, whilst diverting the majority of runoff to sediment dams (or raw/stock water dams) where possible.

5.7.5.2 Surface Water Diversions

Ensham Mine has one surface water diversion existing within the mining tenures. The Boggy Creek Diversion (BCD) was established in 1993 to reroute water away from the planned mining areas. Following extensive planning and the appropriate regulatory approvals, the BCD commenced rehabilitation in 2019 and is scheduled to be completed in 2021. This diversion is a permanent diversion and will require minimal maintenance through its life.

5.7.5.3 Dewatering Requirements

In order to fulfil rehabilitation requirements at Ensham Mine, mine pits will require dewatering. This shall be done by:

- Use of the water for dust suppression
- Release into the Nogoa River
- Translocation to water storages underground
- Evaporation

Avenues for treatment and or sale of water can be explored should it be deemed necessary by the mine.

5.7.5.4 Water Monitoring

Regular water monitoring is undertaken at Ensham Mine to track the quality (and levels for groundwater) of MAW, runoff, groundwater and raw water, inclusive of upstream and downstream reaches of the Nogoa River.

Monitoring of the condition of water management structures, such as dams, sediment dams and levees is also incorporated into Ensham's scheduled monitoring. These inspections assess not only the condition, but also identify any repairs required, and provide recommendations for improvement.

5.8 Revegetation

5.8.1 Revegetation objectives

Revegetation has two primary aims. Initial rapid vegetation establishment is required to achieve a transitional groundcover greater than 50% to control soil loss by water erosion to sustainable levels. This may be achieved in some instances using a non-persistence cover crop such as annual millet, in addition to longer-lived grasses and forbs. In the longer term, establishment and persistence of specific species is needed to achieve specific completion criteria for each PMLUs.

Ensham has developed revegetation objectives for each PMLU (Table 5-10). Some of these are common, like rapid establishment for erosion hazard control effectiveness, while others are specific to PMLUs, e.g., 3P species for beef cattle grazing PMLU.

Table 5-10 Revegetation objectives for each PMLU at Ensham

PMLU	Revegetation objectives
Beef cattle grazing	1. Rapid groundcover establishment to provide long-term erosion hazard control effectiveness. 2. $\geq 50\%$ established and persistent vegetative groundcover for all slopes from 0-15%. 3. $\geq 80\%$ established and persistent vegetative cover for slopes from 15% to 25%. 4. A persistent sward of 3P pasture species including legumes (perennial, palatable and persistent). 5. Weeds comprise less than 10 % of groundcover.
Landholder retained infrastructure	There are no revegetation objectives for this PMLU.
Native bushland corridor	1. Rapid groundcover establishment to provide long-term erosion hazard control effectiveness. 2. $\geq 50\%$ established and persistent vegetative groundcover for all slopes from 0-20%. 3. $\geq 80\%$ established and persistent cover (vegetative and/or rock mulch) for slopes from 20% to 25%. 4. Species richness ≥ 2 tree species, ≥ 3 shrub species, ≥ 5 groundcover species. 5. Weeds comprise less than 10 % of groundcover.
Boggy Creek diversion	1. Rapid groundcover establishment to provide long-term erosion hazard control effectiveness. 2. Terrestrial vegetation communities should aim to resemble RE11.7.2/11.7.4 and RE11.7.1 3. Riparian vegetation communities should resemble RE11.3.25. 4. The revegetation outcome must achieve a long-term self-sustaining vegetation community.
Flood protection landform	1. Rapid groundcover establishment to provide long-term erosion hazard control effectiveness. 2. $\geq 50\%$ established and persistent vegetative groundcover for all slopes from 0-20%.

5.8.2 Key flora species selection

The selection of flora species to be used in revegetation considers the PMLUs outcomes to be achieved. The selection has considered the surrounding and post-mining land use concept, and the capacity of the available topsoil resources at the time of revegetation to support seed.

5.8.2.1 Seed mixes

Key species representative of each PMLU for beef cattle grazing and flood protection landform are provided (Table 5-11). For revegetation of Boggy Creek diversion, Alluvium (2018) recommends more than 60 suitable species. The species mix for Native Bushland Corridor is yet to be decided. It will likely include species such as *Corymbia citriodora* and/or *Acacia shirleyi* (or *A. catenulate*) to ensure development of the appropriate floristic composition in accordance to the regional ecosystems described in the EA.

Where possible, seed mixes will be locally sourced, or at minimum, will aim to be sourced from suppliers that harvest from areas demonstrating similar environmental characteristics to that of Ensham Mine. In many cases, supply availability and historical seed success performance/quality will be the key factors driving seed sourcing.

Table 5-11 Key species for Beef cattle grazing and Flood protection landform

Scientific name	Common name	Sowing rate (kg/ha)
<i>Chloris gayana</i>	Reclaimer Rhodes	2.5
<i>Chloris gayana</i>	Katambora Rhodes	2.5
<i>Chloris gayana</i>	Callide Rhodes	2.5
<i>Macroptilium bracteatum</i>	Burgundy Bean	2.5
<i>Stylosanthes spp.</i>	Stylo Mix	2.5
<i>Urochloa mosambicensis</i> cv. <i>Saraji</i>	Sabi grass	5
<i>Cynodon dactylon</i>	Couch	2.5
TOTAL		20

5.8.2.2 Species of conservation significance

As detailed in Sections 1.4.8 and 1.4.9 of this PRCP, there are a range of vegetation communities and fauna species of conservation significance with potential to occur at Ensham. Recent studies (AARC, 2019) also indicate there are three flora species of conservation significance which may occur in Ensham.

The areas covered by Native Bushland Corridor will be investigated to the view of incorporating species of conservation or cultural significance.

5.8.3 Fauna habitat and use requirements

The predominant PMLU for Ensham will be cattle grazing. The Native bushland corridor PMLU provides opportunities from native fauna species movement in the landscape (Ensham Resources, 2021). Revegetation with native tree species will aim to connect surrounding areas of natural habitat. Where available, logs and other woody debris will be distributed in revegetated areas to provide fauna habitat opportunities as available such as has been incorporated into adjoining areas of the Boggy Creek Diversion.

5.8.4 Analogue sites for monitoring

Rehabilitation efforts at Ensham have been guided by the long history of progressive rehabilitation completed for the site, and an evidence based understanding of what practices result in successful outcomes, as further

described in both Appendix 9.2 PMLU context report and Appendix 9.3 Monitoring summary report. Further, monitoring of rehabilitation has also been informed by an understanding of conditions similar to that anticipated for the rehabilitation areas after closure. These areas are termed analogue or reference sites.

Rehabilitation monitoring has included assessment and comparison of rehabilitation outcomes to the analogue sites. The analogue sites selected are comparative of:

- Soil, land area, and land suitability
- Vegetation form
- Species assemblage; and
- Land use.

As most rehabilitation areas are aimed towards a cattle grazing PMLU, analogue sites established for Ensham are based on unmined areas of grazing land use. Appendix 9.3 Monitoring summary report provides detail of reference sites for rehabilitation.

5.8.5 Process of establishing vegetation

Vegetation establishment in rehabilitation at Ensham is aided by attention to the following basic principles.

5.8.5.1 Growth medium

As described in Section 5.3, Ensham have ~2.8 million cubic metres (Mm³) of topsoil available on site for rehabilitation. Laboratory analysis is the basis for ensuring the suitability (and need for addressing soil limitations where necessary) to ensure it is suitable to sustain the PMLU. Topsoil will be spread at a depth of 150mm across the majority of site. The outcomes of rehabilitation trials will determine strategies to address the current topsoil deficit (eg. amelioration of spoil).

5.8.5.2 Seedbed preparation

Ensham sows into well prepared seedbeds that are loose and friable, with many micro-niches to enable good contact between soil and seeds. This is essential for good germination. At Ensham, deep ripping is usually enough to create a good seedbed as this activity causes significant surface soil disturbance and enables rainfall infiltration.

5.8.5.3 Sowing good quality seed

Ensham sows good quality seed. Whilst there are no established thresholds, the results of independent seed tests are used to compare quality and price of available seed. This includes purity (%), germination (%) and percentage of pure live seeds (purity % x germination %).

5.8.5.4 Sowing at the right time

Sowing at the right time and avoiding a false start is critical to revegetation. Ensham aims to sow in the warmer months of the year from September to March, and ideally November to January when the probability of rainfall is highest. Where possible, use of irrigation may be used to establish germination and pasture in rehabilitation areas, removing the need to sow at the "right time" suited to climatic conditions and rainfall.

5.8.5.5 Correcting soil limitations

Understanding and correcting soil limitations ensures revegetation success. Regular soil and spoil laboratory testing ensures the correct fertilisers and ameliorants are applied to promote revegetation success. Ensham

will sample and test all materials used in future rehabilitation. Addressing soil limitations within Ensham soils has historically included the application of fertiliser, hay-mulch and, more recently, gypsum, where needed.

5.8.5.6 Controlling weeds

Weed prevention is far better than weed control. Weed prevention in rehabilitation is achieved by not over-fertilising, controlling weeds around site generally, ensuring hay mulch is weed free, inspecting machinery before it enters site, sowing soon after seedbed preparation so that weeds do not get a head start. Ensham's weed management will operate in accordance to the Weed and Feral Animal Management Plan.

5.8.5.7 Managing grazing livestock

Livestock are excluded from established rehabilitation until monitoring demonstrates revegetation has been successful, including demonstrating a sustainable groundcover for erosion control. Once cattle are moved onto rehabilitation, best practice grazing management ensures rehabilitation is not overgrazed and the overall land condition is maintained or improved over time. This is done so in accordance to the Grazing Management Plan.

5.9 Erosion control

It is well established that high cover percentages, above 50 % groundcover, reduce erosion in rehabilitation, even on steep slopes, e.g., see Loch (2000) and Carroll (2000). However, the period when the soil is bare and vulnerable to erosion by surface runoff presents a significant window of erosion risk (Loch 2000; Carroll and Tucker 2000; Carroll *et al.* 2001). For typical rehabilitation with slope gradients $\leq 15\%$, this window of erosion risk exists from the time of sowing until $>50\%$ groundcover is established. It is during this period, which may be weeks or months depending on rainfall and other factors that affect plant establishment and growth, that active control erosion is required to prevent unacceptable soil loss and potentially severe gully erosion and landscape failure.

Ensham applies hay mulch immediately after sowing to provide instant groundcover and close the window of erosion risk (Figure 5-10). This is particularly important for any slopes greater than 20%. Hay mulch applied at a minimum rate of 5 t/ha is a quick, cheap, and effective erosion hazard control. It also promotes germination and establishment of sown species by assisting to retain soil moisture through reducing evapotranspiration and lowering soil temperatures in the hotter months.



Figure 5-10 Spreading hay mulch for erosion control in rehabilitation at Ensham

These erosion and sediment control measures are applied for all PMLUs, including those cattle grazing and native bushland corridors areas where slope requires it. Review of the performance of progressive rehabilitation (as contained in Appendix 9.3) as well as long-term modelling of the erosive potential of the landform (as detailed in Appendix 9.6) demonstrate that these erosion control measures are effective for ensuring the landform remains stable.

5.10 Tailings Storage Facilities

Ensham does not operate a traditional coal handling and preparation plant (CHPP) to wash coal and therefore, does not generate fine tailings waste or reject material. There are no tailings storage facilities (TSFs) at the mine.

5.11 Voids

Ensham's final landform has a pre-approved NUMA for Groundwater daylighting water areas. Pits A South, E, F & Y will be partially backfilled to support a final land use of grazing, therefore not considered a void. Pits A, Central, A North, B, C & D will also be partially backfilled but are predicted to have groundwater daylighting areas within them, resulting in a NUMA.

5.11.1 Final void configuration and options

All remaining Ensham voids are considered as NUMA, with the final configuration as detailed in Section 4 of this PRCP. Given that these voids are pre-approved, the justification and options requirement (as per section 126C(1)(g) and 126C(1)(j) of the EP Act) do not apply.

However, it is highlighted that Ensham has undertaken a significant process of considering a range of void configuration options, with extensive investigations and consultation occurring to inform options assessment. This occurred as part of the Residual Void project, which culminated in the selection of a preferred option in relation to the final voids that are to be retained, as presented in this PRCP.

For completeness, the three key conceptual options subject to intense investigation are as summarised below:

- **RV Option 1: Retention of a permanent Landform Levee to provide flood immunity** – this assumed partial backfilling of the residual voids to create a rehabilitated landform protected by permanent landforms along the existing levee alignment.
- **RV Option 2: Flood Mitigation and Beneficial Use** – this option involves two phases, with the first phase involves rehabilitation of the post-mining voids on the floodplain to develop permanent landforms suitable for water storages. The second phase involves the reuse of the void depending on the commercial arrangement for the funding and operation of the water storage area.
- **RV Option 3: Backfill to Probable Maximum Flood (PMF) level** – this comprises significant backfilling of the residual mining voids, up to the elevation of the original floodplain within the lateral extent of the pre-mining PMF level.

The final void option that was selected as part of the subsequent EA amendment application process is aligned in concept to Option 1, with some modification to retain highwalls and maximise the area of land suitable for grazing. The revision was based on feedback from stakeholders (including DAP, DNRME and DES).

5.11.2 Void design details

The design detailed of the remaining Ensham voids are as detailed in Section 4 of this PRCP.

5.11.3 Void stability considerations

5.11.3.1 Highwall stability

Regarding long-term stability of highwalls, a recent geotechnical assessment by (WSP 2018), including slope stability analysis to assess overall factor of safety, determined the following:

- Tertiary-aged materials should be regraded to a slope gradient $\leq 1(V):3(H)$, which is numerically equivalent to grade of 33.3 % or angle of 18.4 degrees, to improve stability to an acceptable standard.
- Weathered Permian-aged materials should be regraded to a slope gradient of $1(V):2(H)$, equivalent to a grade of 50 % or angle of 26.6 degrees.
- Fresh Permian-aged materials should be regraded to a slope gradient of $1(V):1(H)$, equivalent to a grade of 100 % or angle of 45 degrees.
- If recommended slope geometries cannot be achieved, partially backfilling of voids to buttress walls with spoil could be considered.

Risk assessment of the void design was conducted (Rowan and Associates, 2020) to identify risks relating to residual void design. It was observed that weathering, block and slip failures are one of the few risks that were identified in relation to highwall stability. Management actions to mitigate highwall regression include annual inspections and monitoring of highwall stability during post construction phase and prior to relinquishment and modifications of surface drainage. The risk assessment is set out in Section 6.0 to this PRC Plan.

5.11.4 Void hydrology

The void hydrology has been modelled to develop water balance models for the residual voids in Ensham. The model is based on the updated Digital Elevation Model (DEM) of the landforms for the void configuration, climate data, surface runoff and catchment hydrology.

5.11.5 Void hydrogeology

Void hydrogeology, addressing the long-term water balance and water levels within voids and potential to overtop, has been detailed previously in this PRC Plan (see Section 5.1).

5.11.6 Void water quality and balance

A hydrological and limnology assessment conducted on the water quality data of the final void, which includes the pH, EC, temperature and oxygen data showed that there are no chemoclines or thermoclines present in the water bodies (RGS, 2018). This was hypothesised due to overturning of the pit water in February 2018 after heavy rainfall. It was reviewed that the chemoclines and the thermoclines in the residual void could have potential effects on the water quality. However, there will be no flow from the rehabilitated open cut mining areas to the regional groundwater system.

5.11.7 Void rehabilitation strategies

All residual voids will be retained as NUMA, with no expectation to achieve a PMLU outcome.

5.12 Underground mining

Underground mining at Ensham has negligible surface impacts because, unlike longwall mining, bord and pillar mining does not cause discernible surface subsidence. The underground workings are accessed from a section of C Pit highwall (Figure 5-11).



Figure 5-11 Entrances to the existing Ensham underground mine.

The areas above underground mining panels will be subject to short term surface disturbance. The requirement to drill bore holes for geotechnical, coal quality, gas extraction, mine inertisation, groundwater monitoring and service holes will continue for the life of the mine. Once the drill hole is finished with, the bore and the areas disturbed by these activities are rehabilitated and returned to previous land use of cattle grazing consistent with the rehabilitation milestones under the PRCP schedule for the relevant rehabilitation areas.

Exploration and underground service holes are not included in future disturbance or rehabilitation planning. These holes are temporary in nature and rehabilitated upon closure of the hole. Planned disturbance for the drilling of these holes is unable to be identified as the drill locations are fluid based on a series of environmental and operational factors.

5.12.1 Geotechnical stability and surface subsidence

Bord and pillar mining at Ensham forms a regular array of stable coal pillars and roadways in each panel i.e., mining area, and does not cause large scale overburden fracturing or surface subsidence (Gordon 2020). In a recent geotechnical assessment, Gordon (2020) confirmed:

- The long-term stability of the mine layout with a minimum factor of safety of 1.6.
- Predicted surface subsidence of less than 40 mm vertical movement, because of elastic compression of the strata i.e., compression due to the additional load on the pillars after the coal is extracted.
- No surface cracking due to subsidence and associated strains and tilts.
- No surface topographical depressions that would cause ponding of incident rainfall and runoff water.

As underground mining does not cause any discernible surface impacts, no rehabilitation activities are necessary. The potential for measurable subsidence in the long-term is very low due to the stability of the

overburden (Gordon 2020). The size and location of coal pillars is designed to ensure a very conservative long-term factor of safety is maintained i.e., a very low probability of coal pillars crushing out that would cause overburden instability and surface subsidence.

As well as the factor of safety approach, the long-term life expectancy of pillars can be estimated using empirical studies from South Africa. Using this methodology, the 24 m x 28 m (centres) pillars, at 4.5 m high and 130 m depth of cover, are calculated to be stable in excess of 26,000 years. Furthermore, in regards to long-term stability, after mining is completed and the workings flood with groundwater, the buoyancy effect of the groundwater will reduce the vertical load on the pillars by up to 40%. For a pillar below the Nogoa River anabranch, designed with a FoS of 2.11, at 140 m depth of cover, reducing the vertical load on the pillar by a conservative 25%, to account for any potential strength loss in the coal and surrounding strata, increases the FoS to 2.82. This FoS has a probability of failure well in excess of 1 in 10,000,000.

A range of subsidence monitoring is completed for Ensham, including both annual LIDAR surveys and real-time monitoring of ground movement (using RTK technology). This is further detailed in Appendix 9.3 Monitoring Summary Report.

5.12.2 Underground hydrogeology

The hydrogeological setting comprises two groundwater bearing units, viz. the Quaternary aged alluvium and the Permian aged Rangal Coal Measures. The two are separated by a low permeability unit and neither aquifer is suitable for stock or domestic use due to salinity (SLR 2020). Underground mining causes aquifer drawdown of the Permian coal-aquifer during mining operations and recovers post-mining (SLR 2020). This will have no impact on rehabilitation at Ensham.

5.12.3 Sealing requirements

On completion of all underground operations, it is planned to seal all portals and shafts to the underground environment. This sealing process will be risk assessed as and when the portals become available for rehabilitation, so that an approved Mine Sealing Management Plan can be created.

As a minimum, all life of mine seals will be a Type D rated to 345 Kpa (50 psi), however this would be confirmed through the risk assessment outcomes. It would also be assessed to determine if the seals would also need to hold a water head rating. All seals used would be required to have a certified RPEQ qualified engineer rating certificate.

The Sealing Management Plan is to be developed using the guidance of the updated version of the following documents as a minimum:

- Queensland Coal Mining Safety and Health Regulation 2017
- Coal Mining Safety and Health Act 1999
- DNRM Inspectorate Compliance Checklist
- Recognised Standard 9 - The Monitoring of Sealed Areas; and
- MDG 6001 Guideline for the Permanent Filling and Capping of Surface Entries to Coal Mines

5.13 Built infrastructure

All built infrastructure will either be decommissioned, demolished, salvaged and/or disposed, utilising methods as described below. Alternatively, infrastructure such as roads, powerlines and other structures may be formally retained by an appropriate stakeholder, where it is consistent with the PMLU land outcome.

Demolition planning and execution will be undertaken in accordance with relevant standards, policies and legislation requirements, and will include both an investigation of the site and surrounding aspects, and an investigation for the structures to be removed.

All infrastructure to be retained by a landholder is as detailed in Section 3.1.2, this is a complete inventory, and has been grouped into a distinct PMLU. If further opportunities arise to retain additional infrastructure in the future, a similar process of confirming the infrastructure transfer will occur with formal agreements developed. Given the continued operational life for Ensham mine, landowner agreements for infrastructure will be developed at closure.

An inventory of all infrastructure is provided below as Table 5-12, with the intended fate and status identified.

Table 5-12 Register of infrastructure for Ensham

Infrastructure type	Description	Objective	Status
Buildings	Workshops	Decommissioned	-
	Administration	Decommissioned	-
	Warehouse	Decommissioned	-
	Village	Decommissioned	Yongala camp has already been decommissioned
Laydowns	Concrete footings and pads	Decommissioned	-
	Hardstand areas	Decommissioned	-
	Stockpile areas	Decommissioned	-
	Carparks	Decommissioned	-
Utilities and Services	Electrical reticulation	Decommissioned	-
	Powerlines	Main power supply line to be retained for Duckponds homestead and essential property infrastructure	Consultation has confirmed expectations around retention
	Substations	Decommissioned	-
	Communications	Decommissioned	-
	Underground services	Decommissioned	-
	Water and sewage treatment	Decommissioned	-
		Decommissioned	-
Water Management	Sumps	Decommissioned	-
	Tanks	Decommissioned	-
	Boreholes	Decommissioned	-
	Washdown facilities	Decommissioned	-
	Sediment Dams	Sediment dam at Boundary Paddock to be retained	Consultation has confirmed expectations around retention
	Dams/Reservoirs	Water allocation, structures for Clear Water Dam and Sailors Dam line to be retained	Consultation has confirmed expectations around retention
	Water licences (allocation)		
Land Management	Fencelines	Decommissioned if not forming part of grazing property management	-
	Roads and tracks	Gazetted access road into Currimundi property to be retained	Consultation has confirmed expectations around retention
Operational	Mining machinery	Decommissioned	-

Infrastructure type	Description	Objective	Status
	ROM, crusher, conveyors	Decommissioned	-
	Coal stacking and reclaiming	Decommissioned	-
	Transfer stations	Decommissioned	-
	Gantries	Decommissioned	-
	Train load out	Decommissioned	-
	Fuel farm	Decommissioned	-
	Haul roads	A section of Yongala Haul Road to be retained	Consultation has confirmed expectations around retention
	Boreholes	Decommissioned	-
	Rail loop	Decommissioned	-

No equipment, hazardous materials or contamination will remain in the post-mining landscape at Ensham.

5.13.1 Methods for infrastructure decommissioning

Ensham has commenced decommissioning and removal of built infrastructure. In 2019 – 2020, the former Yongala Camp facilities and workshop were decommissioned and removed to allow for Boggy Creek diversion rehabilitation. Remaining infrastructure to be progressively decommissioned and removed from site includes the following.

- Draglines, continuous miners and ancillary opencut and u/g mining equipment.
All equipment will be de-oiled, isolated, and depressurised prior to sale for overhaul and reuse, or salvage and scrap value. All mobile equipment will be removed from site.
- Opencut and u/g administration, office, workshop and stores buildings, and camp facilities.
All buildings will have services terminated prior to removal from site for sale or salvage and scrap value. Concrete foundations, driveways, pathways, and similar non-hazardous wastes will be disposed of in-pit and buried.
- ROM, crusher, coal stacking and reclaiming, and train loading infrastructure.
All coal preparation infrastructure will be pull-down and removed from site for sale or salvage and scrap value. Concrete foundations, driveways, pathways, and similar non-hazardous wastes will be disposed of in-pit and buried. Coal will be disposed of in-pit and buried.
- Vehicle refuelling facilities.
All fuel, oil and lubricants will be extracted for recycling or disposal. All infrastructures will be removed from site for sale or salvage and scrap value. Concrete foundations, driveways, pathways, and similar non-hazardous wastes will be disposed of in-pit and buried.
- Vehicle washdown facilities.
All chemical agents will be extracted for recycling or disposal. All infrastructures will be removed from site for sale or salvage and scrap value. Concrete foundations, driveways, pathways, and similar non-hazardous wastes will be disposed of in-pit and buried.

Following the safe decommissioning and removal of infrastructure from site, a contaminated land investigation will be conducted. The investigation will be guided by the location of any environmentally relevant activities conducted on site.

5.13.2 Infrastructure to be retained post-mining

Built infrastructure that is proposed to be retained in the post-mining landscape is limited to items considered advantageous to on-going land management activities associated with the PMLUs. These items have been listed, and represent a complete inventory (see Section 3.1.2).

5.14 Methods to achieve a stable condition

Further detail of the rehabilitation construction methods and techniques are as described below, with further information as to the landform construction process also provided as Appendix 9.6 Landform design report. Following is a summary of the proven rehabilitation methods used to deliver rehabilitated land in a stable condition at Ensham (Table 5-13). A stable condition is defined in section 111A of the EP Act as follows.

Land is in a stable condition if-

- *The land is safe and structurally stable, and*
- *There is no environmental harm being caused by anything on or in the land, and*
- *The land can sustain a PMLU.*

Table 5-13 Rehabilitation methods for each rehabilitation PMLU at Ensham

PMLU	Rehabilitation methods
Beef cattle grazing.	1. Remove infrastructure. 2. Spoil and soil laboratory testing. 3. Undertake a contaminated land assessment where required. 4. Reshape overburden as required to achieve landform design parameters paired to land suitability requirements and spoil types. 5. Apply gypsum if needed. 6. Respread topsoil to minimum 150 mm depth. 7. Deep rip profile to minimum 600 mm depth. 8. Apply seed and fertiliser. 9. Apply hay mulch at minimum rate of 5 t/ha. 10. Monitor and manage rehabilitation to achieve completion criteria, demonstrating the land is in a stable condition. 11. Certification of progressive rehabilitation. 12. Monitor, manage, and maintain the rehabilitated land in a stable condition until mine closure.

PMLU	Rehabilitation methods
Landholder retained infrastructure.	1. Identify infrastructure to be retained by land holder/s. 2. Monitor and manage until landholder takes control.
Watercourse, bed and banks of the Boggy Creek diversion.	1. Remove infrastructure. 2. Spoil and soil laboratory testing. 3. Undertake a contaminated land assessment where required. 4. Reshape land as required to achieve landform design parameters per DRNM approved design. 5. Revegetate as per requirements of the Water Licence Revegetation Management Plan 6. Monitor and manage rehabilitation to achieve completion criteria, demonstrating the land is in a stable condition. 7. Surrender Water Licence 8. Certification of progressive rehabilitation. 9. Monitor, manage, and maintain the rehabilitated land in a stable condition until mine closure.
Native bushland corridor	1. Remove infrastructure. 2. Spoil and soil laboratory testing. 3. Undertake a contaminated land assessment where required. 4. Apply ameliorants as required. 5. Apply seed and fertiliser. 6. Apply hay mulch at minimum rate of 5 t/ha. 7. Monitor and manage rehabilitation to achieve completion criteria, demonstrating the land is in a stable condition. 8. Certification of progressive rehabilitation. 9. Monitor, manage, and maintain the rehabilitated land in a stable condition until mine closure.
Flood protection landform	1. Spoil and soil laboratory testing. 2. Reshape overburden as required to achieve landform design parameters. 3. Apply gypsum if needed. 4. Respread topsoil to minimum 150 mm depth. 5. Apply rock for erosion / scour protection as needed. 6. Deep rip profile to minimum 600 mm depth (where no rock is applied). 7. Apply seed and fertiliser. 8. Apply hay mulch at minimum rate of 5 t/ha.

PMLU	Rehabilitation methods
	9. Monitor and manage rehabilitation to achieve completion criteria, demonstrating the land is in a stable condition. 10. Certification of progressive rehabilitation. 11. Monitor, manage, and maintain the rehabilitated land in a stable condition until mine closure.

6 RISK ASSESSMENT

In accordance with section 126C(1)(f) of the EP Act, the rehabilitation planning part of the PRC plan must identify the risks of a stable condition for land described as a post-mining land use not being achieved, and how the applicant intends to manage or minimise the risks.

In accordance with section 126C(1)(f) of the EP Act, this section identifies the risks of a stable condition for land described as a PMLU not being achieved, and how Ensham intends to manage or minimise those risks. It also identifies the risks of the NUMA causing environmental harm and not being safe and structurally stable and details how Ensham intends to manage and minimise the identified risks.

6.1 Risk assessment methodology

The risk assessment is built using the Workplace Risk Assessment and Control (WRAC) methodology as described in MDG 1010 Minerals Industry and Safety and Health Risk Management Guideline and the National Minerals Industry Safety and Health Risk Assessment Guideline. The risk assessment methodology applied and the aforementioned guidelines used are in accordance with the ISO31000:2018 Risk Management – Guidelines and ISO 31010:2019 Risk Management – Risk Assessment Techniques.

The procedure describes risk assessment as the overall process of risk identification, risk analysis, risk evaluation and risk treatment, and the framework for each of these aspects is as described further below.

6.1.1 Risk Identification

As a first step, the assessment involves identification of the risks/unwanted event, cause(s) of the event, potential maximum consequences, current controls in place, and current risk control effectiveness.

6.1.2 Risk Analysis and Evaluation

The risk analysis step involves exploring an understanding of risks identified, determining risk causes and sources. The assessment considers potential consequences and the likelihood that those consequences can occur. Consequence and likelihood of the unwanted event occurring are rated using a standard 9x9 risk matrix. This table contains five rating levels for consequence and likelihood each.

After completion of the previous steps, options for addressing the risks are selected for implementation. The most appropriate risk treatment options are selected after consideration of multiple factors including cost benefit, regulatory obligations, social responsibility and protection of the surrounding environment.

The risk treatment step details a justification for selecting the option, details proposed activities, identifies parties responsible for implementation as well as resources required. Performance measures and constraints are highlighted, reporting and monitoring requirements outlined and detail provided on timing and scheduling of each risk treatment option.

6.2 Risk assessment of PMLUs and NUMAs and relevant milestones

A risk assessment workshop was convened on 14 December 2020 at Ensham mine and the risk assessment report has subsequently been revised. A detailed report is provided below (as Table 6-1). All risks associated with the achievement of rehabilitation milestones for PMLUs and management milestones for NUMAs were identified and evaluated using the Ensham risk matrix and risk acceptance threshold model.

This tool includes likelihood and consequence tables, and a quantitative risk matrix. It recognises AS ISO 31000:2018 Risk Management – Guidelines (Standards Australia, 2018), Queensland coal mining safety and health legislation, and other standards.

Where additional risk treatments are proposed to ensure risks are as low as reasonably possible, then the risk treatment step in the risk assessment also highlights-

- The reasons for selecting the treatment option.
- Those responsible for the approval and implementation of the plan
- Proposed actions.
- Resource requirements.
- Performance measures and constraints.
- Reporting and monitoring requirements.
- Timing and scheduling.

There are no significant risks that will prevent Ensham from achieving this PRCP, including rehabilitation milestones and management milestones as stated in the schedule.

Table 6-1 Ensham PRCP risk assessment



PRIMARY EVENTS IDENTIFIED AND EXISTING ACTIONS/ACTIVITIES TO ADDRESS RISKS										IF REQUIRED - SECONDARY ACTIONS/ACTIVITIES REQUIRED TO ADDRESS IDENTIFIED RISKS										
Process Step Substitution Reference	Hazard Type	Description of Unplanned Event	Consequence Type	Current Controls in Place	Control Type	Control Quality	Maximum Reasonable Consequence The likelihood of the RBC or other assessment	Liability	Risk Score	Additional treatment options	Reason for selecting this treatment option	Responsibility for approval and implementation	Proposed actions	Resource requirements	Performance measures and acceptable	Reporting and monitoring requirements	Timing and scheduling	Maximum Reasonable Consequence	Liability	Risk Score
BAC1 Infrastructure decommissioning and removal	Other	Infrastructure decommissioning and removal takes longer than planned	Legal & Regulatory	Asset register As-built drawings Infrastructure maintenance Experience in decommissioning of infrastructure on site	Administrative	90-95%	Minor	Possible	Medium	Infrastructure decommissioning and removal plan to be developed and implemented	A management plan is required to ensure that infrastructure decommissioning and removal is completed on time and budget	CB Operations	Plan to include register of infrastructure, schedule, budget and responsible roles	Time Budget Personnel	None	Internal reporting Monitor project milestones	Annual reviews	Minor	Same	Low
	Chemical	Discovery of unknown hazardous materials e.g. asbestos	Safety	Asbestos register Third party audit and workflow	Administrative	<100%	Insignificant	None	Low	None Required	None Required	N/A	N/A	Nil	None	None Required	None Required			
	Land	Spill of hazardous substances causes potential environmental harm	Environment	Personnel spill training Secondary containment Spill clean up equipment Removal of hazardous substances prior to decommissioning	Elimination	<100%	Insignificant	Unlikely	Low	None Required	None Required	N/A	N/A	Nil	None	None Required	None Required			
	Other	Decommissioning Not all services decommissioned Not all buildings and infrastructure removed from site Not all plant and equipment removed from site No formal agreement reached on replacement with landfill	Legal & Regulatory	Service contract decommissioning, Asset register as per PIP	Administrative	<100%	Insignificant	None	Low	None Required	None Required	N/A	N/A	Nil	None	None Required	None Required			
BAC2 Identification and remediation of contaminated land	Chemical	Previously unknown contamination discovered	Environment	Site based history of contamination and other data within a file	Administrative	<100%	Insignificant	Unlikely	Low	None Required	None Required	N/A	N/A	Nil	None	None Required	None Required			
	Chemical	Previously unknown contamination discovered	Environment	Site based history of contamination and other data within a file	Administrative	<100%	Insignificant	Unlikely	Low	None Required	None Required	N/A	N/A	Nil	None	None Required	None Required			
	Other	Contaminated land assessment not completed by EOP as referenced by PIP and EOP register	Legal & Regulatory	Remediation and soil quality assessments and monitoring to identify contamination, review PIP, SIA reports	Administrative	<100%	Insignificant	Unlikely	Low	None Required	None Required	N/A	N/A	Nil	None	None Required	None Required			
	Land	Identified contaminated land not remediated or managed	Legal & Regulatory	Remediation report, Site Remediation Report Further sign off required as per PIP for requirements Average remediation or continued evaluation if required	Administrative	<100%	Insignificant	Unlikely	Low	None Required	None Required	N/A	N/A	Nil	None	None Required	None Required			
	Other	Land not removed from Contaminated Land Register prior to redevelopment	Legal & Regulatory	Remediation report, Site Remediation Report Further sign off required as per PIP for requirements Average remediation or continued evaluation if required	Administrative	<100%	Insignificant	Unlikely	Low	None Required	None Required	N/A	N/A	Nil	None	None Required	None Required			
	Other	Land not removed from Environmental Management Register prior to redevelopment	Legal & Regulatory	Remediation report, Site Remediation Report Further sign off required as per PIP for requirements Average remediation or continued evaluation if required	Administrative	<100%	Insignificant	Unlikely	Low	None Required	None Required	N/A	N/A	Nil	None	None Required	None Required			
BAC3 Final landfill development	Other	Final landfill development takes longer than planned	Legal & Regulatory	Site planning, scheduling and budgeting Time flexibility for completion build out schedule	Administrative	<100%	Minor	Possible	Medium	Progress of landfill construction to ensure on schedule	Progress of landfill construction to ensure on schedule	Manage HSE Systems	Develop a sign off procedure to ensure relevant site personnel are involved at critical stages in the rehabilitation process, e.g. similar to EOP landfill system	Personnel Time	None	Internal reporting	Starting by 11/12/2022	Minor	Same	Low
	Other	Final landfill design not completed	Legal & Regulatory	Final landfill design to be completed by the Technical Services Team	Administrative	<100%	Minor	Possible	Medium	Final landfill design to be completed by the Technical Services Team	Final landfill design to be completed by the Technical Services Team	CB Operations	Develop a sign off procedure to ensure relevant site personnel are involved at critical stages in the rehabilitation process, e.g. similar to EOP landfill system	Personnel Time	None	Internal reporting	Starting by 11/12/2022	Minor	Same	Low
	Other	Incorrect or inconsistent site plan, problems or delays for rehabilitation to commence or finish	Legal & Regulatory	Landfill design to be completed by the Technical Services Team	Engineering	90-95%	Moderate	Unlikely	Medium	Final landfill design to be completed by the Technical Services Team	Final landfill design to be completed by the Technical Services Team	Manage HSE Systems	Develop a sign off procedure to ensure relevant site personnel are involved at critical stages in the rehabilitation process, e.g. similar to EOP landfill system	Personnel Time	None	Internal reporting	Starting by 11/12/2022	Minor	Unlikely	Low
	Land	Landfill stability and movement during settling	Environment	Material type, volume and use for the landfill design, with different landfill design criteria developed for each waste stream based on underlying risk. In particular, considering the potential of dispersed materials	Engineering	90-95%	Minor	Possible	Medium	Final landfill design to be completed by the Technical Services Team	Final landfill design to be completed by the Technical Services Team	Manage HSE Systems	Develop a sign off procedure to ensure relevant site personnel are involved at critical stages in the rehabilitation process, e.g. similar to EOP landfill system	Personnel Time	None	Internal reporting	Starting by 11/12/2022	Minor	Unlikely	Low
	Land	Final landfill stability	Environment	Landfill design criteria: slope angle, length of slope, and vegetation cover	Engineering	90-95%	Minor	Possible	Medium	Final landfill design to be completed by the Technical Services Team	Final landfill design to be completed by the Technical Services Team	Manage HSE Systems	Develop a sign off procedure to ensure relevant site personnel are involved at critical stages in the rehabilitation process, e.g. similar to EOP landfill system	Personnel Time	None	Internal reporting	Starting by 11/12/2022	Insignificant	Same	Low
	Land	Unstable report quality and condition in accordance with specifications	Environment	Typical mapping region and provision, placement and treatment as per plan	Administrative	<100%	Moderate	Possible	High	Final landfill design to be completed by the Technical Services Team	Final landfill design to be completed by the Technical Services Team	Environmental Superintendent	Develop a sign off procedure to ensure relevant site personnel are involved at critical stages in the rehabilitation process, e.g. similar to EOP landfill system	Personnel Time Budget	None	Internal reporting	Starting by 11/12/2022	Minor	Unlikely	Low
BAC4 Landfill preparation	Land	Typical depth not applied to an appropriate volume or depth to support PIP21 resources	Environment	Typical mapping region and provision, placement and treatment as per plan	Administrative	<100%	Minor	Possible	Medium	Final landfill design to be completed by the Technical Services Team	Final landfill design to be completed by the Technical Services Team	Environmental Superintendent	Develop a sign off procedure to ensure relevant site personnel are involved at critical stages in the rehabilitation process, e.g. similar to EOP landfill system	Personnel Time Budget	None	Internal reporting	Starting by 11/12/2022	Minor	Same	Low
	Land	Insufficient report material available to meet minimum depth requirements	Environment	Typical mapping region and provision, placement and treatment as per plan	Administrative	<100%	Moderate	Unlikely	High	Final landfill design to be completed by the Technical Services Team	Final landfill design to be completed by the Technical Services Team	Environmental Superintendent	Develop a sign off procedure to ensure relevant site personnel are involved at critical stages in the rehabilitation process, e.g. similar to EOP landfill system	Personnel Time Budget	None	Internal reporting	Starting by 11/12/2022	Moderate	Unlikely	Medium
	Land	Insufficient report material available to meet minimum depth requirements	Environment	Typical mapping region and provision, placement and treatment as per plan	Administrative	<100%	Moderate	Unlikely	High	Final landfill design to be completed by the Technical Services Team	Final landfill design to be completed by the Technical Services Team	Environmental Superintendent	Develop a sign off procedure to ensure relevant site personnel are involved at critical stages in the rehabilitation process, e.g. similar to EOP landfill system	Personnel Time Budget	None	Internal reporting	Starting by 11/12/2022	Moderate	Unlikely	Medium
	Land	Insufficient report material available to meet minimum depth requirements	Environment	Typical mapping region and provision, placement and treatment as per plan	Engineering	90-95%	Major	None	High	Final landfill design to be completed by the Technical Services Team	Final landfill design to be completed by the Technical Services Team	Manage HSE Systems	Develop a sign off procedure to ensure relevant site personnel are involved at critical stages in the rehabilitation process, e.g. similar to EOP landfill system	Personnel Time Budget	None	Internal reporting	Starting by 11/12/2022	Moderate	Same	Medium

PRIMARY EVENTS IDENTIFIED AND EXISTING ACTIONS/ACTIVITIES TO ADDRESS RISKS

IF REQUIRED - SECONDARY ACTIONS/ACTIVITIES REQUIRED TO ADDRESS IDENTIFIED RISKS

Primary Events Identified and Existing Actions/Activities to Address Identified Risks										If Required - Secondary Actions/Activities Required to Address Identified Risks										
Process Step Subdivision or Milestone	Hazard Type	Description of Unwanted Event	Consequence Type	Current Controls in Place	Control Type	Control Quality	Minimum Assessable Consequence	Likelihood	Risk Score	Additional treatment options	Reason for selecting this treatment option	Responsibility for approval and implementation	Proposed actions	Resource requirements	Performance measures and indicators	Reporting and monitoring requirements	Timing and scheduling	Minimum Assessable Consequence	Likelihood	Risk Score
							The likelihood of the HSE of the HSE of the HSE													
	Local	Incorrect seed mix application applied	Environmental	Typical quality of seed mix specifications	Administrative	<10%	Minor	Feasible	Medium	Initiate steps in which sign off process for seed mix application	Have relevant site personnel sign off critical stages of the rehabilitation process once seed mix specifications are followed to complete satisfactory rehabilitation	Manager HSE Systems	Ensure rehabilitation sign off procedure considers and implements	Personnel Time	None	Internal reporting	Timing by 11/11/2023	Minor	None	Low
	Local	Unsuitable and limited fertilizer applied	Environmental	Typical quality of fertilizer specifications reviewed against soil fertility requirements	Administrative	<10%	Minor	Unlikely	Low	Review soil fertility data with selected vegetation	Have relevant site personnel sign off critical stages of the rehabilitation process once seed mix specifications are followed to complete satisfactory rehabilitation	Manager HSE Systems	Ensure rehabilitation sign off procedure considers and implements	Personnel Time	None	Internal reporting	Timing by 11/11/2023	Minor	None	Low
	Local	Deep tilling depth and spacing not to specifications	Environmental	Site layout procedure to achieve specifications	Administrative	<10%	Minor	Unlikely	Low	Confirm deep tilling process is documented before site rehabilitation process begins	Have relevant site personnel sign off critical stages of the rehabilitation process once seed mix specifications are followed to complete satisfactory rehabilitation	Manager HSE Systems	Ensure a sign off procedure to ensure relevant site personnel are involved at critical stages in the rehabilitation process, e.g. similar to HSE WorkSafe system	Personnel Time	None	None	Timing by 11/11/2023	Minor	None	Low
	Local	Unsuitable supply volume of rock to meet specifications	Environmental	Review that rock meets or is potentially required within Native Vegetation Control (NVC) which represent only a 10% of the site footprint. Rock must meet requirements for initially assessed from sampling of available rock as per following/verifying suitable materials from demonstrating good stone practice.	Selection	31-40%	Moderate	Feasible	High	Review that the quantity of potential rock material required is not considered in excess of a regional management and the following has been adjusted. Further will further investigate the quality and quantity of rock resources available on site to develop an inventory for those materials according to the supply requirements. The inventory investigation will consider and determine suitable amount of rock from other suppliers/locations if required to address any shortfall. Given the landscape design concept has been deemed to be adequate from a stability perspective, alternative analysis options are not considered to be pursued at this time. However, if the rock inventory investigation reveals that there are no suitable amount of the rock, further investigations (for external design management) will be made for those landscape areas that may require rock for stability.	Identification of suitable rock source and design measures to ensure the requirement for rock can be met.	Environmental Superintendents	Complete a rock inventory investigation, considering rock requirements and supply sources. If needed, also consider alternative suppliers to ensure the need for rock meeting	Personnel Time Budget	None	None	Timing by 11/11/2023	Moderate	None	Medium
2001 Soil	Local	Seed mix not to quality or specifications	Environmental	Representative seed mix specification	Administrative	31-40%	Minor	Feasible	Medium	Initiate seed quality verification process	Seed quality verification process will review the current seed mix, review the seed mix, and ensure the seed mix is of the required quality and quantity.	Environmental Superintendents	Ensure a seed quality verification process	Personnel Time Budget	None	None	Timing by 11/11/2023	Minor	None	Low
	Local	Unsuitable seed mix quality or specifications	Environmental	No seed mix controls in place	Administrative	<10%	Minor	Feasible	Medium	Identify primary and secondary species lists for rehabilitation process. Address seed mix quality in advance to engage with supplier to ensure seed mix quality is of the required quality and quantity.	Environmental Superintendents	Ensure primary and secondary species lists for rehabilitation process. Address seed mix quality in advance to engage with supplier to ensure seed mix quality is of the required quality and quantity.	Personnel Time Budget	None	None	Timing by 11/11/2023	Minor	None	Low	
	Local	Unsuitable seed mix quality or specifications	Environmental	Internal source of seed mix	Administrative	31-40%	Minor	Feasible	Medium	Consider options to grow seed mix on site or from external (sowing) seed	Ensure a seed mix quality verification process will review the current seed mix, review the seed mix, and ensure the seed mix is of the required quality and quantity.	Environmental Superintendents	Investigate feasibility of growing seed mix on site	Personnel Time Budget	None	None	Timing by 11/11/2023	Minor	Unlikely	Low
	Local	Seed mix not applied to specifications	Environmental	Rate of application defined	Administrative	<10%	Minor	Unlikely	Low	Rehabilitation sign off process - include specification for seed mix sowing rate and appropriate application methodology	Have relevant site personnel sign off critical stages of the rehabilitation process once amendment specifications are followed to complete satisfactory rehabilitation	Manager HSE Systems	Ensure a sign off procedure to ensure relevant site personnel are involved at critical stages in the rehabilitation process, e.g. similar to HSE WorkSafe system	Personnel Time	None	None	Timing by 11/11/2023	Minor	None	Low
2002 Vegetation established	Local	Vegetation does not reach completion criteria	Environmental	RMP developed based on intended rehabilitation practices which have demonstrated adequate achievement of completion criteria. Grazing Management Plan, Annual Rehabilitation Monitoring	Administrative	<10%	Moderate	None	Medium	If regeneration fails or trends indicate that criteria will not be achieved, investigate cause, and re-fertilize, re-sowing will, or re-seed or re-plant, as appropriate	Recovery regeneration established as per agreed rehabilitation guidelines and completion criteria	Environmental Superintendents	Annual rehabilitation monitoring	Personnel Time	None	Visual inspection or remote sensing. Monitor vegetation growth/cover in native grazing area	Early as end of growing season (April to June)	Minor	Unlikely	Low
	Local	Overseeding does not reach completion criteria	Environmental	RMP developed based on intended rehabilitation practices which have demonstrated adequate achievement of completion criteria. Grazing Management Plan, Annual Rehabilitation Monitoring	Administrative	<10%	Moderate	None	Medium	If regeneration fails or trends indicate that criteria will not be achieved, investigate cause, and re-fertilize, re-sowing will, or re-seed or re-plant, as appropriate	Recovery regeneration established as per agreed rehabilitation guidelines and completion criteria	Environmental Superintendents	Annual rehabilitation monitoring	Personnel Time	None	Visual inspection or remote sensing. Monitor vegetation growth/cover in native grazing area	Early as end of growing season (April to June)	Minor	Unlikely	Low
	Local	Shrub species in groundcover < 10%	Environmental	RMP developed based on intended rehabilitation practices which have demonstrated adequate achievement of completion criteria. Grazing Management Plan, Annual Rehabilitation Monitoring	Administrative	<10%	Moderate	None	Medium	If regeneration fails or trends indicate that criteria will not be achieved, investigate cause, and re-fertilize, re-sowing will, or re-seed or re-plant, as appropriate	Recovery regeneration established as per agreed rehabilitation guidelines and completion criteria	Environmental Superintendents	Annual rehabilitation monitoring	Personnel Time	None	Visual inspection or remote sensing. Monitor vegetation growth/cover in native grazing area	Early as end of growing season (April to June)	Minor	Unlikely	Low
	Local	No bare soil grazing (NBS) < 10% established and persistent vegetation groundcover for all stages from 1-10%	Environmental	RMP developed based on intended rehabilitation practices which have demonstrated adequate achievement of completion criteria. Grazing Management Plan, Annual Rehabilitation Monitoring	Administrative	<10%	Moderate	Unlikely	Medium	If regeneration fails or trends indicate that criteria will not be achieved, investigate cause, and re-fertilize, re-sowing will, or re-seed or re-plant, as appropriate	Recovery regeneration established as per agreed rehabilitation guidelines and completion criteria	Environmental Superintendents	Annual rehabilitation monitoring	Personnel Time	None	Visual inspection or remote sensing. Monitor vegetation growth/cover in native grazing area	Early as end of growing season (April to June)	Minor	Unlikely	Low
	Local	No bare soil grazing (NBS) < 10% established and persistent vegetation groundcover for all stages from 1-10%	Environmental	RMP developed based on intended rehabilitation practices which have demonstrated adequate achievement of completion criteria. Grazing Management Plan, Annual Rehabilitation Monitoring	Administrative	<10%	Moderate	Unlikely	Medium	If regeneration fails or trends indicate that criteria will not be achieved, investigate cause, and re-fertilize, re-sowing will, or re-seed or re-plant, as appropriate	Recovery regeneration established as per agreed rehabilitation guidelines and completion criteria	Environmental Superintendents	Annual rehabilitation monitoring	Personnel Time	None	Visual inspection or remote sensing. Monitor vegetation growth/cover in native grazing area	Early as end of growing season (April to June)	Minor	Unlikely	Low
	Local	No bare soil grazing (NBS) < 10% established and persistent vegetation groundcover for all stages from 1-10%	Environmental	RMP developed based on intended rehabilitation practices which have demonstrated adequate achievement of completion criteria. Grazing Management Plan, Annual Rehabilitation Monitoring	Administrative	<10%	Moderate	Unlikely	Medium	If regeneration fails or trends indicate that criteria will not be achieved, investigate cause, and re-fertilize, re-sowing will, or re-seed or re-plant, as appropriate	Recovery regeneration established as per agreed rehabilitation guidelines and completion criteria	Environmental Superintendents	Annual rehabilitation monitoring	Personnel Time	None	Visual inspection or remote sensing. Monitor vegetation growth/cover in native grazing area	Early as end of growing season (April to June)	Minor	Unlikely	Low
	Local	No bare soil grazing (NBS) < 10% established and persistent vegetation groundcover for all stages from 1-10%	Environmental	RMP developed based on intended rehabilitation practices which have demonstrated adequate achievement of completion criteria. Grazing Management Plan, Annual Rehabilitation Monitoring	Administrative	<10%	Moderate	Unlikely	Medium	If regeneration fails or trends indicate that criteria will not be achieved, investigate cause, and re-fertilize, re-sowing will, or re-seed or re-plant, as appropriate	Recovery regeneration established as per agreed rehabilitation guidelines and completion criteria	Environmental Superintendents	Annual rehabilitation monitoring	Personnel Time	None	Visual inspection or remote sensing. Monitor vegetation growth/cover in native grazing area	Early as end of growing season (April to June)	Minor	Unlikely	Low
	Local	No bare soil grazing (NBS) < 10% established and persistent vegetation groundcover for all stages from 1-10%	Environmental	RMP developed based on intended rehabilitation practices which have demonstrated adequate achievement of completion criteria. Grazing Management Plan, Annual Rehabilitation Monitoring	Administrative	<10%	Moderate	Unlikely	Medium	If regeneration fails or trends indicate that criteria will not be achieved, investigate cause, and re-fertilize, re-sowing will, or re-seed or re-plant, as appropriate	Recovery regeneration established as per agreed rehabilitation guidelines and completion criteria	Environmental Superintendents	Annual rehabilitation monitoring	Personnel Time	None	Visual inspection or remote sensing. Monitor vegetation growth/cover in native grazing area	Early as end of growing season (April to June)	Minor	Unlikely	Low
	Local	No bare soil grazing (NBS) < 10% established and persistent vegetation groundcover for all stages from 1-10%	Environmental	RMP developed based on intended rehabilitation practices which have demonstrated adequate achievement of completion criteria. Grazing Management Plan, Annual Rehabilitation Monitoring	Administrative	<10%	Moderate	Unlikely	Medium	If regeneration fails or trends indicate that criteria will not be achieved, investigate cause, and re-fertilize, re-sowing will, or re-seed or re-plant, as appropriate	Recovery regeneration established as per agreed rehabilitation guidelines and completion criteria	Environmental Superintendents	Annual rehabilitation monitoring	Personnel Time	None	Visual inspection or remote sensing. Monitor vegetation growth/cover in native grazing area	Early as end of growing season (April to June)	Minor	Unlikely	Low
2003 Achievement of a native condition (land capability rating P&L 3)	Local	Rehabilitation area remains significantly more barren than the surrounding natural landscape	Safety	Rehabilitation design - design process which has considered inherent hazards that may be present and developed an appropriate design response	Administrative	<10%	Minor	None	Low	None Required	None Required	N/A	N/A	High	None	None Required	None Required	None Required	None Required	None Required
	Water	Rehabilitation area surface water runoff does not comply with completion criteria and cause environmental harm	Legal & Regulatory	Min Water Management Plan, Water Management Plan (includes monitoring). RMP and past history of completion criteria. Including the rehabilitation design process which has considered inherent hazards that may be present and developed an appropriate design response	Administrative	<10%	Moderate	None	Medium	Commence an annual review of water quality as part of the rehabilitation monitoring process to allow for early response to non-compliance with water management criteria	Recovery a review of water quality as part of the rehabilitation monitoring process to allow for early response to non-compliance with water management criteria	Environmental Superintendents	Annual rehabilitation monitoring	Personnel Time Budget	None	Internal Reporting	Annual review	Minor	Unlikely	Low
	Local	Rehabilitation area does not achieve a land capability rating between 2 and 3	Legal & Regulatory	Rehabilitation design - design process which has considered inherent hazards that may be present and developed an appropriate design response	Administrative	<10%	Moderate	Feasible	High	Material testing prior to use, including heavy metal, change species mix, as appropriate	Material testing prior to use, including heavy metal, change species mix, as appropriate	Environmental Superintendents	Ensure a material testing process to ensure suitable materials are used in rehabilitation	Personnel Time Budget	None	Internal - Native Vegetation Management Plan	Timing by 11/11/2023	Minor	None	Low
	Local	Rehabilitation area remains significantly more barren than the surrounding natural landscape	Safety	Rehabilitation design - design process which has considered inherent hazards that may be present and developed an appropriate design response	Administrative	<10%	Moderate	Unlikely	Medium	If closure, complete a closure risk assessment with closing focus on addressing completion requirements and risks associated with rehabilitation area. If required as an outcome of this risk assessment, provide additional controls related to establishing infrastructure and vegetation	A detailed closure risk assessment is to be completed prior to any rehabilitation work. If required as an outcome of this risk assessment, provide additional controls related to establishing infrastructure and vegetation	204 Operations	Complete closure risk assessment for completion requirements associated with P&L 3	Personnel Time Budget	None	As per 204 Plan requirements	At closure	Moderate	None	Medium
2004 Achievement of a native condition (land capability rating P&L 3)	Other	The landholder does not accept the condition and inherent integrity of the infrastructure	Legal & Regulatory	Where Indian is not the background landholder or an agreement is not in place, complete removal of the infrastructure has been noted in the DEC	Declaration	<10%	Insignificant	None	Low	None Required	None Required	N/A	N/A	High	None	None Required	None Required	None Required	None Required	None Required
	Water	Rehabilitation area surface water runoff does not comply with completion criteria and cause environmental harm	Legal & Regulatory	Min Water Management Plan, Water Management Plan (includes monitoring). RMP and past history of completion criteria. Including the rehabilitation design process which has considered inherent hazards that may be present and developed an appropriate design response	Administrative	<10%	Moderate	Unlikely	Medium	If recovery, complete a closure risk assessment with closing focus on addressing completion requirements and risks associated with rehabilitation area. If required as an outcome of this risk assessment, provide additional controls related to establishing infrastructure and vegetation	A detailed closure risk assessment is to be completed prior to any rehabilitation work. If required as an outcome of this risk assessment, provide additional controls related to establishing infrastructure and vegetation	204 Operations	Complete closure risk assessment for completion requirements associated with P&L 3	Personnel Time Budget	None	As per 204 Plan requirements	At closure	Moderate	None	Medium
	Other	The landholder does not formally accept the infrastructure	Legal & Regulatory	Where Indian is not the background landholder or an agreement is not in place, complete removal of the infrastructure has been noted in the DEC	Declaration	<10%	Insignificant	None	Low	None Required	None Required	N/A	N/A	High	None	None Required	None Required	None Required	None Required	None Required
	Other	The landholder does not formally accept the infrastructure	Legal & Regulatory	Where Indian is not the background landholder or an agreement is not in place, complete removal of the infrastructure has been noted in the DEC	Declaration	<10%	Insignificant	None	Low	None Required	None Required	N/A	N/A	High	None	None Required	None Required	None Required	None Required	None Required

PRIMARY EVENTS IDENTIFIED AND EXISTING ACTIONS/ACTIVITIES TO ADDRESS RISKS

IF REQUIRED - SECONDARY ACTIONS/ACTIVITIES REQUIRED TO ADDRESS IDENTIFIED RISKS

Process Step Substituted or Mitigated	Hazard Type	Description of Unmitigated Event	Consequence Type	Control Controls in Place	Control Type	Control Quality	Maximum Assessable Consequence	Unlikelihood	Risk Score	Additional treatment options	Reason for selecting this treatment option	Responsibility for approval and implementation	Proposed actions	Resource requirements	Performance indicators and measures	Reporting and monitoring requirements	Timing and scheduling	Maximum Assessable Consequence	Unlikelihood	Risk Score
RMS1 Achievement of a stable condition (dry-gully channel)	Land	Rehabilitation area contains significantly more hazards than the surrounding unmitigated landscape	Safety	Rehabilitation design (budget) provides, which have considered inherent hazards that may be present and developed an appropriate design response	Administrative	<00%	Minor	Low	Low	None Required	None Required	R/J	N/A	Nil	None	None Required	None Required	Minor	Unlikely	Low
	Land	The Rehabilitation area has an index of Disturbance Condition <10	Legal & Regulatory	Rehabilitation design (budget) design plan approved by DMR	Administrative	<00%	Minor	Unlikely	Medium	Rehabilitation monitoring process to incorporate the P&ID and completion criteria are met. Formal compliance, monitoring and remediate process to apply as per the MAP if the rehabilitation does not comply with compliance criteria. No work of investigation may be required.	Rehabilitation monitoring process to incorporate the P&ID and completion criteria are met. Formal compliance, monitoring and remediate process to apply as per the MAP if the rehabilitation does not comply with compliance criteria. No work of investigation may be required.	Environmental Superintendent	Rehabilitation monitoring	Personal Time	None	Visual inspection to the site with a DMR representative on duty (10% of time)	Yearly as part of grazing season (April to June)	Minor	Unlikely	Low
	Water	Rehabilitation area surface water runoff does not comply with completion criteria and cause environmental harm	Environmental	Min Water Management Plan, Water Management Plan (includes monitoring, S&P and review of completed rehabilitation to demonstrate that rehabilitation area comply with water completion criteria)	Administrative	<00%	Minor	Unlikely	Medium	Compliance on annual review of water quality as part of the rehabilitation monitoring process, to allow for early response to non-compliance with water completion criteria. If required by water, investigate further remedial and corrective actions as required.	Compliance on annual review of water quality as part of the rehabilitation monitoring process, to allow for early response to non-compliance with water completion criteria. If required by water, investigate further remedial and corrective actions as required.	Environmental Superintendent	Rehabilitation monitoring	Personal Time Budget	None	Internal Reporting	Annual review	Minor	Unlikely	Low
	Land	Rehabilitation area has considerable erosion potential that is inconsistent with P&ID objectives	Environmental	Min Water Management Plan, Water Management Plan (includes monitoring, S&P and review of completed rehabilitation to demonstrate that rehabilitation area comply with water completion criteria)	Administrative	<00%	Minor	Unlikely	Medium	Ongoing monitoring and response	Compliance on annual review of water quality as part of the rehabilitation monitoring process, to allow for early response to non-compliance with water completion criteria. If required by water, investigate further remedial and corrective actions as required.	Environmental Superintendent	Rehabilitation monitoring	Personal Time Budget	None	Internal Reporting	Annual review	Minor	Unlikely	Low
RMS2 Achievement of a stable condition (shale landfill under P&ID)	Land	Rehabilitation area contains significantly more hazards than the surrounding unmitigated landscape	Safety	Rehabilitation design (budget) provides, which have considered inherent hazards that may be present and developed an appropriate design response	Administrative	<00%	Minor	Low	Low	None Required	None Required	R/J	N/A	Nil	None	None Required	None Required	Minor	Unlikely	Low
	Land	Rehabilitation area surface water runoff does not comply with completion criteria and cause environmental harm	Legal & Regulatory	Min Water Management Plan, Water Management Plan (includes monitoring, S&P and review of completed rehabilitation to demonstrate that rehabilitation area comply with water completion criteria)	Administrative	<00%	Minor	Unlikely	Medium	Compliance on annual review of water quality as part of the rehabilitation monitoring process, to allow for early response to non-compliance with water completion criteria. If required by water, investigate further remedial and corrective actions as required.	Compliance on annual review of water quality as part of the rehabilitation monitoring process, to allow for early response to non-compliance with water completion criteria. If required by water, investigate further remedial and corrective actions as required.	Environmental Superintendent	Rehabilitation monitoring	Personal Time Budget	None	Internal Reporting	Annual review	Minor	Unlikely	Low
RMS3 Achievement of a stable condition (shale landfill under P&ID)	Land	Rehabilitation area contains significantly more hazards than the surrounding unmitigated landscape	Safety	Rehabilitation design (budget) provides, which have considered inherent hazards that may be present and developed an appropriate design response	Administrative	<00%	Minor	Low	Low	None Required	None Required	R/J	N/A	Nil	None	None Required	None Required	Minor	Unlikely	Low
	Water	Rehabilitation area surface water runoff does not comply with completion criteria and cause environmental harm	Environmental	Min Water Management Plan, Water Management Plan (includes monitoring, S&P and review of completed rehabilitation to demonstrate that rehabilitation area comply with water completion criteria)	Administrative	<00%	Minor	Unlikely	Medium	Compliance on annual review of water quality as part of the rehabilitation monitoring process, to allow for early response to non-compliance with water completion criteria. If required by water, investigate further remedial and corrective actions as required.	Compliance on annual review of water quality as part of the rehabilitation monitoring process, to allow for early response to non-compliance with water completion criteria. If required by water, investigate further remedial and corrective actions as required.	Environmental Superintendent	Rehabilitation monitoring	Personal Time Budget	None	Internal Reporting	Annual review	Minor	Unlikely	Low
	Other	Rehabilitation area is not constructed following certified designs	Legal & Regulatory	Rehabilitation design (budget) provides, which have considered inherent hazards that may be present and developed an appropriate design response	Administrative	<00%	Minor	Unlikely	Medium	Compliance on annual review of water quality as part of the rehabilitation monitoring process, to allow for early response to non-compliance with water completion criteria. If required by water, investigate further remedial and corrective actions as required.	Compliance on annual review of water quality as part of the rehabilitation monitoring process, to allow for early response to non-compliance with water completion criteria. If required by water, investigate further remedial and corrective actions as required.	Environmental Superintendent	Rehabilitation monitoring	Personal Time Budget	None	Internal Reporting	Annual review	Minor	Unlikely	Low
RMS4 Information retention for landfill	Other	The landfill does not accept the condition and structural integrity of the infrastructure	Legal & Regulatory	Where failure is not the landfill owner's responsibility or an agreement is not in place, complete removal of the infrastructure has been noted in the P&ID	Decision	<00%	Major	Low	Low	None Required	None Required	R/J	N/A	Nil	None	None Required	None Required	Minor	Unlikely	Low
	Other	The landfill does not comply with the condition and structural integrity of the infrastructure	Legal & Regulatory	Where failure is not the landfill owner's responsibility or an agreement is not in place, complete removal of the infrastructure has been noted in the P&ID	Decision	<00%	Major	Low	Low	None Required	None Required	R/J	N/A	Nil	None	None Required	None Required	Minor	Unlikely	Low
RMS5 Sufficient information to assess erosion stability	Other	Increased slope gradients for R&M are inconsistent to completion criteria	Legal & Regulatory	Final landfill design and geotechnical assessment have assessed that slope gradients for R&M are acceptable	Administrative	<00%	Minor	Unlikely	Medium	Compliance on annual review of water quality as part of the rehabilitation monitoring process, to allow for early response to non-compliance with water completion criteria. If required by water, investigate further remedial and corrective actions as required.	Compliance on annual review of water quality as part of the rehabilitation monitoring process, to allow for early response to non-compliance with water completion criteria. If required by water, investigate further remedial and corrective actions as required.	Environmental Superintendent	Rehabilitation monitoring	Personal Time Budget	None	Internal Reporting	Annual review	Minor	Unlikely	Low
	Other	Landfills are not geotechnically stable (R&M < 1.5)	Legal & Regulatory	Final landfill design and geotechnical assessment have assessed that slope gradients for R&M are acceptable	Administrative	<00%	Minor	Unlikely	Medium	Compliance on annual review of water quality as part of the rehabilitation monitoring process, to allow for early response to non-compliance with water completion criteria. If required by water, investigate further remedial and corrective actions as required.	Compliance on annual review of water quality as part of the rehabilitation monitoring process, to allow for early response to non-compliance with water completion criteria. If required by water, investigate further remedial and corrective actions as required.	Environmental Superintendent	Rehabilitation monitoring	Personal Time Budget	None	Internal Reporting	Annual review	Minor	Unlikely	Low
RMS6 Sufficient information to assess safety and condition of surface environmental harm	Other	A safety fence is not constructed to the correct dimensions	Safety	Construction plan, specialist contractors, supervision, inspection	Administrative	<00%	Major	Low	Low	None Required	None Required	R/J	N/A	Nil	None	None Required	None Required	Minor	Unlikely	Low
	Other	Safety fence is constructed to a substantially variable size	Safety	Construction plan, specialist contractors, supervision, inspection	Administrative	<00%	Major	Low	Low	None Required	None Required	R/J	N/A	Nil	None	None Required	None Required	Minor	Unlikely	Low
	Other	Ground surface is not constructed to the correct dimensions	Safety	Construction plan, specialist contractors, supervision, inspection	Administrative	<00%	Major	Low	Low	None Required	None Required	R/J	N/A	Nil	None	None Required	None Required	Minor	Unlikely	Low
	Land	Regional groundwater quality does not meet water quality (see Table 10.1) - Groundwater quality (see Table 10.1)	Environmental	Min Water Management Plan, Water Management Plan (includes monitoring, S&P and review of completed rehabilitation to demonstrate that rehabilitation area comply with water completion criteria)	Administrative	<00%	Minor	Unlikely	Medium	Compliance on annual review of water quality as part of the rehabilitation monitoring process, to allow for early response to non-compliance with water completion criteria. If required by water, investigate further remedial and corrective actions as required.	Compliance on annual review of water quality as part of the rehabilitation monitoring process, to allow for early response to non-compliance with water completion criteria. If required by water, investigate further remedial and corrective actions as required.	Environmental Superintendent	Rehabilitation monitoring	Personal Time Budget	None	Internal Reporting	Annual review	Minor	Unlikely	Low

6.3 Rehabilitation trials

Rehabilitation for grazing is well understood at Ensham, given a history of over 20 years and >1500ha of successful progressive rehabilitation has been completed. As such, no rehabilitation trials are proposed as a method to manage or minimise a risk of a stable condition not being achieved on grazing areas.

Notwithstanding, rehabilitation trials may be conducted as a component for implementing NBC ecosystems and amelioration of spoil to produce growth media. Rehabilitation trials have been and will continue to be conducted at Ensham from time to time as a component of continuous improvement.

6.3.1 Grazing trials

6.3.1.1 Yongala grazing trial

In Dec 2015 to Apr 2016, a grazing trial was conducted at Ensham. This trial was undertaken at Yongala and aimed to provide evidence that demonstrates the ability of rehabilitated mine spoil to meet an end land use of a grazing rangeland system. The priorities of the grazing trial were to;

- demonstrate the rehabilitated areas can support a carrying capacity of similar land types and conditions of grazing areas in the surrounding district; and
- that rehabilitation remains a safe and stable landform prior to and following the grazing trial; and
- to ensure established rehabilitation pasture species remain viable following the grazing trail.

Whilst not directly analysed in the assessment, condition and performance of the cattle was considered following removal from the rehabilitation area.

Pre and post grazing assessments were completed in the trial areas, collating data on the following parameters:

- Ground cover (%)
- Soil condition rating (1-5)
- Pasture condition rating (1-4)
- Dry matter (DM) yield (kg/ha)
- Yield unpalatable (%)

Assessment of these, alongside consideration of the condition and performance of the cattle within the area enabled the following conclusions to be drawn.

- Dry matter yield decreased with grazing
- % of unpalatable forage decreased significantly (attributed to cattle compacting and mulching rank unpalatable material, whilst promoting new growth through disturbance and rainfall) – this increased the pasture condition rating.
- Slight decrease in groundcover post grazing.
- Soil condition unchanged with the presence of grazing

The native woodland reference site experienced similar conditions, but however did not see as significant of a fluctuation in dry matter yield post grazing.

Overall, the results from the grazing trial indicate that grazing on rehabilitation at Ensham is sustainable to stocking rates comparable to the surrounding district without risk of deterioration in landform stability and viability of pasture species, therefore aiding in developing rehabilitation strategies moving forward.

6.3.1.2 Ramps 10, 22 and 82 grazing trial

A recent grazing assessment was conducted at Ramp10, Ramp 22 and Ramp 82 (Greenfields, 2017; 2018) to demonstrate the ability of rehabilitated mine spoil to meet an end land use of a grazing rangeland system. The priorities of this grazing trial was to demonstrate the rehabilitation could support a carrying capacity of similar land types and conditions of grazing areas in the Fitzroy Basin; and ensure rehabilitation remains a safe and stable landform (with minimum 50% ground cover) conserved both prior to and following the introduction of cattle; and established pasture species remaining viable following grazing.

Soil and pasture condition ratings primarily remained unchanged from pre to post assessment. No visual signs of crusting, compaction, soil movement and or erosion occurred in rehabilitation areas. The grazing assessment on Ramp 22 produced a total average live weight gain of 0.98 kg/per day, well above expectations for Live Weight Gain in the Fitzroy Basin.

6.3.2 Bushland trials

6.3.2.1 Trees on benches

Rehabilitation to promote the establishment of tree and shrub species, as opposed to a grassland or grazing land use, has occurred on benches, which are areas of relatively flat ground. This has been demonstrated as highly effective with progressive rehabilitation, with plant health recorded for Ensham consistently maintained at a high level.

6.3.2.2 NEDO Trial

The earlier of Ensham's trials, the NEDO trial, was aimed to establish a high capacity carbon sink in a short period time by trialling methods of afforestation. This trial expanded from 2001 to 2005 and studied various treatments and conditions (inclusive of soil additives/fertilisers, fungi presence, watering regimes, and groundcover variability) for 2 tree species. The findings from the trial provided a foundation of data to understand the growth of trees in rehabilitation, particularly with respect to measurable carbon fixation.

6.3.2.3 BCS Growth Trials

BCS Consortium (Cammel Consulting, Innovate Enviro and SoilCyclers Pty Ltd) have undertaken growth trials at Ensham using ameliorated and remediated overburden as a growth media as part of a project jointly funded by METS Ignited and Idemitsu. The aim of the trial was to be able to identify strategies to improve spoil and topsoil for use in rehabilitation. Laboratory results of the ameliorated material have shown results to be equal to or better than a typical site topsoil.

SoilCyclers sampled overburden from across the site and they have developed an amelioration strategy to turn overburden into a growth media to address the topsoil shortfall. Two samples of typical Tertiary and Permian spoil material were chosen for onsite amelioration trials which commenced in December 2020. BCS Consortium and Ensham have shown that ameliorating overburden to a growth media is a proven solution to meet rehabilitation needs as required, but further refinement is required.

7 MONITORING AND MAINTENANCE

Monitoring at Ensham is undertaken for a range of environmental aspects, with some monitoring conducted separately under the EA and other regulatory requirements. This section highlights the monitoring methods utilised at Ensham which demonstrate how milestones and milestone criteria will be achieved. Further details of the methods used can be found within Appendix 9.3 – Monitoring summary report.

7.1 Overview of milestone monitoring

A monitoring program has been developed and is aligned to the eleven Rehabilitation Milestones described in Section 9.1.3.2. This is as summarised below, and has also informed the schedule presented as Table 7-1.

7.1.1 Monitoring of RM1 – Infrastructure decommissioning and removal

Where relevant, this RM is the initial step in the rehabilitation process. Achievement of this milestone will be determined by completion of a checklist and formal signoff by relevant Ensham personnel. This may include formal confirmation of the following:

- Have all services been disconnected?
- Have all road materials been removed?
- Have all pipelines been removed?
- Have all buildings and foundations been removed?
- Has all machinery and equipment been removed?
- Has all scrap been removed?
- Has all general and regulated waste been removed?

A report will be compiled of the infrastructure removed and disposal process.

7.1.2 Monitoring of RM2 – Identification and remediation of contaminated land

This RM is relevant to rehabilitation areas that were previously used for an *environmentally relevant activity* e.g., fuel storage, sewage treatment. Where such activities were conducted, the following process will apply:

- Engage a suitably qualified person.
- Site investigation report, to determine if contamination exists.
- Validation report, describing works conducted to remediate any contaminated land.
- Site suitability statement, indicating the land is not contaminated.

The above listed documentation will demonstrate achievement of this RM.

7.1.3 Monitoring of RM3 – final landform development

Achievement of this RM will be determined by ground and aerial survey, and generation of 'as constructed' digital terrain models and/or plans. These will be signed off by relevant Ensham personnel, including technical and operation functions at the mine, confirming design specifications have been achieved within acceptable engineering tolerances.

7.1.4 Monitoring of RM4 – Seedbed preparation

Seedbed preparation will generally require the spreading of topsoil and tillage to create loose, friable surface with plenty of micro-niches for seed/soil contact. Achievement of this RM will be demonstrated as follows:

- Laboratory soil testing to determine material suitability for use as a growth media.
- Amelioration and fertilisation to overcome plant growth limitations identified by soil laboratory testing.
- Survey control and mapping of the extent and depth of topsoil replacement, where topsoil is used.
- The date of topsoil replacement and subsequent treatments e.g., deep ripping, sowing.

7.1.5 Monitoring of RM5 - Sowing

Achievement of this RM will be documented in the site GIS, including the following information:

- The extent (boundaries) of each area sown.
- The seed mix sown.
- Date of sowing.
- Sowing methods.
- Seed quality records.

7.1.6 Monitoring of RM6 – Vegetation establishment

Vegetation establishment will be monitored as:

- Percentage groundcover, using ground methods which may be supplemented with remote sensing methods.
- Prevalence of weeds.

Field assessments are conducted by competent technical personnel, and data review and reporting by an appropriately qualified person.

7.1.6.1 Groundcover monitoring

Specifically, groundcover monitoring consists of visual observations using a transect or quadrat to delineate a representative groundcover measurement for the rehabilitation area. This is then verified over larger areas by remote sensing methods. Observations on the type of cover are made for the assessment area alongside biomass, diversity/species presence and weed infestations.

Groundcover assessments are subsequently also paired with erosion monitoring of the associated rehabilitation areas.

7.1.6.2 Erosion Monitoring

In-field visual observations shall constitute erosion monitoring in rehabilitation areas. This assessment will note the presence of any erosion within the rehabilitation, its severity and any recommended actions, where deemed necessary. This monitoring can also be paired with drainage and runoff assessments with the aim to identify and rectify converging flow paths.

7.1.7 Monitoring of RM7 – Achievement of a stable condition (beef cattle grazing PMLU)

7.1.7.1 The rehabilitation area is safe

Ensham will use formal hazard assessment methods aligned to Australian Standard for risk management (AS/NZS ISO13000:2009) to demonstrate each rehabilitation is safe, relative to unmined lands used for the same purpose e.g., cattle grazing.

7.1.7.2 Rehabilitation does not cause environmental harm

Surface water monitoring shall be used to demonstrate nothing on or in rehabilitation areas is causing environmental harm. This will include monitoring for the following parameters:

- pH
- Salinity, as electrical conductivity (EC)
- Total suspended solids
- Arsenic
- Molybdenum
- Selenium
- Sulphate.

Rainfall runoff will be sampled to ensure rehabilitation areas are in compliance with the criterion outlined in the EA. Any instances of seepage from rehabilitation areas will be sampled.

7.1.7.3 PMLU

Agricultural land resource evaluation and land suitability assessment will be used to determine if rehabilitation areas can sustain a PMLU of cattle grazing. Details of this land evaluation methodology have been provided (refer to Section 5.5.2.2). Alongside this, pasture productivity assessment will be conducted to identify its suitability for cattle grazing (eg. 3P grasses).

7.1.8 Monitoring of RM8 - Achievement of a stable condition (landholder retained infrastructure PMLU)

7.1.8.1 The rehabilitation area is safe

Ensham will use formal hazard assessment methods aligned to Australian Standard for risk management (AS/NZS ISO13000:2009) to demonstrate each rehabilitation area is safe, relative to unmined lands used for the same purpose.

7.1.8.2 Rehabilitation does not cause environmental harm

Surface water monitoring shall be used to demonstrate nothing on or in areas is causing environmental harm. This may include monitoring for the following parameters:

- pH
- Salinity, as EC
- Total suspended solids
- Arsenic
- Molybdenum

- Selenium
- Sulphate.

7.1.8.3 PMLU

This PMLU will be demonstrated by formal agreement between the underlying landholders and Ensham.

7.1.9 Monitoring of RM9 - Achievement of a stable condition (Boggy Creek diversion PMLU)

7.1.9.1 The rehabilitation area is safe

Ensham will use formal hazard assessment methods aligned to Australian Standard for risk management (AS/NZS ISO13000:2009) to demonstrate each rehabilitation is safe, relative to unmined lands used for the same purpose.

7.1.9.2 Rehabilitation does not cause environmental harm

Surface water monitoring shall be used to demonstrate nothing on or in rehabilitation areas is causing environmental harm. This will include monitoring for the following parameters:

- pH
- Salinity, as EC
- Total suspended solids
- Arsenic
- Molybdenum
- Selenium
- Sulphate.

Rainfall runoff will be sampled to ensure rehabilitation areas are in compliance with the criterion outlined in the EA. Any instances of seepage from rehabilitation areas will be sampled.

7.1.9.3 PMLU

This PMLU will be demonstrated by application of diversion monitoring methods outlined in Criteria for functioning river landscape units in mining and post-mining landscapes (ACARP Project C20017). Specifically, this will require assessment of riparian vegetation to determine an index of diversion condition (IDC) score. IDC is designed specifically for Bowen Basin diversions and provides rapid assessment of channel condition and flags potential management issues.

7.1.10 Monitoring of RM10 - Achievement of a stable condition (native bushland corridor PMLU)

7.1.10.1 The rehabilitation area is safe

Ensham will use formal hazard assessment methods aligned to Australian Standard for risk management (AS/NZS ISO13000:2009) to demonstrate each rehabilitation is safe, relative to unmined lands used for the same purpose.

7.1.10.2 Rehabilitation does not cause environmental harm

Surface water monitoring shall be used to demonstrate nothing on or in rehabilitation areas is causing environmental harm. This will include monitoring for the following parameters:

- pH
- Salinity, as EC
- Total suspended solids
- Arsenic
- Molybdenum
- Selenium
- Sulphate.

Rainfall runoff will be sampled to ensure rehabilitation areas are in compliance with the criterion outlined in the EA. Any instances of seepage from rehabilitation areas will be sampled.

7.1.10.3 PMLU

To monitoring native bushland rehabilitation areas, Ensham will establish permanent transects and adapt the BioCondition methodology by Eyre et al. (2015). This may include:

- Transects.
- Canopy cover.
- Stem counts, grouped into type (tree, shrub) and genus (Eucalypt, Acacia).
- Groundcover.
- Species richness.

7.1.11 Monitoring of RM11 - Achievement of a stable condition (flood protection landform PMLU)

7.1.11.1 The rehabilitation area is safe

Ensham will use formal hazard assessment methods aligned to Australian Standard for risk management (AS/NZS ISO13000:2009) to demonstrate each rehabilitation is safe, relative to unmined lands used for the same purpose.

7.1.11.2 Rehabilitation does not cause environmental harm

Surface water monitoring shall be used to demonstrate nothing on or in rehabilitation areas is causing environmental harm. This will include monitoring for the following parameters:

- pH
- Salinity, as EC
- Total suspended solids
- Arsenic
- Molybdenum
- Selenium
- Sulphate.

Rainfall runoff will be sampled to ensure rehabilitation areas are in compliance with the criterion outlined in the EA. Any instances of seepage from rehabilitation areas will be sampled.

7.1.11.3 PMLU

Survey monitoring and generation of 'as constructed' digital terrain models and/or plans. These will be signed off by relevant personnel, including technical and operation functions at the mine, confirming design specifications have been achieved within acceptable engineering tolerances.

7.1.12 Improvement areas

A monitoring program has also been developed for the Improvement Areas (IAs) and it is aligned with the Management Milestones (MM) set in Section 9.1.4. Monitoring methodologies to ensure both MMs are achieved are through site assessment of the slopes (LiDAR and/or survey information) to ensure long-term stability on the slopes. Groundwater monitoring is also conducted to meet the MMs, ensuring that the groundwater quality does not exceed water quality limits and does not cause environmental harm.

7.2 Schedule of monitoring and maintenance

The schedule provided as Table 7-1, over the page, forms the basis of a monitoring and maintenance program that identifies and describes the monitoring to be carried out in order to demonstrate that milestone and management criteria have been achieved. This provides site-specific detail as to the proposed timing and methodology, attributes to be monitored, who may conduct monitoring and what the outputs should be.

This has been developed in a manner that would allow for a repeatable program of monitoring to be carried out.

Table 7-1 Monitoring and maintenance schedule for Ensham

Criteria	Monitoring Methods	Frequency	Contingency/ Maintenance	Reporting	Review
RM 1 Infrastructure decommissioning and removal					
Redundant services to be disconnected by end of closure phase, as evidenced by formal notice.	Review services documentation, visual inspection assisted by checklist	Once off	Arrange disconnection	Internally	Annually
Redundant buildings and infrastructure to be removed from RA by end of closure, as evidenced by site inspection	Review hazardous materials documentation, visual inspection assisted by checklist	Once off	Arrange removal	Internally	Annually
Redundant plant and equipment to be removed from RA by end of closure, as evidenced by site inspection	Review hazardous materials documentation, visual inspection assisted by checklist	Once off	Arrange removal	Internally	Annually
RM2 Identification and remediation of contaminated land					
Contaminated land assessment to be completed by SQP, as evidenced by Preliminary Site Investigation (PSI) and Detailed Site Investigation (DSI) if needed.	Review water and soil quality assessments and monitoring to identify contamination, review PSI, DSI reports	Once off, upon receipt of PSI, DSI reports	Arrange PSI, DSI	Internally	Annually
Identified contaminated land to be remediated or managed, as evidenced by auditor sign-off as per EP Act requirements	Review DSI report, Site Validation Report	Upon receipt of DSI Report, Site Validation Report	Arrange remediation or continued remediation if required	Internally	Annually
Removal of land from Contaminated Land Register, prior to relinquishment	Review Contaminated Land Register	Upon receipt of Site Validation Report showing full remediation	Arrange deregistration	Internally	Annually
Removal of land from Environmental Management Register if feasible, prior to relinquishment	Review Environmental Management Land Register	Upon receipt of Site Validation Report showing full remediation	Arrange deregistration	Internally	Annually
RM3 Final landform development					
Beef cattle grazing					
All outward facing overburden slopes to achieve 0-10% slopes for Tertiary materials and 0-15% slopes for Permian materials.	Site assessment of slopes and or Lidar by AQP review AQP report, review Annual Rehabilitation Monitoring Reports	Upon receipt of AQP report, and annually for ongoing monitoring	Re-shape landform to design specifications prior to topsoiling	Internally	Upon completion of re-shaping
90% of the inward facing slopes achieving 0-10% slopes for Tertiary materials and 0-15% slopes for Permian materials.	Site assessment of slopes and or Lidar by AQP review AQP report, review Annual Rehabilitation Monitoring Reports	Upon receipt of AQP report, and annually for ongoing monitoring	Re-shape landform to design specifications prior to topsoiling	Internally	Upon completion of re-shaping
Up to 10% of the inward facing slopes may include slopes between 15% to 25%, subject to these areas being fully contained within areas of 0-15% slopes.	Site assessment of slopes and or Lidar by AQP review AQP report, review Annual Rehabilitation Monitoring Reports	Upon receipt of AQP report, and annually for ongoing monitoring	Re-shape landform to design specifications prior to topsoiling	Internally	Upon completion of re-shaping
Landforms are assessed as being geotechnically stable with a factor of safety ≥ 1.5.	Assessment of RPEQ and review of RPEQ assessment	Upon receipt of RPEQ assessment	Arrange remediation	Internally	Upon completion of remediation

Criteria	Monitoring Methods	Frequency	Contingency/ Maintenance	Reporting	Review
Native bushland corridor PMLU					
Maximum 25% slope	Site assessment of slopes and or Lidar by AQP, review AQP report, review Annual Rehabilitation Monitoring Reports	Upon receipt of AQP report, and annually for ongoing monitoring	Re-shape landform to design specifications prior to topsoiling or rock mulching	Internally	Upon completion of re-shaping
Areas > 15% to be certified by a suitably qualified person as being stable long term, with rock mulch applied as required.	Site assessment of by AQP, review AQP report, review Annual Rehabilitation Monitoring Reports	Upon receipt of AQP report, and annually for ongoing monitoring	Re-shape landform to design specifications prior rock mulching	Internally	Upon completion of re-shaping
Flood protection landform PMLU					
Watercourse facing slopes $\leq 15\%$.	Site assessment of slopes and/or Lidar by AQP, review AQP report, review Annual Rehabilitation Monitoring Reports	Upon receipt of AQP report, and annually for ongoing monitoring	Re-shape landform to design specifications prior to topsoiling	Internally	Upon completion of re-shaping
Void facing slopes $\leq 15\%$, except where constrained by proximity to void regrade, batters can be reduced to $\leq 25\%$.	Site assessment of slopes and/or Lidar by AQP, review AQP report, review Annual Rehabilitation Monitoring Reports	Upon receipt of AQP report, and annually for ongoing monitoring	Re-shape landform to design specifications prior to topsoiling	Internally	Upon completion of re-shaping
Bench of 10m to separate inward toe embankment from adjacent edge of void stabilisation regrade.	Site assessment and/or Lidar by AQP, review AQP report	Upon receipt of AQP report	Re-shape landform to design specifications	Internally	Upon completion of re-shaping
Landform – 0.1%AEP +0.5m freeboard.	Site assessment and/or Lidar by AQP, review AQP report	Upon receipt of AQP report	Re-shape landform to design specifications	Internally	Upon completion of re-shaping
Line the river facing embankments at sharp changes in alignment where turbulence could occur with hard, durable rock rip rap.	Site assessment by AQP, review AQP report	Upon receipt of AQP report	Re-line embankment with rip-rap to design specifications	Internally	Upon completion of re-lining
Must be fenced to exclude stock and permanent fencing in place post construction and maintained.	Visual inspection	Monthly	Re-install fencing	Internally	Annually, and upon re-installation
Boggy Creek Diversion PMLU					
Geotechnically stable with a factor of safety ≥ 1.5	Assessment of RPEQ and review of RPEQ assessment	Upon receipt of RPEQ assessment	Arrange remediation	Internally	Upon completion of remediation
As constructed drawings submitted to Department of Regional Development, Manufacturing and Water	Review submission evidence (email, submission slip, receipt)	Upon completion of construction	Arrange submission	Department of Regional Development, Manufacturing and Water	During annual reporting
RM4 Seedbed preparation					
Topsoil is replaced to 150mm depth on all areas to be revegetated.	Visual inspection	Upon completion of placement	Re-place or place topsoil to specifications	Internally	Upon re-placement
Soil ameliorants and fertilisers are applied as needed to address soil limitations.	Review soil laboratory documentation, rehabilitation records	Upon completion of amelioration, annually for ongoing monitoring	Re-ameliorate or ameliorate	Internally	Upon completion of re-amelioration

Criteria	Monitoring Methods	Frequency	Contingency/ Maintenance	Reporting	Review
RM5 Sowing					
Beef cattle grazing PMLU: 3P pasture species mix sown at appropriate rate	Review seed mix specification, rehabilitation records, annual rehabilitation monitoring	Upon completion of seeding, and annually for ongoing monitoring	Re-seed or seed according to specifications	Internally	Upon completion of re-seeding
Native bushland corridor PMLU: Native trees and shrub species mix sown at appropriate rate	Review seed mix specification, rehabilitation records, annual rehabilitation monitoring	Upon completion of seeding, and annually for ongoing monitoring	Re-seed or seed according to specifications	Internally	Upon completion of re-seeding
Flood protection landform PMLU: Native trees and shrub species mix sown, grass species sown at appropriate rate	Review seed mix specification, rehabilitation records, annual rehabilitation monitoring	Upon completion of seeding, and annually for ongoing monitoring	Re-seed or seed according to specifications	Internally	Upon completion of re-seeding
Hay mulch applied as required	Review mulching specification, rehabilitation records, annual rehabilitation monitoring	Upon completion of mulching, and annually for ongoing monitoring	Re-mulch according to specifications	Internally	Upon completion of re-mulching
RM6 Vegetation establishment					
Beef cattle grazing PMLU: ≥50% established and persistent vegetative groundcover for all slopes from 0-15%.	Annual rehabilitation monitoring	Annually	If revegetation fails or trends indicate that criterion will not be achieved, investigate cause, and re-fertilise, treat top soil, re-sow or re-plant, as appropriate	Internally	Upon completion of annual rehabilitation monitoring reports
Beef cattle grazing PMLU: ≥80% established and persistent vegetative cover for slopes from 15% to 25%.	Annual rehabilitation monitoring	Annually	If revegetation fails or trends indicate that criterion will not be achieved, investigate cause, and re-fertilise, treat top soil, re-sow or re-plant, as appropriate	Internally	Upon completion of annual rehabilitation monitoring reports
Native bushland corridor PMLU: ≥50% established and persistent vegetative groundcover for all slopes from 0-20%.	Annual rehabilitation monitoring	Annually	If revegetation fails or trends indicate that criterion will not be achieved, investigate cause, and re-fertilise, treat top soil, re-sow or re-plant, as appropriate	Internally	Upon completion of annual rehabilitation monitoring reports
Native bushland corridor PMLU: ≥80% established and persistent cover (vegetative and/or rock mulch) for slopes from 20% to 25%.	Annual rehabilitation monitoring	Annually	If revegetation fails or trends indicate that criterion will not be achieved, investigate cause, and re-fertilise, treat top soil, re-sow or re-plant, as appropriate	Internally	Upon completion of annual rehabilitation monitoring reports
Native bushland corridor PMLU: Species richness ≥ 2 tree species, ≥ 3 shrub species, ≥ 5 groundcover species.	Annual rehabilitation monitoring	Annually	If revegetation fails or trends indicate that criterion will not be achieved, investigate cause, and re-fertilise, treat top soil, change species mix, re-sow or re-plant, as appropriate	Internally	Upon completion of annual rehabilitation monitoring reports

Criteria	Monitoring Methods	Frequency	Contingency/ Maintenance	Reporting	Review
RM7 Achievement of PMLU to a safe, stable, and non-polluting condition					
Certification from an AQP that the area is geotechnically safe and stable at end of closure phase (including through subsidence)	Review AQP certification	Upon receipt of certification	Arrange corrective actions, as required	Internally	Upon completion of corrective actions
Certification from an AQP that surface water quality will not cause environmental harm to the surrounding environment, using release contaminant trigger investigation levels outlined in the EA at end of closure phase	Review AQP certification	Upon receipt of certification	Arrange corrective actions, as required	Internally, Administering Authority	Upon completion of corrective actions
0 (zero) significant difference as defined in AS/NZS ISO 31000:2009 Risk Management (from DES comments)	Hazard assessment by AQP, review of AQP report	Upon receipt of AQP report	Arrange corrective actions, as required	Internally	Upon completion of corrective actions
RM8 Achievement of a self-sustaining condition with respect to beef cattle grazing PMLU					
Certification from an AQP that rehabilitation is suitable for sustainable cattle grazing and is land suitability class 2 to 4 as defined in the Guidelines for Agricultural Land Evaluation in Queensland (State Department of Queensland 2013).	Site assessment by AQP, review AQP report	Upon receipt of AQP report	Investigate cause of failure to achieve suitability class 2 to 4, re-fertilise, treat top soil, change species mix, re-sow, as appropriate	Internally	Upon completion of remediation
RM9 Achievement of a stable condition (Boggy Ck diversion)					
Certification from an AQP that riparian vegetation is suitable for conservation of rehabilitated creek diversion areas and has an IDC score >10 as defined in Criteria for functioning river landscape units in mining and post-mining landscapes (ACARP Project number C20017).	Site assessment by AQP, review AQP report	Upon receipt of AQP report	Investigate cause of failure to score >10, and remediate as appropriate	Internally	Upon completion of remediation
RM10 Achievement of a stable condition (native bushland corridor)					
Certification from an AQP that rehabilitation has native species and bushland characteristics, including: • ≥2 tree species at relevant benchmark density • ≥3 shrub species at relevant benchmark density • ≥5 groundcover species at relevant benchmark density as per relevant Regional Ecosystem BioCondition Benchmark = 11.10.1 and/or 11.10.3)	Annual rehabilitation monitoring	Annually	If revegetation fails or trends indicate that criterion will not be achieved, investigate cause, and re-fertilise, treat top soil, re-sow or re-plant, as appropriate	Internally	Upon completion of annual rehabilitation monitoring reports
RM11 Achievement of a stable condition (flood protection landform)					
Certification from an AQP that construction is per certified designs provided under condition H11 of the EA.	Site inspection, review of AQP report	Upon receipt of AQP report	Arrange corrective actions, as required	Internally	Upon completion of remediation
Permanent flood structure in place at end of closure phase	Site inspection by AQP, review of AQP report	Upon receipt of AQP report	Arrange corrective actions, as required	Internally	Upon completion of remediation
Floodplain width re-instated. Minimum 2km width between the northern section of B Pit and the southern	Site and/or remote sensing imagery inspection by AQP, review of AQP report	Upon receipt of AQP report	Arrange corrective actions, as required	Internally	Upon completion of remediation

Criteria	Monitoring Methods	Frequency	Contingency/ Maintenance	Reporting	Review
section of C Pit as located generally in accordance with Appendix 5 (of the EA).					
RM12 Infrastructure retention for handover					
Transfer of ownership agreements in place where infrastructure to be retained	Review legal agreements for retention of infrastructure	Annually	Arrange transfer	Internally	Annually
MM1 Sufficient improvements to ensure structural stability					
Slope gradients achieved as follows for NUMAs- - Maximum of 275% slopes for competent high walls. - Maximum of 50% slopes for incompetent material - A south pit, F Pits and Y Pits highwall must be reshaped to a maximum of 25% slopes. - Northern Endwall of B Pit maximum 15% slope	Site assessment of slopes and or Lidar by AQP, review AQP report	Upon receipt of AQP report	Re-shape landform to design specifications	Internally	Upon completion of re-shaping
RPEQ geotechnical assessment to certify that landforms are geotechnically and erosionally stable with a factor of safety ≥ 1.5	Review of RPEQ assessment	Upon receipt of assessment	Arrange remediation	Internally	Upon completion of remediation
Water run-off from above the highwall is channelled to the groundwater daylighting water areas PMLU through design pathways.	Site inspection by AQP, review AQP report	Upon receipt of AQP report	Re-shape landform to ensure water drains into channels as envisaged	Internally	Upon completion of re-shaping
MM2 Sufficient improvements to ensure safety and avoidance of serious environmental harm					
All areas to be certified by AQP as being safe long-term.	Site inspection by AQP, review AQP report	Upon receipt of AQP report	Install additional safety measures, as required	Internally	Upon completion of installation of additional safety measures
Improvement areas to be bunded, fenced and signed to exclude humans and stock	Site inspection	Monthly	Re-install bunds, fences, and signage if required	Internally	Upon completion of re-instalment
Regional groundwater aquifers maintain their current water quality and groundwater monitoring bores do not exceed the water quality limits detailed in Table C11 – Groundwater quality limits in the relevant EA as a result of mining activities.	Bore inspection, quarterly monitoring, review monitoring report	Upon receipt of quarterly monitoring report	Review water management arrangements and initiate remedial actions	Internally, Administering Authority (2 yearly Groundwater Management and Monitoring Program Report)	Upon completion of remedial actions
Groundwater daylighting water areas maximum dimensions:					
A Central – Surface Water Level -133mAHD, Water storage Volume -0.5GL, and Water Area – 3ha	Site and/or LiDAR inspection by AQP, review AQP report	1 July and 1 November annually, upon receipt of AQP report	Review water management arrangements and initiate remedial actions	Internally, Administering Authority	Upon completion of remedial actions

Criteria	Monitoring Methods	Frequency	Contingency/ Maintenance	Reporting	Review
A North – Surface Water Level – 133mAHD, Water storage volume – 1.2GL, and Water Area – 16ha	Site and/or LiDAR inspection by AQP, review AQP report	1 July and 1 November annually, upon receipt of AQP report	Review water management arrangements and initiate remedial actions	Internally, Administering Authority	Upon completion of remedial actions
B – Surface Water Level – 123mAHD, Water Storage Volume – 3.1GL and Water Area – 33ha	Site and/or LiDAR inspection by AQP, review AQP report	1 July and 1 November annually, upon receipt of AQP report	Review water management arrangements and initiate remedial actions	Internally, Administering Authority	Upon completion of remedial actions
C and D – Surface Water Level – 125mAHD, Water Storage Volume – 22.1GL and Water Areas – 65ha for C and 75ha for D	Site and/or LiDAR inspection by AQP, review AQP report	1 July and 1 November annually, upon receipt of AQP report	Review water management arrangements and initiate remedial actions	Internally, Administering Authority	Upon completion of remedial actions

7.3 QA/QC processes

QA/QC processes are to be undertaken by an appropriately qualified personnel (AQP). Monitoring data collected will be reviewed by an AQP and evaluated for the initial purpose of analysis and manipulation of data by preparing tables and graphs. The QA/QC process will aim to identify the inherent quality of data collected, as well as provide assurance that relevant internal checks and balances are in place to consider and review summary statistics that indicate the suitability of sampling resolution and number, spread of data, repeatability over time/space as well as use for predicting the future trajectory of rehabilitation performance.

7.3.1 Corrective actions

As required by EA conditions H7 and H8, an annual rehabilitation monitoring report is prepared to incorporate all monitoring completed for the annual campaign. The purpose of the annual report is to present an annual update of the rehabilitation progress towards the achievement of rehabilitation requirements specified by the EA, which are analogous to the PMLU criteria.

The results of each additional year of monitoring will be compared to previous years to show the trending of areas towards the achievement of the safe, stable, non-polluting and self-sustaining PMLU criteria, with recommendations provided to improve and further support the continued progression of the rehabilitation.

The report may also describe corrective actions/contingency strategies, should these require implementation. Examples of some of the corrective actions that will be taken are set out in Appendix 9.3. The report is to be reviewed by Ensham for implementation of contingency strategies as appropriate.

8 REFERENCES

- AARC, 2019 Threatened Species Survey of Regrowth Vegetation at the Ensham Mine. Letter to Idemitsu Australia Resources, dated 13th March 2019
- ABARES (2015) *Catchment Scale Land Use of Australia - Update March 2015*, Department of Environment 2015, Natural Resource Management (NRM) Boundaries 2015, viewed on 11 December 2020 at Land Use and Management Information for Australia - Fitzroy NRM Region - Queensland (daff.gov.au)
- Australasian Groundwater and Environmental (2006) Ensham Central Project – EIA, groundwater impact assessment, Australasian Groundwater and Environmental, Brisbane.
- Bureau of Meteorology (2020a) Climate statistics for Australian locations, Emerald Airport, accessed on 10 December 2020, from http://www.bom.gov.au/climate/averages/tables/cw_035264_All.shtml#other
- Bureau of Meteorology (2020b) Evapotranspiration calculations, Emerald Airport, accessed on 10 December 2020, from http://www.bom.gov.au/watl/eto/tables/qld/emerald_airport/emerald_airport.shtml
- Carroll C, Merton L and Burger P (2000) Impact of vegetative cover and slope on runoff, erosion, and water quality for field plots on a range of soil and spoil materials on central Queensland coal mines, Australian Journal of Soil Research 38:313-327.
- Carroll C and Tucker A (2000) Effects of pasture cover on soil erosion and water quality on central Queensland coal mine rehabilitation, Tropical Grasslands 34:254-262.
- Carroll C, Tucker A, Merton L, Burger P and Pink L (2001) Sustainability Indicators for Coal Mine Rehabilitation, ACARP project C7006, Queensland Department of Natural Mines and Resources, Brisbane.
- CHRC (2016) *Central Highlands Regional Council Planning Scheme*, viewed on 11 December 2020 at [Central Highlands Regional Council Planning Scheme 2016 - Central Highlands Regional Council](#)
- CMLR (2005) *'Ensham coal mine, rehabilitation resource survey'*, Centre for Mined Land Rehabilitation, The University of Queensland, Brisbane.
- Cote C (2020) *Ensham Residual Void Study, Summary of Water Studies*, Sustainable Minerals Institute, The University of Queensland, 2020.
- CSIRO (2016) Climate change in Australia, projections for Australia's NRM regions, accessed on 10 December 2020, from <https://www.climatechangeinaustralia.gov.au/en/climate-projections/future-climate/regional-climate-change-explorer/super-clusters/?current=ESC&tooltip=true&popup=true>
- DAWE (2021) *EPBC Act protected matters report*, Commonwealth of Australia Department of Agriculture, Water and the Environment, Canberra.
- Ensham Resources (2017) *Ensham Residual Void Study Community Reference Group Charter*, Ensham Resources, Brisbane.
- Ensham Resources Pty Limited. (1992). *Environmental Management Overview Strategy November 1992 - Ensham Coal Project - Yongala Mine*.
- Ensham Resources Pty Limited. (1993). *Environmental Management Overview Strategy July 1993 - Ensham Coal Project - Ensham Operations*.
- Ensham Resources. (2021). Rehabilitation Management Plan V3.0 – EIMP.06.00.03. Initially prepared by La Terra Pty Ltd on behalf of Ensham Resources, Emerald.

- Gordon N (2020) *Subsidence report for the Ensham life of mine extension project*, a report prepared for AECOM Australia Pty Ltd on behalf of Ensham Resources Pty Ltd by Gordon Geotechniques Pty Ltd.
- Greenfields Agricultural and Environmental Services (2017). Ramp 22 - Grazing Assessment and 2017 Report, Ensham Mine.
- Greenfields Agricultural and Environmental Services (2018). Ramp 10, 22 and 82 – 2018 Grazing Assessment, Ensham Mine.
- Grigg AH, Emmerton BR and Callum NJ (2001) The development of draft completion criteria for ungrazed rehabilitation pastures after opencut coal mining in central Queensland, ACARP project C8038, The University of Queensland, Brisbane.
- Hydro Engineering and Consulting (HEC) (2020). Ensham Residual Voids Project: Stage 3 Void Water Balance Supplementary Report for Additional Model Run. Letter Report to Idemitsu
- Hollingsworth, Dames and Moore (1990) Ensham coal project, Impact assessment study, Hollingsworth, Dames and Moore, Brisbane.
- Hansen (2006) *Terrain, soils and land capability assessment*, Ensham Central Project, Hansen Consulting, Brisbane.
- Hansen Consulting (2006) *Revised Ensham Central Project, environmental impact statement*, Hansen Consulting, Brisbane.
- Hazelton P and Murphy b (2007) *Interpreting soil test results, what do all the numbers mean?* CSIRO Publishing, Melbourne.
- Kew G, Mengler F and Gilkes F (2007) *Regolith Strength, Water Retention, and Implications for Ripping and Plant Root Growth in Bauxite Mine Restoration*, Restoration Ecology, Vol 15, Issue s4, pp 54-64.
- Koch, J.M. (2007) Alcoa's mining and restoration process in South Western Australia, Restoration Ecology, Vol. 15, pp. s11–s16.
- Lardner, T.D. and Tibbett, M. (2013) Chapter: Deep ripping after topsoil return affects root proliferation and floristic diversity in a restored biodiverse forest after bauxite mining, Publisher: Australian Centre for Geomechanics, Editors: Mark Tibbett, Andy Fourie, Caroline Digby, pp.363-376.
- Loch R (2000) *Effects of vegetation cover on runoff and erosion under simulated rain and overland flow on a rehabilitated site on the Meandu Mine, Tarong, Queensland*, Australian Journal of Soil Research (2000), vol 38, pp 299-312.
- Loch R (2004) *Standards for the supply and application of hydromulch products, stage 1 critical shear testing*. Prepared for Qld Department of Main Roads, October 2004.
- Queensland Department of Mines and Energy (1995) Technical Guidelines Index, Queensland Government via Department of Mines and Energy, Brisbane.
- Queensland Government (2013) Central Queensland Regional Plan, Queensland Government via Department of State Development, Infrastructure and Planning, Brisbane.
- Queensland Government (2013b) Guidelines for agricultural land evaluation in Queensland, Queensland Government via Department of Science, Information Technology and Innovation (DSITI) and Department of Natural Resources and Mines (DNRM), Brisbane.

- RGS (2018) Material Characterization and source term development for the Ensham Coal Mine Final Void Plan, September 2018.
- RGS (2019) Final technical report, material characterisation and source term development for the Ensham coal mine final void plan, RGS, Brisbane.
- RGS (2021) Ensham Mining Waste Management Plan, RGS, Brisbane.
- SLR (2020) *Ensham life of mine extension project, groundwater impact assessment*, prepared for AECOM Australia Pty Ltd by SLR Consulting Australia Pty Ltd.
- SLR Consulting (2020) Ensham Life of Mine Extension Project, Groundwater impact assessment, SLR Consulting, Brisbane.
- SLR (2021) Residual void groundwater monitoring design, SLR, Brisbane
- So HB, Sheridan GJ, Loch RJ, Carroll C, Willgoose G, Short M and Grabski A (1998) Post Mining Landscape Parameters for Erosion and Water Quality Control, ACARP project C4011, The University of Queensland, Brisbane.
- SRK (2020) *Project Memorandum: Sulphide and Metal/Metalloid Source Depletion Estimates*. Prepared for Ensham Resources Pty Ltd.
- Story R, Galloway R W and Gunn R H (1967) *Land systems of the Isaac-Comet area*, CSIRO, Melbourne.
- Szota C, Veneklass E, Koch J and Lambers H (2007) *Root Architecture of Jarrah (Eucalyptus marginata) Trees in Relation to Post-Mining Deep Ripping in Western Australia*, Restoration Ecology, Vol 15, Issue s4, pp s65-s73.
- Umwelt (2019) *Social impact assessment, Ensham Residual Void Project*, Final – Confidential, prepared by Umwelt (Australia) Pty Ltd for Idemitsu Australia Resources Pty Ltd Newcastle.
- URS (2005) '*Geochemical characterisation and assessment of overburden and potential coal reject material at the Ensham Central Project*', a report prepared for Ensham Resources by URS Australia, Brisbane.
- URS (2015), '*Geochemical characterisation of overburden and potential rejects*', a report prepared for Ensham Resources by URS Australia, Brisbane.
- Umwelt (2019b) *Stage 3 ecological assessment report confidential*, Umwelt, Newcastle.
- Williams DJ (2000) Assessment of Embankment Parameters, Pages 275-284 in W. A. Hustrulid, M. K. McCarter, and D. J. A. V. Zyl, editors. Slope stability in Surface Mining. Society for Mining, Metallurgy, and Exploration, Inc, Littleton, Colorado.
- WRM (2019) *Ensham mine residual void study, Geomorphic impact assessment of options, Stage 3*, WRM, Brisbane.
- WSP (2018) Stage 3 geotechnical assessment, WSP, Brisbane.

9 APPENDICES & ATTACHMENTS

9.1 PRCP schedule & supporting information

In accordance with section 126D(1) of the EP Act, the PRCP schedule in the PRC plan must:	
a) describe the area of each resource tenure either a post-mining land use or non-use management area, and	Section 3 & Section 4
b) for each post-mining land use state: i. each rehabilitation milestone required to achieve a stable condition, and ii. when each rehabilitation milestone is to be achieved, and	Section 9.1.3, Table 9-5 and Table 9-6.
c) for each non-use management area state: i. each management milestone, and ii. when each management milestone is to be achieved, and	Section 9.1.4 & Section 9.1.6
d) include maps showing the land mentioned in (a), (b) and (c).	Figure 9-10 to Figure 9-24 Error! Reference source not found. (inclusive)

9.1.1 Final site design

PMLUs and NUMAs at Ensham are as listed in the land outcome document EA *EPML00732813*, with a description of each PMLU and NUMA provided in the planning part of this PRCP.

The location of all PMLUs and NUMAs within all Ensham MLs is as shown in Figure 9.1, as the Final Site Design map. Both disturbed and undisturbed areas are shown in the same way to emphasise the continuity of the mine disturbance land uses with land use in surrounding undisturbed areas, as well as showing the maximum disturbance footprint and resource tenure (ML) boundaries. The floodplain extent (aligned to the 0.01% AEP flood event) is also shown.

Figure 9-2 to Figure 9-8 (inclusive) shows the key PMLUs and NUMAs for each of the mining leases, and includes both disturbed and undisturbed lands. Subsequently, Figure 9-10 to Figure 9-21 are further focused on the disturbance footprint at Ensham, which related to both rehabilitation and/or improvement areas.

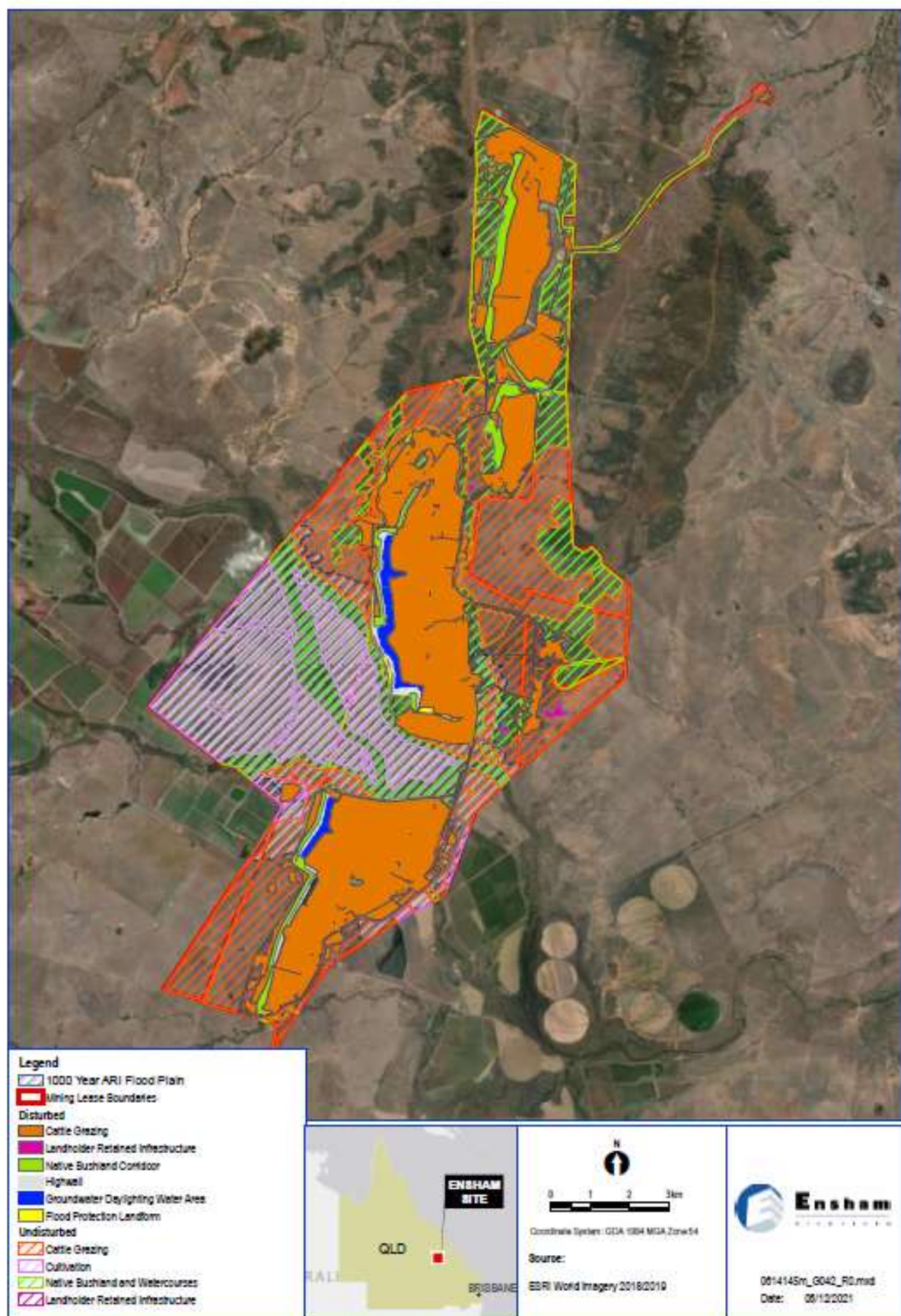


Figure 9-1 Final site design map

9.1.2 Land use categorisation

All lands within the relevant mining lease tenements, including undisturbed lands, have been provided with either a PMLU or a NUMA (as per Table 9-1, and as shown from Figure 9-2 to Figure 9-8). There are seven mining lease tenements, which combined cover 12,642.4 ha of land.

Table 9-1 All tenements land use categories

Undisturbed	PMLU	Cattle grazing	3,444.2
		Cultivation for cropping	1,900.5
		Native bushland and watercourses	2,553
		Major landholder infrastructure	4.3
		Subtotal	7,902.3
Disturbed by mining	PMLU	Cattle grazing	3,987.6
		Landholder retained infrastructure	38.5
		Native bushland corridor	341.8
		Boggy Creek diversion	88.7
		Flood protection landform	65.3
		Subtotal	4,521.9
	NUMA	Groundwater daylighting water areas	145.7
		Highwalls	83.1
		Subtotal	228.8
TOTAL			12,653.0
Registered survey (QSpatial)			12,626.3

- For discrete rehabilitation or improvement areas, the hectares presented herein are accurate to $\pm 15\%$.
- For total areas of PMLUs and NUMAs, the hectares presented herein are accurate to $\pm 5\%$.

It is also noted that there is some minor overlapping of the areas disturbed, as a result of maintenance and rework required for existing rehabilitation areas. As such, the above table (Table 9-1) should not be used for verification of areas subject to this PRCP, and the areas contained within the PRC Schedules should be taken as the formal estimate of areas subject to progressive rehabilitation, and requiring progression of rehabilitation and closure activities in accordance with the established milestones.

9.1.3 Post-mining land uses

PMLUs at Ensham are listed in the land outcome document EA *EPML00732813* and reproduced here as follows.

- Mine Domain 1 - Cattle grazing on overburden and infrastructure areas.
- Mine Domain 2 - Landholder retained infrastructure.
- Mine Domain 3 - Boggy Creek diversion.
- Mine Domain 4 - Native bushland corridor.
- Mine Domain 7 - Flood protection landform.

A description of each PMLU is provided in the planning part of this PRCP (see Section 2.4). These PMLUs account for approximately 95 % of mining disturbance in the post-mining landscape at Ensham.

9.1.3.1 Rehabilitation areas

A total of 14 rehabilitation areas (RAs) have been identified at Ensham (as shown in Figure 9-10 to Figure 9-22). This includes 4 areas of existing rehabilitation, RA1 to RA4, and 10 areas of future rehabilitation, RA5 to RA14 (as detailed in Table 9-4). A schedule of future RA availability for rehabilitation is provided (Table 9-3).

This schedule is cognisant of mining activities and infrastructure requirements, particularly as these relate to underground mining operations, and the feasibility of completing rehabilitation. Feasibility of completing rehabilitation includes considerations of timing and management complexity, and safety, cost, and engineering requirements for each RA.

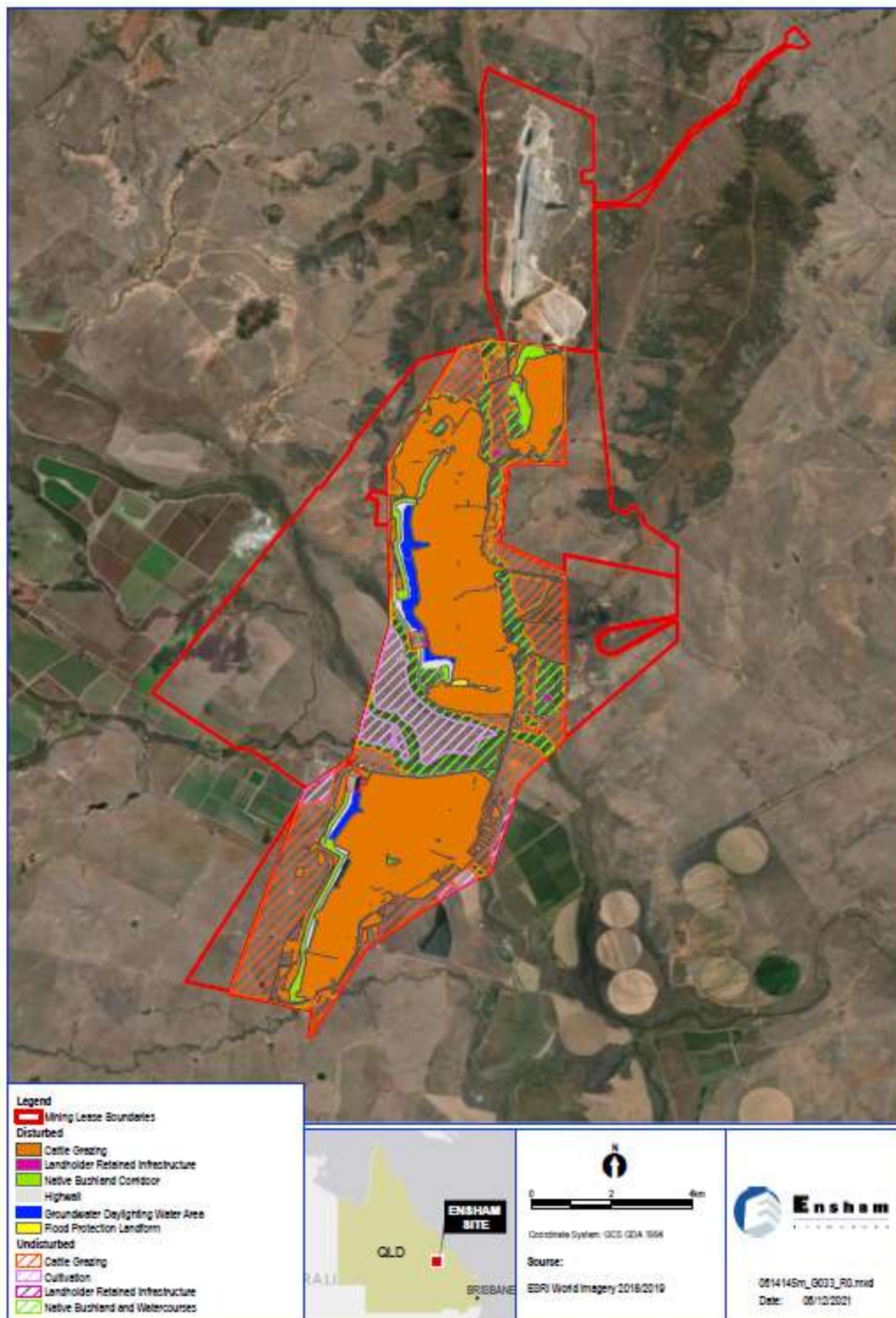
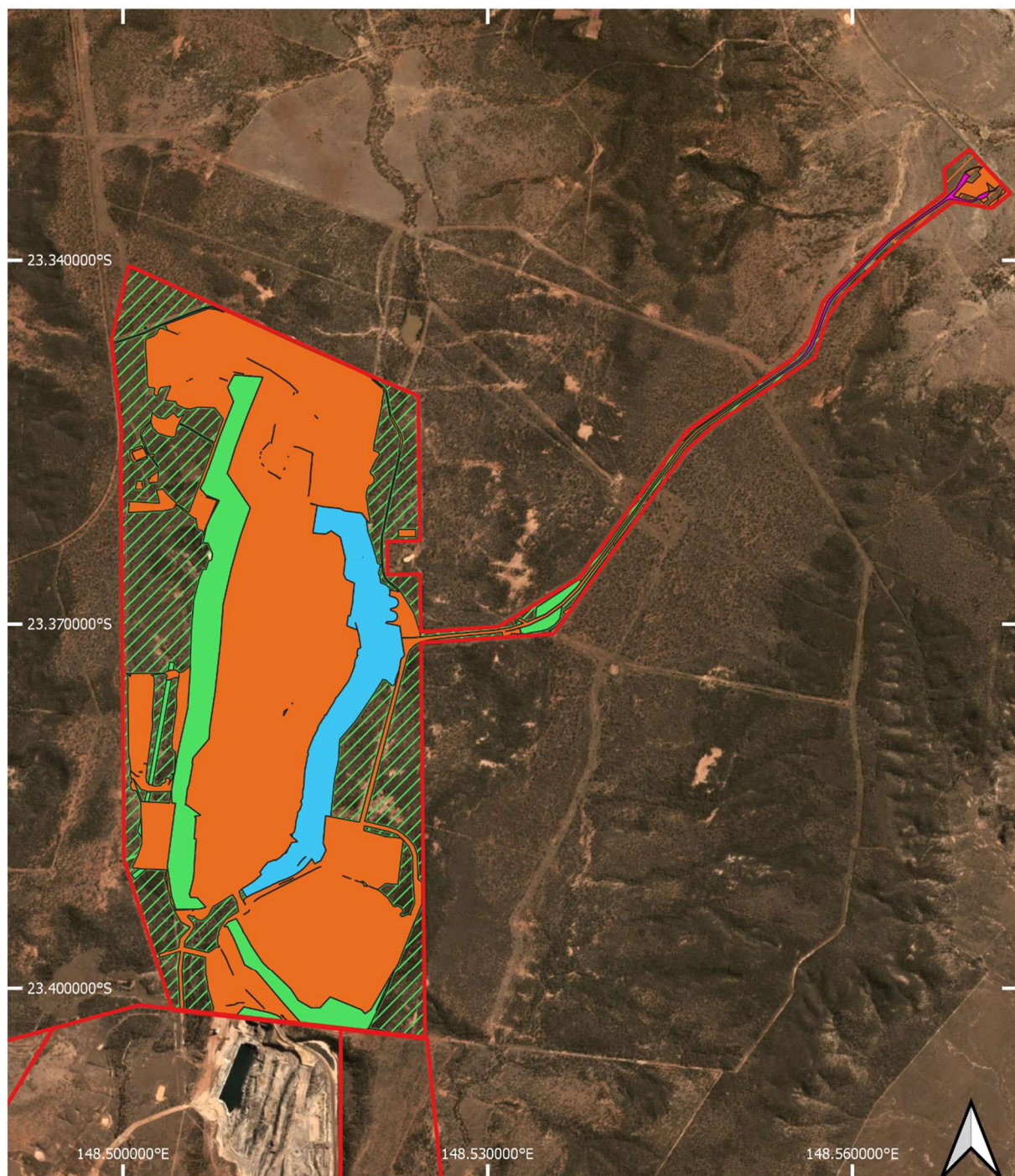


Figure 9-2 ML7459 land use categories



Figure 9-3 ML7460 land use categories



Legend

- Mining lease boundaries
- Mine domain 1 - Cattle grazing
- Mine domain 2 - Landholder retained infrastructure
- Mine domain 3 - Boggy Creek diversion
- Mine domain 4 - Native bushland corridor
- Cattle grazing
- Native bushland and watercourses

0 1 2 km

Scale @ A4: 1:34,000
GDA 2020
Prepared on 31 March 2021

Figure 9-4 ML70049 land use categories



Figure 9-5 ML70326 land use categories



Figure 9-6 ML70365 land use categories



Figure 9-7 ML70366 land use categories



Figure 9-8 ML70367 land use categories

Table 9-2 Rehabilitation Areas and descriptions

RA #	PMLU	Area (ha)	Comment
1	Cattle grazing	662.8	Existing rehabilitation, certified in 2019 and 2021
2	Cattle grazing	861.7	Existing rehabilitation, not certified
3	Native bushland corridor	44.1	Existing rehabilitation, not certified
4	Boggy Creek diversion	78.8	Existing rehabilitation, not certified
Subtotal		1647.4	Existing rehabilitation at Ensham
5	Cattle grazing	617.3	Scheduled rehabilitation, Yongala
6	Native bushland corridor	137.3	Scheduled rehabilitation, Yongala
7	Boggy Creek Diversion	9.9	Scheduled rehabilitation, Yongala
8	Cattle grazing	1137.2	Scheduled rehabilitation, Ensham Central
9	Native bushland corridor	84.2	Scheduled rehabilitation, Ensham Central
10	Flood landform levee	35.7	Scheduled rehabilitation, Ensham Central Levee
11	Cattle grazing	927.1	Scheduled rehabilitation, Ensham South
12	Native bushland corridor	76.2	Scheduled rehabilitation, Ensham South
13	Flood landform levee	29.6	Scheduled rehabilitation, Ensham South Levee
14	Landowner retained infrastructure	38.5	Landowner retained infrastructure*
Subtotal		3054.5	Scheduled rehabilitation at Ensham

** It is noted that this RA area has not been included in the subtotal, as the infrastructure will be retained*

Note: There are areas of existing established rehabilitation (within RA2) which will be disturbed and rehabilitated again in order to construct the agreed final landform. This means that some areas of land are overlapped by two RAs.

There is also an overlap regarding Boggy Creek Diversion as some of the future milestones have already been achieved (and as such, the area in hectares included in Table 9-2 relates only to the areas that are scheduled to have further rehabilitation works occur).

As such, Table 9-1 through to Table 9-4 should not be used for verification of areas subject to different treatment under this PRCP. Each of the tables provided indicate different activities and timeframes, and as such cannot be compared or tallied, as each table includes variance with the areas included. They are not intended to be a compilation of all areas.

The areas contained within the PRC Schedules (provided as Sections 9.1.5 and 9.1.6) should be taken as the formal estimate of areas subject to progressive rehabilitation and ongoing management, and requiring progression of activities in accordance with the established milestones.

Table 9-3 Schedule of PMLU RM3 (landform) completion

RA	2001-2021 (ha)	2022 (ha)	2023 (ha)	2024 (ha)	2025 (ha)	2026 (ha)	2027 (ha)	2028 (ha)	2029 (ha)	2030 (ha)	2031 (ha)	2032 (ha)	2033 (ha)	2034 (ha)	2035 (ha)	2036 (ha)	2037 (ha)	2038 (ha)	2039 (ha)	2040 (ha)	2041 (ha)	2042 (ha)	2043 (ha)
RA1	662.8																						
RA2	861.7																						
RA3	44.1																						
RA4	78.8																						
RA5		80.5	81.2	107.1	58.1	90.5	199.9																
RA6		24.2		85.2			27.9																
RA7		9.9																					
RA8							1.22		58.3	104.3	39.5	20.7			94.5	10.9	190	164.8		120.6	142.2	83.4	106.8
RA9							2.8			25.2	1.6				12	22.3		13.9		6.4			
RA10																		8.5		14.2	11	2	
RA11								71.7			44.9	198.3	106.1	25.3		94.9			178.4	112		17.2	78.2
RA12														29.4		21.8			25				
RA13								3				2.1	4.8	12.2								3.1	4.4
Total by year (ha)	1647.4	104.7	81.2	192.3	58.1	90.5	231.8	74.7	58.3	129.5	86.1	221.2	110.9	66.9	106.5	149.9	190.0	187.2	203.4	253.2	153.2	105.7	194.4

- For discrete rehabilitation or improvement areas, the hectares presented herein are accurate to $\pm 15\%$.
- For total areas of PMLUs and NUMAs, the hectares presented herein are accurate to $\pm 5\%$.
- Note: There are areas of existing established rehabilitation (RA2) which will be disturbed and rehabilitated again in order to construct the agreed final landform. This means that some areas of land are overlapped by two RAs. There is also an overlap regarding Boggy Creek Diversion as some of the future milestones have already been achieved.

Table 9-4 Schedule of PMLU RM7 to PM10 (Certification of Stable Condition)

RA/IA	2001-2021 (ha)	2027 (ha)	2028 (ha)	2029 (ha)	2030 (ha)	2031 (ha)	2032 (ha)	2033 (ha)	2034 (ha)	2035 (ha)	2036 (ha)	2037 (ha)	2038 (ha)	2039 (ha)	2040 (ha)	2041 (ha)	2042 (ha)	2043 (ha)	2044 (ha)	2045 (ha)	2046 (ha)	2047 (ha)	2048 (ha)	2049 (ha)
RA1	662.8																							
RA2																		861.7						
RA3																		44.1						
RA4			78.8																					
RA5			80.5	81.2	107.1	58.1	290.4																	
RA6				24.2		85.2	27.9																	
RA7			9.9																					
RA8								1.22		58.3	104.3	39.5	20.7			94.5	10.9	190	164.8		120.6	142.2	83.4	106.8
RA9									2.8			25.2	1.6				12	22.3		13.9		6.4		
RA10																			8.5		14.2	11	2	
RA11									71.7			44.96	198.3	106.1	25.3		94.9			178.4	112		95.4	
RA12																29.4		21.8			25			
RA13									3				2.1	4.8	12.2								3.1	4.4
RA14			6.7															31.8						
IA1												3				18.9	7.7	11.9		8.6	12.9	20.1		
IA2																30.7		35		32.4	14.3	33.4		
Total by year (ha)	662.8	0	175.9	105.4	107.1	143.3	318.3	1.2	77.5	58.3	104.3	109.8	222.8	110.9	37.5	123.8	117.8	1134.3	173.3	192.3	271.8	156.6	183.9	111.2

- For discrete rehabilitation or improvement areas, the hectares presented herein are accurate to $\pm 15\%$.
- For total areas of PMLUs and NUMAs, the hectares presented herein are accurate to $\pm 5\%$.
- Note: There are areas of existing established rehabilitation (RA2) which will be disturbed and rehabilitated again in order to construct the agreed final landform. This means that some areas of land are overlapped by two RAs. There is also an overlap regarding Boggy Creek Diversion as some of the future milestones have already been achieved.

9.1.3.2 Rehabilitation milestones and criteria

Rehabilitation milestones and criteria have been developed for all rehabilitation areas that have a PMLU (Table 9-5). These milestones are SMART, meaning they are:

Specific – is it clear what must be done.

Measurable - it is possible to know when it is achieved.

Achievable - it is capable of being achieved.

Reasonable – there is a clear connection between the milestone and the desired rehabilitation outcome.

Timely – it is clear when the milestone will be completed.

Table 9-5 Rehabilitation milestones

ID	Rehabilitation milestone	Milestone criteria
RM1	Infrastructure decommissioning and removal	1.1 All services disconnected, except that to be retained by landholder by formal agreement. 1.2 All buildings and infrastructure removed from RA, except that to be retained by landholder by formal agreement or consent with the administering authority. 1.3 All plant and equipment removed from RA, except that to be retained by the landholder by formal agreement.
RM2	Identification and remediation of contaminated land	2.1 Contaminated land assessment by SQP. 2.2 Remediation or management of identified contaminated land. 2.3 Removal of land from Contaminated Land Register. 2.4 Removal of land from Environmental Management Land Register if feasible.
RM3	Final landform development	3.1 Permian material and rock to be placed preferentially on top part of landform profile as practicable, with more dispersive materials adequately buried. 3.2 Where Permian material and rock cannot be placed on surface, refer to RM 3.3 and 3.4. 3.3 Landform has been established and satisfies completion criteria for each PMLU: <u>Beef cattle grazing PMLU</u> • All outward facing overburden slopes to achieve 0-10% slopes for Tertiary materials and 0-15% slopes for Permian materials. • 90% of the inward facing slopes achieving 0-10% slopes for Tertiary materials and 0-15% slopes for Permian materials. • Up to 10% of the inward facing slopes may include slopes between 15% to 25%, subject to these areas being fully contained within areas of 0-15% slopes. • Landforms are assessed as being geotechnically stable with a factor of safety ≥ 1.5. <u>Native bushland corridor PMLU</u> • Maximum 25% slope • Areas > 15% to be certified by a suitably qualified person as being stable long term, with rock mulch applied as required. <u>Flood protection landform PMLU</u> • Watercourse facing slopes $\leq 15\%$. • Void facing slopes $\leq 15\%$, except where constrained by proximity to void regrade, batters can be reduced to $\leq 25\%$. • Bench of 10m to separate inward toe embankment from adjacent edge of void stabilisation regrade. • Landform – 0.1% AEP +0.5m freeboard.

ID	Rehabilitation milestone	Milestone criteria
		- Line the river facing embankments at sharp changes in alignment where turbulence could occur with hard, durable rock rip rap. - Must be fenced to exclude stock and permanent fencing in place post construction and maintained. <u>Boggy Creek Diversion PMLU</u> - Geotechnically and erosionally stable with a factor of safety ≥ 1.5 - As constructed drawings submitted to Department of Regional Development, Manufacturing and Water 3.4 Soil ameliorants and fertilisers are applied as needed to address spoil limitations.
RM4	Seedbed preparation	4.1 Soil assessment completed to confirm quantity, quality, compatibility with rehabilitation methodology and PMLU, and guide amelioration of material. 4.2 Topsoil is replaced to 150mm depth on areas to be revegetated, or alternate treatments adopted as appropriate. 4.3 Soil ameliorants, fertilisers and surface treatments (i.e. hay mulch) are applied as required to address soil and spoil limitations.
RM5	Sowing	5.1 Seed sown at appropriate rates for each PMLU- <u>Beef cattle grazing PMLU</u> 3P pasture species mix sown. <u>Native bushland corridor PMLU</u> > Native tree and shrub species mix sown. <u>Flood protection landform PMLU</u> > Native tree and shrub species mix sown. > Grass species sown. 5.2 Hay mulch applied as required.
RM6	Vegetation establishment	6.1 Vegetation has established and satisfies rehabilitation completion criteria for each PMLU- <u>Beef cattle grazing PMLU</u> $\geq 50\%$ established and persistent vegetative groundcover for all slopes from 0-15%. $\geq 80\%$ established and persistent vegetative cover for slopes from 15% to 25%. <u>Native bushland corridor PMLU</u> $\geq 50\%$ established and persistent vegetative groundcover for all slopes from 0-20%. $\geq 80\%$ established and persistent cover (vegetative and/or rock mulch) for slopes from 20% to 25%. - Species richness ≥ 2 tree species, ≥ 3 shrub species, ≥ 5 groundcover species.
RM7	Achievement of a stable condition (beef cattle grazing PMLU)	7.1 The RA is safe, with safety hazards in rehabilitation similar to surrounding unmined landscapes to meet 0 (zero) significant difference as defined in AS/NZS ISO 31000:2009 Risk Management.. 7.2 There is no environmental harm being caused by anything on or in the RA. - Surface water runoff is non-polluting to receiving waters and complies with the following- - pH 7.1 – 8.2 - EC (salinity) $< 403 \mu\text{S/cm}$ - Total Suspended Solids (TSS) (sediment loss) $< 405 \text{ mg/L}$ - Arsenic $\leq 13 \mu\text{g/L}$ - Molybdenum $\leq 34 \mu\text{g/L}$

ID	Rehabilitation milestone	Milestone criteria
		○ Selenium $\leq 5 \mu\text{g/L}$ ○ Sulphate (SO_4^{2+}) $< 16.34 \text{ mg/L}$ 7.3 The RA can sustain a PMLU. • Rehabilitation is suitable for sustainable cattle grazing and is land suitability class 2 to 4 as defined in the Guidelines for Agricultural Land Evaluation in Queensland (State Department of Queensland 2013).
RM8	Achievement of a stable condition (landholder retained infrastructure)	8.1 The RA is safe, with safety hazards in rehabilitation similar to surrounding unmined landscapes. 8.2 There is no environmental harm being caused by anything on or in the RA. • Surface water runoff is non-polluting to receiving waters and complies with the following- ○ pH 7.1 – 8.2 ○ EC (salinity) $< 403 \mu\text{S/cm}$ ○ Total Suspended Solids (TSS) (sediment loss) $< 405 \text{ mg/L}$ ○ Arsenic $\leq 13 \mu\text{g/L}$ ○ Molybdenum $\leq 34 \mu\text{g/L}$ ○ Selenium $\leq 5 \mu\text{g/L}$ ○ Sulphate (SO_4^{2+}) $< 16.34 \text{ mg/L}$ 8.3 Landholder formally accepts infrastructure for his/her ongoing beneficial use, with evidence of agreement provided for ownership transfer. Landholder accepts the condition of infrastructure, including its structural integrity through a legally binding agreement executed by each party. 8.4 For those areas where the landowner is Ensham, the administering authority provides consent to the retention of infrastructure, in accordance with EA conditions.
RM9	Achievement of a stable condition (Boggy Creek diversion)	9.1 The RA is safe, with safety hazards in rehabilitation similar to surrounding unmined landscapes. 9.2 There is no environmental harm being caused by anything on or in the RA. • Surface water runoff is non-polluting to receiving waters and complies with the following- ○ pH 7.1 – 8.2 ○ EC (salinity) $< 403 \mu\text{S/cm}$ ○ Total Suspended Solids (TSS) (sediment loss) $< 405 \text{ mg/L}$ ○ Arsenic $\leq 13 \mu\text{g/L}$ ○ Molybdenum $\leq 34 \mu\text{g/L}$ ○ Selenium $\leq 5 \mu\text{g/L}$ ○ Sulphate (SO_4^{2+}) $< 16.34 \text{ mg/L}$ 9.3 Riparian vegetation is suitable for conservation of rehabilitated creek diversion areas and has an IDC score > 10, assessed by a suitably qualified geomorphologist as defined in Criteria for functioning river landscape units in mining and post-mining landscapes (ACARP Project number C20017).
RM10	Achievement of a stable condition (Native bushland corridor)	10.1 The RA is safe, with safety hazards in rehabilitation similar to surrounding unmined landscapes. 10.2 There is no environmental harm being caused by anything on or in the RA. • Surface water runoff is non-polluting to receiving waters and complies with the following- ○ pH 7.1 – 8.2

ID	Rehabilitation milestone	Milestone criteria
		- EC (salinity) <403 µs/cm - Total Suspended Solids (TSS) (sediment loss) <405 mg/L - Arsenic ≤13 µg/L - Molybdenum ≤34 µg/L - Selenium ≤5 µg/L - Sulphate (SO₄²⁺) <16.34 mg/L 10.3 The RA can sustain the desired PMLU and rehabilitation has some native species and some native bushland characteristics demonstrating native species richness, including: ≥2 tree species at relevant benchmark density ≥3 shrub species at relevant benchmark density ≥5 groundcover species at relevant benchmark density - as per relevant Regional Ecosystem BioCondition Benchmark = 11.10.1 and/or 11.10.3)
RM11	Achievement of a stable condition (Flood protection landform)	11.1 The RA is safe, with safety hazards in rehabilitation similar to surrounding unmined landscapes. 11.2 There is no environmental harm being caused by anything on or in the RA. - Surface water runoff complies with the following- - pH 7.1 – 8.2 - EC (salinity) <403 µs/cm - Total Suspended Solids (TSS) (sediment loss) <405 mg/L - Arsenic ≤13 µg/L - Molybdenum ≤34 µg/L - Selenium ≤5 µg/L - Sulphate (SO₄²⁺) <16.34 mg/L 11.3 A permanent flood structure is in place, constructed as per certified designs provided under condition H11 of the EA, and certified by a suitably qualified and experienced person. 11.4 Floodplain width re-instated with a minimum 2km width between the northern section of B Pit and the southern section of C Pit, located generally in accordance with Appendix 4 of the EA.

9.1.4 Non-use management areas

There are two pre-approved NUMAs at Ensham. These are shown in land outcome document EA *EPML00732813* and reproduced here as follows.

- Mine Domain 5 - Groundwater daylighting water areas.
- Mine Domain 6 - Highwalls.

9.1.4.1 Improvement areas

A total of 2 improvement areas have been identified at Ensham (as shown in Figure 9-23 and Figure 9-24). A schedule of improvement area availability for management is provided (Table 9-6).

This schedule is cognisant of mining activities and infrastructure requirements, particularly as these relate to underground mining operations, and the feasibility of completing rehabilitation. Feasibility includes considerations of timing and management complexity, and safety, cost, and engineering requirements.

Table 9-6 Schedule of NUMA land availability for improvement

IA	2021 (ha)	2022 (ha)	2023 (ha)	2024 (ha)	2025 (ha)	2026 (ha)	2027 (ha)	2028 (ha)	2029 (ha)	2030 (ha)	2031 (ha)	2032 (ha)	2033 (ha)	2034 (ha)	2035 (ha)	2036 (ha)	2037 (ha)	2038 (ha)	2039 (ha)	2040 (ha)	2041 (ha)	2042 (ha)
1												3.0				18.9	7.7	11.9		8.6	12.9	20.1
2																30.7		35.0		32.4	14.3	33.4
Total by year (ha)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	49.6	7.7	46.9	0.0	41.0	27.2	53.5

9.1.4.2 Improvement area milestones

Improvement area milestones and criteria have been developed for all improvement areas that have a NUMA (Table 9-7). These milestones are SMART, meaning they are:

Specific – is it clear what must be done.

Measurable - it is possible to know when it is achieved.

Achievable - it is capable of being achieved.

Reasonable – there is a clear connection between the milestone and the desired rehabilitation outcome.

Timely – it is clear when the milestone will be completed.

Table 9-7 Improvement area milestones

ID	Management milestone	Milestone criteria
MM1	Sufficient improvements to ensure structural stability	1.1 Slope gradients achieved as follows for NUMAs- • Maximum of 275% slopes for competent high walls. • Maximum of 50% slopes for incompetent material • A south pit, F Pits and Y Pits highwall must be reshaped to a maximum of 25% slopes. • Northern Endwall of B Pit maximum 15% slope 1.2 Landforms are assessed as geotechnically and erosionally stable with a factor of safety ≥ 1.5 1.3 Water run-off from above the highwall is channelled to the groundwater daylighting water areas PMLU through design pathways.
MM2	Sufficient improvements to ensure safety and minimisation of environmental harm	2.1 The NUMA is safe. • All areas to be certified by suitably qualified person as being safe long-term. • Bunded, fenced and signed to exclude humans and stock 2.2 There is no environmental harm being caused by anything on or in the NUMA. The existence of the highwalls themselves does not constitute environmental harm. • Regional groundwater aquifers maintain their current water quality and groundwater monitoring bores do not exceed the water quality limits detailed in Table C11 – Groundwater quality limits in the relevant EA as a result of mining activities. 2.3 Groundwater daylighting water areas Maximum dimensions: • A Central – Surface Water Level -133mAHD, Water storage Volume -0.5GL, and Water Area – 3ha • A North – Surface Water Level – 133mAHD, Water storage volume – 1.2GL, and Water Area – 16ha • B – Surface Water Level – 123mAHD, Water Storage Volume – 3.1GL and Water Area – 33ha • C and D – Surface Water Level – 125mAHD, Water Storage Volume – 22.1GL and Water Areas – 65ha for C and 75ha for D

The milestones will be achieved by:

- Inspection and assessment by suitably qualified person for each highwall to determine the boundaries of competent and incompetent materials.
- Design of construction process for slope of incompetent material.
- Design and construction process for reshaping A South, F & Y pit highwalls to < 25% slopes.
- Backfill northern endwall of B pit to < 15% using suitably sourced material.
- Monitor the groundwater aquifers and investigate any emerging trends.

9.1.5 Rehabilitation Areas schedule

Following are schedules with key dates and milestones for all RAs at Ensham that have not yet achieved certification. RA 01 relates to existing areas of rehabilitation that have now achieved certification, however it has been included for completeness.

The location of each RA is shown from Figure 9-10 to Figure 9-22 inclusive and within the provided spatial files.

9.1.5.1 RA 01

It is noted that the areas within RA1 relate to existing rehabilitation which has now achieved certification. As such, the achievement of relevant final milestones is in the past. This schedule, and map has been included for completeness.

Post-mining land uses (PMLU)										
Rehabilitation area (description)	RA1 (certified rehabilitation)									
Relevant activities	Mine domain 1 - Cattle grazing									
Total rehabilitation area size (ha)	662.8									
Commencement of first milestone: RM7	1/01/2018									
PMLU	Mine domain 1 - Cattle grazing									
Date area is available	1/01/18	1/01/19								
Cumulative area available (ha)	97.2	662.8								
Milestone completed by	10/12/18	10/12/21								
Milestone Reference	Cumulative area achieved (ha)									
RM7	97.2	662.8								

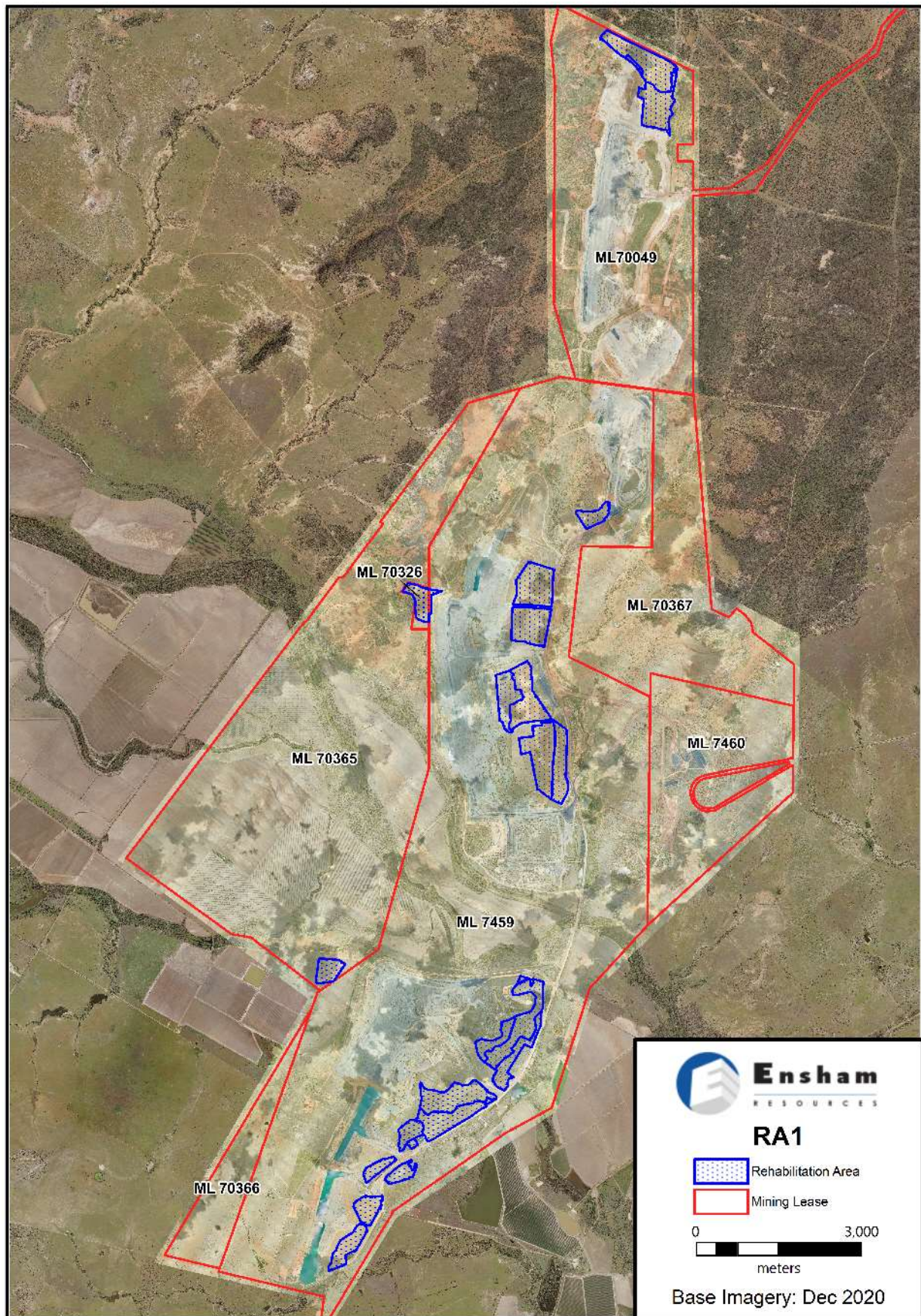


Figure 9-9 Rehabilitation Area 1 (RA 01)

9.1.5.2 RA 02

Post-mining land uses (PMLU)										
Rehabilitation area (description)	RA2 (existing rehabilitation)									
Relevant activities	Mine domain 1 - Cattle grazing									
Total rehabilitation area size (ha)	861.7									
Commencement of first milestone: RM7	31/12/2021									
PMLU	Mine domain 1 - Cattle grazing									
Date area is available	1/01/22	1/01/22								
Cumulative area available (ha)	26.8	861.7								
Milestone completed by	10/12/23	10/12/43								
Milestone Reference	Cumulative area achieved (ha)									
RM6	26.8									
RM7		861.7								

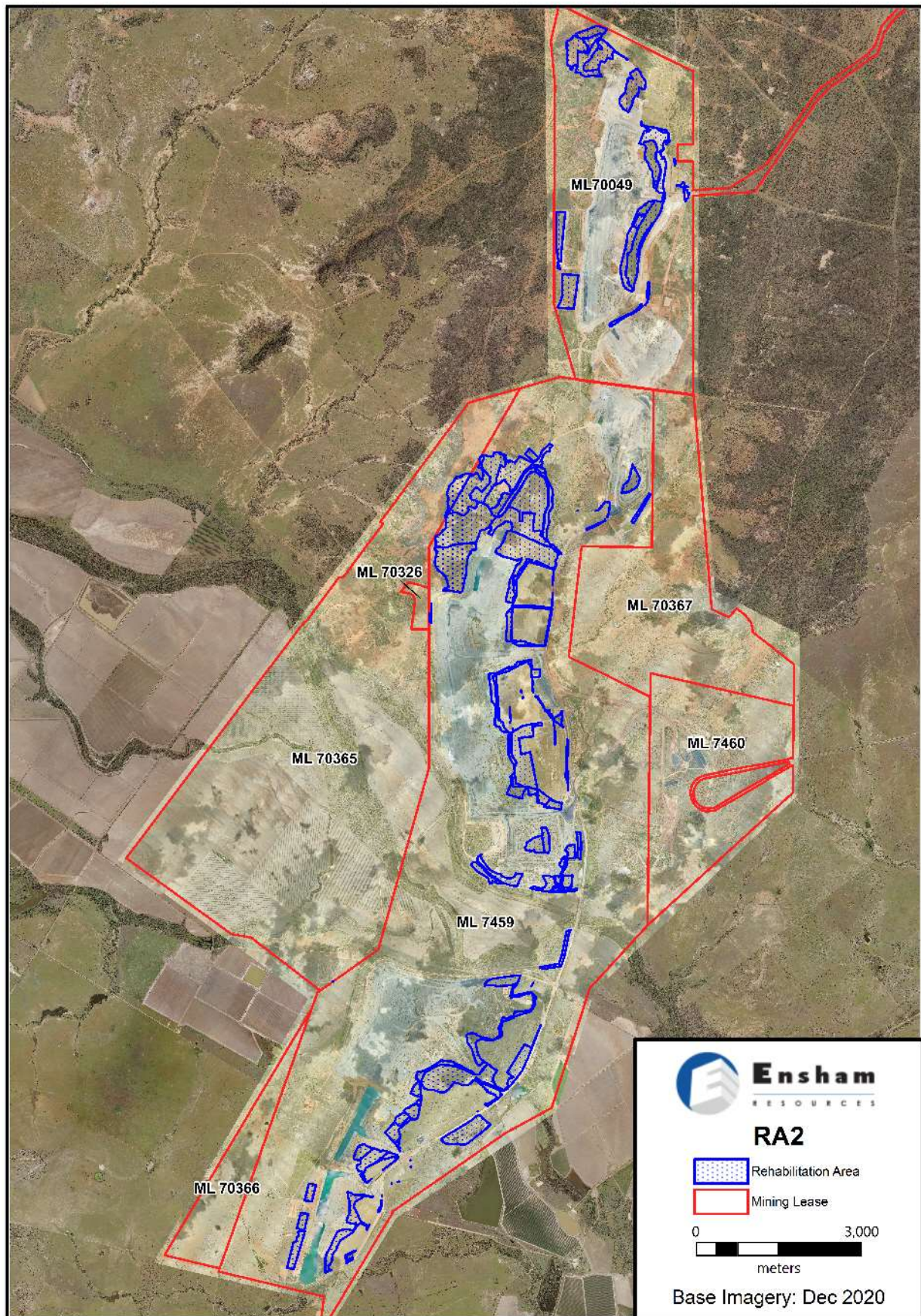


Figure 9-10 Rehabilitation Area 2 (RA 02)

9.1.5.3 RA 03

Post-mining land uses (PMLU)									
Rehabilitation area (description)	RA3 (existing rehabilitation)								
Relevant activities	Mine domain 3 - Native bushland corridor								
Total rehabilitation area size (ha)	44.1								
Commencement of first milestone: RM9	31/12/2021								
PMLU	Mine domain 3 - Native bushland corridor								
Date area is available	31/12/21								
Cumulative area available (ha)	44.1								
Milestone completed by	10/12/43								
Milestone Reference	Cumulative area achieved (ha)								
RM10	44.1								



Figure 9-11 Rehabilitation Area 3 (RA 03)

9.1.5.4 RA 04

Post-mining land uses (PMLU)										
Rehabilitation area (description)	RA4 (existing rehabilitation)									
Relevant activities	Mine domain 3 - Boggy creek diversion									
Total rehabilitation area size (ha)	78.8									
Commencement of first milestone: RM6	1/01/2022									
PMLU	Mine domain 3 - Boggy Creek diversion									
Date area is available	1/01/22	1/01/22								
Cumulative area available (ha)	78.8	78.8								
Milestone completed by	10/12/24	10/12/28								
Milestone Reference	Cumulative area achieved (ha)									
RM6	78.8									
RM9		78.8								

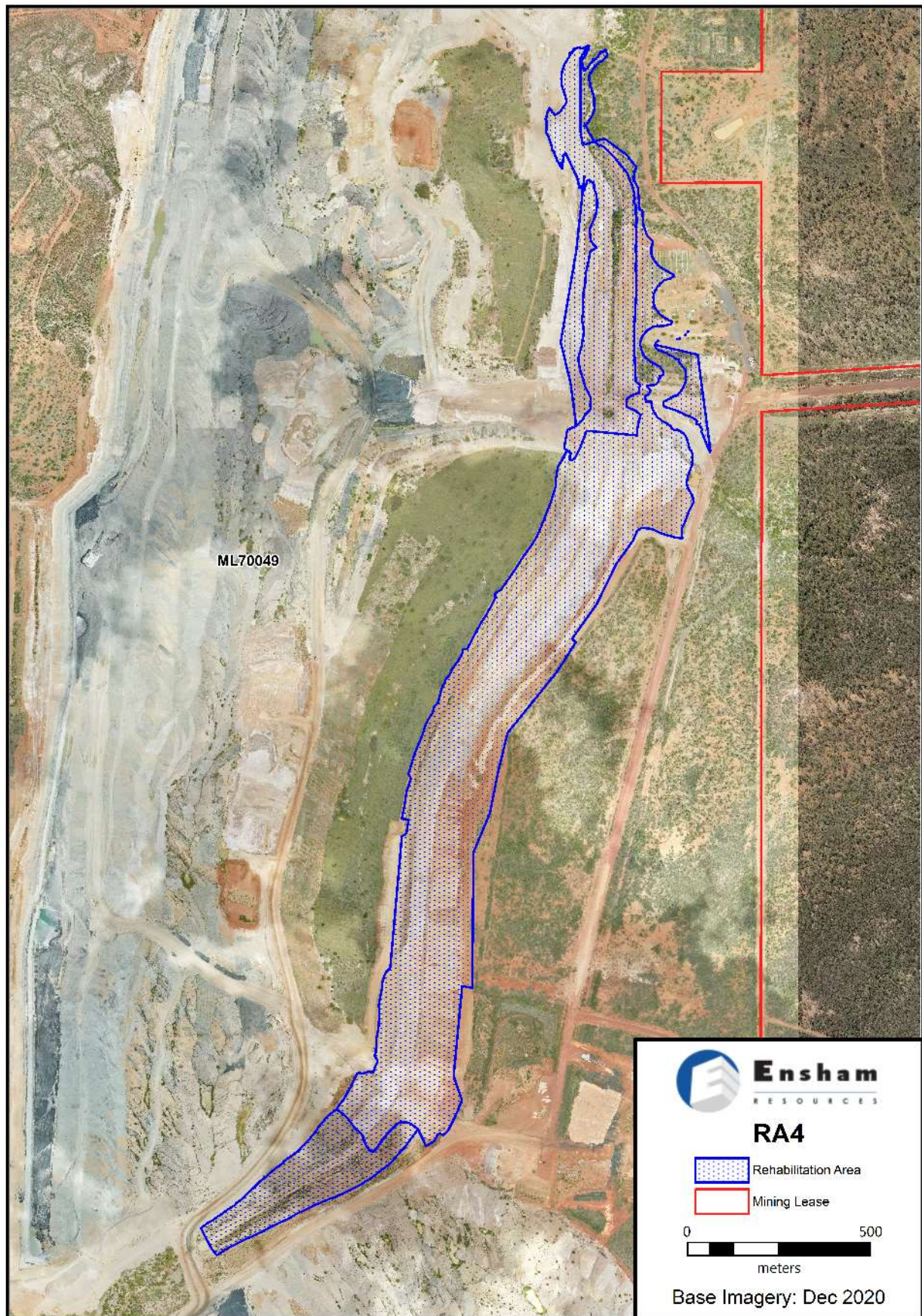


Figure 9-12 Rehabilitation Area 4 (RA 04)

9.1.5.5 RA 05

Post-mining land uses (PMLU)											
Rehabilitation area (description)	RA5 (Yongala Cattle Grazing)										
Relevant activities	Mine domain 1 - Cattle grazing										
Total rehabilitation area size (ha)	617.3										
Commencement of first milestone: RM3	1/01/2022										
PMLU	Mine domain 1 - Cattle grazing										
Date area is available	1/01/22	1/01/23	1/01/24	1/01/25	1/01/26	1/01/27	1/01/28	10/12/29	1/01/30	1/01/31	1/01/32
Cumulative area available (ha)	80.5	161.7	268.8	326.9	417.4	617.3	617.3	617.3	617.3	617.3	617.3
Milestone completed by	10/12/22	10/12/23	10/12/24	10/12/25	10/12/26	10/12/27	10/12/28	10/12/29	10/12/30	10/12/31	10/12/32
Milestone Reference	Cumulative area achieved (ha)										
RM1						617.3					
RM2						2					
RM3	80.5	161.7	268.8	326.9	417.4	617.3					
RM4		80.5	161.7	268.8	326.9	417.4	617.3				
RM5		80.5	161.7	268.8	326.9	417.4	617.3				
RM6				80.5	161.7	268.8	326.9	617.3			
RM7							80.5	161.7	268.8	326.9	617.3

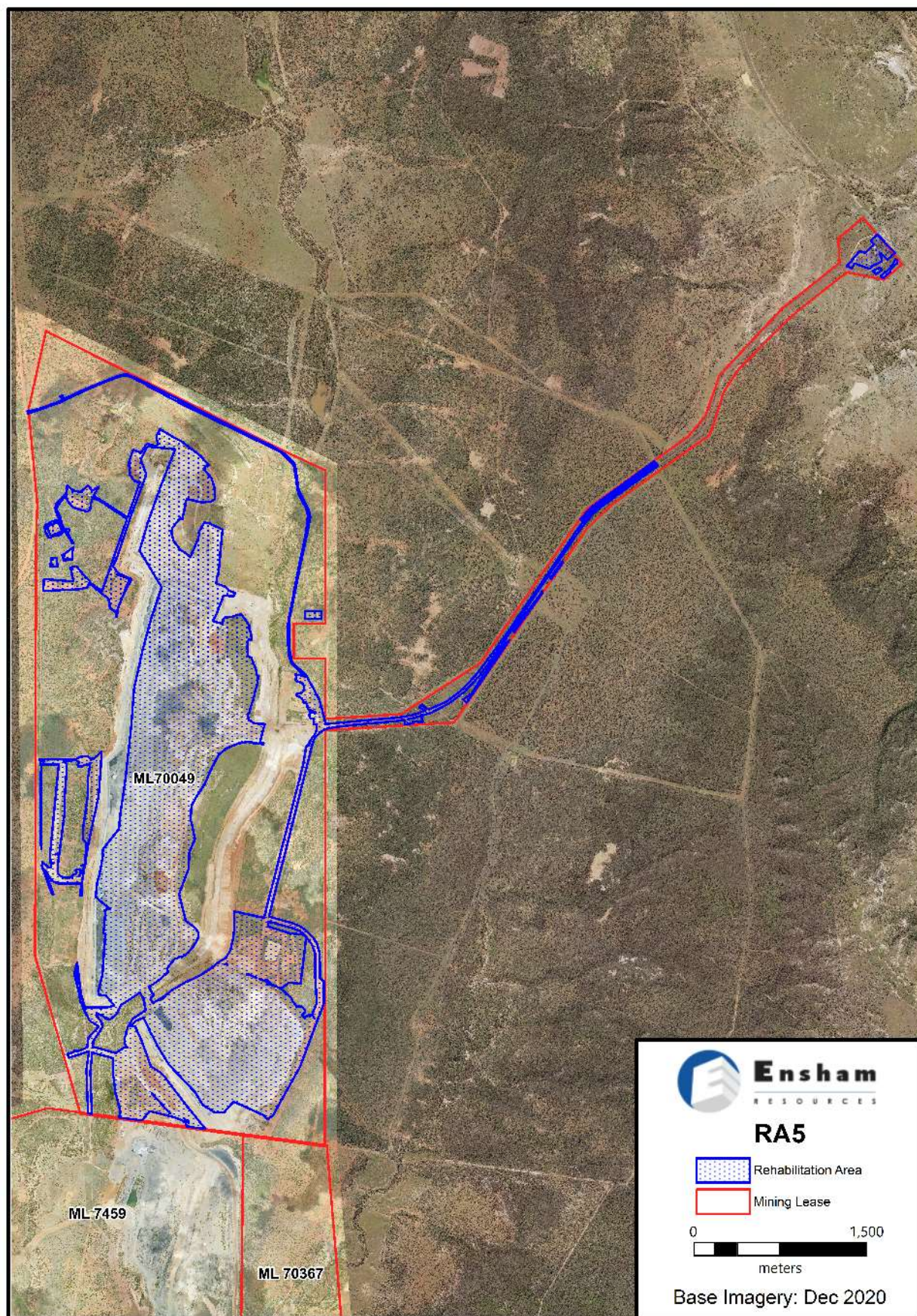


Figure 9-13 Rehabilitation Area 5 (RA 05)

9.1.5.6 RA 06

Post-mining land uses (PMLU)											
Rehabilitation area (description)	RA6 (Yongala NBC)										
Relevant activities	Mine domain 3 - Native bushland corridor										
Total rehabilitation area size (ha)	137.3										
Commencement of first milestone: RM3	1/01/2022										
PMLU	Mine domain 3 - Native bushland corridor										
Date area is available	1/01/22	1/01/23	1/01/24	1/01/25	1/01/25	1/01/27	1/01/28	1/01/29	1/01/30	1/01/31	1/01/32
Cumulative area available (ha)	24.2	24.2	109.4	109.4	109.4	137.3	137.3	137.3	137.3	137.3	137.3
Milestone completed by	10/12/22	10/12/23	10/12/24	10/12/25	10/12/26	10/12/27	10/12/28	10/12/29	10/12/30	10/12/31	10/12/32
Milestone Reference	Cumulative area achieved (ha)										
RM3	24.2		109.4			137.3					
RM4		24.2		109.4		137.3					
RM5		24.2		109.4		137.3					
RM6					24.2		109.4		137.3		
RM10								24.2		109.4	137.3

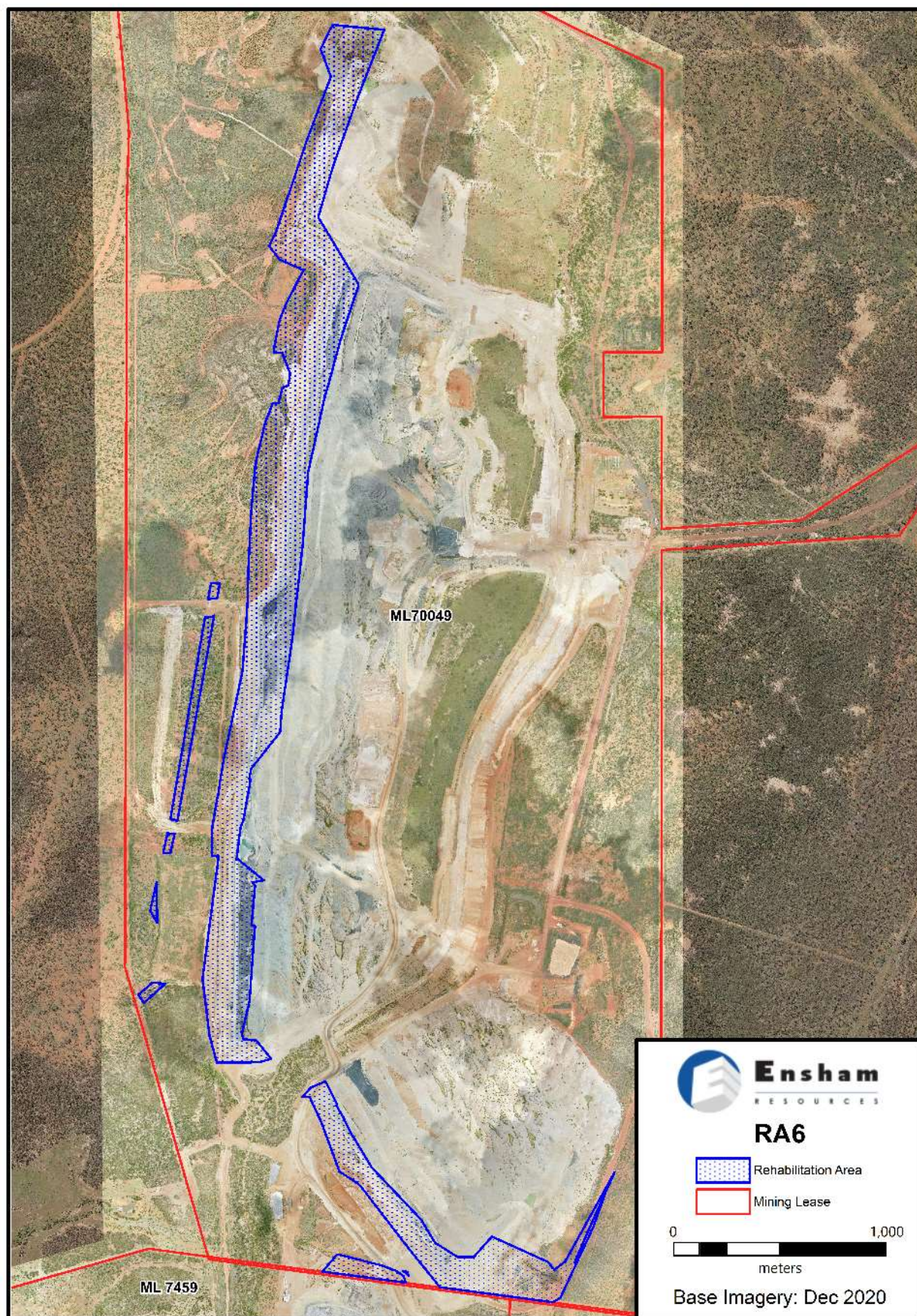


Figure 9-14 Rehabilitation Area 6 (RA 06)

9.1.5.7 RA 07

Post-mining land uses (PMLU)												
Rehabilitation area (description)	RA7 (Yongala BCD)											
Relevant activities	Mine domain 3 - Boggy creek diversion											
Total rehabilitation area size (ha)	9.9											
Commencement of first milestone: RM4	1/01/2022											
PMLU	Mine domain 3 - Boggy creek diversion											
Date area is available	1/01/22	1/01/25	1/01/28									
Cumulative area available (ha)	9.9	9.9	9.9									
Milestone completed by	10/12/22	10/12/25	10/12/28									
Milestone Reference	Cumulative area achieved (ha)											
RM4	9.87											
RM5	9.87											
RM6		9.87										
RM9			9.87									

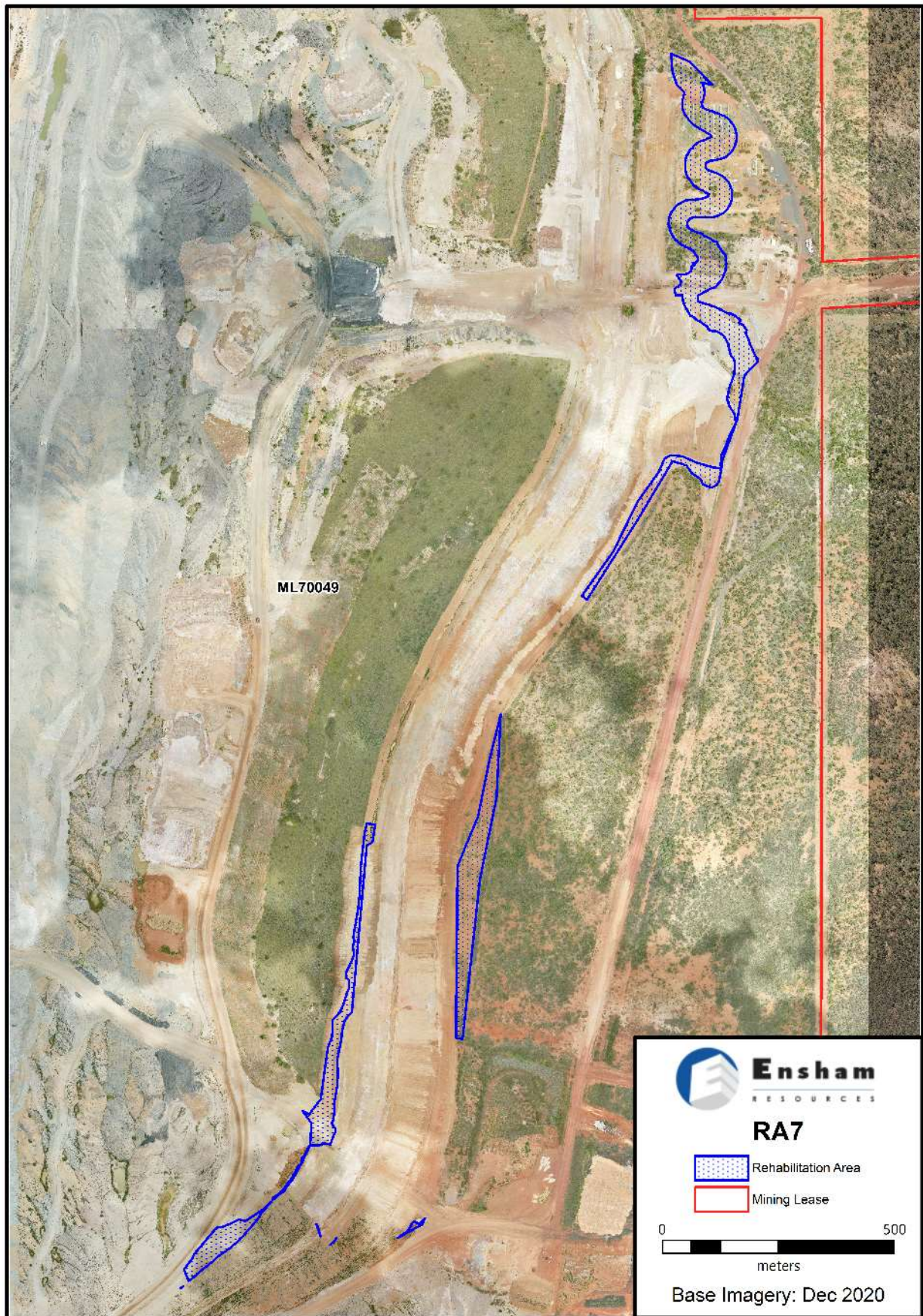


Figure 9-15 Rehabilitation Area 7 (RA 07)

9.1.5.8 RA 08

Post-mining land uses (PMLU)																							
Rehabilitation area (description)	RA8 (Central Cattle Grazing)																						
Relevant activities	Mine domain 1 - Cattle grazing																						
Total rehabilitation area size (ha)	1137.2																						
Commencement of first milestone: RM3	1/01/2027																						
PMLU	Mine domain 1 - Cattle grazing																						
Date area is available	1/01/27	1/01/28	1/01/29	1/01/30	1/01/31	1/01/32	1/01/33	10/12/34	1/01/35	1/01/36	1/01/37	1/01/38	1/01/39	1/01/40	1/01/41	1/01/42	1/01/43	1/01/44	1/01/45	1/01/46	1/01/47	1/01/48	1/01/49
Cumulative area available (ha)	1.2	1.2	59.5	163.8	203.4	224.1	224.1	224.1	318.5	329.4	519.4	684.2	684.2	804.8	947.0	1030.4	1137.2	1137.2	1137.2	1137.2	1137.2	1137.2	1137.2
Milestone completed by	10/12/27	10/12/28	10/12/29	10/12/30	203.4	10/12/32	10/12/33	10/12/34	10/12/35	10/12/36	10/12/37	10/12/38	10/12/39	10/12/40	10/12/41	10/12/42	10/12/43	10/12/44	10/12/45	10/12/46	10/12/47	10/12/48	10/12/49
Milestone Reference	Cumulative area achieved (ha)																						
RM1																	1137.2						
RM2																	5						
RM3	1.2		59.5	163.8	203.4	224.1			318.5	329.4	519.4	684.2		804.8	947	1030.4	1137.2						
RM4		1.22		59.5	163.8	203.4	224.1			318.5	329.4	519.4	684.2		804.8	947	1137.2						
RM5		1.22		59.5	163.8	203.4	224.1			318.5	329.4	519.4	684.2		804.8	947	1137.2						
RM6				1.22		59.5	163.8	203.4	224.1			318.5	329.4	519.4	684.2		804.8	947	1030.4	1137.2			
RM7							1.22		59.5	163.8	203.4	224.1		318.5	329.4	519.4	684.2		804.8	947	1030.4	1137.2	

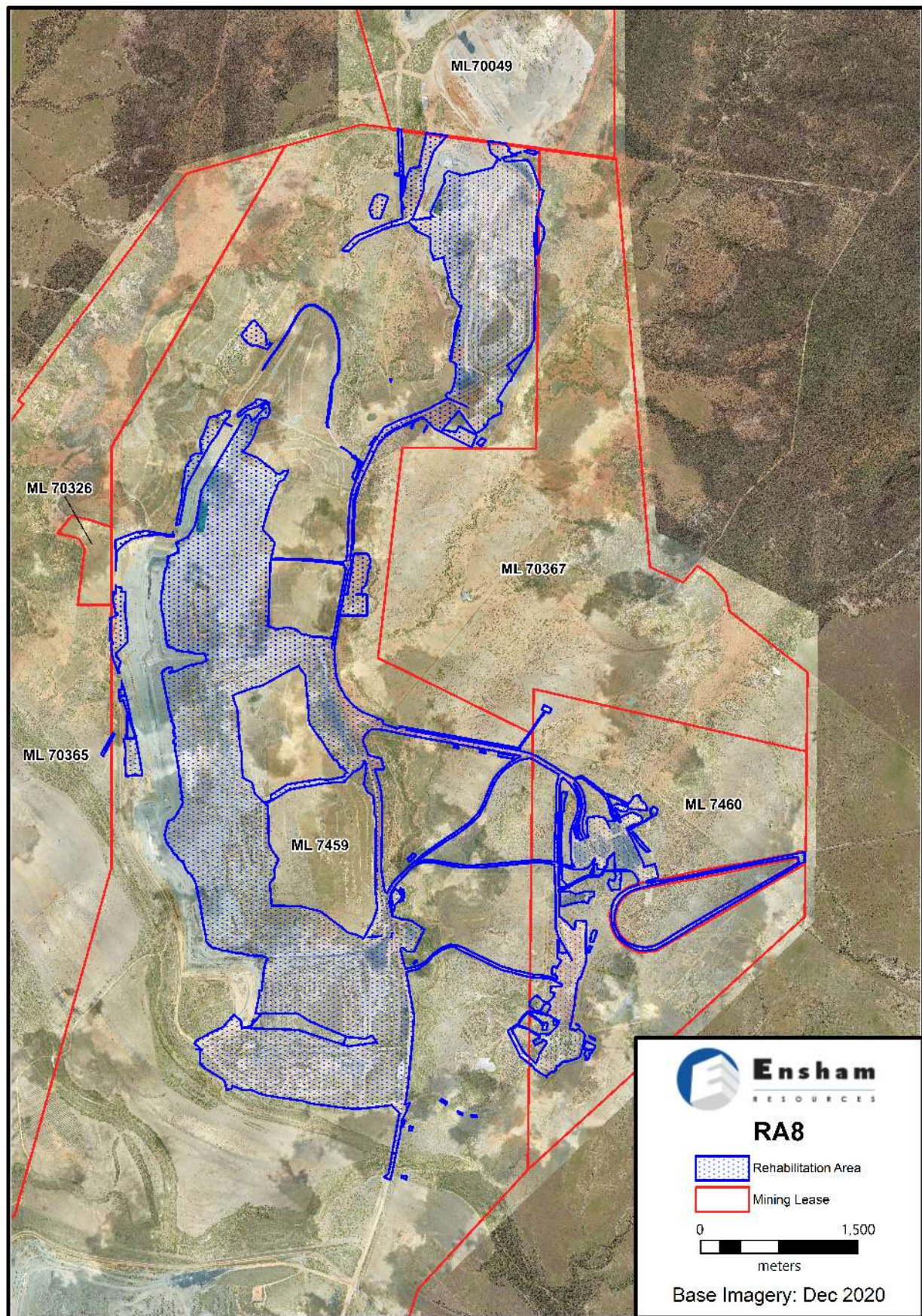


Figure 9-16 Rehabilitation Area 8 (RA 08)

9.1.5.9 RA 09

Post-mining land uses (PMLU)																		
Rehabilitation area (description)	RA9 (Central NBC)																	
Relevant activities	Mine domain 3 - Native bushland corridor																	
Total rehabilitation area size (ha)	84.2																	
Commencement of first milestone: RM3	1/01/2027																	
PMLU	Mine domain 3 - Native bushland corridor																	
Date area is available	1/01/27	1/01/28	1/01/30	1/01/31	1/01/32	1/01/34	1/01/35	1/01/36	1/01/37	1/01/38	1/01/39	1/01/40	1/01/41	1/01/42	1/01/43	1/01/44	1/01/45	1/01/47
Cumulative area available (ha)	2.8	2.8	28.0	29.6	29.6	29.6	41.6	63.9	63.9	77.8	77.8	84.2	84.2	84.2	84.2	84.2	84.2	84.2
Milestone completed by	10/12/27	10/12/28	10/12/30	10/12/31	10/12/32	10/12/34	10/12/35	10/12/36	10/12/37	10/12/38	10/12/39	10/12/40	10/12/41	10/12/42	10/12/43	10/12/44	10/12/45	10/12/47
Milestone Reference	Cumulative area achieved (ha)																	
RM3	2.8		28	29.6			41.6	63.9		77.8		84.2						
RM4		2.8		28	29.6			41.6	63.9		77.8		84.2					
RM5		2.8		28	29.6			41.6	63.9		77.8		84.2					
RM6				2.8		28	29.6				41.6	63.9		77.8		84.2		
RM10						2.8			28	29.6				41.6	63.9		77.8	84.2

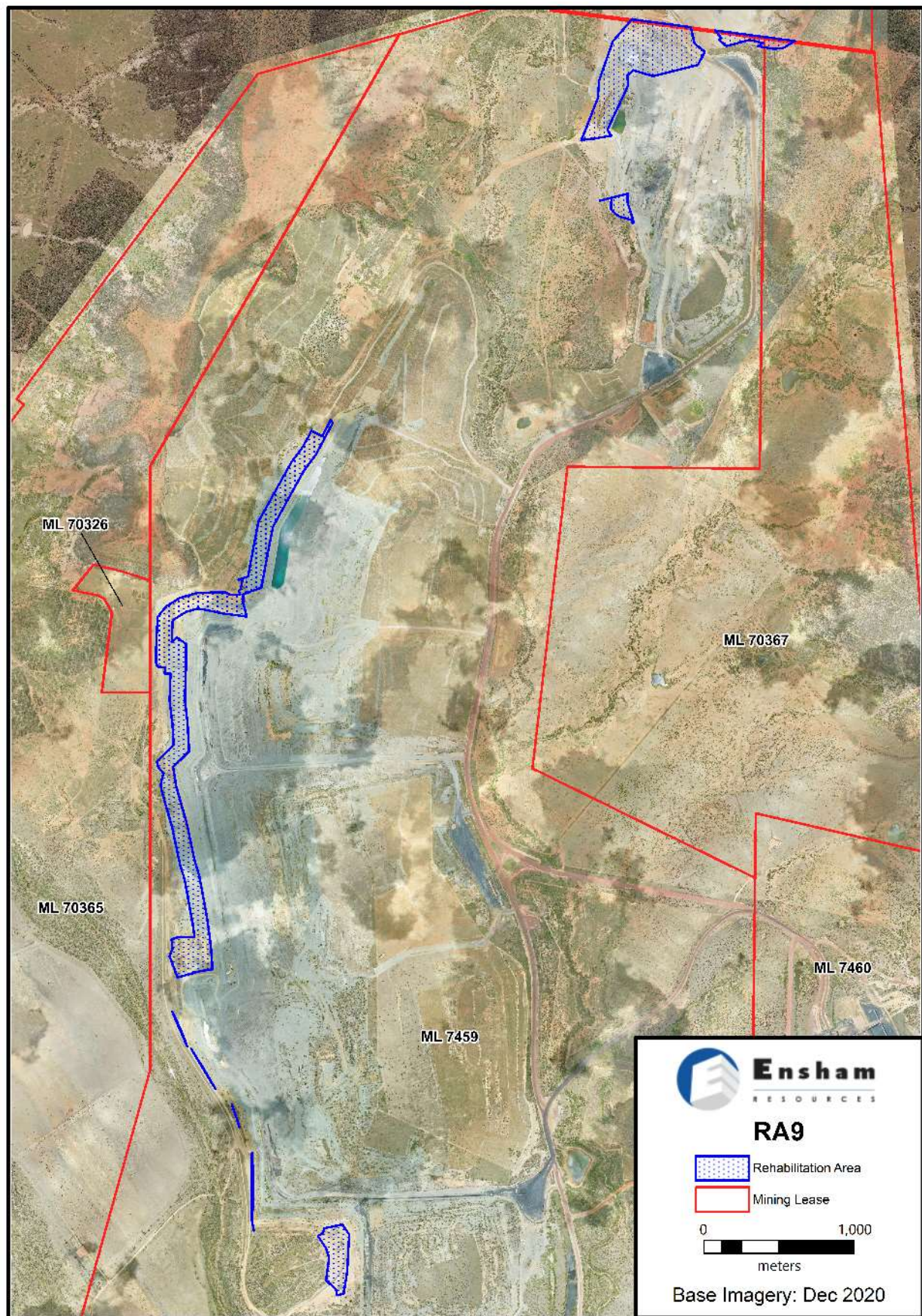


Figure 9-17 Rehabilitation Area 9 (RA 09)

9.1.5.10 RA 10

Post-mining land uses (PMLU)											
Rehabilitation area (description)	RA10 (Central Levee)										
Relevant activities	Mine domain 7 - Flood protection landform										
Total rehabilitation area size (ha)	35.7										
Commencement of first milestone: RM3	1/01/2038										
PMLU	Mine domain 7 - Flood protection landform										
Date area is available	1/01/38	1/01/39	1/01/40	1/01/41	1/01/42	1/01/43	1/01/44	1/01/45	1/01/46	1/01/47	1/01/48
Cumulative area available (ha)	8.5	8.5	22.7	33.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7
Milestone completed by	10/12/38	10/12/39	10/12/40	10/12/41	10/12/42	10/12/43	10/12/44	10/12/45	10/12/46	10/12/47	10/12/48
Milestone Reference	Cumulative area achieved (ha)										
RM3	8.5		22.7	33.7	35.7						
RM4		8.5		22.7	33.7	35.7					
RM5		8.5		22.7	33.7	35.7					
RM6				8.5		22.7	33.7	35.7			
RM11							8.5		22.7	33.7	35.7

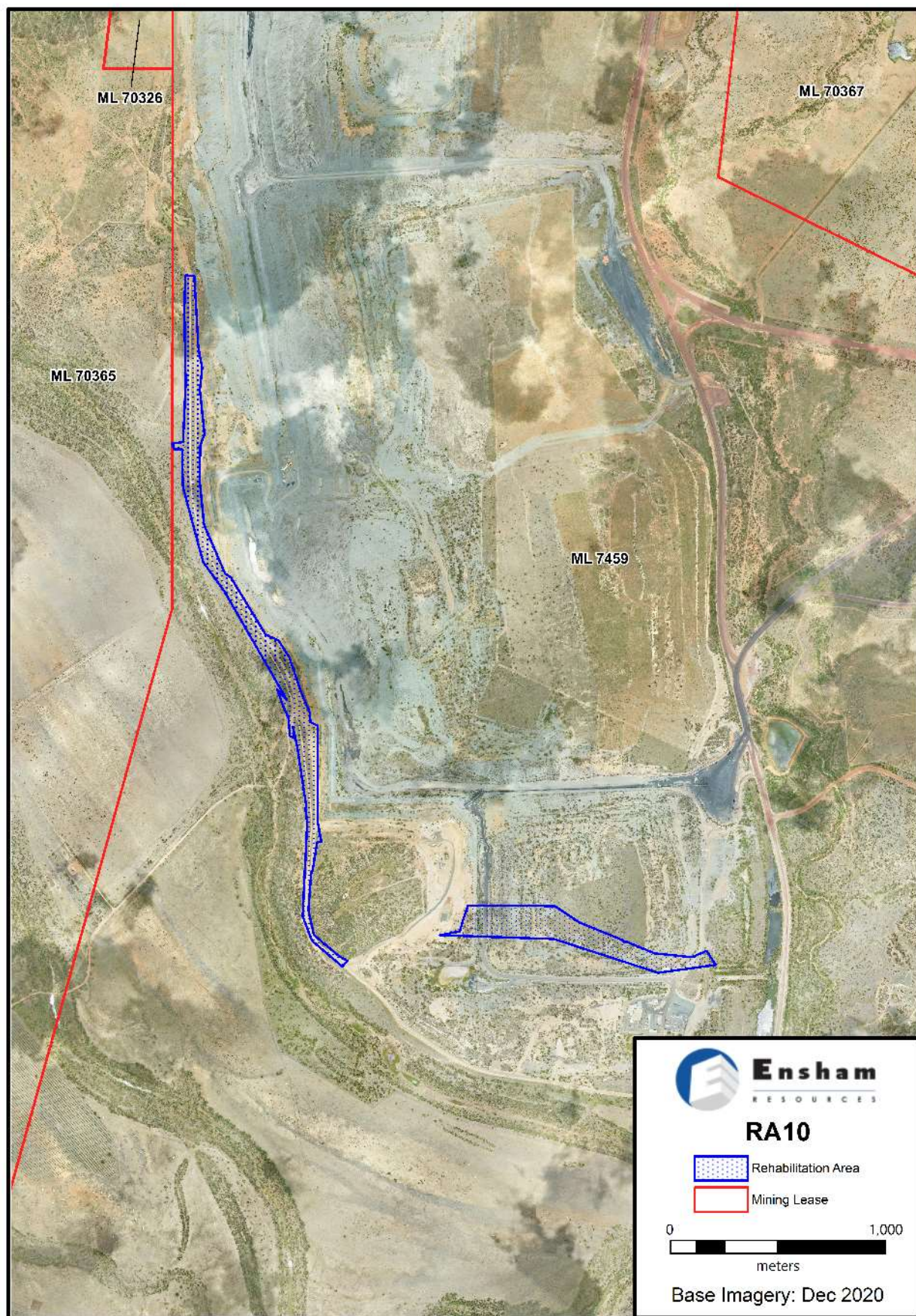


Figure 9-18 Rehabilitation Area 10 (RA 10)

9.1.5.11 RA 11

Post-mining land uses (PMLU)																		
Rehabilitation area (description)	RA11 (Southern Cattle Grazing)																	
Relevant activities	Mine domain 1 - Cattle grazing																	
Total rehabilitation area size (ha)	927.1																	
Commencement of first milestone: RM3	1/01/2028																	
PMLU	Mine domain 1 - Cattle grazing																	
Date area is available	1/01/28	1/01/29	1/01/31	1/01/32	1/01/33	1/01/34	1/01/35	1/01/36	1/01/37	1/01/38	1/01/39	1/01/40	1/01/41	1/01/42	1/01/43	1/01/45	1/01/46	1/01/48
Cumulative area available (ha)	71.7	71.7	116.7	315.0	421.1	446.4	446.4	541.3	541.3	541.3	719.7	831.7	831.7	848.9	927.1	927.1	927.1	927.1
Milestone completed by	10/12/28	10/12/29	10/12/31	10/12/32	10/12/33	10/12/34	10/12/35	10/12/36	10/12/37	10/12/38	10/12/39	10/12/40	10/12/41	10/12/42	10/12/43	10/12/45	10/12/46	10/12/48
Milestone Reference	Cumulative area achieved (ha)																	
RM1															927.1			
RM2															3			
RM3	71.7		116.7	315	421.1	446.4		541.3			719.7	831.7		848.9	927.1			
RM4		71.7		116.7	315	421.1	446.4		541.3			719.7	831.7		927.1			
RM5		71.7		116.7	315	421.1	446.4		541.3			719.7	831.7		927.1			
RM6			71.7			116.7	315	421.1	446.4		541.3			719.7	831.7	927.1		
RM7						71.7			116.7	315	421.1	446.4		541.3		719.7	831.7	927.1

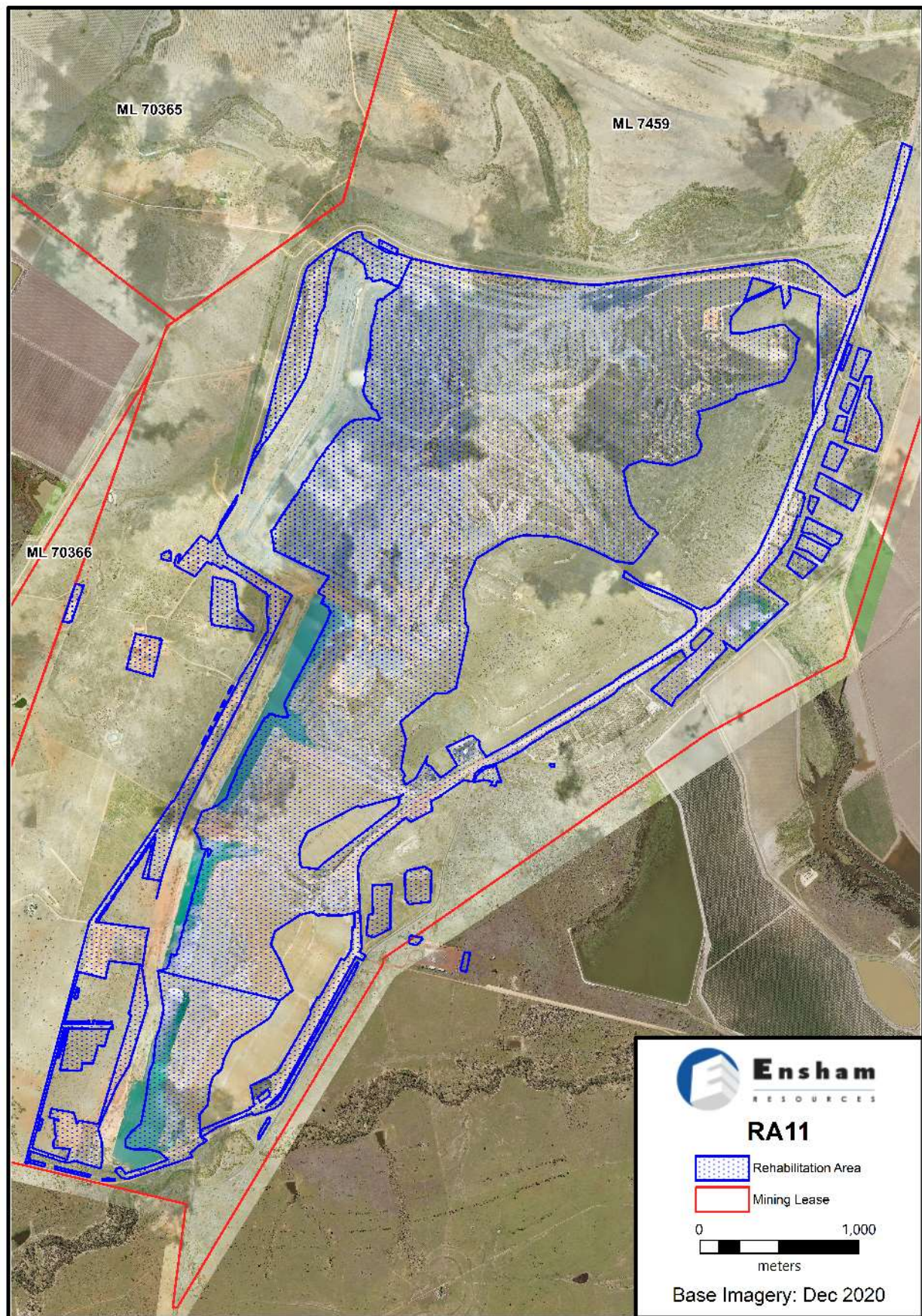


Figure 9-19 Rehabilitation Area 11 (RA 11)

9.1.5.12 RA 12

Post-mining land uses (PMLU)										
Rehabilitation area (description)	RA12 (Southern NBC)									
Relevant activities	Mine domain 3 - Native bushland corridor									
Total rehabilitation area size (ha)	76.2									
Commencement of first milestone: RM3	1/01/2034									
PMLU	Mine domain 3 - Native bushland corridor									
Date area is available	1/01/34	1/01/35	1/01/36	1/01/37	1/01/38	1/01/39	1/01/40	1/01/41	1/01/43	1/01/46
Cumulative area available (ha)	29.4	29.4	51.2	51.2	51.2	76.2	76.2	76.2	76.2	76.2
Milestone completed by	10/12/34	10/12/35	10/12/36	10/12/37	10/12/38	10/12/39	10/12/40	10/12/41	10/12/43	10/12/46
Milestone Reference	Cumulative area achieved (ha)									
RM3	29.4		51.2			76.2				
RM4		29.4		51.2			76.2			
RM5		29.4		51.2			76.2			
RM6					29.4		51.2		76.2	
RM10								29.4	51.2	76.2

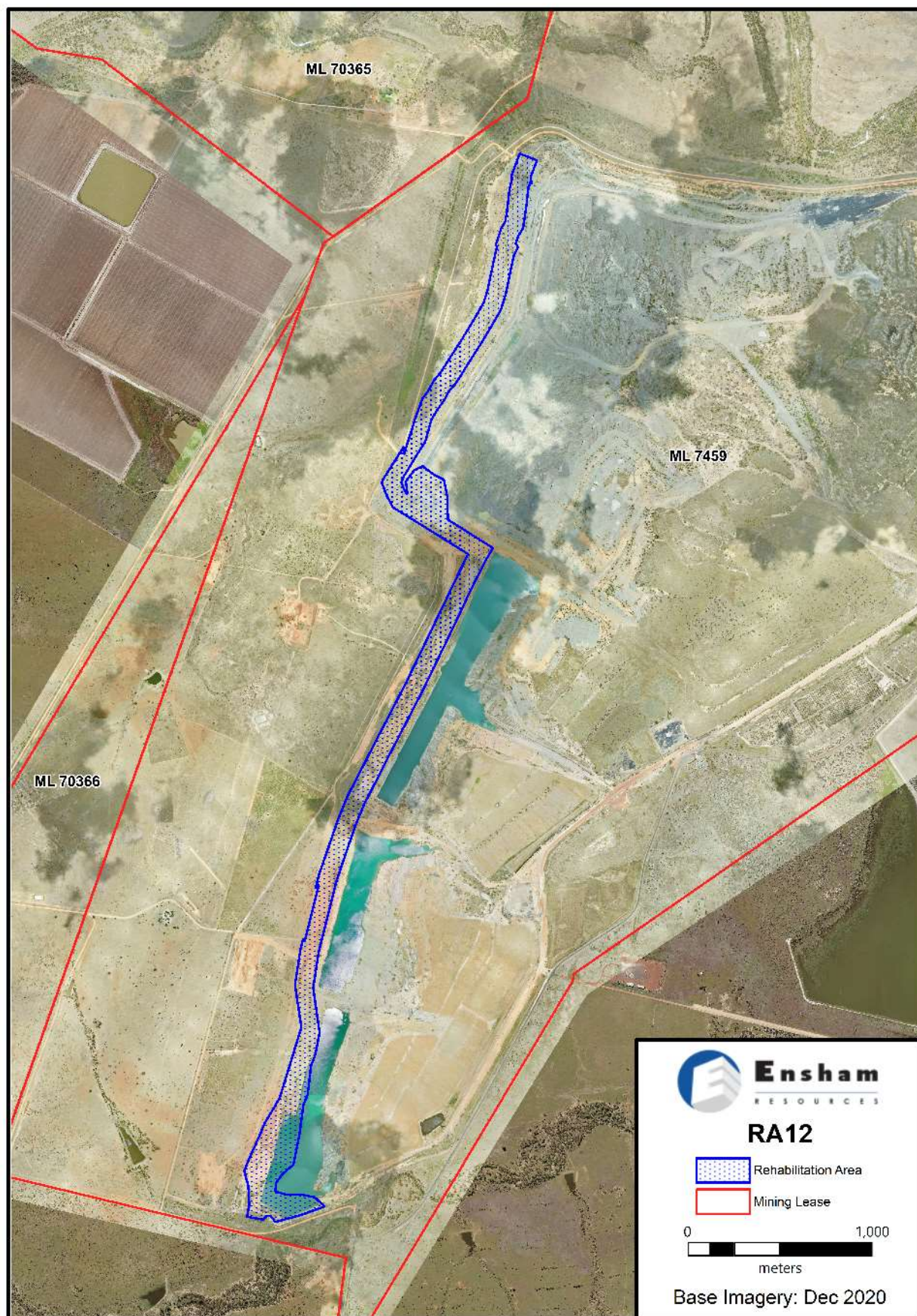


Figure 9-20 Rehabilitation Area 12 (RA 12)

9.1.5.13 RA 13

Post-mining land uses (PMLU)																		
Rehabilitation area (description)	RA13 (Southern Levee)																	
Relevant activities	Mine domain 7 - Flood protection landform																	
Total rehabilitation area size (ha)	29.6																	
Commencement of first milestone: RM3	1/01/2028																	
PMLU	Mine domain 7 - Flood protection landform																	
Date area is available	1/01/28	1/01/29	1/01/31	1/01/32	1/01/33	1/01/34	1/01/35	1/01/36	1/01/37	1/01/38	1/01/39	1/01/40	1/01/42	1/01/43	1/01/45	1/01/46	1/01/48	1/01/49
Cumulative area available (ha)	3.0	3.0	3.0	5.1	9.9	22.1	22.1	22.1	22.1	22.1	22.1	22.1	25.2	29.6	29.6	29.6	29.6	29.6
Milestone completed by	10/12/28	10/12/29	10/12/31	10/12/32	10/12/33	10/12/34	10/12/35	10/12/36	10/12/37	10/12/38	10/12/39	10/12/40	10/12/42	10/12/43	10/12/45	10/12/46	10/12/48	10/12/49
Milestone Reference	Cumulative area achieved (ha)																	
RM3	3			5.1	9.9	22.1							25.2	29.6				
RM4		3			5.1	9.9	22.1							29.6				
RM5			3		5.1	9.9	22.1							29.6				
RM6				3			5.1	9.9	22.1						25.2	29.6		
RM11						3				5.1	9.9	22.1					25.2	29.6



Figure 9-21 Rehabilitation Area 13 (RA 13)

9.1.5.14 RA 14

Post-mining land uses (PMLU)												
Rehabilitation area (description)	RA14 (Nogoa Pastoral and Simmons Infrastructure)											
Relevant activities	Mine domain 2 - Landholder retained infrastructure											
Total rehabilitation area size (ha)	38.5											
Commencement of first milestone: RM3	1/01/2028											
PMLU	Mine domain 2 - Landholder retained infrastructure											
Date area is available	1/01/28	1/01/43										
Cumulative area available (ha)	6.7	38.5										
Milestone completed by	10/12/28	10/12/43										
Milestone Reference	Cumulative area achieved (ha)											
RM8	6.7	38.5										

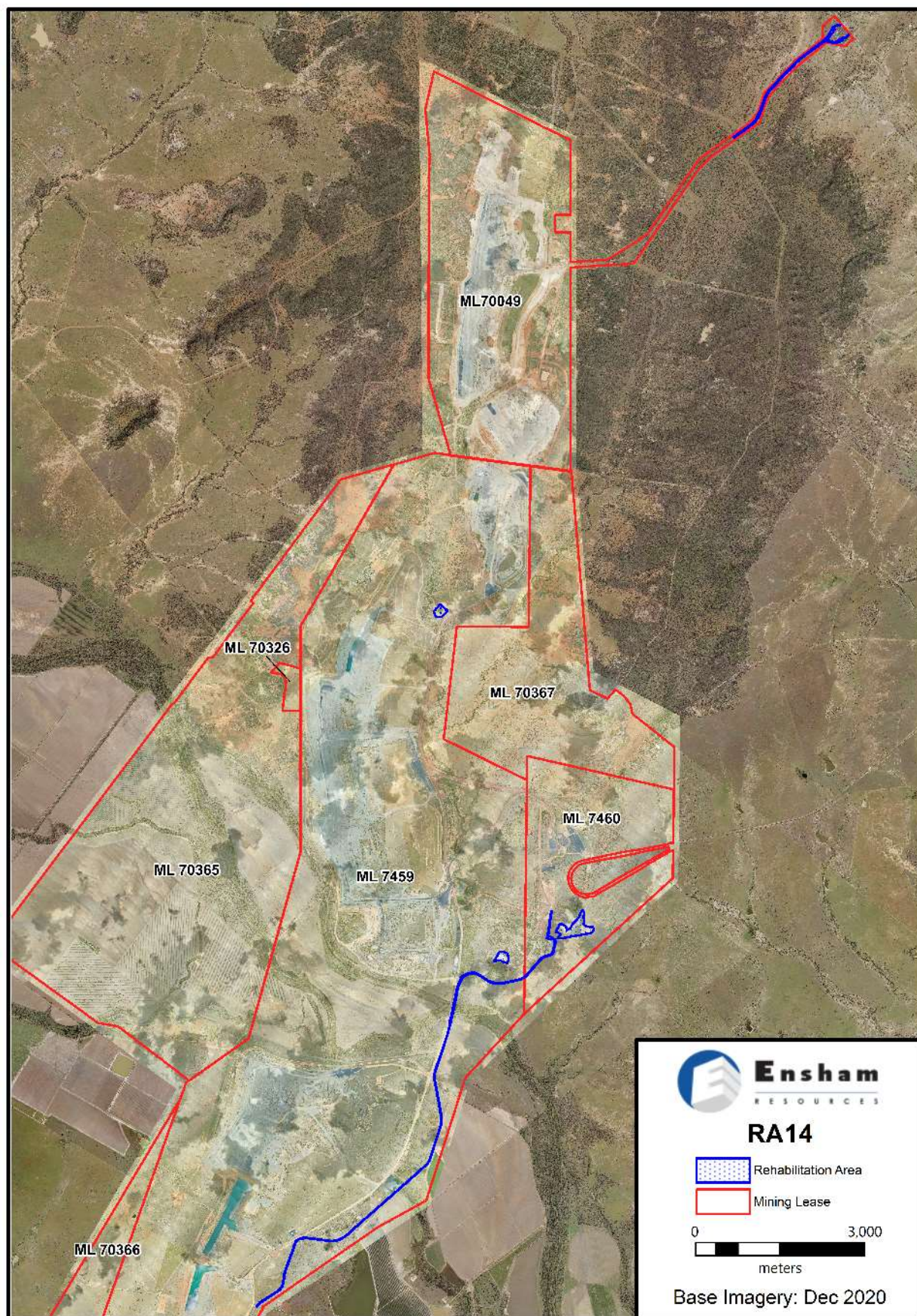


Figure 9-22 Rehabilitation Area 14 (RA 14)

9.1.6 Improvement Areas schedule

Following are schedules with key dates and milestones for all future IAs at Ensham. The location of each IA is as shown in Figure 9-23 and Figure 9-24, as well as being detailed within the provided spatial files.

9.1.6.1 IA 1

Non-use management area (NUMA)												
Improvement area (description)	IA1 (Highwalls)											
Relevant activities	Mine domain 6 - Highwalls											
Total size (ha)	83.1											
Commencement of first milestone: MM1	1/01/2032											
NUMA	Mine domain 6 - Highwalls											
Date area is available	1/01/32	1/01/36	1/01/37	1/01/38	1/01/40	1/01/41	1/01/42	1/01/43	1/01/45	1/01/46	1/01/47	
Cumulative area available (ha)	3.0	21.9	29.6	41.5	50.1	63.0	83.1	83.1	83.1	83.1	83.1	
Milestone completed by	10/12/32	10/12/36	10/12/37	10/12/38	10/12/40	10/12/41	10/12/42	10/12/43	10/12/45	10/12/46	10/12/47	
Milestone Reference	Cumulative area achieved (ha)											
MM1	3.0	21.9	29.6	41.5	50.1	63	83.1					
MM2			3			21.9	29.6	41.5	50.1	63	83.1	

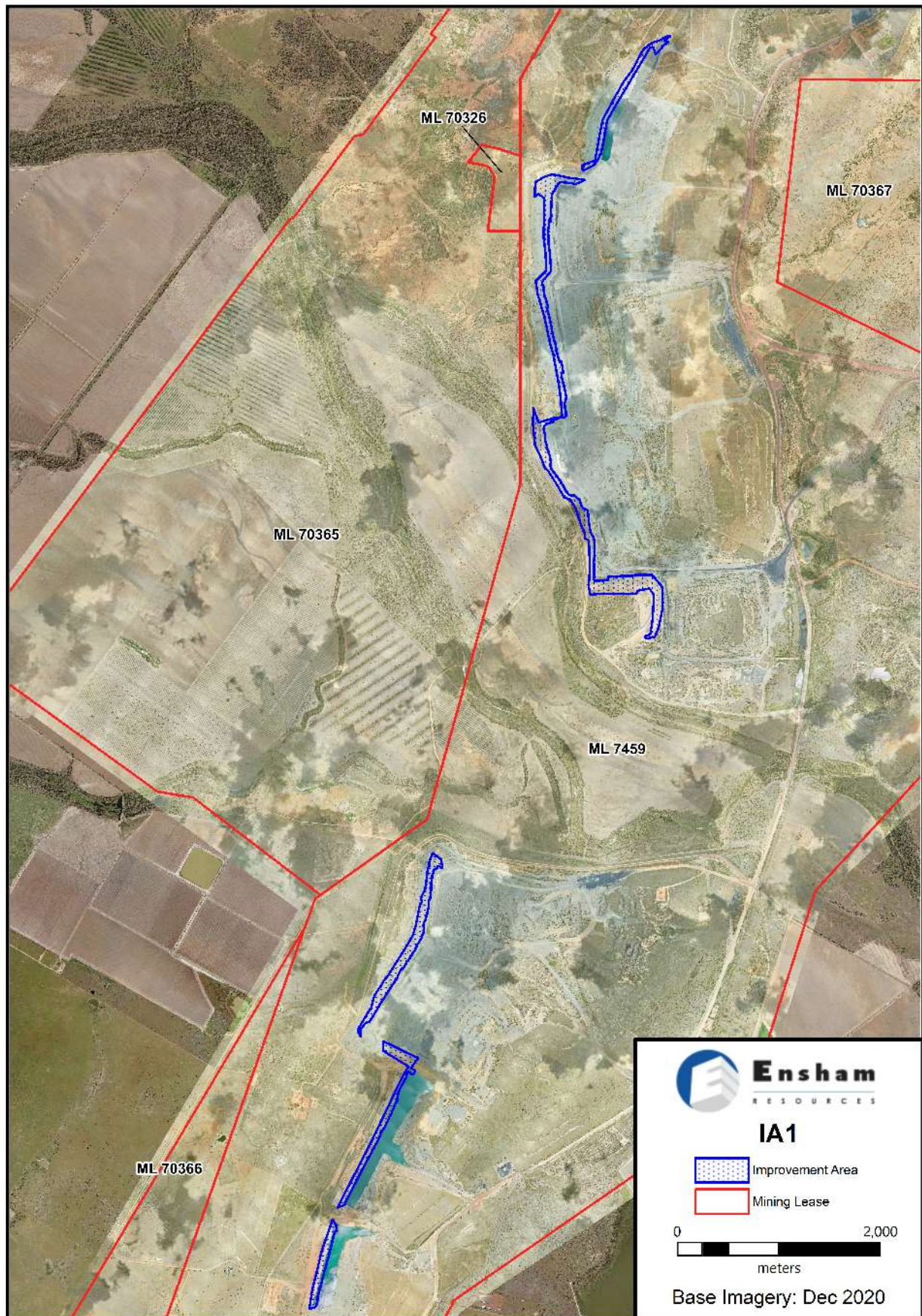


Figure 9-23 Improvement Area 1 (IA 01)

9.1.6.2 IA 2

Non-use management area (NUMA)										
Improvement area (description)	IA2 (GDA's)									
Relevant activities	Mine domain 5 - Groundwater daylighting water areas									
Total size (ha)	145.8									
Commencement of first milestone: MM1	1/01/2036									
NUMA	Mine domain 5 - Groundwater daylighting water areas									
Date area is available	1/01/36	1/01/38	1/01/40	1/01/41	1/01/42	1/01/43	1/01/45	1/01/46	1/01/47	
Cumulative area available (ha)	30.7	65.7	98.1	112.4	145.8	145.8	145.8	145.8	145.8	
Milestone completed by	10/12/36	10/12/38	10/12/40	10/12/41	10/12/42	10/12/43	10/12/45	10/12/46	10/12/47	
Milestone Reference	Cumulative area achieved (ha)									
MM1	30.7	65.7	98.1	112.4	145.8					
MM2				30.7		65.7	98.1	112.4	145.8	

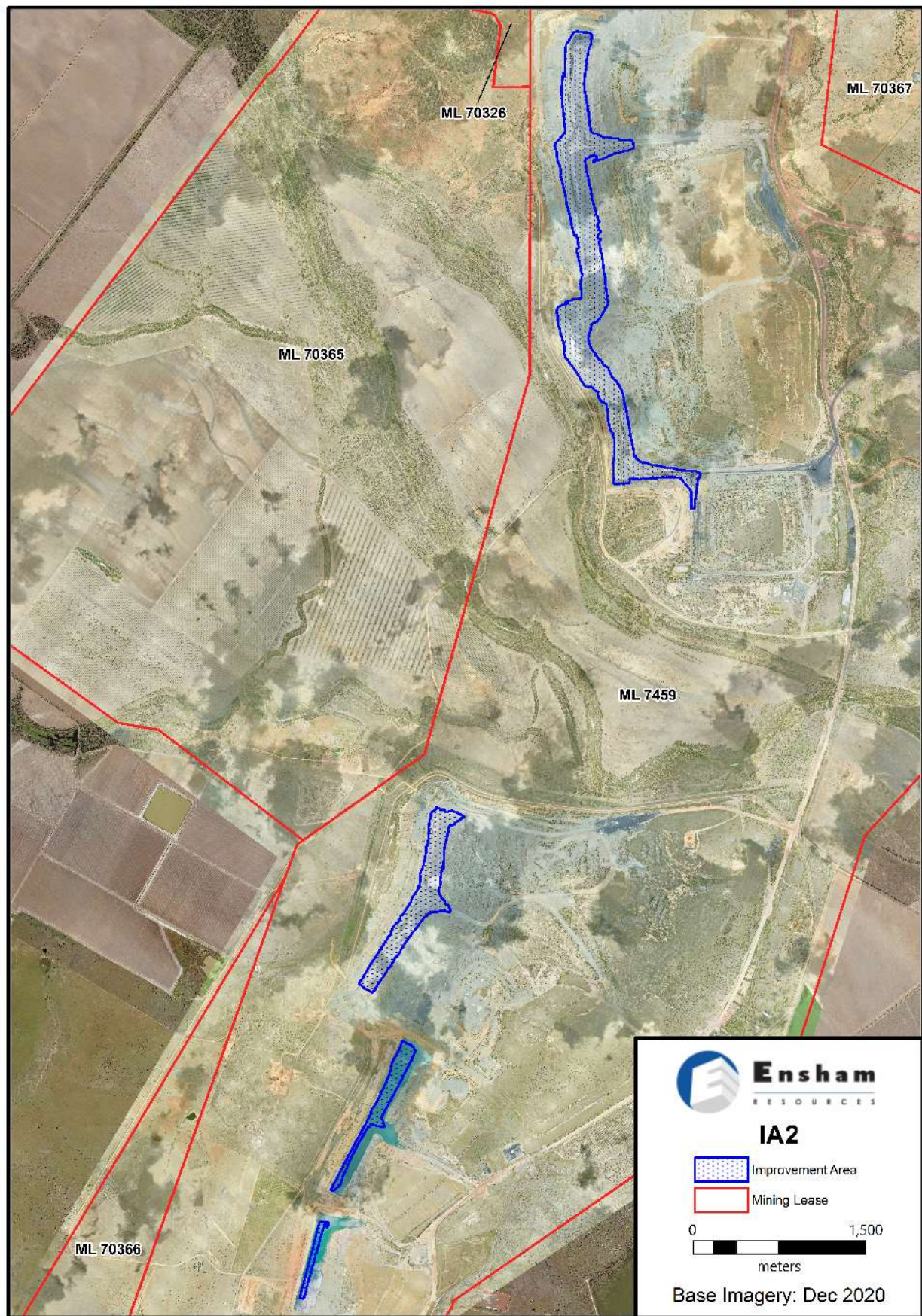


Figure 9-24 Improvement Area 2 (IA 02)

9.2 Post-Mining Land Use Context Report



Ensham
R E S O U R C E S



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RESOURCES
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The Ensham Coal Project
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following companies which
are liable severally in the
following proportions:

Bligh Coal Limited
ABN 20 010 186 393
47.5%

Idemitsu Australia
Resources Pty Ltd
ABN 45 010 236 272
37.5%

Bowen Investment
(Australia) Pty Ltd
ABN 12 002 806 831
15.0%

APPENDIX 9.2 – POST-MINING LAND USE CONTEXT

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1 INTRODUCTION

The nomination of appropriate post-mining land uses (PMLU) for the mining operation is a key component of the PRCP. It is important to clearly establish PMLUs so that rehabilitation and closure activities are focussed on achieving these outcomes, and that the objectives are appropriate for the context for the region and also achievable.

Ensham have developed this document to summarise the background and context of the planned PMLUs, noting they reflect agreed outcomes between Ensham and the Department of Environment and Science (DES). They were selected on the basis of foundational analysis of historic and current information on land use, mining constraints and expected landform outcomes explored as part of the residual void study.

In this document, performance information from existing rehabilitation has been used to support the development of appropriate milestones and milestone criteria that reflect a compilation of the best available information for the site and the proposed PMLU, and show consistency with the currently approved completion criteria contained within Ensham's EA (EPML00732813).

Ensham is a transitional PRCP and to this end, PMLUs that have been previously identified in a land outcome document have been transitioned into the PRCP.

This report focuses on the following outcomes:

- Understanding the potential PMLUs which may be suitable in the context of the pre-mining and surrounding landscape;
- Confirming what PMLUs were previously envisaged for the site and what has already been approved for Ensham; and
- Outline linkages between the PMLUs and rehabilitation performance to demonstrate that the proposed milestones and milestone criteria are appropriate for demonstrating that a PMLU has achieved a 'stable condition' in accordance with the EP Act definition.

2 PRE-MINING AND SURROUNDING LAND USE CONSIDERATIONS

2.1 Land use

Prior to mining, the land was used for many years for agricultural purposes, predominantly cattle grazing, but also irrigated and dryland farming on the floodplain areas. Cultivation was restricted to land within the floodplain of the Nogoia River, most of which has not been disturbed by open cut mining. Section 1.3.10 of the main PRCP describes the pre-mining land uses at Ensham. This outlines that the historical land uses were beef cattle grazing on predominantly native pastures of low to moderate productivity that were in a moderately to severely degraded condition prior to mining activities. Overall, the pre-mining attributes are similar to the current surrounding land uses of agriculture, with predominant uses for cattle grazing with a secondary use of irrigation and cropping where the land is suitable.

2.2 Land suitability/capability

As part of initial assessment that investigated the pre-mining and surrounding land suitability, the Ensham central area was evaluated as suitable for rainfed (dryland cropping), grazing of natural and improved pastures as well as irrigated agriculture (Hansen, 2006). Approximately 40% of the site is rated as Agricultural Land Class A with a further 4% as Class B. The majority of the remainder of the mining lease area falls within Land Class C, with a small portion of Class D. the Yongala area and the northern parts of the 'Duckponds' property were largely uncleared, and considered Class 3, 4 and 5 grazing land only.

As such, Ensham is not priority land for dryland cropping. The majority of the land has been assessed as suitable for grazing, with varying levels of land management required to sustain this land use.

2.3 Soil characteristics

As detailed in Section 1.3.6 of the main PRCP, there are several land systems and associated soil groups at Ensham. There are six major soil groups present, each with one or more variants. Soils are generally highly weathered and chemically and physically poor, with salinity and sodicity limiting productivity at depth i.e., saline and sodic subsoils.

2.4 Landform

The pre-mining topography at Ensham is described in Section 1.3.1 of the main PRCP. In summary, the site is comprised of two main landform types, with terrain in the northern half of the mining leases comprising mildly dissected gently to moderately sloping and undulating lands, forming slopes and outwash plains flanking Boggy Creek. Remnants of the plateau areas feature steep escarpments, with slopes up to 66% gradient or more, and local relief up to 50 m high escarpments.

In the southern half of the mining lease, terrain is more gently sloping, and encompasses the floodplain area of the Nogoia River and its major tributaries. These watercourses flow through the area in a south-easterly direction, and comprise a broad alluvial tract approximately 4 km wide.

2.4.1 Stability and erodibility

As described in Section 1.3.7 of the main PRCP, the land systems and associated soils at Ensham have moderate to high erosion potential and are considered to be generally unsuitable for clearing and agricultural development. Prior to mining, the northern part of the Ensham site was in a moderately to severely degraded (in places) condition with very deep erosion gullies present across the property. The size and severity of gullying reflects the generally dispersive nature of the soils and substrate materials, coupled with uncontrolled surface water runoff.

As described in Section 3.1.1 of the main PRCP, the majority of slopes in existing cattle grazing paddocks surrounding Ensham's mining and rehabilitation areas are between 0 – 10% in slope. However, a notable portion of the surrounding areas are between 10% and 15% in slope, as well as up to 25%.

2.5 Vegetation communities

Much of the land at Ensham had been cleared of vegetation for agricultural development prior to mining, as described in Section 1.3.8 of the main PRCP. Vegetation mapping shows there are 13 regional ecosystems within and surrounding the mining leases with four Threatened Ecological Communities identified as potentially occurring. An understanding of the function, structure and biodiversity of these vegetation communities has informed the PMLUs as relevant.

2.6 Community and social context

As described in Section 2 of the main PRCP, increasing the availability of land for future agricultural uses (such as grazing and/or cropping) is deemed as of high importance to the region within which Ensham is located. Past social impact assessment for Ensham (Umwelt, 2019) noted that a broad range of potential community uses would provide an opportunity to strengthen the economy and create sustainable employment.

2.7 Tenure and landholders

As detailed in Section 1.1. of the main PRCP, of a total of seven (7) MLs, all apart from one (1) are located on property where the tenure is also held by the Ensham JV partners. It is noted that ML70049 is held by another party. This represents approximately 13% of the total land area of the Ensham mine site.

3 MINING RELATED LAND USE CONSIDERATIONS

As described at the start of the main PRCP (rehabilitation planning part), Ensham is an existing mine operating under an existing site-specific EA and subject to the transitional provisions of the EP Act.

Ensham has pre-approved non-use management areas (NUMAs) as detailed in land outcome document EA EPML00732813. The land outcome documents also identify a number of rehabilitation PMLUs which are approved for Ensham.

This document highlights how these approved PMLUs are suitable in the context of the pre-mining and surrounding landscape as well as demonstrating how a review of rehabilitation performance can demonstrate that the PMLUs (and underlying rehabilitation prescriptions) will result in successful rehabilitation outcomes to demonstrate that the PLMU has achieved a 'stable condition'.

The remainder of this section supports Sections 3 and 4 of the main PRCP, and has been summarised simply to illustrate the context of the PMLUs within the further surrounding information that has led to their development. It should not be taken as a justification or options assessment of the PMLUs, which is not required for this transitional PRCP.

3.1 Approved Post-Mining Land Uses

3.1.1 Cattle grazing on overburden / infrastructure areas

Beef cattle grazing is the largest land use in the Fitzroy Natural Resource Management (NRM) Region (ABARES 2015) occupying 12 million ha or 78 % of the total regional area. It is also the largest PMLU at Ensham and will occupy the majority of land areas for the mining leases.

Rehabilitation that will be used for beef cattle grazing will have slope gradients not greater than 25% and will be sown to a mix of 3P (perennial, palatable and persistent) grasses and legumes. This rehabilitation will be land suitability class 2 (suitable) to class 4 (marginally suitable).

The design of the grazing domain will deliver a significantly better post mining land suitability for grazing than pre-mining for some areas. For example, some areas of land at Yongala which were previously class 5 will be rehabilitated to class 4 or better.

These slopes will have a growth medium placed on the surface, as well as being seeded and hay mulched at a minimum, with other suitable treatment included as required to further reduce erosion risk potential. Benches within the spoil rehabilitation will not be topsoiled to allow germination of tree seed as part of cattle shelterbelts and for visual amenity.

3.1.2 Landholder retained infrastructure

Some mining infrastructure will be retained by the background landholders, with written agreements in place at the end of the closure period. This includes roads, dams, pipelines, bridges and electrical reticulation to assist in meeting ongoing land management requirements. Though important to facilitating other PMLUs, landholder retained infrastructure are expected to be minimal.

3.1.3 Boggy Creek diversion

Construction of the Boggy Creek diversion was completed in 2021 and rehabilitation practices have involved re-establishment of required geomorphological functionality to the watercourse, including suitable riparian vegetation. This is a relatively minor PMLU that will occupy approximately 88 ha of PMLUs at Ensham.

3.1.4 Native bushland corridor

Regional ecosystems in the Brigalow Belt Bioregion have been extensively cleared for agriculture and within the Fitzroy NRM Region protected, conservation and minimum use areas occupy 7.8 % of land (ABARES 2015). Native bushland corridor rehabilitation at Ensham will provide important habitat for a variety of native animals and plants, with linkages to existing remnant regional ecosystems associated with the Nogoa River. This is a relatively minor PMLU that will occupy approximately 295 ha or 4.9 % of PMLUs at Ensham.

3.1.5 Flood protection landform

The purpose of this PMLU is to prevent flood inundation of other rehabilitation domains and replace existing flood protection levees. A key indicator that the area is meeting the rehabilitation objective is the design level of the landform crest. This has been agreed to be designed to contain a flood

level at least 0.5 m above the estimated 1:1000 (0.1%) Annual Exceedance Probability (AEP) (equivalent to the 1 in 1,000-year annual recurrence interval (ARI) flood event). Using the height of the existing levees at >1m above the 0.1% AEP, the landform will exceed the 0.5m criteria easily. However, it is noted that these landforms will be suitable to be incorporated into pastoral activities similar to that occurring elsewhere at Ensham, which will allow for grazing activities to be maximised.

This is a relatively minor PMLU that will occupy approximately 65 ha or 0.9 % of PMLUs at Ensham.

3.2 Environmental factors

Post-mining land use at Ensham has been agreed as an outcome of the residual void study or project, whereby suitable void, landform and PMLUs outcomes have been extensively investigated and assessed. The relevant stakeholders, and notably governmental stakeholders such as DES, DNRME and DAF have endorsed the adopted PMLUs as presented in this PRCP, as further reflected in the current EA for Ensham.

Having said that, these PMLUs have been developed from a synthesis of relevant technical and environmental factors, as well as an understanding of the constraints, to ensure that proposed future use will be self-sustaining. The adopted PMLU concept has considered any underlying environmental factors or constraints, and also responds to any site- specific factors to assure adequate long-term performance. The key environmental factors that have driven the PMLU concept include the following areas:

- previously approved post-mining land uses and non-use management areas that have been agreed for the site
- the expected treatment and post-closure recovery of voids and areas where groundwater is expected to daylight for the site
- floodplain interactions and protection
- spoil type and nature
- adoption of appropriate slope design criteria for each spoil type and landform, including both waste rock dumps and highwalls
- an understanding of growth media characteristics and constraints
- the success of different revegetation techniques, as evidenced through review of rehabilitation performance and trials

Considering this list of environmental factors of relevance, it is noted that the ability of the rehabilitation to support Cattle Grazing PMLU and support a Native Bushland Corridor PMLU are key considerations. It is also noted that the allowance of the NUMAs resulted from, and were a condition of acceptance by stakeholders, for the final landform as presented in the residual void project. This was to maximise grazing potential of the Ensham area.

3.2.1 Land suitability requirements for beef cattle grazing

By area, more than 90% of rehabilitation at Ensham has a target PMLU of beef cattle grazing. Determination of rehabilitation suitability has required an evaluation of soil and landform attributes based on the requirements for beef cattle grazing using current technology and management.

Five land suitability classes are defined for use in Queensland, with land suitability decreasing progressively from class 1 to class 5. These classes are used to describe an area of land in terms of suitability for a particular land use which allows optimum, sustainable production using current technology, while minimising degradation to the land resource in the short, medium or long term.

Land is considered less suitable as the severity of limitations for a specified land use increase, reflecting:

- reduced potential for production.
- increased inputs required to achieve an acceptable level of production.
- increased inputs required to prepare the land for successful production.
- increased inputs required to prevent land degradation.

The five land suitability classes are summarised below in Table 3-1.

Table 3-1 Land suitability classes (from DNRM/DSITIA 2013)

Class	Suitability	Limitations	Description
1	Suitable	Negligible	Highly productive land that is well suited to the proposed use.
2	Suitable	Minor	Land with limitations that either constrain production, or require more than the simple management practices of class 1 land to maintain sustainable production.
3	Suitable	Moderate	Land with limitations that either further constrain production, or require significant inputs to ensure sustainable use.
4	Marginally suitable	Severe	Severe Land which is marginally suited for a proposed use and would require major inputs to ensure sustainability; often the inputs required may not be justified in terms of the benefits to be gained from using the land for a proposed use and the land is considered presently unsuitable for that use.
5	Not suitable	Extreme	Land with extreme limitations that preclude any possibility of successful sustained use of the land in the proposed manner.

Classes 1 to 3 are considered suitable for a specified land use because the benefits from using the land (for that particular use) outweigh the inputs required to initiate and maintain production.

Class 4 is also used in situations where reducing the effect of a particular limitation may indicate production is possible, but additional studies are needed to determine the feasibility of such actions, e.g. fertilisation.

In contrast, there is no doubt regarding the long-term suitability of Class 1–3 lands or the overall unsuitability of Class 5 land in large and continuous portions. Class 5 land typically has significant limitations that mean the benefits do not justify the inputs required to enable profitable production. It would require a major change in economics, technology or management expertise before the land could be considered as suitable overall. Some Class 5 lands have physical characteristics that preclude any form of development, e.g. mountains, and will always remain unsuitable for agriculture.

However, it is also noted that, for some areas, Class 5 lands can occur naturally as small interspersed portions that are interspersed with more suitable lands. Such is the case at Ensham, where Class 5 and occurs naturally through the site in small portions and is incorporated into the cattle grazing paddocks, for example small ridgy areas and isolated bare patches. In a paddock as a whole, these are coexists and form part of the overall functioning landscape.

3.2.1.1 Classification for beef cattle grazing rehabilitation

Suitability classification evaluates rehabilitation in terms of the potential to graze and finish cattle on improved pastures. The evaluation is not discounted because the land is rehabilitated land. Rather, it applies a strict set of rules to determine suitability and is based on frameworks developed and applied previously to unmined land in the region, e.g., Shields and Williams (1991).

Typical grazing systems in inland central Queensland aim to produce young, finished, grass fed, export quality cattle without inputs other than pasture development. Most production is based around improved grass-legume pastures. Improved pasture development in many areas is dominated by Buffel grass, although Rhodes grass, introduced bluegrasses (Indian bluegrass, creeping bluegrass), Purple Pigeon grass and Panic species all have a role in certain situations.

Legume establishment and species vary significantly depending on soil characteristics and microclimates. Commonly used legumes include shrubby stylos species, Desmanthus species, Wynn Cassia (sandy soils), Butterfly Pea (clay soils), Medics, Siratro and Leucaena (cropping soils). However, Siratro and Leucaena are no longer recommended in rehabilitation due to their propensity to become environmental weeds.

Considering descriptions provided in DNRM/DSITIA (2013) and DSITI/DNRM (2015), earlier work by Shields and Williams (1991) and typical grazing systems in central Queensland, land classes for grazing in rehabilitation at Ensham mine have been developed (Table 3-2).

Table 3-2 Suitability classes for beef cattle grazing PMLU at Ensham

Class	Suitability	Grazing system	Description
1	Suitable	Fattening / finishing	Rehabilitation capable of attaining maximum grazing productivity, i.e. production of young, finished, grass fed, export quality cattle in most seasons.
2	Suitable	Growing	Rehabilitation on which younger cattle perform well but may be difficult to finish at a young age, depending on seasonal conditions.
3	Suitable	Year-round breeding	Rehabilitation able to carry breeding stock all year round depending on seasons.
4	Marginally suitable	Seasonal breeding	Rehabilitation able to carry breeding stock only in better seasons or for short periods in conjunction with higher class country.
5	Not suitable	Never	Rehabilitation that is not suitable for cattle grazing.

3.2.1.2 Beef cattle grazing suitability rule set

There are certain land use requirements for beef cattle grazing. The inherent properties of the soil and landform that are used to assess land use requirements (and hence determine land suitability) are called land use limitations (shortened here to 'limitations'). According to DSITI/DNRM (2015), limitations can be regarded as land use requirements stated in a negative sense, e.g., rockiness,

wetness, frost. Requirements, limitations and the effect of limitations on land uses are developed by precedent, i.e., earlier studies, and experience and consultation with other practitioners.

Limitation subclasses are used to develop rule sets that define suitability. The suitability rule set applicable to rehabilitation at Ensham was developed by Highlands Environmental, consulting soil scientists based in Emerald, following DSITI/DNRM (2015), DME (1995), Shields and Williams (1991) and McClurg (1999), plus extensive field testing and consultation with Mr George Bourne at DNRME, Emerald, and other practitioners (Table 3-3).

Table 3-3 Limitation rule-set for beef cattle grazing on coal mine rehabilitation

Limitation	Code	Indicator	Units	Class				
				1	2	3	4	5
Water availability	m	PAWC in ERD	mm/0.6m	>75	75-60	<60-45	<45-30	<30
Nutrient supply	nd	P in 0.1m	mg/kg 0.1m	>20	20-14	<14-8	<8-4	<4
	nr	pH in 0.1m	None	7.3 – 6.6	<6.6 – 6.0 >7.3 – 8.0	<6.0 – 5.5 >8.0 – 8.5	<5.5 – 5.0 >8.5-9.0	<5.0 or >9.0
Soil physical factors	p	Surface soil structure	variable	Fine (peds <10mm)	Coarse (peds >10mm)	Surface crust	Very hard setting	Massive
Salinity	sa	ECe in ERD	dS/m	<2	2-<4	4-<10	10-<16	≥16
Rockiness	r	Fragments on surface	%	<5	5-10	10-30	30-60	>60
Topography, slope and microrelief	ts	Gradient, surface	%	<5	5-<10	10-<15	15->20	≥20
	tm	Vertical interval, surface	m	Nil ripping furrows	Regular ripping furrows <0.2m	Regular ripping furrows 0.2-0.4m	Regular ripping furrows >0.4-0.6m	Regular ripping furrows >0.6m
Water erosion, surface soil	e	Slope, ESP<6	%	<5	5-8	>8-12	>12-18	>18
		Slope, ESP>6<14	%	<3	3-6	>6-10	>10-12	>12
		Slope, ESP>14	%	<1	1-2	>2-4	>4-6	>6
Subsoil erosion	es	ESP at 0.5m	%	<7	7-14	>14-23	>23-34	>34
Potentially acid forming materials	d	pH<4.5	none	Not likely to be present within 5m of surface	Not likely to be present within 3m of surface	Not likely to be present within 2m of surface	Present immediately below root zone, 0.9-0.6m	Present within root zone, 0.6m

This rule set describes in detail the soil and landform characteristics that more than 90 % of rehabilitation at Ensham will achieve. While this table prescribes the limitation rule set for the

respective classes, there are variations to the indicators for the Ensham mine which have been assessed and approved under the EA with the relevant criteria designed specifically in line with the site specific conditions for example slopes up to 25% are authorised under the EA to achieve Class 4 gradient surface indicators.

4 REHABILITATION PERFORMANCE

Rehabilitation monitoring has been completed since around 2000, however it is noted that many areas of the earlier rehabilitation completed have been reworked since this time. As such, the record of monitoring was reviewed and compiled since 2007, representing a substantial body of evidence as to the rehabilitation performance at Ensham. Monitoring techniques and reporting outcomes have changed over this time, so only information deemed relevant and relatively continuous has been compiled to illustrate the long term performance of previous rehabilitation at Ensham.

Over this time, a total of over 110 discrete rehabilitation and reference sites have been assessed, located across all areas of rehabilitation, equating to a robust sample size of time and space based observations of rehabilitation performance. Key monitoring methods used have included observational surveys, transect based field monitoring as well as specialised satellite analysis, as further detailed in Appendix 9.3 – Monitoring Summary Report.

This monitoring record has been reviewed and summarised in this document with the specific intent to inform and validate the PMLUs for the site, as well as rehabilitation prescriptions and treatments for the primary vegetation based PMLUs as relevant. In addition, linkages have been made in this document to demonstrate how this history of performance data has informed the milestones and milestone criteria for each relevant PMLU. In this way, Ensham can demonstrate not only that the PMLUs are appropriate and achievable, but also that the milestone criteria are a suitable analogue to illustrate rehabilitation success.

In terms of considering how Ensham rehabilitation performs, the summary of a recent site inspection by an industry expert on rehabilitation (Landloch 2016) provided the following key observations:

- Ensham utilises relatively low gradients for rehabilitated areas (with 10% adopted as standard rather than 17% commonly on most Central Queensland coal mines)
- Consistently high levels of surface vegetative cover were evident across the site, with revegetation primarily targeting the establishment of pasture grasses and legumes
- A general absence of flow control structures in place, simply because they are not required as a positive consequence of the lower slope gradients; and
- A general absence of areas of concentrated surface water flow and erosion/incision on rehabilitated areas, again as a positive outcome from the landform design philosophy.

The location of monitoring locations, in the context of areas of rehabilitation completed, is as shown on Figure 4-3 below.

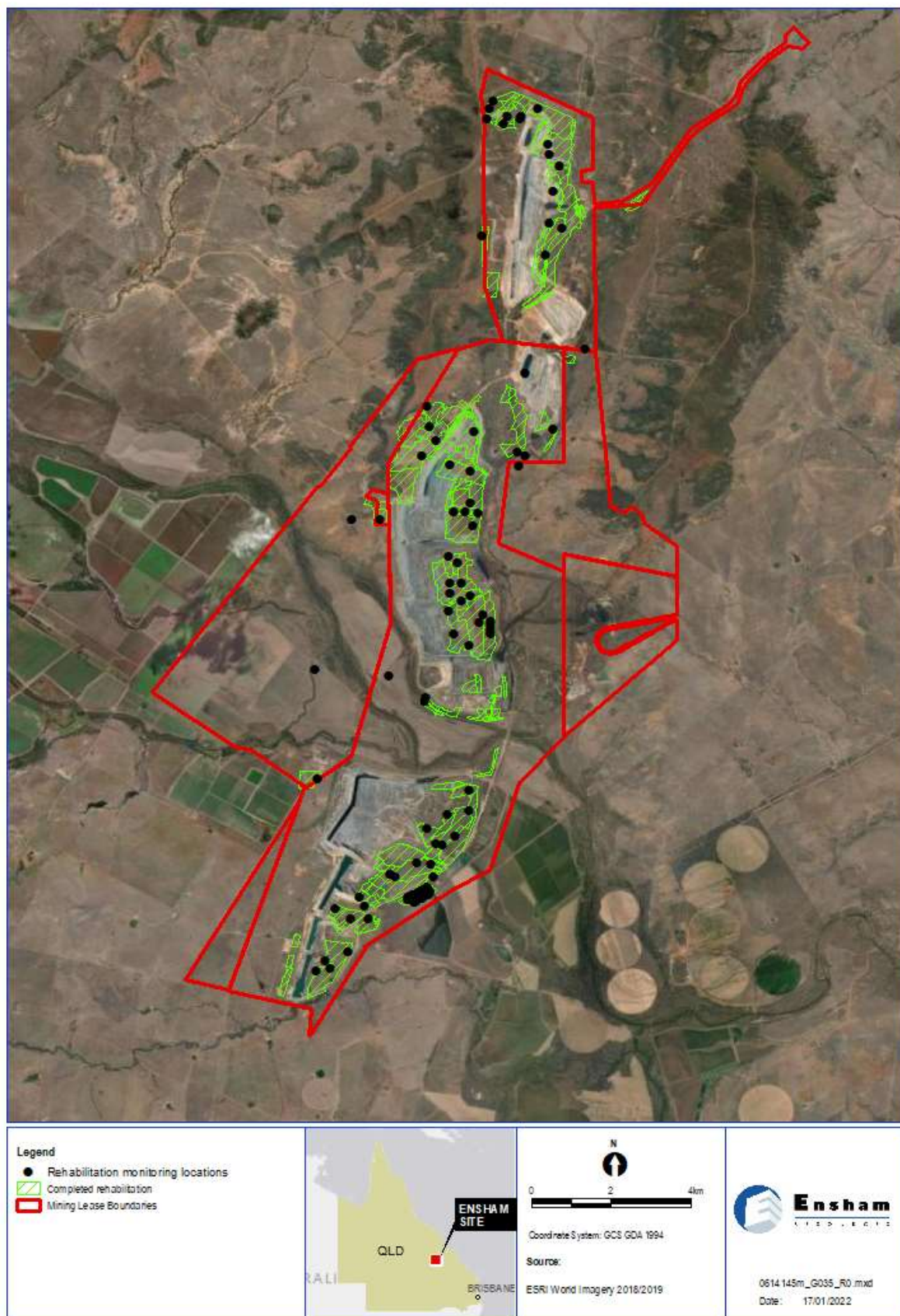


Figure 4-1 Rehabilitation and monitoring locations at Ensham

4.1 Summary of past beef cattle grazing rehabilitation

The reinstatement of the beef cattle grazing PMLU is consistent with the pre mining land use (Hollingsworth, Dames and Moore, 1990) and aligned with Hierarchy no: 4 - reinstate previous land use (e.g. grazing or cropping). Grazing has been, and continues to remain, a key industry for the Central Highlands (Central Highlands Economic Master Plan, 2017).

Rehabilitation that has been completed so as to establish beef cattle grazing has the following characteristics:

- Outward facing overburden slopes have achieved 0 to 10% slopes for tertiary materials, and 0 to 15% slopes for Permian materials.
- Overall, inward facing slopes have achieved 0 to 10% slopes for tertiary materials, and 0 to 15% slopes for Permian materials. A proportion of inward facing slopes have been developed between 15% to 25% and contained within the areas of 0 to 15% slopes.
- A minimum factor of safety of 1.5 has been achieved.

In terms of the rehabilitation method that is adopted for this PMLU, the landform is reshaped using mine machinery to the overall specifications, according to land suitability requirements and spoil types. Ameliorants are applied (e.g. Gypsum) if needed, and topsoil material is respread to a minimum depth. The profile is then deep ripped to a minimum 600 mm depth and seed and fertiliser applied. Hay mulch or other suitable surface treatment is applied at minimum rate of 5 t/ha (or 20 round bales/ha) to further reduce erosion risk potential.

Benches within the spoil rehabilitation are not topsoiled, to allow for preferential germination of tree seed as part of cattle shelterbelts and visual amenity. It is noted that the bench areas are relatively flat, and this practice has been demonstrated to be effective without risk of excess erosion.

Past investigations for the site indicate that the cattle grazing PMLU has the potential to deliver a significantly better post mining land suitability for grazing than occurred prior to mining for some areas. Land mapping completed prior to mining shows significant amounts of the northern mining areas as being Land Suitability Class 5 (EMOS, 1992). The suitability rule set adopted for Ensham (as detailed in Section 3.2.1.2) identifies that the areas that were Class 5 areas are required to be equal to or greater than Class 4.

Considering the past performance of rehabilitation completed to achieve a cattle grazing land use, it is noted that the total ground cover percentage is accepted as a suitable indicator of rehabilitation success. The Ensham EA (EPML00732813) identifies completion criteria for vegetative groundcover as $\geq 50\%$ for slopes up to 15%, and $\geq 80\%$ for slopes between 15% and 25%.

From Figure 4-2, it can be seen that the rehabilitation history reviewed for Ensham generally achieves the minimum ground coverage, almost immediately after completion, however it also persists over time. It is noted that season changes, drought conditions and fire recovery have seen short-term reductions in cover in the past, however, overall, the trending is strong.

Further, a notable proportion of the record is also above the higher criteria of 80%, indicating the rehabilitation practices utilised have more than sufficient potential to achieve the required vegetation ground coverage.

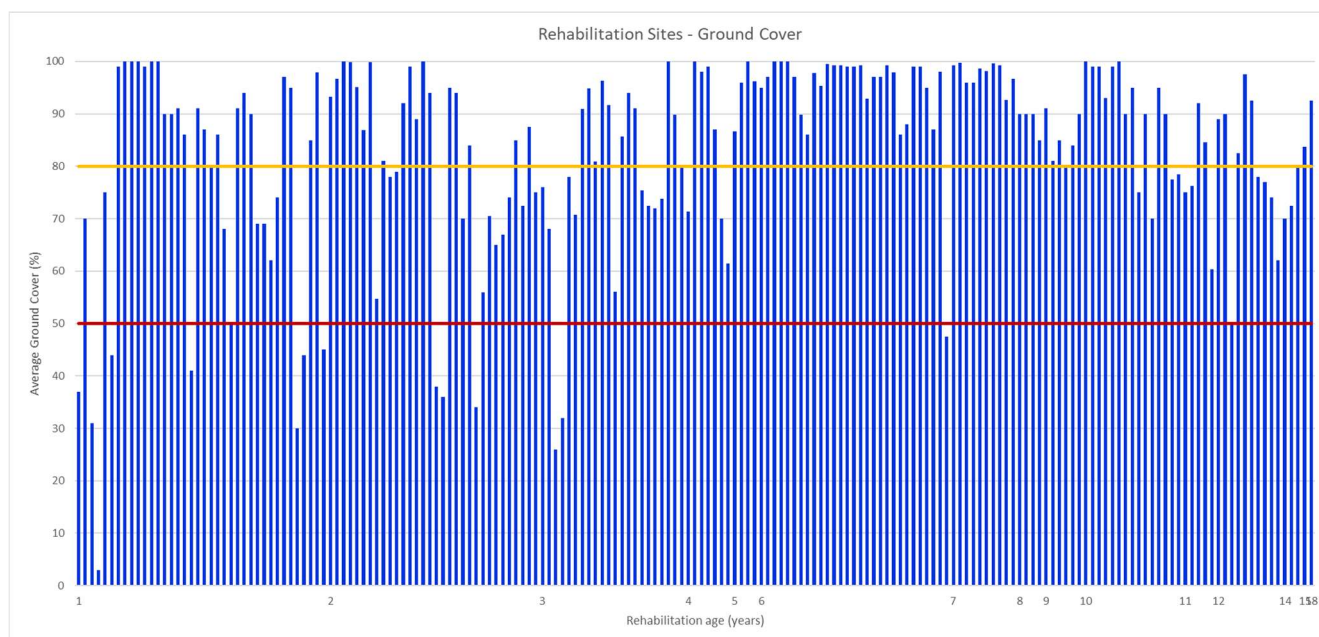


Figure 4-2 Rehabilitation groundcover (%) over time

Figure 4-3, over page, indicates all rehabilitation areas which are considered to have met completion criteria for vegetation ground cover. This has utilised the latest information available to indicate a snapshot in time for the rehabilitation. However from the graph above it can also be assured that the current record is consistent with the long term trend.

4.1.1 Grazing trials within rehabilitation

Though not a criterion in land suitability assessment, cattle have grazed rehabilitated pastures at Ensham since 2012 and currently have access to about 600 ha of rehabilitated land.

A recent grazing assessment was conducted at Ramp10, Ramp 22 and Ramp 82 (Greenfields, 2017; 2018) to demonstrate the ability of rehabilitated mine spoil to meet an end land use of a grazing rangeland system. The priorities of this grazing trial was to demonstrate the rehabilitated areas can support a carrying capacity of similar land types and conditions of grazing areas in the Fitzroy Basin; and ensure rehabilitation remains a safe and stable landform (with minimum 50% ground cover) conserved both prior to and following the introduction of cattle; and established pasture species remaining viable following grazing.

Grazing was conducted over 47 days in 2018, or 26% average annual pasture utilisation, which is within the guideline for long term carrying capacity, with no detrimental effect on soil, pasture and landform (Greenfields, 2018). Soil and pasture condition ratings primarily remained unchanged from pre to post assessment. No visual signs of crusting, compaction, soil movement and or erosion

occurred in rehabilitation areas. The grazing assessment on Ramp 22 produced a total average live weight gain of 0.98 kg/per day, well above expectations for live weight gain in the Fitzroy Basin.

Earlier grazing trials has also been completed at Yongala between 2015 and 2016, which demonstrated similar outcomes, and confirmed that rehabilitated areas can support a carrying capacity of similar land types and conditions of grazing areas in the surrounding district; that the landform can remain safe and stable prior to and following grazing; and that established rehabilitation pasture species remain viable following the grazing trial.

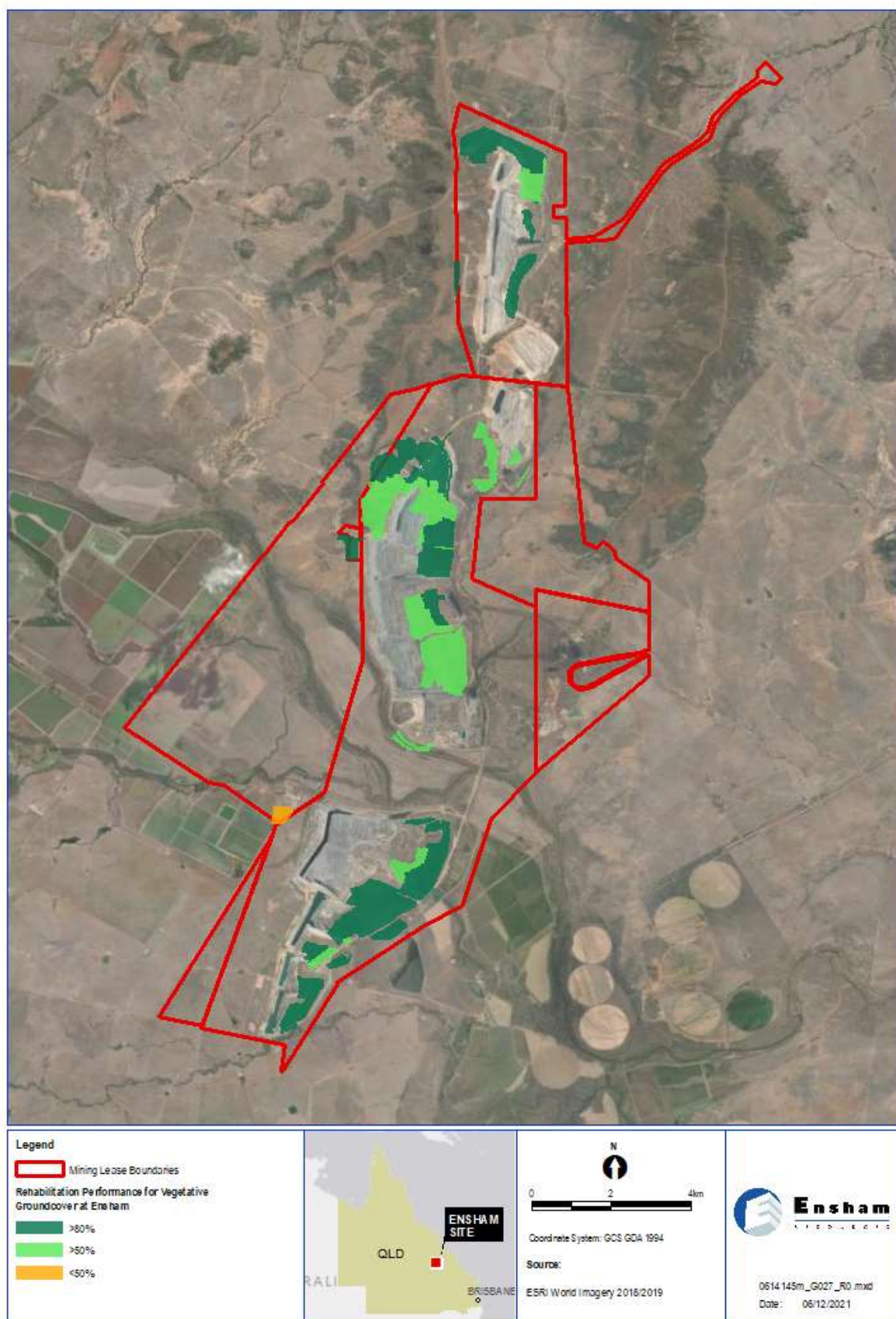


Figure 4-3 Rehabilitation performance for vegetative groundcover at Ensham, as at 2020

4.2 Summary of past native bushland corridor rehabilitation

Completion of Native Bushland Corridor rehabilitation at Ensham will provide important habitat for a variety of native animals and plants, with linkages to existing remnant regional ecosystems associated with the Nogoa River. This PMLU is located on the western side of the rehabilitated open cut mining areas, connecting Corkscrew Creek with the Nogoa River floodplain and the escarpment country, as well as Boggy Creek.

Rehabilitation that has been completed, or will be completed, so as to establish a native bushland corridor has the following characteristics:

- $\geq 50\%$ established and persistent vegetative groundcover for all slopes from 0-20% and $\geq 80\%$ established and persistent cover (vegetative and/or rock mulch if required) for slopes from 20% to 25%.
- Species richness ≥ 2 tree species, ≥ 3 shrub species, ≥ 5 groundcover species
- Maximum of 25% slope with areas $> 15\%$ to be certified by a suitably qualified person as being stable long term, with rock mulch applied if required.

This PMLU will also prohibit vehicle access onto the rehabilitated highwall slopes and reduce any visual impacts that may be associated with the rehabilitated open cut mining areas.

In terms of the rehabilitation method that will be adopted for this PMLU, the landform will be reshaped using mine machinery to the overall specifications, according to land suitability requirements and spoil types. Ameliorants are applied (e.g. Gypsum). It is noted that topsoil is not planned to be respread to provide a competitive advantage to tree and shrub flora species. The profile will be deep ripped to a minimum 600 mm depth and seed and fertiliser applied. Hay mulch or other suitable surface treatment will be applied at minimum rate of 5 t/ha to further reduce erosion risk potential.

Considering the past performance of rehabilitation completed to achieve a native bushland corridor land use, it is noted that little historical rehabilitation has been completed, and the focus of monitoring for these areas was to understand the success of vegetation without topsoil. As a result, monitoring information provides a wealth of data relating to the tree and shrub species assemblages, species richness as well as condition, but no information relating to ground coverage. The Ensham EA (EPML00732813) identifies completion criteria for vegetative groundcover as $\geq 50\%$ for slopes up to 15%, and $\geq 80\%$ for slopes between 15% and 25% in addition to criteria relating to species richness, and as such, it is expected that this information will be available from future monitoring.

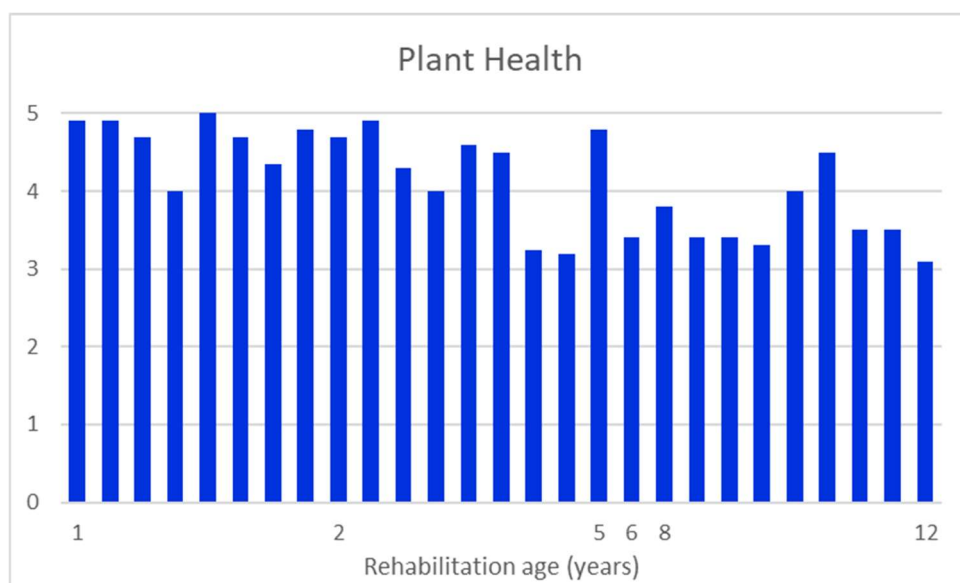


Figure 4-4 Plant health for bushland rehabilitation over time

Figure 4-4 above shows a ranking of plant health that has been monitored for areas of bushland rehabilitation at Ensham over time, for the historical areas where the establishment of trees and shrubs were desirable. To explain the ranking, 1 is a rating of poor health, whilst 5 is considered to be excellent plant health and condition, and the scale is considered continuous.

It can be seen that the plant health recorded for Ensham rehabilitation is consistently at a high level, with ratings over 3 (which is considered to be 'good' health and condition). Similar complementary data analysis is provided in the Monitoring Summary Report (Appendix 9.3 of the PRCP), which further demonstrate how these areas are tracking against completion criteria.

4.2.1 Bushland trials within rehabilitation

As is standard practice at Ensham, investigations and trials have been undertaken to inform the application and use of native trees and shrubs in rehabilitation for a native bushland land use. As part of normal monitoring processes, and explained above, the establishment of trees and shrubs have been monitored in a controlled manner.

In addition to this, a trial was also commenced between 2001 and 2005 to inform suitable methods of afforestation to establish a high capacity carbon sink quickly, this was termed the NEDO trial. The trial studied various treatments and conditions (inclusive of soil additives/fertilisers, fungi presence, watering regimes, and groundcover variability) for 2 tree species, and has provided a solid foundation for Ensham to understand the growth of trees in rehabilitation, primarily within the native bushland corridor PMLU.

4.3 Consideration of other PMLU types

4.3.1 Boggy Creek diversion PMLU

Rehabilitation of the Boggy Creek diversion is very recent, and has been completed in 2021.

The development and adoption of this PMLU has been supported by an extensive body of published work on the requirements for creek diversions associated with mining, rather than background performance information. There is no site specific monitoring record to review for this PMLU. A key requirement of this PMLU and associated rehabilitation, is to re-establish geomorphological functionality to the watercourse, including suitable riparian vegetation. This PMLU provides important habitat and ecosystem services, and links upstream and downstream remnant regional ecosystems, including those associated with the Nogoia River.

4.3.2 Flood protection landform PMLU

As with the previous section, this PMLU is considered to be recent, and rehabilitation associated with the area is not complete. Therefore, there is no site specific monitoring record for this PMLU.

5 SUMMARY OF POST-MINING LAND USE CONTEXT

The post-mining land use (PMLU) concept for Ensham has been informed by a wide range of factors as detailed, and this document has evaluated the post-mining land use concept and detailed the contextual information that underlies the PMLU outcomes, to demonstrate that the concept is suitable and appropriate for the Ensham site.

5.1 PMLU contextual decision framework

The PMLU concept is shown visually with the flowchart provided as Figure 5-2, and is intended to illustrate the key conceptual decision making process and inputs that have been used to validate the PMLU outcomes.

Pre-mining and surrounding land use considerations	
- Land use - Land suitability/capability - Soils - Landform - Stability and erodibility - Vegetation - Community aspects	Key considerations for Ensham PMLU: Area has historically been used for agricultural purposes, primarily cattle grazing, and land capacity has varied. Soils are generally highly weathered, chemically and physically poor, with moderate to high erosion potential. Landform is dominated by gentle slopes and plains to the south and east, and steep escarpments to the north. Most of Ensham has been cleared for agricultural development prior to mining. Availability of land for agricultural uses is of high importance to the community.



Mining considerations

- Pre-approved PMLU and NUMA as per LOD
- Environmental factors
- Feasibility of prior land uses

Key considerations for Ensham PMLU:

EA (EPML00732813) has detailed and pre-approved PMLUs, including rehab objectives and completion criteria. A wide range of environmental factors have informed the planned PMLU concept for Ensham, including landform design, spoil nature and type, behaviour of voids, floodplain interactions, and revegetation techniques. These factors have compiled an understanding of whether and how the mine rehabilitation may achieve pre-mining land uses and condition.



Rehabilitation performance

- Record of monitoring
- Evidence of rehabilitation success
- Linkages to rehabilitation practices and prescriptions
- trials with further investigations of use

Key considerations for Ensham PMLU:

Rehabilitation monitoring shows that completion criteria for cattle grazing are met rapidly, and are demonstrated to be sustained over the long term. Rehabilitation treatments to ensure preferential establishment of trees and shrubs can also be demonstrated, as relevant to the native bushland corridor PMLU as well as for cattle shelterbelts. Grazing and bushland trials also demonstrate that rehabilitation can successfully sustain the desired land use.



Key factors for determining preferred PMLU

- regulatory and physical constraints
- chemical characteristics
- rehabilitation methods
- relative costs
- potential economic benefits to the community and/or landholders
- potential environmental and social benefits
- compatibility with pre-mining and surrounding uses



Adopted PMLU outcomes				
Domain 1 - Cattle grazing	Domain 2 - Landholder retained infrastructure	Domain 3 - Boggy Creek diversion	Domain 4 - Native bushland corridor	Domain 7- Flood protection landform

Figure 5-1 Ensham PMLU contextual decision framework

5.2 PMLU concept for Ensham

Based on the decision framework the PMLUs for Ensham are as follows:

- Cattle grazing on overburden / infrastructure areas (Mine domain 1)
- Landholder retained infrastructure (Mine domain 2)
- Boggy Creek diversion (Mine domain 3)
- Native bushland corridor (Mine domain 4)
- Flood protection landform (Mine domain 7)

Figure 5-2 illustrates the PMLUs for the Ensham site. There are also two pre-approved NUMAs, which are as described in Section 4 of the main PRCP.

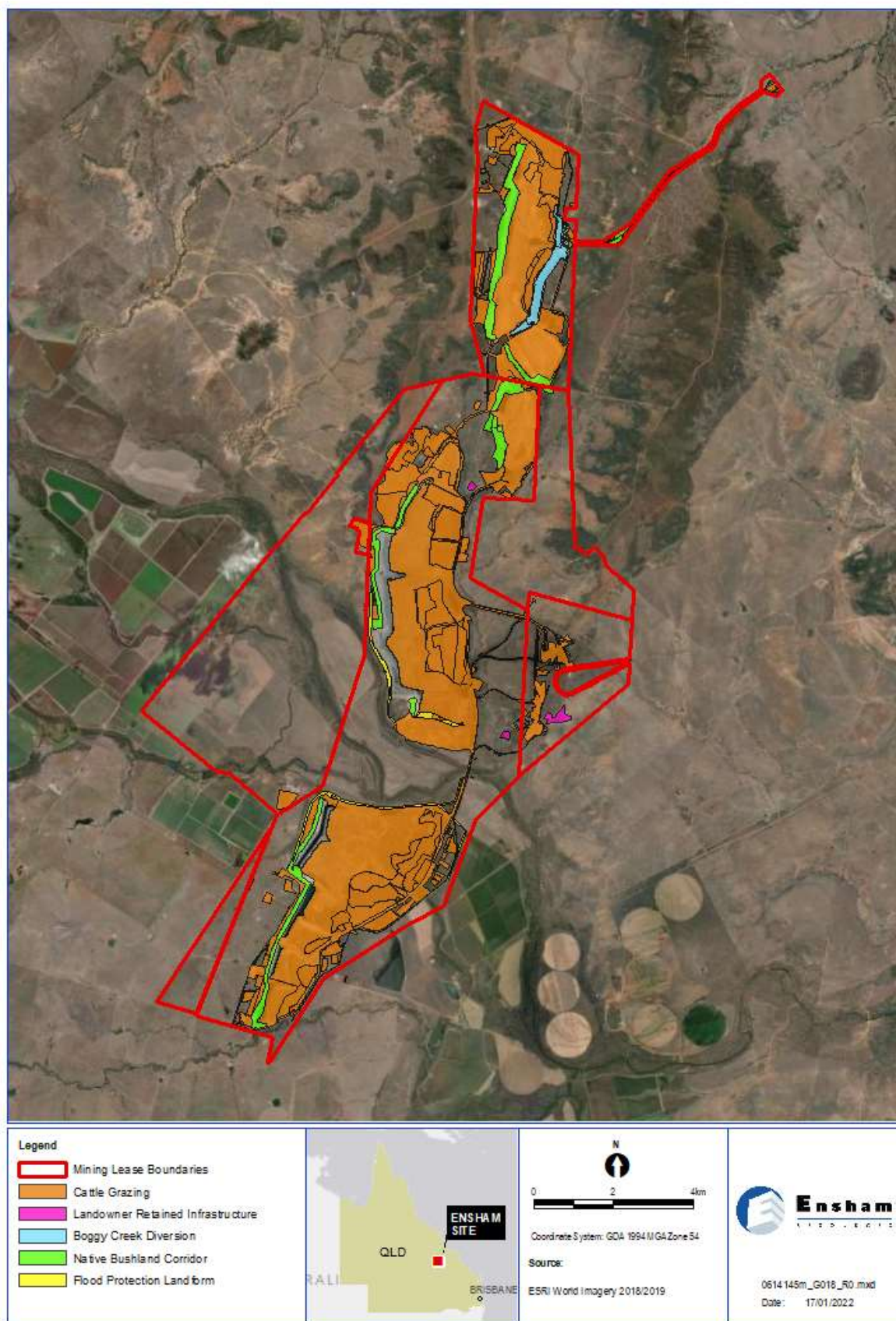


Figure 5-2 PMLU concept for Ensham

6 MILESTONES FOR PMLU

Rehabilitation objectives and completion criteria as contained in the Ensham EA (EPML00732813), are able to be transitioned into the PRCP as milestones and milestone criteria respectively, for the approved PMLUs. Table 6-1 below provides an overview of the milestones that are applicable to each PMLU, on the basis of the approach adopted in this report. Further detail of both the milestones and milestone criteria is contained within the Ensham PRCP Schedule and supporting information, provided as Appendix 9.1.

Additional commentary has been provided to highlight the key considerations, as explored in this report.

Table 6-1 Validation of PMLU considerations for milestones

PMLU	Milestone	Key considerations for PMLU
Cattle grazing	RM 1 - Infrastructure decommissioning and removal RM2 - Identification and remediation of contaminated land RM3 - Final landform development RM4 – Seedbed preparation RM5 – Sowing RM 6 – Vegetation establishment RM7 – Achievement of a stable condition (beef cattle grazing PMLU)	• Ensure suitable landform slope gradients • Topsoil to be placed as per specification to support PMLU outcomes • Ameliorant and fertilizers to be applied • Vegetation establishment (ground cover) is a key metric • Rehabilitation to be suitable for sustainable cattle grazing, and is deemed to be land suitability class 2 to 4
Landholder retained infrastructure	RM 1 - Infrastructure decommissioning and removal RM2 - Identification and remediation of contaminated land RM8 – Achievement of a stable condition (landholder retained infrastructure PMLU) RM12 – Infrastructure retention for handover	• Nothing of note for PMLU assessment outcomes
Boggy Creek diversion	RM 1 - Infrastructure decommissioning and removal RM2 - Identification and remediation of contaminated land RM3 - Final landform development RM6 - Vegetation establishment RM9 – Achievement of a stable condition (Boggy Creek diversion PMLU)	• Ensure suitable landform slope gradients and geotechnically stable • Riparian condition (using Index of Diversion Condition) is a key metric
Native bushland corridor	RM 1 - Infrastructure decommissioning and removal RM2 - Identification and remediation of contaminated land RM3 - Final landform development RM4 – Seedbed preparation RM5 – Sowing	• Ensure suitable landform slope gradients • Ameliorant and fertilizers to be applied • Vegetation establishment (species diversity and ground cover) are key metrics

PMLU	Milestone	Key considerations for PMLU
	RM 6 – Vegetation establishment RM10 – Achievement of a stable condition (Native bushland corridor PMLU)	
Flood protection	RM 1 - Infrastructure decommissioning and removal RM2 - Identification and remediation of contaminated land RM3 - Final landform development RM4 – Seedbed preparation RM5 – Sowing RM 6 – Vegetation establishment RM11 – Achievement of a stable condition (Flood protection landform PMLU)	• Ensure suitable landform slope gradients, and construction of landform structures as per design requirements • Ameliorant and fertilizers to be applied • Vegetation establishment (ground cover) is a key metric • Construction to be certified as per designs

7 REFERENCES

- ABARES (2015) *Catchment Scale Land Use of Australia - Update March 2015*, Department of Environment 2015, Natural Resource Management (NRM) Boundaries 2015, viewed on 11 December 2020 at Land Use and Management Information for Australia - Fitzroy NRM Region - Queensland (daff.gov.au)
- CMLR (2005) '*Ensham coal mine, rehabilitation resource survey*', Centre for Mined Land Rehabilitation, The University of Queensland, Brisbane.
- Greenfields Agricultural and Environmental Services (2017). Ramp 22 - Grazing Assessment and 2017 Report, Ensham Mine.
- Greenfields Agricultural and Environmental Services (2018). Ramp 10, 22 and 82 – 2018 Grazing Assessment, Ensham Mine.
- Hollingsworth, Dames and Moore (1990) Ensham coal project, Impact assessment study, Hollingsworth, Dames and Moore, Brisbane.
- Hansen (2006) *Terrain, soils and land capability assessment*, Ensham Central Project, Hansen Consulting, Brisbane.
- Landloch (2016). Assessment of stability of final void and landform shaping options, Ensham Coal Mine. . Report produced for Ensham Resources.
- McClurg J I (1999), 'Soils and land suitability of the Gavial-Gracemere area, Central Queensland'. Department of Natural Resources report (DNRQ990146).
- Queensland Government Department of Science, Information Technology and Innovation (DSITI) and Department of Natural Resources and Mines (DNRM/DSITIA) (2013) Guidelines for agricultural land evaluation in Queensland, Queensland Government via Department of Science, Information Technology and Innovation (DSITI) and Department of Natural Resources and Mines (DNRM), Brisbane.
- Shields P and Williams, B 1991, 'Land resource survey and evaluation of the Kilcummin area, Queensland'. QDPI bulletin QV 91001.

9.3 Monitoring Summary Report



Ensham
R E S O U R C E S



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are liable severally in the
following proportions:

Bligh Coal Limited
ABN 20 010 186 393
47.5%

Idemitsu Australia
Resources Pty Ltd
ABN 45 010 236 272
37.5%

Bowen Investment
(Australia) Pty Ltd
ABN 12 002 806 831
15.0%

APPENDIX 9.3 – MONITORING SUMMARY REPORT

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1 INTRODUCTION

The purpose of this report is to provide a summary of past monitoring processes and practices, with a view to informing the PRCP by reviewing and assessing existing rehabilitation knowledge and data for Ensham Coal Mine (Ensham). A deep knowledge and understanding of past rehabilitated areas underpins the knowledge base that subsequently informs current prescriptions for the rehabilitation and management for the remainder of the site.

Ensham Coal Mine (Ensham) commenced rehabilitation many decades ago, however it is noted that all rehabilitation areas completed prior to 2000 have now been reworked to meet current performance standards. Additional areas of rehabilitation have also been added progressively most years since this time. This represents a significant knowledge base comprising 20 years of on-ground demonstrated rehabilitation practice, based on a deeper understanding of the success and failure of earlier rehabilitation treatments, to illustrate rehabilitation success at Ensham.

Rehabilitation monitoring is undertaken annually to also comply with the current EA (EPML00732813), dated 3 September 2020, and specifically with conditions H7 & H8, which require an annual monitoring process. This is to confirm that rehabilitation is occurring as intended and to demonstrate compliance with approved completion criteria, thus also future supporting relinquishment of approvals.

Monitoring can thus demonstrate that the rehabilitation completed is on track to achieving stable outcomes, and achieves adequate performance against a range of criteria.

This monitoring summary report focuses on the following outcomes:

- Outline of the methodology and processes already in place for undertaking progressive rehabilitation monitoring at Ensham; and
- Summarise the performance and current status of progressive rehabilitation at Ensham, with a view to demonstrating that the rehabilitation and management methodologies can achieve rehabilitation success criteria.

Ensham has a scientifically robust Rehabilitation Monitoring and Mapping program in place that supports the site to understand the progression of rehabilitated areas through to a standard that meets regulatory rehabilitation success/ completion criteria, and allows for corrective actions to be identified early and implemented when required (Ensham, 2017).

2 PROGRESSIVE REHABILITATION COMPLETED

Table 2-1 below provides a summary of progressive rehabilitation completed at Ensham since 2001, with some descriptive details included. It is noted that rehabilitation had been occurring prior to this time, however the majority of areas have been reworked to improve performance. As such, this record of progressive rehabilitation is considered to be comprehensive.

This demonstrates that progressive rehabilitation has been occurring across the disturbance footprint and for the full range of PMLUs proposed for the Ensham site. Figure 2-1 shows the location of these areas.

Table 2-1 Summary of progressive rehabilitation by area

Completion Year	Rehab Age	Description	Area (hectares)	Intended PMLU
2001	20	AB Pit	22.8	Cattle grazing
2003	18	AB Pit and CDE Pit	42.4	Cattle grazing
2004	17	AB Pit	18.0	Cattle grazing
2006	15	AB Pit and CDE Pit	24.7	Cattle grazing
2007	14	AB Pit, CDE Pit and Yongala	294.5	Cattle grazing
2008	13	F Pit	2.4	Cattle grazing
2009	12	AB Pit, CDE Pit, F Pit, Y Pit and Yongala	299.4	Cattle grazing
2010	11	AB Pit, CDE Pit, F Pit and Yongala	145.1	Cattle grazing
2011	10	AB Pit and Yongala	61.2	Cattle grazing
2012	9	Ab Pit and CDE Pit	23.0	Cattle grazing
2013	8	CDE Pit and Yongala	27.2	Cattle grazing
		F Pit	33.2	Native bushland corridor
2014	7	Yongala	6.9	Native bushland corridor
2015	6	AB Pit, CDE Pit and Yongala	143.5	Cattle grazing
		Yongala	4.1	Native bushland corridor
2016	5	AB Pit	12.4	Cattle grazing
2017	4	A Pit AB Pit, CDE Pit	204.4	Cattle grazing
2018	3	E Pit	110.8	Cattle grazing
2019	2	E Pit and Y Pit	45.4	Cattle grazing
2020	1	Y Pit and Boggy Creek Diversion	17.5	Cattle grazing
			10.0	Boggy Creek diversion
2021	0	Yongala and Boggy Creek Diversion	3.4	Cattle grazing
			94.4	Boggy Creek diversion

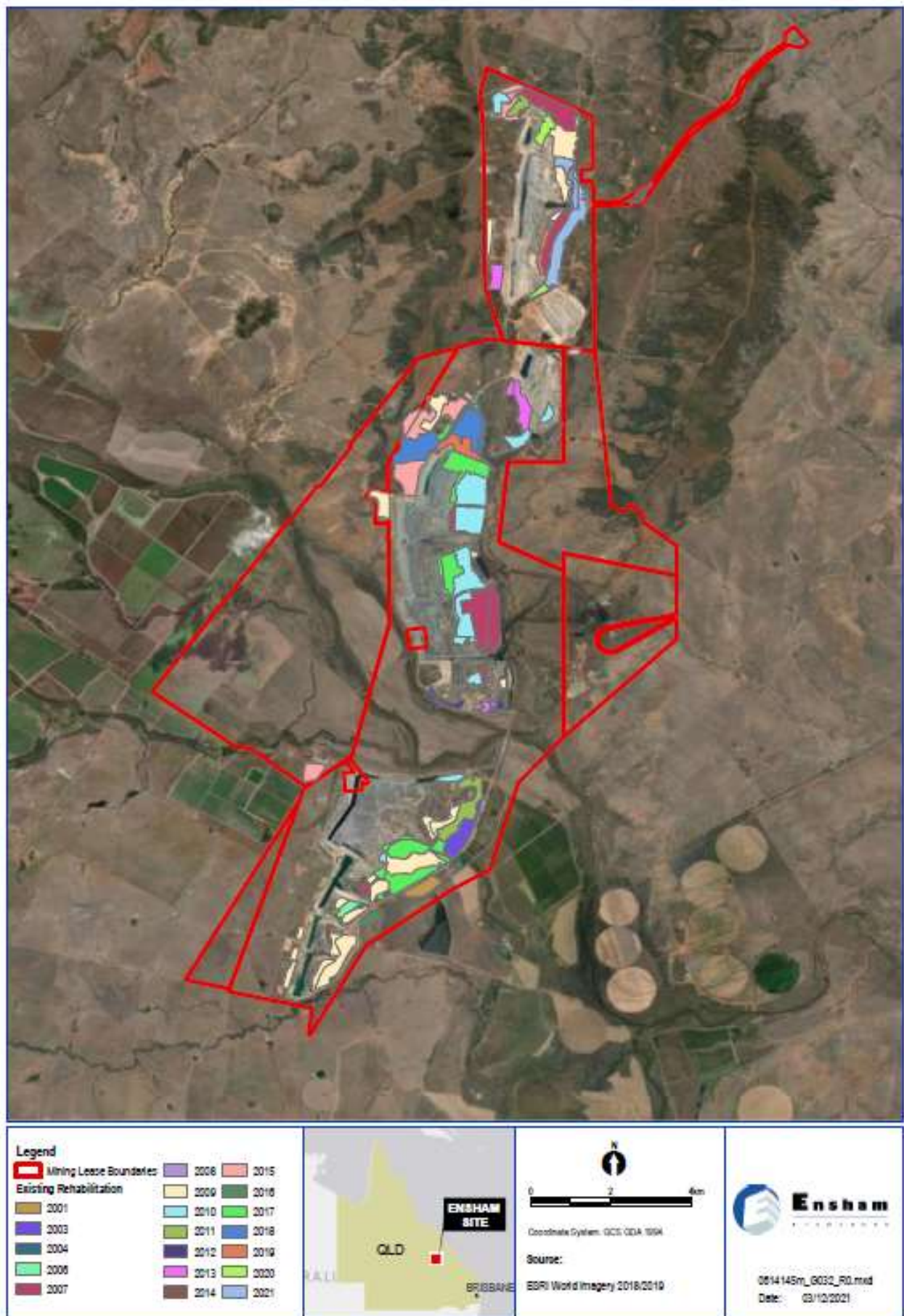


Figure 2-1 Progressive rehabilitation areas at Ensham

3 EXISTING MONITORING PROGRAM

3.1 Development of the monitoring program

A comprehensive Rehabilitation Resource Survey was undertaken by the University of Queensland's Centre for Mined Land Rehabilitation in 2005 (CMLR 2005). The purpose of this work was to complete a review and inventory of resources relevant to the progressive rehabilitation process, and to improve not only an understanding of the value of these resources, but also outline monitoring processes to ensure the value of the resources could be protected and enhanced into the future.

The survey encompassed and reviewed a range of rehabilitation resources, including:

- Soils and overburden materials (spoils) removed and stored by the mining operation. Soils and spoils were characterised and assessed for their suitability for the establishment of stable plant communities
- Remnant vegetation within nominated reference sites on and surrounding the Ensham mine lease. The characteristics of the assessed communities were used to evaluate suitable vegetative criteria for the rehabilitation of the mine.

Based on the soils, spoils, and vegetation inventory, recommendations were made for the future rehabilitation monitoring program, including recommendations on:

- Determining post-mining land use (PMLU)
- Defining suitable rehabilitation targets
- Documentation and data management
- Monitoring parameters
- Review
- Rehabilitation success criteria

Considering the above recommendations, a Rehabilitation monitoring plan was subsequently formulated (Ensham, 2017). This document provides details about completion criteria, monitoring methods, data management, mapping, and responsibilities. Monitoring has been conducted annually for the last 20 years, with information provided as to monitoring methods and techniques in each annual report.

Monitoring is primarily based around a dominant PMLU of cattle grazing across the vast majority of the mine site, with small areas of native bushland corridor, Boggy Creek diversion and flood protection land uses. These latest methods considered to be appropriate for monitoring of rehabilitation at Ensham are as summarised below.

3.2 Monitoring locations and occurrence

3.2.1 Monitoring Scope & Timing

Rehabilitation monitoring and reporting is completed annually at Ensham. A range of monitoring methods are used and the frequency of each varies (as per Section 2.3 below). Assessments may occur at several levels of intensity or scale, with a cartographic scale of 1:50,000 or larger adopted for rehabilitation mapping. This requires a monitoring site density of one site per 20 to 100 ha.

A monitoring site is taken as an area considered to be representative of the rehabilitation. Three types of sites are subjected to different assessments in the field, in the following proportions:

- Detail (10% of total effort).
- Check (20% of total effort).
- Observation (70% of total effort).

Detail and Check sites are done at specific locations (point samples), and Check sites are less detailed than Detailed sites. Observation sites are less detailed again than Check sites. Observation sites may be completed at specific sampling points or for a boundary or for an entire polygon.

Results for rehabilitation areas are compared against an acceptable outcome for each of the data attributes, so that interpretive mapping can be developed. In this way, Ensham can determine how progressive rehabilitation is progressing against success criteria

3.2.2 Progressively rehabilitated sites

Figure 3-1 shows areas of monitoring locations within areas of progressive rehabilitation from the most recent monitoring campaign completed in 2020. This campaign aimed to complete a comprehensive baseline of rehabilitation monitoring data for all areas of historical progressive rehabilitation. In this way, a recent and consistent data set has been established for Ensham.

Monitoring sites and areas were subsequently divided by method of assessment in accordance with the type of site as detailed in Section 3.2.1 above. Satellite assessments were conducted for observation sites (using VegMachine) and on-ground survey was completed for detail/check sites, using field flora survey, photo assessment and satellite review.

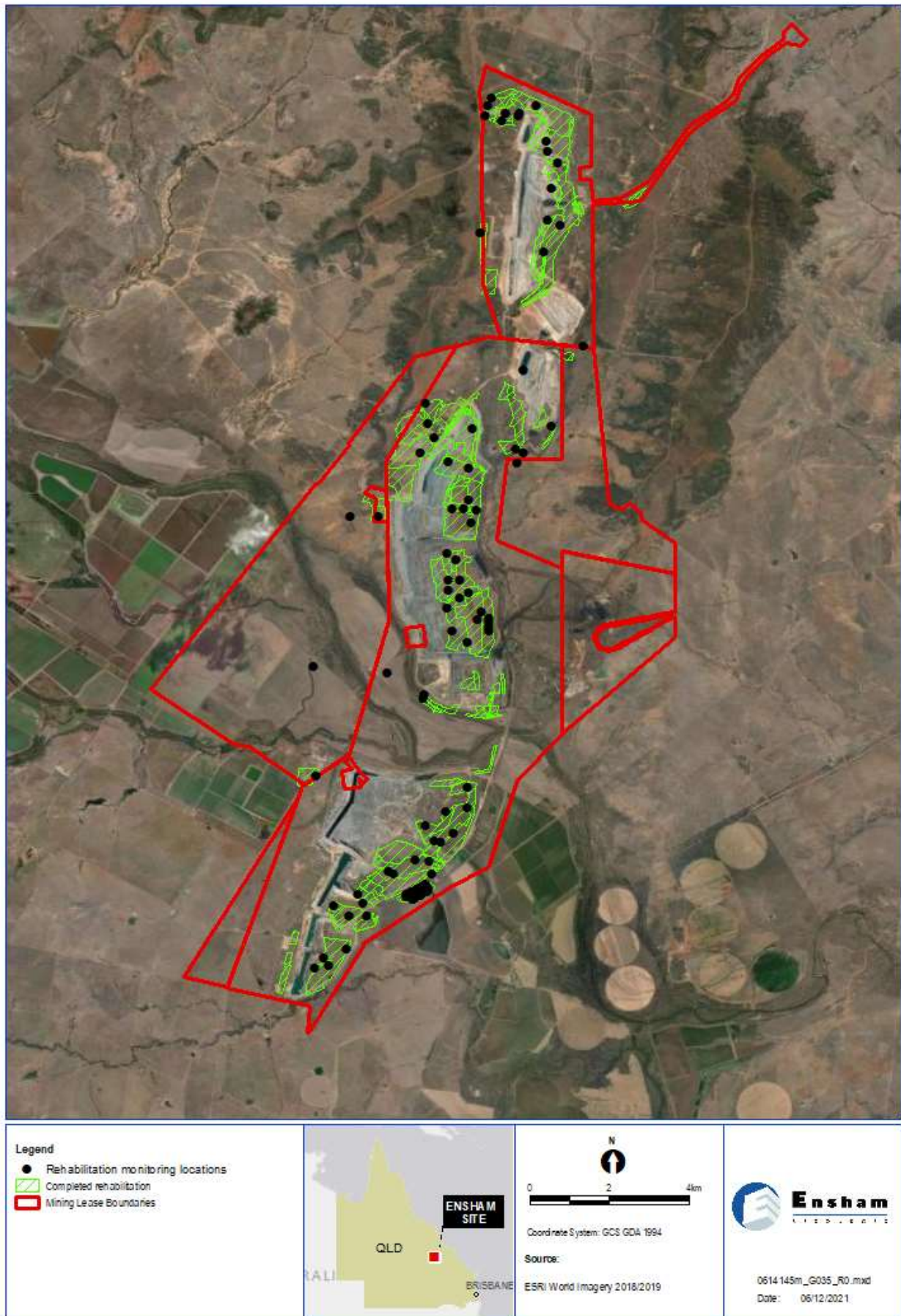


Figure 3-1 Rehabilitation monitoring locations at Ensham

3.2.3 Reference sites

Ensham have undertaken assessment and comparison of rehabilitation monitoring outcomes against reference sites since 2005. Reference sites have been selected to provide 'target conditions' for rehabilitation and therefore are comparable in terms of:

- Soil, land area, and land suitability
- Vegetation form
- Species assemblages
- Land use.

However, it is noted that it is difficult to select reference sites to compare rehabilitation due to the transformative impacts of mining on hydrology, topography and geology of the land, and as such, it is important to exercise caution when using reference sites in benchmarking rehabilitation outcomes. Lack of comparability against a reference site does not necessarily indicate poor rehabilitation performance. It is reasonably foreseeable that some rehabilitation may achieve the rehabilitation goals of safe, stable, will not cause environmental harm and will be able to sustainable the proposed land use or sustainable vegetation cover, but may remain 'different' in form and function to unmined reference sites (Ensham, 2021).

Despite these recognised difficulties, a number of reference sites have been established and are monitored at Ensham as shown in Table 3-1. As the planned PMLU for the majority of rehabilitation areas is a cattle grazing land use, the selection of reference sites primarily targets unmined areas that are used for pasture and/or grazing.

Table 3-1 Summary of reference sites

Reference site ID	Description	Easting	Northing
DPREF1	Alluvial plain, ungrazed	650976	7402880
DPREF2	Alluvial plain, grazed	649302	7403072
ENREF1	Ungrazed grassland	654151	7408247
ENREF2	Grazed grassland	654063	7408087
Ironbark REF5	Open woodland	655590	7411002
Yapunyah REF6	Open woodland	650168	7406780

3.3 Monitoring methods

Methods described in the RMP are outlined below.

3.3.1 Hazard assessment

The hazard assessment is to be undertaken at 5-yearly intervals in accordance with AS/NZS 13000: 2009, using appropriate Ensham personnel, an Appropriately Qualified Person (APQ), and members of the site's Rehabilitation Stakeholder Group. The scope of the assessment is restricted to assessing the hazards to people and domestic stock posed by progressive rehabilitation, and is completed via a visual inspection.

3.3.2 Run-off water quality

Rehab runoff samples are collected to demonstrate compliance to completion criteria. Sampling is completed for pH, salinity (EC), sediment loss (TSS), sulfate (SO₄), Arsenic, Molybdenum and Selenium after significant rainfall events, when runoff is present and access is safe. This is conducted by competent personnel, which is understood to typically be Ensham personnel.

Monthly receiving environmental sampling also occurs in the Nogoia River, this occurs upstream and downstream of compliance locations in accordance with the Environmental Authority requirements. An APQ is to subsequently undertake data review and reporting.

Sampling of pit water storages is also conducted opportunistically and analysed for a complementary suite of parameters.

3.3.3 Subsidence assessment

Subsidence monitoring is conducted, which comprises of:

- annual LIDAR surveys (+/- 50 mm accuracy), which also considers different soil types; and
- Real Time Kinematic (RTK) GPS monitoring (+/- 5 mm accuracy), which will indicate ground movements as a result of mining, as distinguished from surface soil movement.

Fixed RTK-GPS monitoring survey stations have recently been installed above the Ensham underground workings to provide a much higher level of survey accuracy (± 5 mm) than the LIDAR data (+/-50mm). These stations are installed 1.5-2 m below the ground surface level. This monitoring has been set up by GNSS Monitoring and the data can be easily accessed remotely in real time. Some monitoring stations seem to indicate a level of negligible subsidence within the margin of error of the equipment.

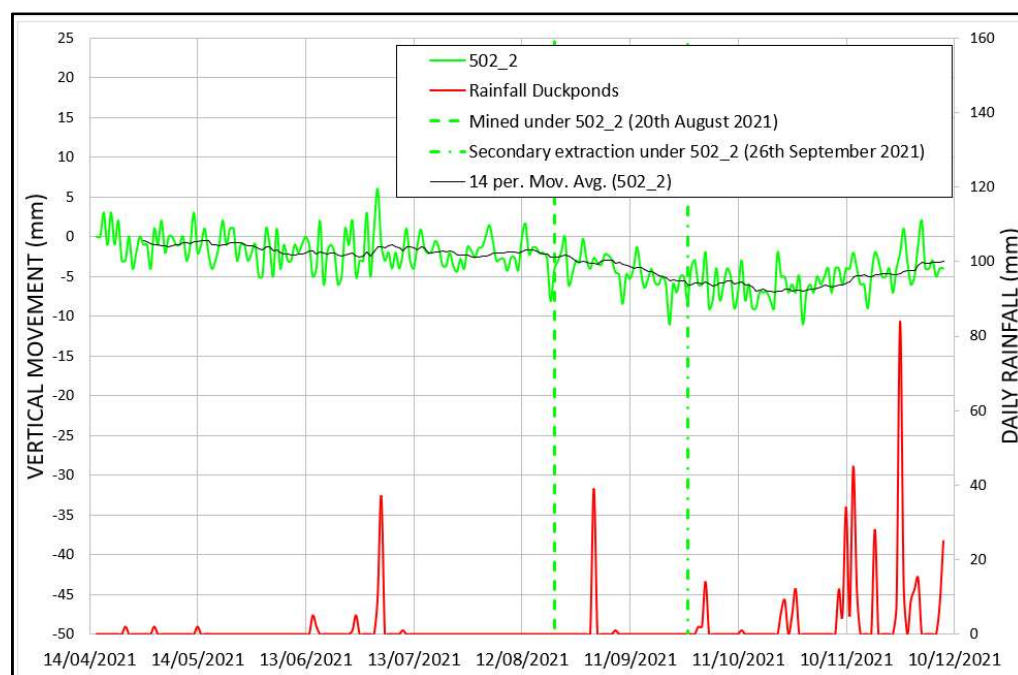


Figure 2 Subsidence Monitoring above 502 Panel

At other monitoring stations the movement of the ground is influenced by rainfall at levels that prevent any realistic assessment of any subsidence.

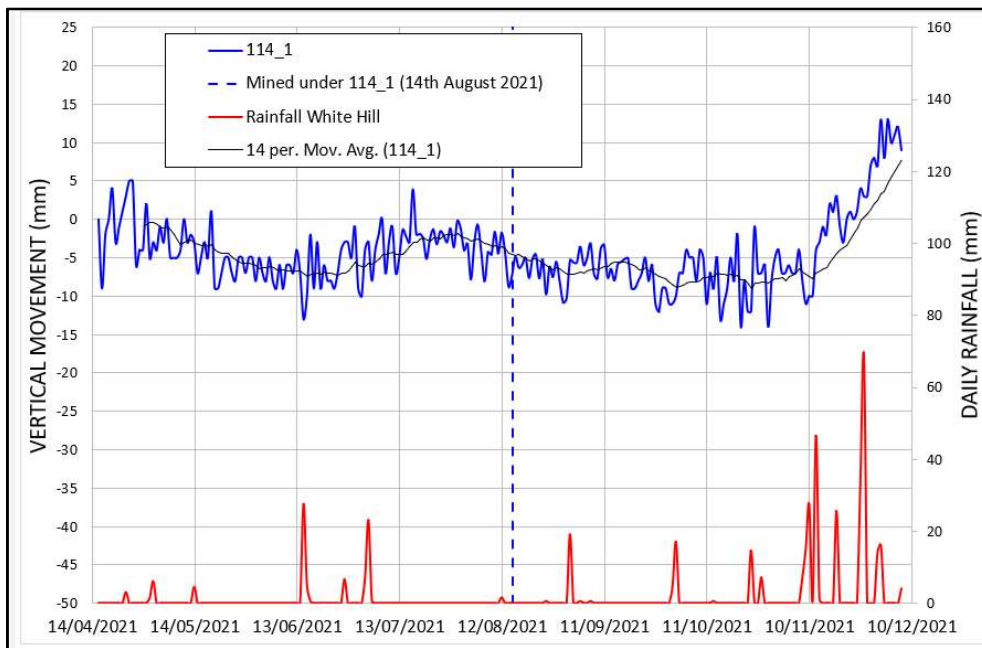


Figure 3 Subsidence Monitoring above 114 Panel

It is considered that lower accuracy (± 50 mm) LIDAR surveys will still be applicable in assessing ground movements over larger areas. This data is considered to be a back up to the more accurate GPS data and can be used to determine any trends.

These surface effects may also include natural ground movements, as well as potential subsidence effects. Mining was completed in the shallower 204 Panel in the southern part of the mining area between the 2016 and 2017 LIDAR surveys.

The section line shows that any ground movement is less than the ± 50 mm accuracy of the LIDAR surveys. These measurements validate the subsidence predictions of typically less than 35 - 40 mm.

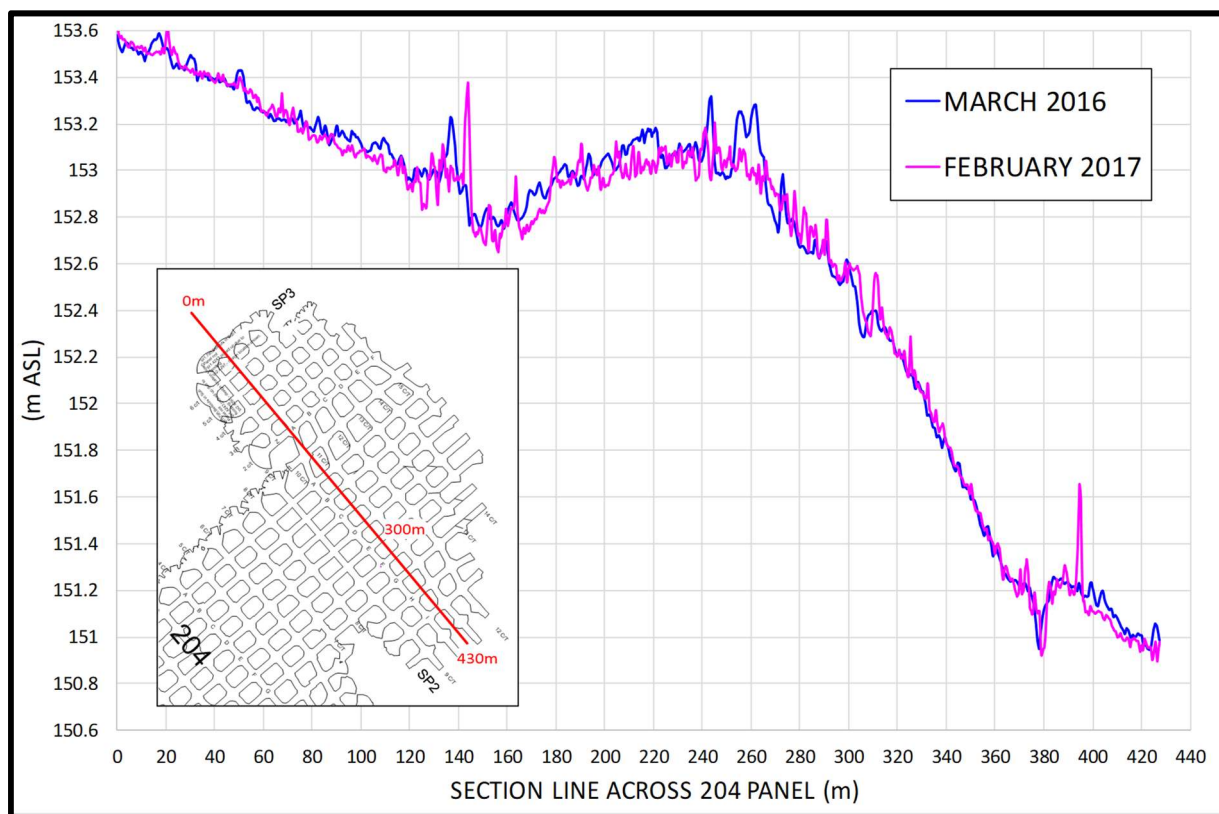


Figure 4 Section Line above 204 Panel

Lidar taken over longer periods of time on unmined areas display a range of surface soil movement far in excess of measured or predicted subsidence levels.

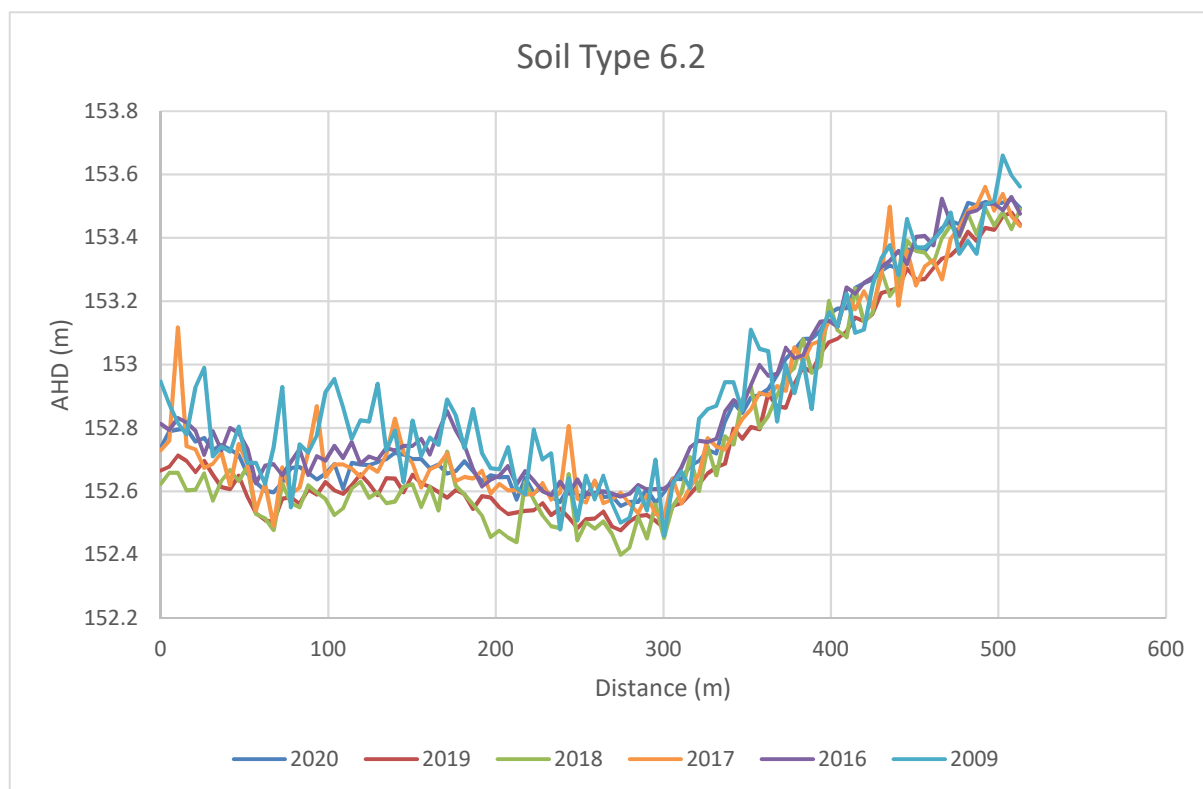


Figure 5 Lidar transect across an area of unmined land

More detailed surface inspections will be conducted, if LIDAR and/or RTK monitoring indicates exceedance of one or more subsidence trigger levels. In addition, groundwater monitoring is also completed to determine whether Environmental Authority (EA) trigger levels have been exceeded.

All monitoring results will be used to confirm subsidence predictions, and any significant changes in subsidence from that expected will trigger a review of mitigation and management measures.

3.3.4 Geotechnical safety and stability

Slope analysis, to determine slope angle of rehabilitation surfaces with an FoS equal to or larger than 1.5, is to be undertaken by an experienced geotechnical engineer who is also a Registered Professional Engineer Queensland (RPEQ). Monitoring of this indicator will occur at 5-yearly intervals.

3.3.5 Slope gradient

Slope gradient is to be measured yearly during operations by remote sensing or ground survey, with results verified by a Registered Surveyor Queensland. Slopes are not to exceed 25%, and all slopes over 15% are to be certified by an appropriately qualified personnel (AQP) as being stable in the long term.

3.3.6 Vegetative ground cover

Vegetative ground cover is to be measured yearly by competent personnel at the end of the growing season (April-June), when grass seed heads are present. Assessment is by visual inspection and/or remote sensing. The completion criterion is for a minimum of 50% of vegetative cover, and a total cover of 80% minimum in steeper sloped areas. Data review and reporting is to be undertaken by an AQP.

3.3.7 Native bushland surveys

For areas to be rehabilitated as native bushland, annual inspections and measurements are to be carried out to assess tree canopy cover and native species richness for trees and shrubs. The monitoring should include the following methods:

- Percentage of established and persistent vegetative tree, shrub and groundcover for all slopes
- Percentage of established and persistent cover other than vegetation (such as debris or mulch) for all slopes
- Completion of a timed-area flora survey within each area of rehabilitation to determine the presence or absence of tree, shrub and groundcover species, with a high-level estimation of species density for comparison to relevant benchmark density.

3.3.8 Riparian vegetation and diversions

An assessment of the index of diversion (ACARP C20017) is to be completed, including the use of fixed monitoring points, remote sensing (diversion condition, changes in channel dimensions,

changes in vegetation coverage, and impacts on adjoining reaches) and hydraulic monitoring using flow gauges. Assessment is to be completed annually by competent personnel, with data review and reporting undertaken by an AQP.

3.3.9 Land contamination

Prior to relinquishment, Ensham will undertake a contaminated land assessment. This will be performed by an AQP.

3.3.10 Land suitability for grazing

Land suitability will be assessed using testing and analysis by an AQP prior to certification.

The assessment will classify rehabilitated areas according to five land suitability classes, with consideration of 15 land use requirements and limitations to inform subclass threshold limits (RMP, 2018). Land Suitability Class 4 or better is required for beef cattle grazing areas as defined in the Guidelines for Agricultural Land Evaluation in Queensland (State Department of Queensland 2013).

It is noted that these guidelines are now superseded, however this criterion is specifically referenced in the EA as per the 2013 guidelines, and thus continues to be the relevant benchmark for this PMLU at Ensham.

3.3.11 Legally binding agreements

Legally binding agreements need to be entered into by Ensham for infrastructure to be retained post-closure, in agreement with the post-closure landholder (where this is not Ensham themselves).

3.4 Data analysis

Analysis of monitoring data will be undertaken by AQPs. In most cases, data analysis will be simple and restricted to plotting of trends, calculation of averages, standard deviations and basic statistics.

3.5 Reporting and review

A report is prepared at the conclusion of each annual monitoring event to incorporate all monitoring completed within the campaign. The purpose of the annual report is to satisfy the requirements of EA conditions H7 and H8. This requires an annual update of the rehabilitation progress towards the achievement of PMLU criteria.

The results of each additional year of monitoring are compared to those of previous years by showing the trends towards the achievement of the safe, stable, will not cause environmental harm and self-sustaining PMLU criteria, with recommendations provided to improve and further support the continued progression of the rehabilitation.

The report may also describe corrective actions/contingency strategies, should these require implementation. These may include one or more of, for example, the following:

- Application of additional soil amelioration
- Reshaping and stabilisation of erosion features
- Reseeding and/or replanting

- Review the seed mix, including species, supplier, viability, application method

The report is to be reviewed by Ensham for implementation of contingency strategies as appropriate.

3.6 Quality assurance and data management

All monitoring will be undertaken by AQPs. On completion of the monitoring, the data will be reviewed by appropriately qualified personnel and evaluated for the purpose of preparing tables and graphs for reporting. Information to be stored on Ensham Resources secure servers will include raw and manipulated data as well as electronic versions of the completed monitoring reports.

INX InViron, a web-accessible, centralised system is used to manage most environmental data across Idemitsu Australia sites. It ensures the security of data and that changes made throughout the system are tracked and date stamped to provide complete transparency and accountability of any activity within the system. Remote sensing / aerial photography and field monitoring is used to capture GIS data. Mapinfo is used for the analysis and display of GIS data.

4 REVIEW OF PERFORMANCE

Many areas of earlier rehabilitation completed have been reworked since 2001. As such, the record of monitoring was reviewed and compiled since 2007, representing a substantial body of evidence as to the rehabilitation performance at Ensham. Monitoring techniques and reporting outcomes have changed over this time, so only information deemed relevant and relatively continuous has been compiled to illustrate the long term performance of previous rehabilitation at Ensham.

Over this time, a total of over 110 discrete rehabilitation and reference sites have been assessed, located across all areas of rehabilitation, equating to a robust sample size of time and space based observations of rehabilitation performance. Key monitoring methods used have included observational surveys, transect based field monitoring as well as specialised satellite analysis, as further detailed in Section 3.3

This monitoring record has been reviewed to highlight linkages between this history of performance and the relevant PMLU milestones and milestone criteria. In this way, Ensham can demonstrate not only that the PMLUs are appropriate and achievable, but also that the milestone criteria are a suitable analogue to illustrate rehabilitation success.

In terms of considering how Ensham rehabilitation performs, the summary of a recent site inspection by an industry expert on rehabilitation (Landloch 2016) provided the following key observations:

- Ensham utilises relatively low gradients for rehabilitated areas (with 10% adopted as standard rather than 17% commonly on most Central Queensland coal mines)
- Consistently high levels of surface vegetative cover were evident across the site, with revegetation primarily targeting the establishment of pasture grasses and legumes

- A general absence of flow control structures in place, simply because they are not required as a positive consequence of the lower slope gradients; and
- A general absence of areas of concentrated surface water flow and erosion/incision on rehabilitated areas, again as a positive outcome from the landform design philosophy.

Figure 2-1 shows the locations of previously disturbed surfaces and waste rock dumps that have been rehabilitated at Ensham since 2001. Figure 3-1 shows the locations where monitoring has been conducted over time. To date, a total of over 1500 hectares has been rehabilitated, with more than 3000 ha scheduled for rehabilitation as part of progressive rehabilitation and closure (as per Table 9-9 in the main PRCP).

4.1 Summary of recent performance

The latest rehabilitation monitoring results available are from December 2020 (Greenfields 2020). A total of 26 sites were assessed using satellite imagery with 17 of these sites also assessed with a complementary field survey. Two reference sites were monitored.

While there was some variation between the ground cover results from the VegMachine and those from the on the ground assessments, the average ground cover for either methods was nearly the same (76.01% and 76.55%, respectively). All sites contained a cover over 50%, except for a single site (Duckponds Old Dam) for which on the ground monitoring indicated a cover of 47.5%, (Veg Machine indicated a cover of 56.3%). This was also the only site with a ground cover lower than that of the grazed reference site (58.7% as measured on the ground).

The ground cover criterion of 50% is exceeded in nearly all sites, indicating successful establishment of vegetation suitable for a Beef Cattle Grazing PMLU. Cover is, nevertheless, considered to be relatively low due to long term drought conditions.

4.2 PMLU based review of long-term performance

Considering the past performance of rehabilitation completed to achieve a cattle grazing land use, it is noted that the total ground cover percentage is accepted as a suitable indicator of rehabilitation success. The Ensham EA (EPML00732813) identifies completion criteria for vegetative groundcover as $\geq 50\%$ for slopes up to 15%, and $\geq 80\%$ for slopes between 15% and 25%.

From Figure 4-1, it can be seen that the rehabilitation history reviewed for Ensham generally achieves the minimum ground coverage, almost immediately after completion, however it also persists over time.

It is noted that season changes, drought conditions and fire recovery have seen short-term reductions in cover in the past, however, overall, the trending is strong. Further, a notable proportion of the record is also above the higher criteria of 80%, indicating the rehabilitation practices utilised have more than sufficient potential to achieve the required vegetation ground coverage.

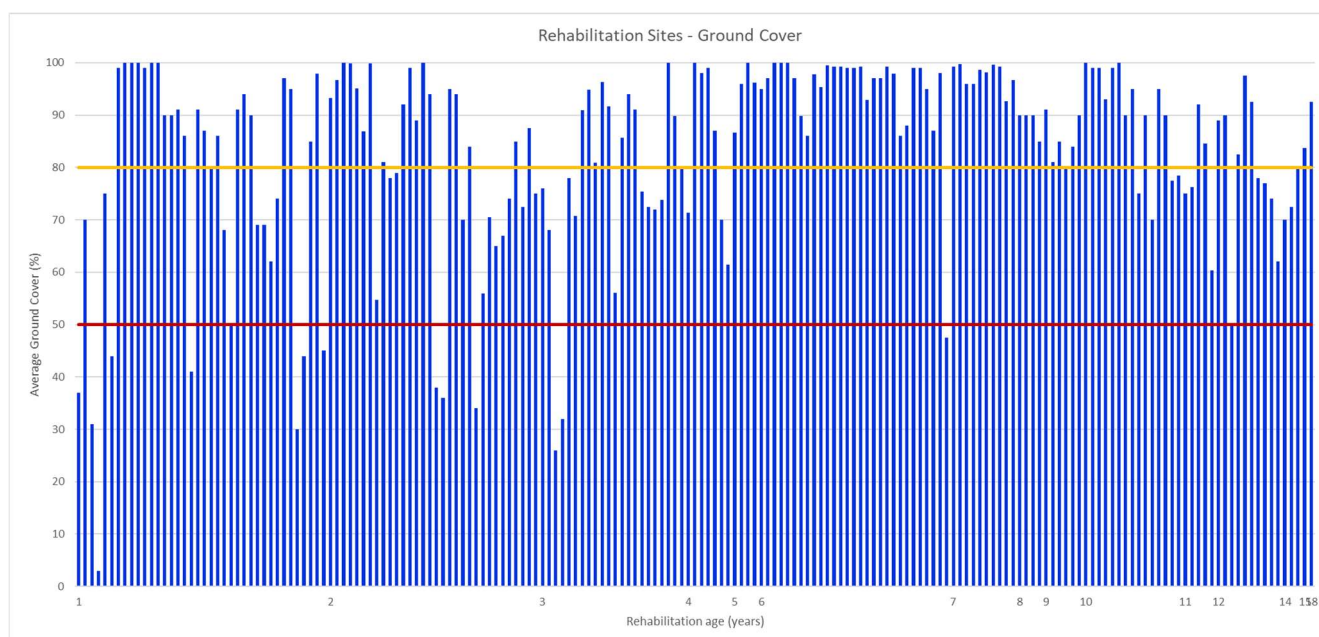


Figure 4-1 Rehabilitation groundcover (%) over time

Figure 4-3, over page, indicates all rehabilitation areas which are considered to have met completion criteria for vegetation ground cover. This has utilised the latest information available to indicate a snapshot in time for the rehabilitation. However, from the graph above it can also be assured that the current record is consistent with the long term trend.

4.2.1 Grazing trials within rehabilitation

A recent grazing assessment was conducted at Ramp10, Ramp 22 and Ramp 82 (Greenfields, 2017; 2018) to demonstrate the ability of rehabilitated mine spoil to meet an end land use of a grazing rangeland system. The priorities of this grazing trial was to demonstrate the rehabilitated areas can support a carrying capacity of similar land types and conditions of grazing areas in the Fitzroy Basin; and ensure rehabilitation remains a safe and stable landform (with minimum 50% ground cover) conserved both prior to and following the introduction of cattle; and established pasture species remaining viable following grazing.

Grazing was conducted over 47 days in 2018, or 26% average annual pasture utilisation, which is within the guideline for long term carrying capacity, with no detrimental effect on soil, pasture and landform (Greenfields, 2018). Soil and pasture condition ratings primarily remained unchanged from pre to post assessment. No visual signs of crusting, compaction, soil movement and or erosion occurred in rehabilitation areas. The grazing assessment on Ramp 22 produced a total average live weight gain of 0.98 kg/per day, well above expectations for live weight gain in the Fitzroy Basin.

Earlier grazing trials has also been completed at Yongala between 2015 and 2016, which demonstrated similar outcomes, and confirmed that rehabilitated areas can support a carrying capacity of similar land types and conditions of grazing areas in the surrounding district; that the landform can remain safe and stable prior to and following grazing; and that established rehabilitation pasture species remain viable following the grazing trial.

4.3 Summary of past native bushland corridor rehabilitation

Considering the past performance of rehabilitation completed to achieve a native bushland corridor land use, it is noted that little historical rehabilitation has been completed, and the focus of monitoring for these areas was to understand the success of vegetation without topsoil.

As a result, monitoring information provides a wealth of data relating to the tree and shrub species assemblages, species richness as well as condition, but no information relating to ground coverage. The Ensham EA (EPML00732813) identifies completion criteria for vegetative groundcover as $\geq 50\%$ for slopes up to 15%, and $\geq 80\%$ for slopes between 15% and 25% in addition to criteria relating to species richness, and as such, it is expected that this information will be available from future monitoring.

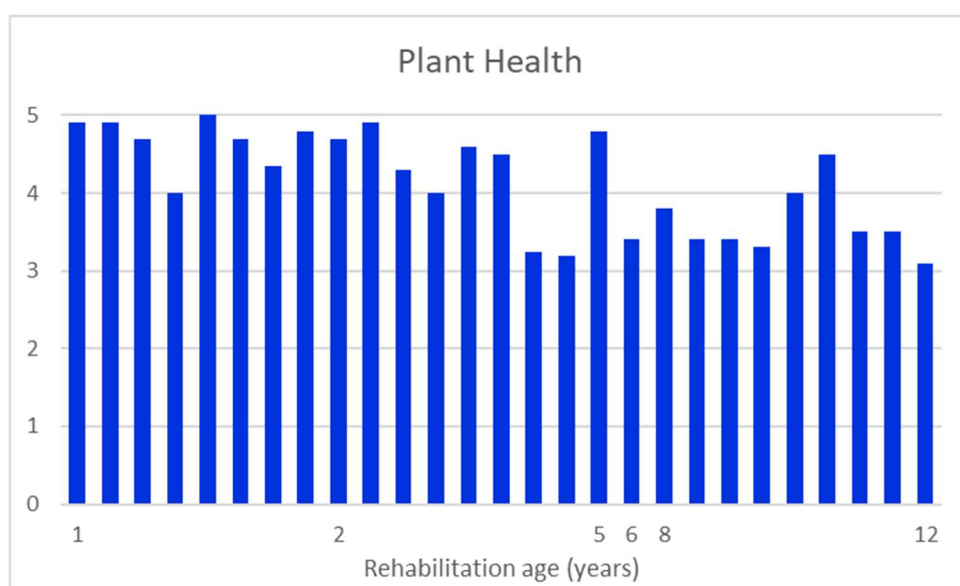


Figure 4-2 Plant health for bushland rehabilitation over time

Figure 4-2 above shows a ranking of plant health that has been monitored for areas of bushland rehabilitation at Ensham over time, for the historical areas where the establishment of trees and shrubs were desirable. To explain the ranking, 1 is a rating of poor health, whilst 5 is considered to be excellent plant health and condition, and the scale is considered continuous.

It can be seen that the plant health recorded for Ensham rehabilitation is consistently at a high level, with ratings over 3 (which is considered to be 'good' health and condition).

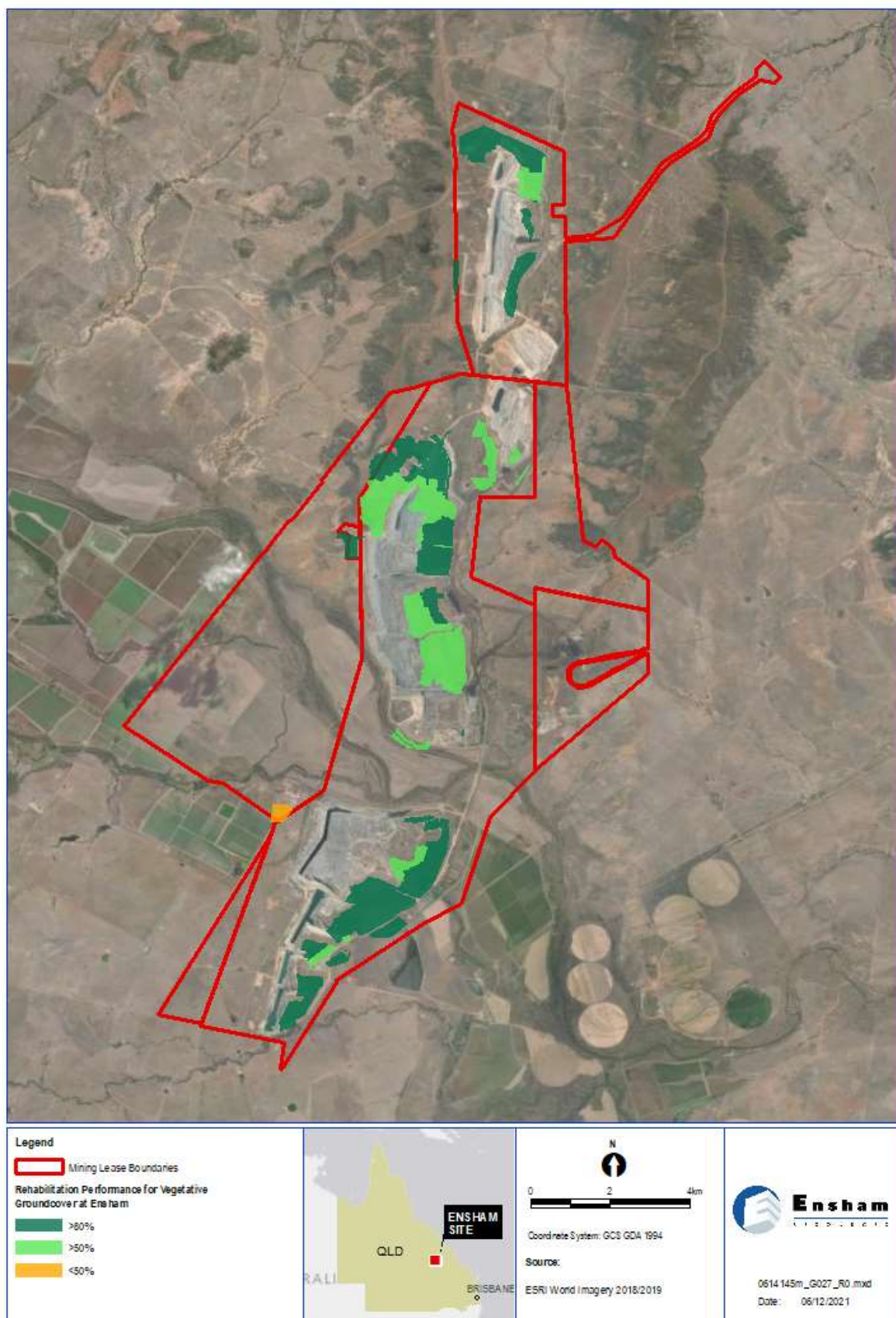


Figure 4-3 Rehabilitation performance for vegetative groundcover at Ensham, as at 2020

4.4 Consideration of other PMLU types

4.4.1 Boggy Creek diversion PMLU

Rehabilitation of the Boggy Creek diversion is very recent, and has been completed in 2021.

The development and adoption of this PMLU has been supported by an extensive body of published work on the requirements for creek diversions associated with mining, rather than background performance information. There is no site specific monitoring record to review for this PMLU. A key requirement of this PMLU and associated rehabilitation, is to re-establish geomorphological functionality to the watercourse, including suitable riparian vegetation. This PMLU provides important habitat and ecosystem services, and links upstream and downstream remnant regional ecosystems, including those associated with the Nogoa River.

4.4.2 Flood protection landform PMLU

This PMLU is also considered to be recent, and rehabilitation associated with the area is not complete. Therefore, there is no site specific monitoring record for this PMLU.

4.5 Linkage between rehabilitation performance and milestone criteria

A summary of progressive rehabilitation performance has been included in Table 4-1 below, with both complementary milestones and milestone criteria proposed as appropriate. This only includes milestones and milestone criteria that have been developed with respect to rehabilitation performance information, which would be expected to be informed by a record of monitoring data verified and drawn in part from performance of progressive rehabilitation. Milestones which apply primarily to activities required as part of the closure phase have been excluded.

The key purpose of this table is to show how historical performance of progressive rehabilitation has shaped selection and development of the Ensham PRCP milestones that have been included into the main PRCP document. Table 4-1 also provides evidence that the milestones are underpinned by a real world understanding of how past progressive rehabilitation activities have resulted in successful rehabilitation at Ensham. The past performance of rehabilitation has therefore informed the rehabilitation and management methodologies that continue to be applied. In this way, Ensham can both assure the success of the rehabilitation approaches proposed in the PRC planning part but also show that the milestones and milestone criteria are sufficient for the PRCP schedules.

Table 4-1 Linkages between performance of progressive rehabilitation and milestone criteria for Ensham

Intended PMLU	Monitoring methods applied	Completion year	Rehabilitation age	Summary of performance	Linkages to proposed milestones
Beef cattle grazing	- Field estimation of vegetation groundcover GRASSCHECK - VegMachine	2001 - 2020	20 years to 1 year	- Confirmation of slopes is important to understand erosional stability - Topsoil depth not a factor? - Soil ameliorant important for 0-5 year timeframe only 3P pasture species important for pasture quality - Total groundcover most important factor for grazing quality - Detailed and rehabilitation specific classification system (rule set) has been developed - Consistently achieving required vegetation groundcover completion criteria after year 1	- require slope review and classification (RM3 – Final landform development) - topsoil depth on rehabilitation to be verified, along with initial application of soil ameliorants (RM4 Seedbed preparation) - include 3D pasture species in seed mix (RM5 Sowing) - Ensure minimum groundcover requirements (RM6 Vegetation establishment) - Use rule set to establish post-mining land class (RM8 Achievement of a self-sustaining condition with respect to beef cattle grazing PMLU)
Native bushland corridor	- Tree survey	2001 -2007	20 years to 14 years	- Confirmation that a range of native species are persisting, with structural diversion and apparent plant health - Apparent that rehabilitation techniques ensure a safe, stable and non-polluting bushland corridor PMLU that has persisted over the long-term - Minimization of slopes are important to understand erosional stability - Limited scope of monitoring over time restricts ability to analyse detailed trends - Recommend further monitoring to inform completion criteria - Vegetation does not appear particularly sensitive to topsoil type or depth, although lack of topsoil can be seen to provide a competitive advantage over grass dominated groundcover - Vegetation establishment (species diversity and ground cover) are key metrics	- require slope review and classification (RM3 – Final landform development) - Topsoil or rock mulch depth to be verified, along with initial application of soil ameliorants (RM4 Seedbed preparation) - Ensure minimum groundcover requirements and species richness (tree, shrub and groundcover) requirements are met (RM6 Vegetation establishment) - Certification from an AQP that rehabilitation has native species and bushland characteristics ((RM10 Achievement of a self-sustaining condition with respect to native bushland corridor PMLU)

5 REFERENCES

CMLR (2005) Ensham coal mine, rehabilitation resource survey. Centre for Mined Land Rehabilitation, University of Queensland, Brisbane.

Ensham Resources Australia Pty Ltd (2017) Rehabilitation Monitoring and Mapping Plan V2.0. Report prepared by Highlands Environmental.

Ensham Resources. (2021). Rehabilitation Management Plan V3.0 – EIMP.06.00.03. Initially prepared by La Terra Pty Ltd on behalf of Ensham Resources, Emerald.

Greenfields Agricultural and Environmental Services (2020). Rehabilitation Monitoring Report Final V.2. Report produced for Ensham Resources.

9.4 Hydrogeology Summary Report



Ensham
R E S O U R C E S



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are liable severally in the
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Idemitsu Australia
Resources Pty Ltd
ABN 45 010 236 272
37.5%

Bowen Investment
(Australia) Pty Ltd
ABN 12 002 806 831
15.0%

q

APPENDIX 9.4 – HYDROGEOLOGY SUMMARY REPORT

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1 INTRODUCTION

The purpose of this report is to address the hydrogeological requirements of the PRCP by reviewing and assessing existing hydrogeological knowledge and data for Ensham Coal Mine (Ensham). A hydrogeological assessment is important to provide confidence in the knowledge base of groundwater behaviour for the site. It is particularly important in allowing prediction of groundwater behaviour and understanding the interaction with surface water and to determine likely impacts on other dependent users. Providing a summarised hydrogeology background will assist in understanding the risks and future groundwater conditions after closure.

The methodology for this report included:

- Review of groundwater modelling reports, groundwater monitoring data and reports and other relevant literature available; and
- Evaluation of the groundwater modelling work to date, historical, present and predicted groundwater response from the modelling. Assessment of the data including groundwater levels, groundwater quality and water use.

2 GEOLOGICAL CONTEXT

Ensham mine is located within the western Bowen Basin. The stratigraphic sequence across the mining lease is comprised of unconsolidated Quaternary sediments overlying consolidated Permian and Triassic materials (Table 2-1). The Permian and Triassic strata form regular layered fluvio-deltaic sedimentary sequences, while the Quaternary sediments are more complex and irregular (Ensham Resources 2018).

The coal deposits targeted for mining are located within the Rangel Coal Measures, the uppermost Permian unit. The Rangel Coal Measures are 100 m thick, and subcrop over a strike length of approximately 80 km around the northern and eastern limits of the mine.

Table 2-1 Ensham stratigraphic summary

Age	Unit	Description
Quaternary	-	Alluvium, comprising soil, silt, clay, sand, and gravel.
Tertiary	Emerald Formation	Mudstone, sandstone, conglomerate, siltstone sediments, weakly consolidated in parts. Tertiary volcanics (basalt) are also mapped as being present over 10 km to the west of the mine.
Triassic	Rewan Group	Mudstone with lithic sandstone interbeds.
Permian	Rangel Coal Measures	Feldspathic and lithic sandstone, carbonaceous mudstone, siltstone, tuff and coal seams.
	Burngrove Formation	Sandstones, siltstones and mudstones, and banded coal seams frequently interbedded with tuff and tuffaceous mudstones.
	Fair Hill Formation	Lithic and feldspathic labile sandstone, siltstone, mudstone and conglomerate.
	Macmillian Formation	Lithic and feldspathic sublabile mudstone, siltstone and sandstone.

3 GROUNDWATER INFORMATION

The key reports used to develop this summary report are as listed as references at the end of this summary report. A compiled understanding of the groundwater system at Ensham has been developed using these key sources, and images and maps have been sourced from these reports where appropriate. It is notable that a significant volume of past studies have been completed for Ensham to understand and characterise the groundwater systems, primarily as part of Environmental Impact assessments (AGE, 2006; EIS, 2020; SLR, 2020) and for the Residual Void Study (HEC, 2019; Cote, 2020; HEC, 2020; Hydrosimulations, 2020; SLR, 2021).

The layout and extent of the existing groundwater bore monitoring network is presented in Figure 3-1.



Figure 3-1 Groundwater monitoring network for Ensham

4 NATURE OF GROUNDWATER AT ENSHAM

4.1 Groundwater units and occurrence

The following section outlines the main water bearing units relevant to Ensham. The conceptualisations of the groundwater flows are shown in the cross sections provided as Figure 2-2, Figure 2-3 and Figure 2-4, and discussed below. The Ensham area comprises two hydrogeological groundwater bearing units, the Quaternary aged alluvium/sediments which are associated with Nogoa River floodplain and the Permian aged Rangal Coal Measures. These units are not hydraulically connected and are separated by the low permeability Rewan Group.

4.1.1 Quaternary Alluvium

The Quaternary aged alluvial deposits are associated with the Nogoa River and comprise shallow sequences of clay, silty sand and sand, underlain by basal sands and gravel. However, based on the salinity differences between the more saline alluvial groundwater and the fresher river water it is inferred that the alluvium is not well connected with Nogoa River, and is instead recharged by rainfall and irrigation practices in the catchment. It has been reported that some of the groundwater monitoring bores, screened the alluvium, have been periodically dry indicating that the alluvium might not be saturated continuously, but rather form stagnant lenses with unsaturated regions, also suggesting a lack of permanent hydraulic communication with the Nogoa River.

4.1.2 Rewan Group

The Rewan Group comprises low permeability siltstones, mudstones and lithic sandstones and is recognised to be a regional scale aquitard. The formation thickness is up to 200 m in the study area, providing a barrier to groundwater flow between the overlying alluvium and the underlying coal measures. The Rewan Group is described along with the other aquifers present in the Ensham area, as there is a noted groundwater presence within this formation but remains an aquitard and inhibitor to groundwater flow.

4.1.3 Rangal Coal Measures

The most permeable lithological units at Ensham are the coal seams, which form aquifers that generally exhibit low transmissivities, and are confined by overlying and underlying shales and mudstones (AGE, 2017a). Groundwater storage and movement largely occur within the coal seams, along cleats and fissures and occasionally within minor fault zones that intercept the seams (as shown in Figure 2-5). The other lithologies present in the overburden and interburden sequence are usually considered to be relatively impermeable and form aquitards.

The Rangal Coal Measures comprise economic coal seams interbedded with low permeability siltstone, sandstone and shale. This unit can be subdivided into the following hydrogeological units:

- Very low to low permeability siltstones and sandstones that comprise the majority of the Permian age interburden and overburden; and

- Low to moderately permeable coal seams, of varying degrees of competency and fracturing.

The Rangal Coal Measures outcrop along the eastern edge of Ensham, where recharge would occur from direct rainfall on the ground surface, infiltrate into the underlying formations through the thin soil cover, weathered profile and spoil at site. The coal measures also subcrop in localised zones beneath alluvium associated with the Nogoa River, where the unit may be recharged by:

- downward seepage where there is an absence of clay and silt layers
- recharge may also occur via downward leakage from the Triassic Rewan Group, and
- from areas of site surface water storage (i.e. in-pit water storages).

The regional groundwater flow direction particularly south to southwest of the mine, is not well defined regionally, but based on available data to the west and northwest, groundwater in the Rangal Coal Measures flows primarily towards the active underground mine area (as shown in the conceptual hydro-stratigraphic site model provided as Figure 4-9).

The interconnectivity between adjacent pits has been presented in the conceptual long section provided as Figure 2-2, showing different water levels in the adjacent pits. Water transfers from one pit to another through the intervening pit walls, from Pit A South, Pit A North towards Pit B (south of Nogoa River), as indicated. The differences in the groundwater levels for the Rewan Group, Rangal Coal Seam and underlying Burngrove Formation are showed in the conceptual cross sections presented in Figure 2-3 and Figure 2-4

The slightly elevated groundwater levels around A Pit and B Pit is ascribed to a weak connection as implied by the retained surface water in the pits and local elevated groundwater conditions. Fracture flow and flow through seams as depicted in Figure 2-5 is likely. The result will have the effect of prolonged drainage of the southern and central pits into the underground void until groundwater levels recover towards pre-mining elevations after underground mining is completed.

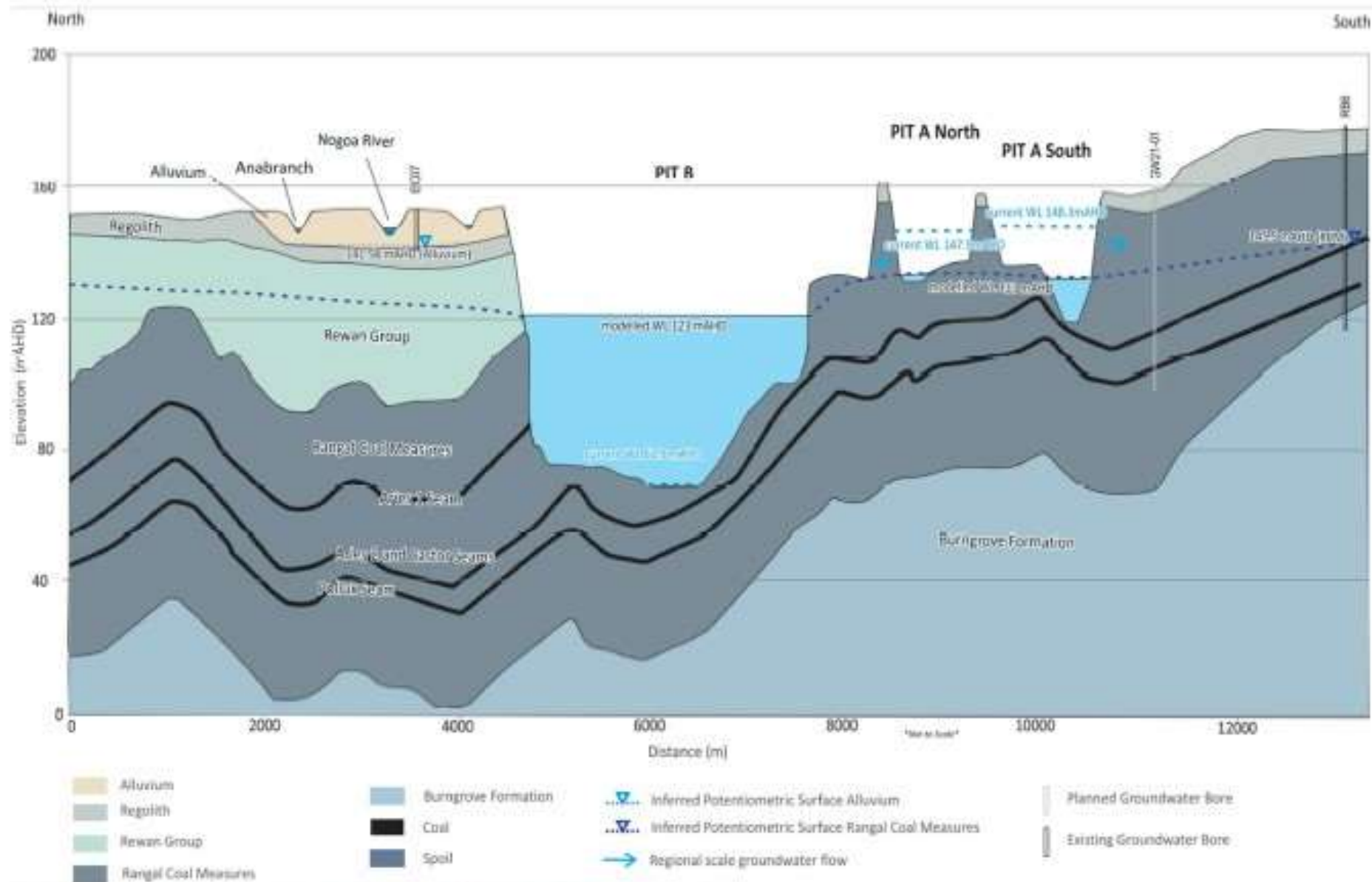


Figure 4-1 Long section of Nogoia River and Ensham Pits A and B (north to south) (SLR, 2020)

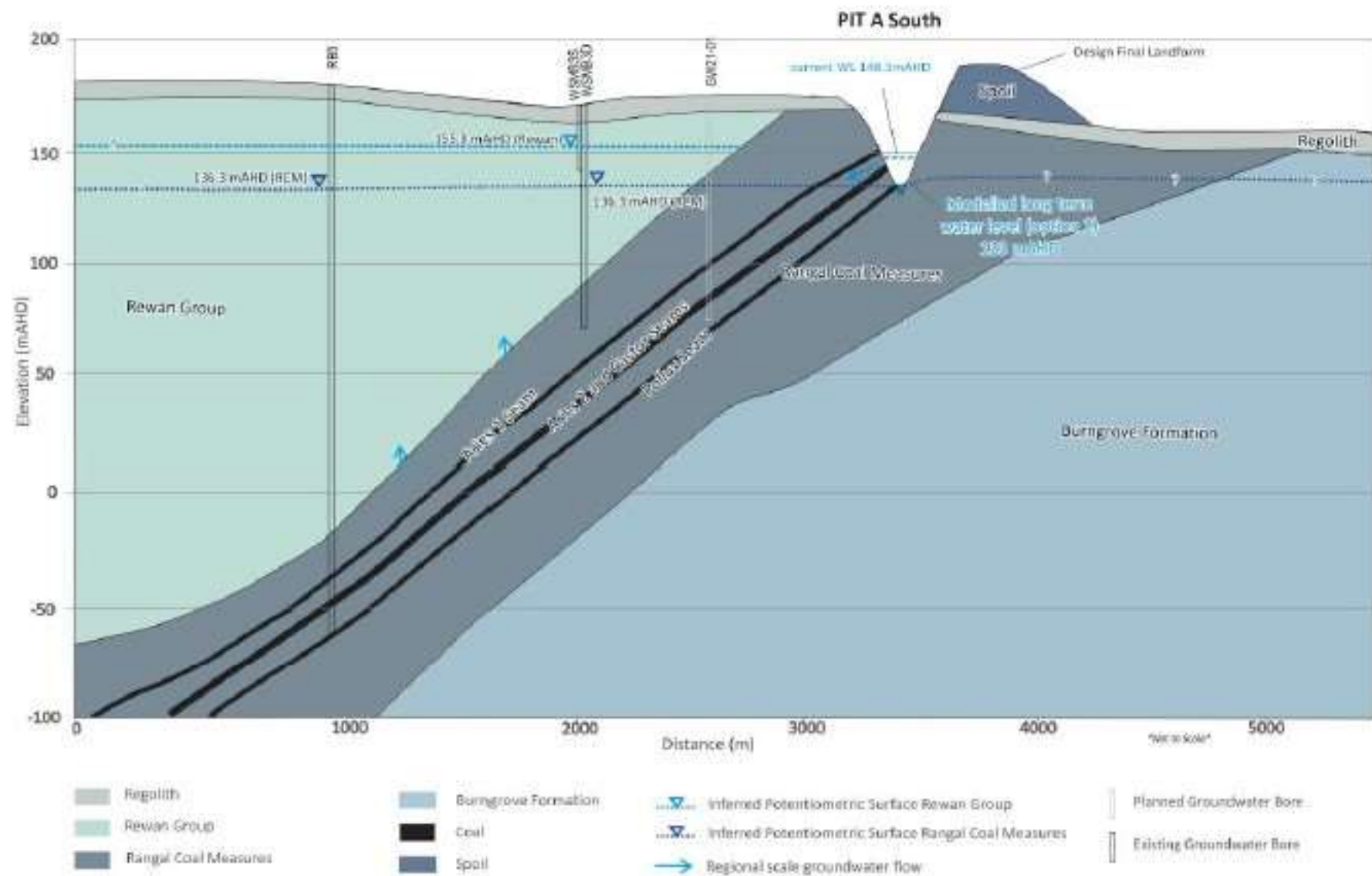


Figure 4-2 Cross section through Ensham Pit A (west to east) (SLR,2020)

4.2 Groundwater level, direction and flow

Groundwater level observations are recorded quarterly for the bores within the Ensham monitoring network and contours were developed for each aquifer to illustrate flow directions (as shown in Figure 4-4 and Figure 4-5). Some professional judgement is applied to development of groundwater contour plots by reconciling observed groundwater levels with hydrogeologically significant features such as mining features (mine dewatering and waste storages) and surface water bodies.

4.2.1 Quaternary Alluvium

Groundwater occurrence in the alluvium is highly variable with thin saturated zones of poor-quality water in deeper sections of an otherwise largely unsaturated formation (SLR, 2020). Recent observations from these bores show the water level in the alluvium decreases from 153.54 mAHD (Twin Bore) in the west to 138.34 mAHD (GW01) in the east, as shown in Figure 4-4. Based on the inconsistent water occurrence in bores throughout this area (EC02, EC04, EC06 and EC17_2 were dry when measured), the alluvium is interpreted to possess zones where sediment is not fully saturated. Previous hydraulic testing was carried out and indicate the conductivities are variable and have been shown to range from $1.00\text{E}+02$ m/day (AGE, 2006) to $9.00\text{E}-04$ m/day (SLR, 2020).

The primary driver of groundwater flow in this aquifer is topographic gradients, following the direction of the Nogoa River from north-west to south-east in the study area, as can be seen in Figure 4-4.

Lithological observations of the base of the creek have identified lenses of aquitard material (clays) dividing the surface water areas from basal gravel layers that comprise the lower areas of this aquifer feature. The shallow silts and clays are anticipated to be partially isolating the Nogoa River, limiting leakage from the river into the basal sands and gravels. It is possible that leakage may occur where these clays are absent or where the basal sands are exposed within the river.

The area south-east and west of the Ensham Mine, on the floodplain and to the south of the floodplain, is dominated by intense agricultural activity and associated irrigation, sourced from the Nogoa River surface water takes and channel water from Fairbairn Dam. Monitoring also indicates that the effect of irrigation is limited.



Figure 4-4 Potentiometric mapping for the Quaternary Alluvium

4.2.2 Rewan Group

Despite being an aquitard, there are four groundwater monitoring bores screened within the Rewan group, Landowner bores Jamar and Winton Creek, and Water Storage Monitoring Bores WSMB2S and WSMB3S (as shown in Figure 3-1). The most recent water level observations (November 2020) show that the ground water level ranges from 115.75 mAHD (Jamar bore) to 155.27 mAHD (WSMB3S). Evaluation of the hydrographs of landowners bores indicates a strong influence of abstraction on the water level observed, so they may not represent reliable assessments of regional groundwater levels. Given the paucity of data in this unit, no contour plots of water level in this aquifer were possible.

4.2.3 Rangal Coal Measures

As the mined unit for Ensham, this formation is well monitored regionally. The groundwater level observations from November 2020, show that water level ranges from 133.46 mAHD (RB3) to 145.51 mAHD (RB1). Groundwater in the Rangal Coal Measures flows primarily towards the Ensham underground mine area due to the dewatering and depressurisation associated with underground mine development. Potentiometric level contours of November 2020 monitoring shown in Figure 4-5 illustrate the influence of this depressurisation.

Recharge to the Rangal Coal Measures occurs primarily from rainfall infiltration on exposed outcrop. The coal measures also subcrop in localised zones beneath alluvium associated with the Nogoa River, where the unit may be recharged by downward seepage where there is an absence of clay and silt layers. Limited recharge may also occur via downward leakage from the Triassic age Rewan Group and Tertiary sediments, as well as from areas of site surface water storage (i.e. in-pit water storages from open-cut mining at the Ensham Mine). The coal seams are connected with the open-cut pits (which are the mined-out areas of the outcropping coal seams). If the pit voids fill up with water, this can create flow into the coal seams.

Hydraulic conductivities within the Rangal Coal Measures interburden have been measured to vary significantly, ranging from 1.20E-01 m/day (JBT 2016) to 2.00E-05 m/day (SLR, 2020). The coal seams themselves form aquifers that generally exhibit low transmissivities and are confined by overlying and underlying shales and mudstones. Hydraulic conductivities of the coal seams are variable and have been shown to range from 5.00E+00 m/day (SLR, 2020) to 1.00E-06 m/day (MatrixPLus, 2010)

4.2.3.1 Interactions between open cut and underground

Groundwater flow direction in the Rangal Coal Measures indicates that groundwater from the coal seams flows primarily towards underground workings. When underground workings are in close proximity to rehabilitated and/or open cut mining areas, there can also be pathways with relatively high hydraulic conductivity that convey water from the rehabilitated and/or open cut mining areas to the underground workings. This impacts on the water levels in the rehabilitated and/or open cut mining areas, which will likely only stabilise once the underground workings have filled with water after mining activities have ceased, after which time, this groundwater will daylight to any residual voids in proximity.

As a result, a pit lake will start to form in some voids, as described in Section 4.1.1 of the main PRCP. These areas as referred to as Mine Domain 5 – Groundwater daylighting water areas. Briefly, it is anticipated for this to occur in Pits A (central and north), B, C and D. No daylighting of groundwater is expected for Pit A (south), nor with Pits E, F and Y (Yongala) due to backfilling above the modelled final groundwater levels.

In contrast, groundwater levels in the regional coal aquifer system are higher than the underground workings, so hydraulic flow will occur from the regional/surrounding system into the underground workings during the initial period of equilibration. In the long term the Ensham system (voids and underground workings) will act as a sink for groundwater as recovered void water levels will be in the order of 10m lower than pre-mining based on the predictive 220 year water level modelling post underground mining. Flow will only occur between the rehabilitated and/or open cut mining areas and the underground workings as indicated in Figure 4-9.

Further, limited hydraulic connection between the A and B Pits and underground is implied by the presence of retained surface water in these pits and local elevated groundwater conditions. Fracture flow and flow through seams may be likely, which would have the effect of prolonged drainage of the southern and central pits into the underground void until underground mining is completed and groundwater levels recover towards the levels associated with the final voids.

4.2.4 Summary of hydraulic properties

The hydraulic properties are as described for each of the groundwater units above (within Section 4.2.1 and 4.2.2 respectively), with hydraulic conductivity also summarised below in Table 3-1. These properties have been developed from historical investigations into the groundwater for Ensham, dating back to 2009, and as compiled by SLR (2020).

Table 4-1 Summary of hydraulic properties for groundwater

Age	Formation	Kh (m/d)	Kv (m/d)
Quaternary	Alluvium	1.00E+0.2 to 9.00E-04	2.50E+0.1 to 4.00E-03
Triassic	Rewan Group	1.00E+0.1 to 1.30E-05	5.00E+0.4 to 5.80E-09
Permian	Rangal Coal Measures – Coal Seams	5.00E+0.0 to 1.00E-06	1.00E+0.0 to 1.00E-06
	Rangal Coal Measures – Interburden	1.20E+0.1 to 2.00E-05	3.00E+0.2 to 7.00E-08

4.2.5 Groundwater-surface water interactions

There is limited connectivity between the Nogoa River and groundwater, which is apparent when looking at both water level and salinity data (EC) between the Nogoa River stream water quality data and levels and groundwater monitoring record for Ensham.

Previous site inspections have identified groundwater expressions into the Nogoa River, and the water quality at this location shows similarities to the Alluvium groundwater aquifer. These groundwater expressions are not considered natural springs, but rather are considered to be caused by upstream irrigation activities.

This is consistent with findings that groundwater levels at EC01 and EC03 have been identified as being impacted by irrigation, with groundwater levels staying high during dry climatic conditions and when other alluvial bores showed a decline.



Figure 4-5 Potentiometric mapping for the Rangal Coal Measures

4.3 Groundwater quality

The groundwater chemistry for each groundwater aquifer has been described herein, based on the available information for each of the relevant groundwater environments, as well as considering interaction between surface water and groundwater.

As previously explained, there are two main groundwater bearing units at Ensham, the shallow Quaternary Alluvium associated with the Nogoa River floodplain and the much deeper Permian aged Rangal Coal Measures. These units are not hydraulically connected and are separated by a low permeability unit, and thus their chemistry is unique.

Groundwater in the Rangal Coal Measures is saline and not suitable for stock water supply or irrigation. This aquifer is confined by the overlying and underlying shale and mudstones and exhibits relatively low transmissivity and recharge rates. Groundwater quality is variable but typically very poor within this aquifer due to high salinity.

4.3.1 Quaternary Alluvium

The alluvium is an unconfined system recharged by rainfall, flooding and irrigation practices. The groundwater quality in the alluvium shows high salinity and is therefore unsuitable for groundwater uses typically required in the area, such as stock watering and irrigation. However it is noted that past flooding events have covered the surface area of these bores, significantly reducing the EC values.

The majority of bores screened in the alluvium are of sodium-chloride (Na-Cl) water type dominance. Water pH is neutral with a median value of 7.1 and as indicated, the alluvium is hydraulically isolated from the Nogoa River, resulting in brackish to highly saline conditions. Slow infiltration recharge and evapotranspiration are likely to be the dominant processes resulting in salinisation of the alluvium.

The alluvium bores show a wide range in salinity with recorded EC values from approximately 1,000 $\mu\text{S}/\text{cm}$ to 30,000 $\mu\text{S}/\text{cm}$. Historical water quality records prior to mining activities (from DRNME bores) also indicate high EC values, indicating that these EC values occurred naturally. The EC observations in the late 1990s and early 2000s ranged from 710 $\mu\text{S}/\text{cm}$ in Bore RN13020175 to 38,900 $\mu\text{S}/\text{cm}$ in Bore RN13020173 (SLR, 2020).

Most alluvium bores are responsive to rainfall events indicating that rainfall infiltration is likely the main recharge process. The EC in bores EC07, EC09A, EC11 and EC13 is responsive to rainfall changes, with various delay of response (as shown in Figure 4-6). A large recharge event reduces the EC and prolonged drought will increase the EC over time.

Those bores had a higher EC before a significant flood recharge event in late 2010 (shown with an increasing Cumulative Rainfall Departure (CRD), and then decreased during the inflow of fresher water (blending)). The bores have since increased in EC with different timing in onset, with EC07 (most upstream) starting in 2013 and EC13 (downstream), starting around 2016.

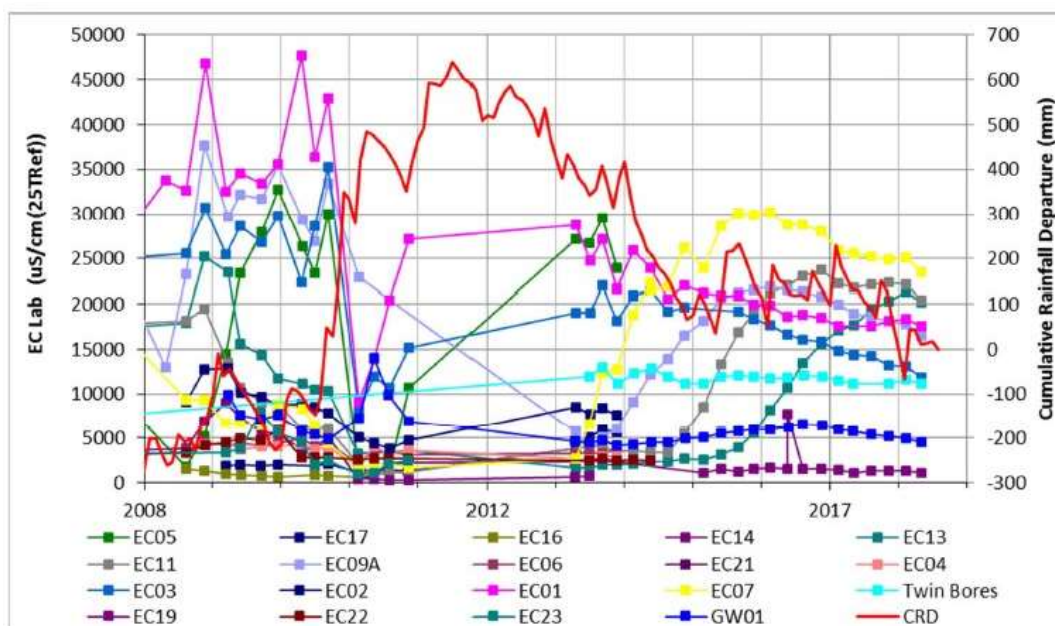


Figure 4-6 Summary of electrical conductivity (EC) in the Alluvium

4.3.2 Rewan Group

Bores screened in the Rewan Group (Winton Creek Bore and Jamar Bore) are all Na-Cl dominant. EC is variable with recorded values ranging from approximately 1300 $\mu\text{S}/\text{cm}$ to 8300 $\mu\text{S}/\text{cm}$. Water pH is neutral with a median value of 7.7. Laboratory EC available from 2004 at Winton Creek Bore and Jamar Bore show that these bores are likely to respond to very high intensity rainfall events and associated major flooding, with EC level decreasing for a short period of time following such events. (Figure 4-7). Overall, little trend in groundwater chemistry change over time illustrates the low degree of groundwater flow within this aquifer, so that chemistry values are relatively stable.

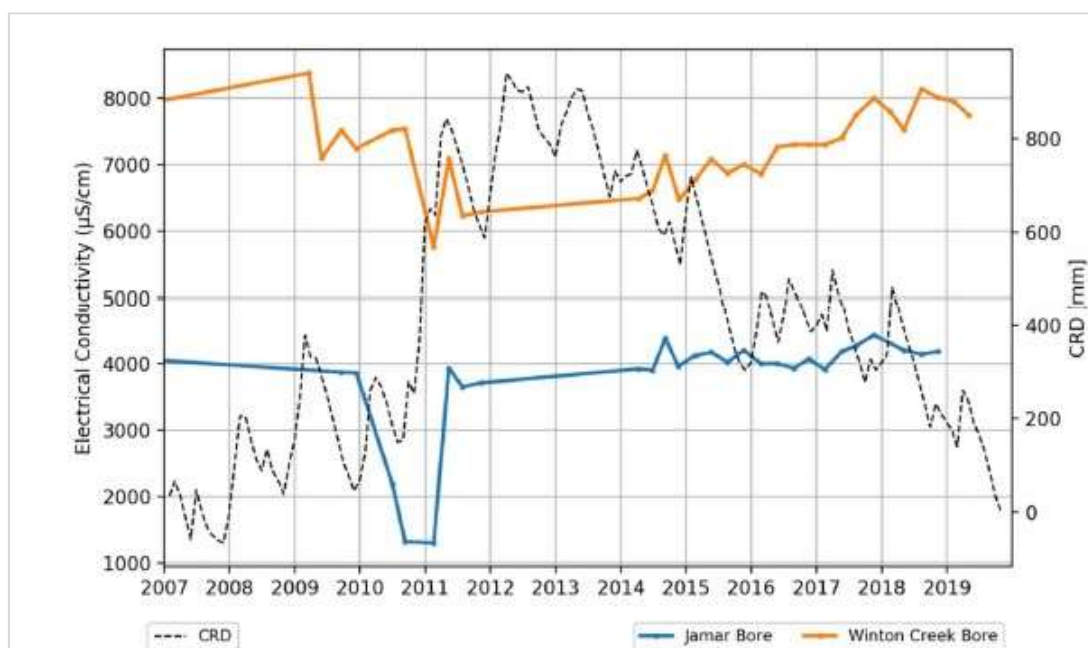


Figure 4-7 Summary of electrical conductivity (EC) in the Rewan Group

4.3.3 Rangal Coal Measures

Groundwater in this unit is saline and not suitable for stock water supply or irrigation. All bores monitoring the Rangal Coal Measures are Na-Cl dominant with the exception of Karanga Bore (private bore to the south of the open-cut pits), which is Mg-Cl dominant. The presence of Mg ions, which are strongly adsorbed compared to K or Na ions may indicate that this bore monitors an area that receives higher recharge and where groundwater is younger. This corresponds with the location of the bore where the coal measures occur at outcrop. Furthermore, this bore presents consistently lower EC values and groundwater level variations which are not matched to the other bores. This may indicate the influence of abstraction at this bore.

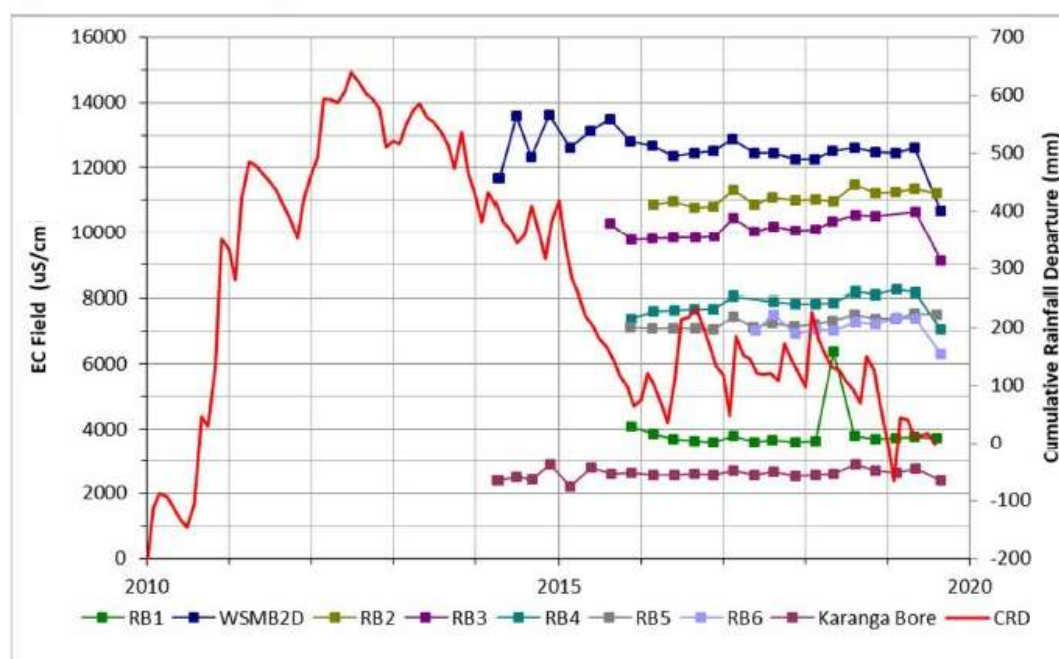


Figure 4-8 Summary of electrical conductivity (EC) in the Rangal Coal Measures

As presented in Figure 4-8, the EC ranges within the Rangal Coal Measures are variable, with values measured from approximately 2000 $\mu\text{S}/\text{cm}$ to 4000 $\mu\text{S}/\text{cm}$ (Karanga bore and RB1) and approximately 7000 $\mu\text{S}/\text{cm}$ to 13000 $\mu\text{S}/\text{cm}$ (all other bores). Water pH is neutral with a median value of 7.7. The bores screened within the deeper Rangal Coal Measures generally record relatively stable trends in EC and highlight the relatively low response to rainfall recharge.

4.3.4 Groundwater-surface water interactions

4.3.4.1 Water entrained in spoil

Water infiltrating through the spoil material will trigger a range of chemical reactions that will lead to various solutes or metals being exported to the rehabilitated open cut mining areas, which will contribute to final water quality within the void areas. There are many geochemical processes that can impact on water quality and the geochemical characteristics of the spoil determine which processes are likely to be the most prevalent.

Overburden characterisation by RGS (2019) indicated that the key geochemical processes are dissolution and transport of salts (total dissolved solids, calcium, chloride, magnesium, potassium,

and sodium) and oxidation of sulphide minerals. These salts identified in the overburden characterisation are immediately soluble and will be mobilised by water flow. Leaching tests performed by RGS (2019) showed that salt concentrations in the leachate from the spoil material declines over time, with a solute concentration reduction of about 50% for each pore water volume displacement.

4.3.4.2 Groundwater daylighting areas (residual voids)

All predicted water levels in the rehabilitated open cut mining areas are beneath the regional groundwater levels, and groundwater will flow from the regional system into the rehabilitated open cut mining areas. There will be no flow from the rehabilitated open cut mining areas (voids) towards the regional groundwater system.

Regarding salt and long-term water quality, in the rehabilitated open cut mining area at A Pit, concentrations reach an equilibrium of approximately 12,500 $\mu\text{S}/\text{cm}$ after about 20 years. This is because there is flow through the porous medium from A Pit to B Pit. There is a balance between the inputs and outputs of solutes so that concentrations remain around a stable value.

For rehabilitated open-cut mining areas at AB Pits, and CD Pits, concentrations are predicted to keep increasing. This is because the only outflow from these areas is via evaporation, which does not contain solutes. There is no output of solutes and concentrations increase with time.

Given that the water held in the rehabilitated open cut mining areas does not reach levels that result in overflow to surface water or groundwater, this does not pose a threat to the receiving environment. In addition, it is not proposed to use the water for any PMLU, as areas where groundwater is expected to daylight in the future will be designated a NUMA (as further described in Section 4.1.1. of the main PRCP document). For these reasons, Cote (2020) concluded that all rehabilitated open cut mining areas are predicted to be non-polluting.

4.3.4.3 Surface expressions

As summarised in Section 4.2.5, groundwater – surface expression has been noted into the Nogoia River, and the water quality at this location shows similarities to the Alluvium groundwater aquifer. The groundwater expression is not considered a natural spring, but rather are caused by upstream irrigation activities.

4.4 Conceptual cross section

The conceptual cross section in Figure 4-9 captures the relevant formations, their apparent thickness and the recharge/discharge processes and was selected from west to east to best show the site hydro-stratigraphic processes at play. Two landholder bores are shown. The conceptual model also includes the Nogoia River, as well as indicating the agricultural areas that are located within the floodplain area.

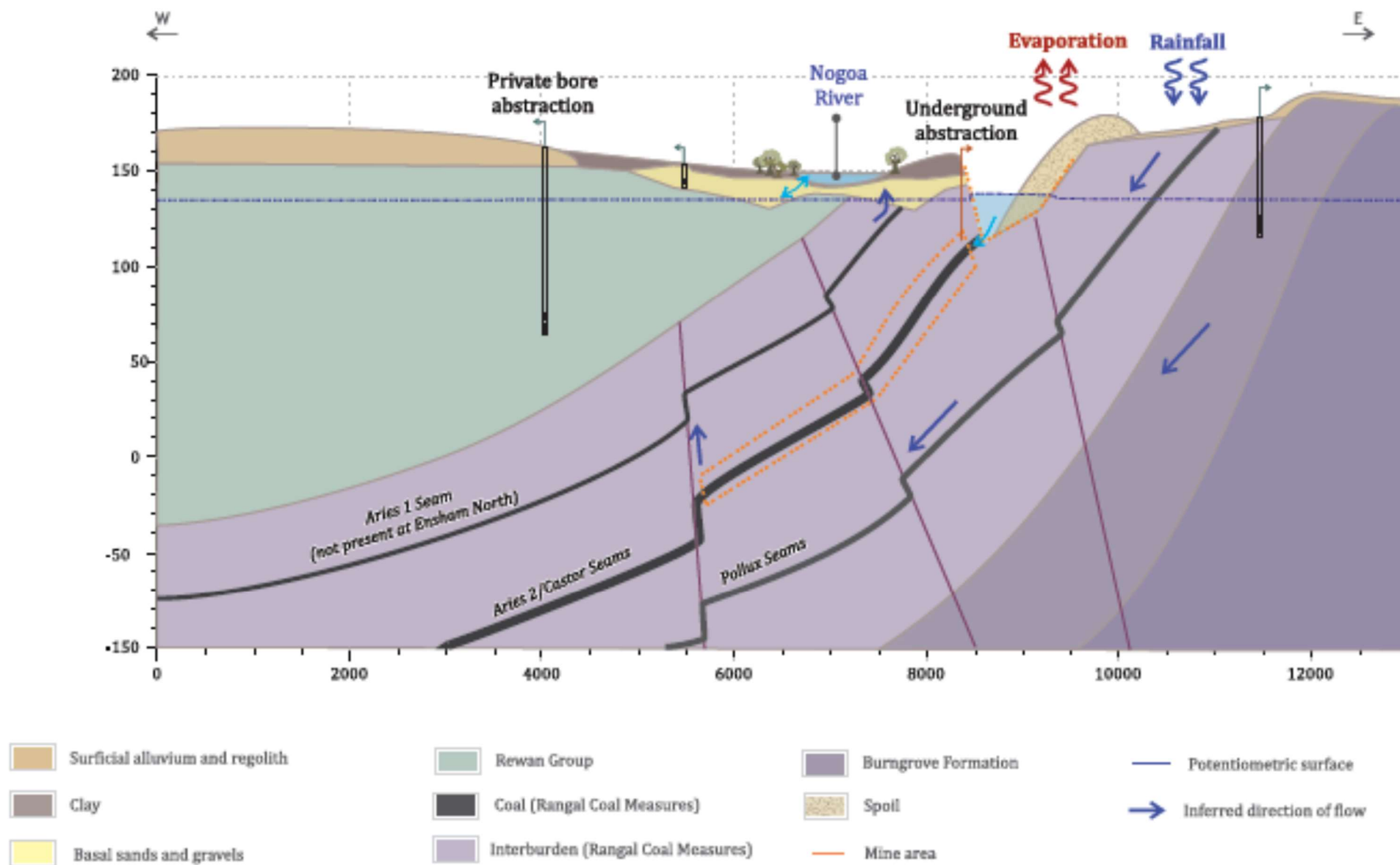


Figure 4-9 Conceptual hydro-stratigraphic site model

5 GROUNDWATER USE

Ensham is within by the Highlands Groundwater Management Area under the Fitzroy Water plan, and is located in the lower Nogoa Groundwaters of the Fitzroy Groundwater plan. Environmental values for the area that are pertinent to groundwater in the vicinity of Ensham include aquatic ecosystems, irrigation, farm supply/use and stock water supply.

Groundwater from the coal measures are not used for primary recreation or drinking water. As detailed in Section 4.3, the groundwater quality for Ensham is not suitable for drinking. Primary recreation is typically appropriate for permanent water bodies and reservoirs.

A review of potential groundwater uses showed that there are 19 landholder bores within a 15 km radius from the Ensham mine area as detailed in Table 5.1 and as shown in Figure 5-1. This census shows that no bores are used for drinking water within the vicinity of Ensham mine.

Table 5-1 Details of private monitoring bores

Registered RN (ID)	Bore name	Geology	Bore Depth (m)	Use
103788	Conmurra	Fair Hill Formation	66	Irrigation (stock and domestic)
132040	Currimundi	Burngrove Formation	-	Not in use
57402	Kensington	Tertiary undifferentiated	-	Not in use
84403	-	Alluvium	-	Unknown
89380	Fair Hills	Burngrove Formation	77	Stock
89383	Yongala	Burngrove Formation	74	Not in use
89382	-	Burngrove Formation	74	Not in use
89384	-	Burngrove Formation	78	Stock
90140	Railway	Fair Hill Formation	61	Stock
-	Chelbrook 1	Tertiary undifferentiated	24	Not in use
-	Chelbrook 2	Rangal Coal Measures	>100	Not in use
-	Currimundi (Field 5 bore)	Alluvium	29	Not in use
-	Cypress	Rangal Coal Measures	>160	Not in use
-	Euro Park	Rewan Group	74	Not in use
-	Jamar	Rewan Group	90	Stock
-	Jenson	MacMillan Formation	41	Stock
-	Karanga	Rangal Coal Measures	~50	Stock
-	Twin Bores	Basal Alluvium	18	Stock
-	Winton Creek	Rewan Group	60	Stock

No cultural and spiritual values have been identified as part of previous studies or are known. Considering the brackish nature of the groundwater and the availability of freshwater in the nearby Nogoa River, it is unlikely that groundwater in the area will hold significant cultural or spiritual values. Of the private bores identified as being in use, eight were reported to be used for stock water and one bore is in use for irrigation / stock and domestic.

Mapped groundwater dependent ecosystems (GDEs) were also visualised in the vicinity of Ensham on Figure 5-1. It can be seen that there are low confidence GDEs identified along the Nogoa River and a wetland south of the open-cut area of Ensham Mine.



6 GROUNDWATER MODELLING

A groundwater flow model is a computer-based three-dimensional mathematical representation of a groundwater system using the laws of physics and was generally developed for all or part of the groundwater system. Groundwater modelling at Ensham has been an evolutionary process with a number of models completed and updated by various parties, most recently by SLR in 2020.

This previous groundwater model represented both the existing underground mining and the above-ground open pit operations. The groundwater model domain extends 43 km from north to south and 35 km from east to west. The stratigraphy is discretised into 12 model layers. Consistent with the previous model iterations, the most recent model was developed as a fully unstructured model using MODFLOW-USG.

The groundwater model was updated with the most recent groundwater observations, in 2020, and the proposed mine plan was added. The model was validated against the new observation data and deemed fit for purpose to understand the Ensham groundwater system, and investigate long term impacts and patterns.

6.1 Accuracy of model

A sensitivity analysis approach was adopted to assess the model uncertainty. Nine selected model parameters were assessed, and the changes in the predictions, both from a water balance and drawdown perspective, were assessed. Parameters sensitive for the underground mine inflow predictions included coal seam hydraulic conductivity, the alluvium hydraulic conductivity, and the streambed conductance.

Parameters sensitive for the Nogoia River baseflow changes are the alluvium hydraulic conductivity (horizontal and vertical) and the streambed conductance. The predicted drawdown contours are most sensitive to the coal seam horizontal hydraulic conductivity. Recharge and storage parameters were found not to be sensitive for the model predictions.

6.2 Modelling of post mining impacts

6.2.1 Long-term groundwater recovery

Assessments have modelled the post underground mining groundwater response. The predictive modelling included a 220 year water level recovery period after the cessation of the underground mining (a 17-year mine life). The groundwater level recovery (or rebound) indicated:

- Some permanent reduction in water levels is predicted for the water levels in the target coal seams.
 - The water levels in the alluvium and Tertiary sediments, the shallow groundwater system, are predicted to fully recover to pre-mining conditions.
 - The water levels in the Rangal Coal Measures are predicted to recover slowly to around 10 m lower than in the surrounds.

- The predicted incremental groundwater drawdown in the target coal seams at end of mining extends 5 km to the north-west and 7 km to the west and the south-west. The drawdown is limited to the extent of the coal seams in the east where the coal seams outcrop or subcrop.
- The cumulative drawdown extends a kilometre further, i.e. around 6 km to the north-west and 8 km to the west and south-west.

The limited Rangal Coal Measures water level rebound is related to the influence of the Ensham Mine final voids, which will continue to act as a localised groundwater “sink”.

6.2.2 Long-term groundwater and void interactions

Considering the potential for groundwater interactions with the residual voids, it is noted that the final landform for Ensham has a pre-approved NUMA to encompass Mine Domain 5 - Groundwater daylighting water areas. Considering this domain, the following is noted:

- Pits A South, E, F & Y will be partially backfilled to support a final land use of grazing, and thus no daylighting of groundwater will occur. They are not considered to be residual voids.
- Pits A, Central, A North, B, C & D will also be partially backfilled but are predicted to have groundwater daylighting areas within them that creates a residual void or pit lake in the future, resulting in a NUMA.

It is predicted for “groundwater outflow” to occur from Pit A and from Pit E (HEC 2020), whereby flow from one pit occurs down-gradient into the adjacent pit, and not to the regional groundwater system, as the regional levels are always much higher than the pit lake water levels.

The movement down-gradient is called “groundwater outflow” because there is a narrow strip of “aquifer” material separating adjacent pits in the groundwater model. The model reports a loss to groundwater, but it is really a short-term transfer of water from one pit lake to another through intervening aquifer material.

Final void modelling has determined that some of the rehabilitated open cut mining areas will maintain a permanent water body (a pit lake) with a water level that will fluctuate around a steady state ‘equilibrium’ level in response to climate variations (Cote, 2020). Equilibrium level is predicted to be reached after 50 years at A Pit, 100 years for the B Pit area, and 150 years for the CD Pits rehabilitated open cut mining areas (HEC, 2019; HEC, 2020).

All predicted long-term average water levels are below the external “spill” level, the level at which water would overflow out of the rehabilitated open cut mining area. Further, all predicted water levels in the rehabilitated open cut mining areas are beneath the regional groundwater levels. Groundwater will flow from the regional system to the rehabilitated open cut mining areas. There will be no flow from the rehabilitated open cut mining areas back into the regional coal measure aquifer as previously indicated.

6.2.3 Potential impacts to users

The developed groundwater model was also used to assess potential future impacts on groundwater users that may occur post-mining. The worst case scenario outcomes have been described in this summary report, and the assessment indicated the following:

- There was some incremental groundwater level drawdown within the Alluvium to the east of the open-cut voids.
- There are no predicted long-term water levels reductions of greater than 2 m in any of the landholder bores. Jamar and Winton Creek bores show the largest incremental drawdown of 10 cm and cumulative drawdown of 17 cm.
- The identified GDEs and the identified wetland are not predicted to be impacted by the additional groundwater extraction or drawdown.
- There are no long-term impacts predicted on groundwater quality.
- There are no long-term impacts from predicted subsidence on groundwater.
- There were no predicted long-term changes to Nogoa River stream losses and no leakage from the coal seams into the alluvium has been predicted.

7 REFERENCES

Australasian Groundwater and Environmental (AGE) (2006). Report on Ensham Central Project – EIA, Groundwater Impact Assessment, Project No. G1258 - Appendix C of EIS.

Australasian Groundwater and Environmental (AGE) (2017). Ensham Underground Groundwater Model, Report prepared for Ensham Resources Pty Ltd.

Cote C (2020), Ensham Residual Void Study, Summary of Water Studies, Sustainable Minerals Institute, The University of Queensland, 2020.

Ensham Life of Mine Extension Project Environmental Impact Assessment (EIS) (2020) – Chapter 12, May 2020, Prepared by AECOM Pty Ltd.

Hydro Engineering and Consulting (HEC) (2019), Ensham Coal Mine Residual Voids Project: Stage 3 Void Water Quantity and Quality Balance Modelling. Report J1504-04.r1o.docx prepared for Ensham Resources Pty Ltd.

Hydro Engineering and Consulting (HEC) (2020). Ensham Residual Voids Project: Stage 3 Void Water Balance Supplementary Report for Additional Model Run. Letter Report to Idemitsu

Hydrosimulations (2020), Residual Void Project - Groundwater Assessment Stage 3. HS2018/33 [Final]. Prepared for Ensham Resources Pty Ltd.

Office of Groundwater Impact Assessment (OGIA) (2016), Groundwater modelling report for the Surat Cumulative Management Area. State of Queensland, September 2019.

SLR (2020) Ensham life of mine extension project, groundwater impact assessment, prepared for AECOM Australia Pty Ltd by SLR Consulting Australia Pty Ltd.

SLR (2021) Residual Void Groundwater Monitoring Design, Ensham Mine, February 2021.

9.5 Soils and Capping Material Assessment Report



Ensham
R E S O U R C E S



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are liable severally in the
following proportions:

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47.5%

Idemitsu Australia
Resources Pty Ltd
ABN 45 010 236 272
37.5%

Bowen Investment
(Australia) Pty Ltd
ABN 12 002 806 831
15.0%

APPENDIX 9.5 – SOILS AND CAPPING MATERIAL ASSESSMENT REPORT

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1 INTRODUCTION

The purpose of this report is to address the soil and capping material assessment requirements of the PRCP by reviewing and assessing existing information and data for Ensham Coal Mine (Ensham). Growth media management is often a crucial factor in successful rehabilitation, particularly where topsoil can be recovered from areas where native vegetation communities exist. A decision on the extent of topsoil profile recovery and the resulting volume of soil to be conserved during mining can be made only after an evaluation of the nature and distribution of the salvaged materials. A range of topsoil application strategies exist for areas at Ensham, to ensure the growth media utilised for rehabilitation will support the desired post-mining land use (PMLU).

The rehabilitation and management methodology for Ensham is dynamic, and ongoing surveys and assessments will likely supplement the understanding contained within the assessment report. Targeted surveys will continue to be conducted at appropriate intervals to assess the soil resources immediately prior to use, and further specific detail will be provided at this time to guide rehabilitation activities.

In addition to the assessment requirements, the proposed rehabilitation methodologies also outline management strategies to be employed to safeguard topsoil quality and quantities. An evidence based and PMLU driven approach has been adopted, so that the soil (or growth media) quantity and quality to be utilised is in accordance with a proven methodology that has been shown to be successful within existing areas of progressive rehabilitation at Ensham or by trial. Integrated soil and waste rock characterisation, as well as review of the success of rehabilitation practices, has formed the foundation of the rehabilitation strategies.

The methodology for this report included:

- Review of the pre-mining soil resources available at Ensham, with comparison of current available resources, to build an understanding of whether the available soil resources have changed in nature. These changes could be due to factors such as weathering or as a result of stripping or stockpiling practices;
- Review of the availability of soil and capping materials, as well as suitability to support and sustain the desired PMLUs, and to identify what remediation may be appropriate, such as amelioration or fertiliser. The locations of materials has also been assessed; and
- The relationship between soils and vegetation ecosystems for each PMLU, with reference to the proposed rehabilitation methodologies.

2 STANDARDS AND GUIDELINES

Standards and guidelines for soil survey, mapping and land evaluation in Queensland included the following:

- The Australian Soil Classification (Isbell, 2016);
- Guidelines for surveying soil and land resources (McKenzie et al. 2008);
- Australian Soil Survey and Land Survey field handbook (NCST, 2009);
- Protocols for soil condition and land capability monitoring (DECCW, 2009);
- Leading Practice Sustainable Development Program for the Mining Industry: Mine Rehabilitation (DISER, 2016);
- Integrated Mine Closure: Good practice guide - 2nd edition (ICMM, 2019);
- Soil chemistry (Rayment and Lyon, 2011); and
- Soil colour charts (Munsell Colour, 2009).

3 PRE-MINING UNDERSTANDING OF SOIL RESOURCES

3.1 Land and soil setting

Prior to mining, the land at Ensham was used for agricultural purposes, predominantly cattle grazing, but also irrigated and dryland farming or cropping. Cultivation was restricted to land within the floodplain of the Nogoa River, most of which has not been disturbed by open-cut mining.

Several land systems and associated soil groups have been observed at Ensham as described by Story et al. (1967) and outlined in Table 3-1 and presented in Figure 3-1.

Table 3-1 Pre-mining land systems

Land System	Description	Approximate area within mining lease (ha)
Humboldt	Blackbutt and brigalow on weathered clay plains occurring in most parts of the area; texture contrast and cracking clay soils.	3208.8
Monteagle	Lowlands with box and texture-contrast soils on undissected Tertiary land surface throughout the area except in the extreme south and north-east.	1308.7
Blackwater	Characterized by brigalow plains and cracking clay soils on weathered tertiary clay and older rocks along the central axis of the area.	1923.6
Comet	Alluvial plains with brigalow and cracking clay soils, often flooded, along major streams.	3834.4
Durandella	Hills with lancewood and narrow-leaved ironbark on weathered Tertiary and Permian rocks in the north-west, center, and south-east; shallow rocky soils.	1922.9
Girrah	Lowlands with downs and brigalow and cracking clay soils on unweathered Permian shale and lithic sandstone in the north and center.	414.7

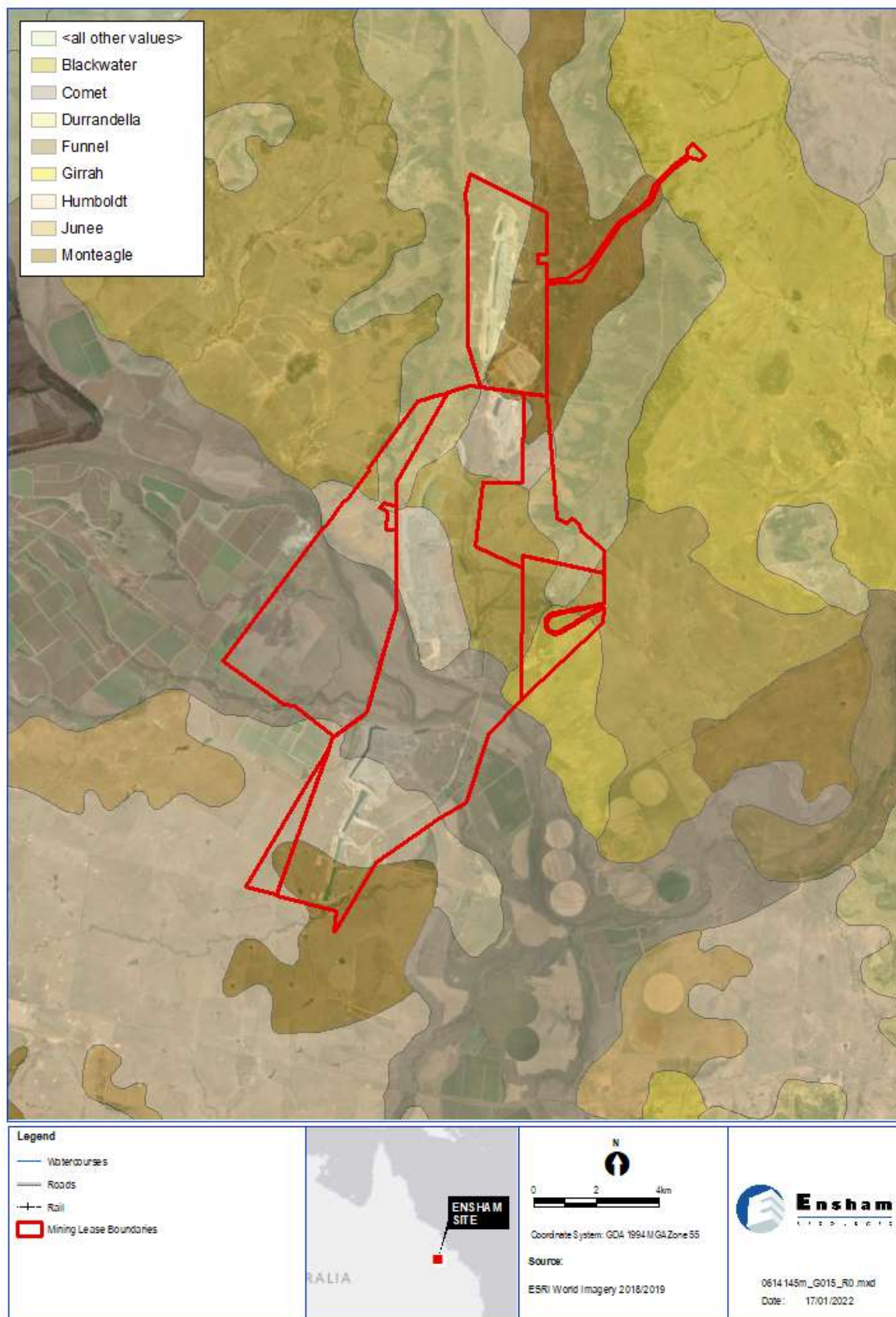


Figure 3-1 Pre-mining land systems at Ensham

Soils at Ensham have also been comprehensively characterised with six major soil groups identified (Hansen Consulting 2006), each with one or more soil type variants as outlined in Table 3-2. Soils at Ensham are generally highly weathered and chemically and physically poor, with salinity and sodicity limiting productivity at depth i.e., saline and sodic subsoils.

Table 3-2 Soil groups at Ensham

Major Soil Group	Soil Type	Soil Classification	Soil Description
1 - Shallow Rocky Soils	1	Leptic Rudosols	Soil type 1 occurs on low rocky hills and steep escarpment slopes and eroded plateau remnants. These soils are shallow (<0.5m), exhibit very little profile development and contain gravel and rock cobbles from various geological formations.
2 – Moderately Shallow Gravelly Sands, Loams or Clay Soils	2.1	Colluvic Clastic Rudosols	This soil group occurs on eroded middle and lower slopes and broad low gravelly rises. These soils are shallow to medium depth and comprise uniform or weakly gradational sands, loamy sands or sandy loams, loams or clayey soils with varying amounts of ferruginous and siliceous gravel or stone. These soils exhibit low soil fertility and water storage capacity.
	2.2	Regolithic Chemic Tenosols	
	2.3	Acidic Brown Clastic-Leptic Rudosols	
3 – Gradational Red and Yellow Earth Soils	3.1	Petroferric Red Kandosols-Tenosols	These soils are present on the elevated dissected and eroded Tertiary plateau remnants and undulating plains associated with the Tertiary Emerald Formation.
	3.2	Acidic Mesotrophic Red Kandosols	These soils include sandy, sandy loam or loamy surface soils grading to red, reddish brown or yellowish-brown sandy loam to light to medium massive or structured clay subsoils often with appreciable amounts of ferruginous gravel.
	3.3	Haplic Mesotrophic Red Ferrosols	
4 – Texture Contrast (Duplex) Soils	4.1	Subnatric Brown Sodosol	Group 4 soil types have formed on Permo-Triassic sedimentary rocks, on gently inclined slopes, dissection slope interfluvies, broad low rises and plains and on alluvial terraces and drainage flats.
	4.2	Eutrophic Mesonatric Brown Sodosols	
	4.3	Eutrophic Subnatric Yellow Sodosols	These soils are sandy, silty or loamy on the surface with a clear to abrupt change to a clayey subsoil horizon.
5 – Uniform Fine-textured (Non-cracking) Clay Soils	5.1	Sodic Pedaric Brown Dermosols	These soil types are present on erosional plains, levees and high terraces along stream systems, undulating alluvial plains and associated with cracking clays of Soil Group 6. These soils exhibit uniform profiles or weakly gradational profiles where clay content may increase slightly with depth.
	5.2	Sodic Pedaric Brown Dermosols	
	5.3	Sodic Pedaric Brown Dermosols	
6 – Cracking Clay Soils	6.1	Epipedal Black, Grey or Black Vertosols	Group 6 soil types form the dominant soil type within the alluvial plains associated with the Nogoa River and its tributaries.
	6.2	Endohypersodic, Epipedal Black, Grey or Brown Vertisols	These soils have uniform medium to high clay content, pronounced swelling and shrinkage properties and commonly feature gilgai.

3.1.1 Land stability

Many land systems and associated soils at Ensham have moderate to high erosion potential and are unsuitable for clearing and agricultural development. The initial Ensham Environmental Impact Statement (EIS) found soil stability was variable across the site (Hollingsworth, Dames and Moore 1990). A more recent assessment also found soils were variably affected by an accumulation of salts which affected structural stability (Hansen Consulting 2006).

For example, major soil groups 2, 4, 5 and 6 are described as moderately to highly saline (as per Table 3-2). This study concluded that due to accumulated salts, soils will generally have low infiltration and hydraulic conductivity, and as a result, will be prone to dispersion and excessive erosion, if exposed to uncontrolled rainfall runoff.

3.2 Vegetation setting

Much of the land at Ensham has historically been cleared of vegetation for agricultural development well prior to mining. Vegetation mapping shows there are 13 regional ecosystems within and surrounding the mining leases as outlined in Table 3-3 and presented in Figure 3-2.

Table 3-3 Regional Ecosystems at Ensham

Regional ecosystem	Description	Biodiversity status	VM Act class ¹
11.3.1	<i>Acacia harpophylla</i> and/or <i>Casuarina cristata</i> open forest on alluvial plains	Endangered	Endangered
11.3.1/11.3.25	<i>Acacia harpophylla</i> and/or <i>Casuarina cristata</i> open forest on alluvial plains and <i>Eucalyptus tereticornis</i> or <i>E. camaldulensis</i> woodland fringing drainage lines.	Endangered/of concern	Endangered
11.3.1/11.3.3/ 11.3.37/11.3.2	<i>Acacia harpophylla</i> and/or <i>Casuarina cristata</i> open forest on alluvial plains, <i>Eucalyptus coolabah</i> woodland on alluvial plains, <i>Eucalyptus coolabah</i> fringing woodland on alluvial plains and <i>Eucalyptus populnea</i> woodland on alluvial plains.	Endangered/ of concern/ no concern/ of concern	Endangered
11.3.25/11.3.3/ 11.3.3c	<i>Eucalyptus tereticornis</i> or <i>E. camaldulensis</i> woodland fringing drainage lines and <i>Eucalyptus coolabah</i> woodland on alluvial plains	Of concern/of concern	Least concern
11.3.25e	<i>Eucalyptus tereticornis</i> or <i>E. camaldulensis</i> woodland fringing drainage lines	Of concern	Least concern
11.3.25e/11.3.3	<i>Eucalyptus tereticornis</i> or <i>E. camaldulensis</i> woodland fringing drainage lines and <i>Eucalyptus coolabah</i> woodland on alluvial plains.	Of concern/ of concern	Least concern
11.3.3	<i>Eucalyptus coolabah</i> woodland on alluvial plains	Of concern	Of concern
11.4.8	<i>Eucalyptus cambageana</i> woodland to open forest with <i>Acacia harpophylla</i> or <i>A. argyrodendron</i> on Cainozoic clay plains	Endangered	Endangered
11.4.9/11.4.9b/ 11.4.8	<i>Acacia harpophylla</i> shrubby woodland with <i>Terminalia oblongata</i> on Cainozoic clay plains and <i>Eucalyptus cambageana</i>	Endangered/endangered	Endangered

Regional ecosystem	Description	Biodiversity status	VM Act class ¹
	woodland to open forest with <i>Acacia harpophylla</i> or <i>A. argyrodendron</i> on Cainozoic clay plains.		
11.4.9a	<i>Acacia harpophylla</i> shrubby woodland with <i>Terminalia oblongata</i> on Cainozoic clay plains	Endangered	Endangered
11.5.9b	<i>Eucalyptus crebra</i> and other <i>Eucalyptus spp.</i> and <i>Corymbia spp.</i> woodland on Cainozoic sand plains and/or remnant surfaces	No concern at present	Least concern
11.7.1	<i>Acacia harpophylla</i> and/or <i>Casuarina cristata</i> and <i>Eucalyptus thozetiana</i> or <i>E. microcarpa</i> woodland on lower scarp slopes on Cainozoic lateritic duricrust	Of concern	Least concern
11.7.1/11.7.2	<i>Acacia harpophylla</i> and/or <i>Casuarina cristata</i> and <i>Eucalyptus thozetiana</i> or <i>E. microcarpa</i> woodland on lower scarp slopes on Cainozoic lateritic duricrust and <i>Acacia spp.</i> woodland on Cainozoic lateritic duricrust. Scarp retreat zone.	Of concern/least concern	Least concern
11.7.2	<i>Acacia spp.</i> woodland on Cainozoic lateritic duricrust. Scarp retreat zone	No concern at present	Least concern
11.7.2/11.7.1	<i>Acacia spp.</i> woodland on Cainozoic lateritic duricrust. Scarp retreat zone and <i>Acacia harpophylla</i> and/or <i>Casuarina cristata</i> and <i>Eucalyptus thozetiana</i> or <i>E. microcarpa</i> woodland on lower scarp slope on Cainozoic lateritic duricrust.	No concern / least concern	Least concern
11.7.2/11.7.4	<i>Acacia spp.</i> woodland on Cainozoic lateritic duricrust. Scarp retreat zone and <i>Eucalyptus decorticans</i> and/or <i>Eucalyptus spp.</i> , <i>Corymbia spp.</i> , <i>Acacia spp.</i> , <i>Lysicarpus angustifolius</i> woodland on Cainozoic lateritic duricrust.	No concern/ no concern	Least concern
11.7.4	<i>Eucalyptus decorticans</i> and/or <i>Eucalyptus spp.</i> , <i>Corymbia spp.</i> , <i>Acacia spp.</i> , <i>Lysicarpus angustifolius</i> woodland on Cainozoic lateritic duricrust	No concern at present	Least concern
11.7.4/11.7.2	<i>Eucalyptus decorticans</i> and/or <i>Eucalyptus spp.</i> , <i>Corymbia spp.</i> , <i>Acacia spp.</i> , <i>Lysicarpus angustifolius</i> woodland on Cainozoic lateritic duricrust and <i>Acacia spp.</i> woodland on Cainozoic lateritic duricrust. Scarp retreat zone.	No Concern/ no concern	Least concern
11.9.2	<i>Eucalyptus melanophloia</i> +/- <i>E. orgadophila</i> woodland on fine-grained sedimentary rocks	No concern at present	Least concern



Figure 3-2 Regional Ecosystems mapped at Ensham

4 NATURE OF AVAILABLE SOIL RESOURCES

Soil investigations completed for Ensham have assessed the topsoil quality, inventories quantities and suitability for use in rehabilitation. Since the initial EIS ((Hollingsworth, Dames and Moore 1990), there have been three major topsoil resource studies, including:

- 2005 Rehabilitation Resource Survey (CMLR 2005) which sought to determine and describe a 'rehabilitation vegetation type', and to propose practical and quantifiable parameters for assessing the success of rehabilitation efforts at the Ensham mine;
- 2006 terrain, soils and land capability assessment (Hansen Consulting 2006), that has been included in the revised Ensham Coal Project EIS; and
- 2017 Ensham Resources topsoil review of the topsoil quality, inventory and use in rehabilitation (Premise Environment 2017). This 2017 review is the most recent audit of soil resources at Ensham, and was aimed at providing high levels of detail as to management practices for the use and amelioration of topsoil materials, so as to achieve stable landforms that meet the rehabilitation completion criteria.

The following sections provide a summary of the nature of topsoil materials for the Ensham site.

4.1 Topsoil quality factors

Natural soils have horizons or layers, approximately parallel to the land surface, with morphological properties different from layers below and/or above it (NCST, 2009). Typical horizon notations are A horizons of darker, organic rich surface materials, B horizons of mineral soil layers with distinct colours, and C horizons of partly weathered parent materials beneath the solum (AB profile).

4.1.1 Soil pH

Soil acidity/alkalinity affects the availability of various nutrients, toxic elements and chemical species present in soil solution and available to plant roots (Hazelton and Murphy, 2007). Strong soil alkalinity reduces the plant-availability of both macro- and micro-nutrients in soils regardless of total concentration. In very strongly alkaline conditions, where $\text{pH} \geq 9.0$; the availability of 8 of the 13 essential plant nutrients is reduced.

The availability of soil nutrients is a major limitation to plant production in central Queensland (Shields and Williams 1991) and phosphorous (P) deficiency is widespread. Unlike soil nitrogen (N), which can be 'fixed' from the atmosphere by rhizobium bacteria in symbiotic relationships with plant roots, all soil P is derived from soil parent materials and fertilisers applied. Plants require relatively large amounts of available P for normal, productive growth. The yield of Buffel grass (*Cenchrus ciliaris*), for example, is halved if available soil P is reduced from 20 to 10 mg/kg (Campbell *et al.* 2012).

As the availability of P reduces when soil pH exceeds 8.5, this is a useful starting threshold when deciding soil suitability for use in rehabilitation. However, it is noted that soils available for use in rehabilitation in central Queensland are inherently strongly alkaline. Therefore, a practical approach

is proposed to decide soil suitability based on pH (Table 4-1). Marginally suitable soils, pH 8.5 – 8.9, should only be used if no suitable alternative soil resources are available.

Table 4-1 Soil suitability based on alkalinity as pH

Soil pH	Suitability
<8.5	Suitable
8.5 – 8.9	Marginally suitable
≥9.0	Not suitable without amelioration

4.1.2 Salinity

Soil salinity is the concentration of dissolved salts in soil solution. These are mainly sodium (Na⁺) but also potassium (K⁺), calcium (Ca²⁺) and magnesium (Mg²⁺) which may be chlorides, sulphates, or carbonates. Excess salt in soil solution, i.e., high salinity, inhibits osmotic processes that enable plant roots to absorb soil moisture. Salinity is measured as electrical conductivity (EC) in a 1:5 soil/water suspension (EC1:5 or EC_{WATER} dS/m). This is converted to saturated EC (EC_{SAT} dS/m) by accounting for the moisture holding capacity of the soil, i.e., clay content. EC_{SAT} is preferred as it better approximates the salinity of soil solutions experienced by plant roots.

4.1.3 Sodicity

Sodicity occurs when the exchangeable Na⁺ on the cation exchange complex leads to clay dispersion in soil. Sodic soils have the following issues.

- Surface crusting,
- Low infiltration and hydraulic conductivity,
- Hard, dense subsoils, and
- Tunnel and gully erosion.

The level of exchangeable Na⁺ is determined by measuring the concentration of all the exchangeable cations in the soil and expressing the amount of exchangeable sodium as a proportion of the sum of all the exchangeable cations, known as the cation exchange capacity (CEC) (Hazelton and Murphy 2007). This proportion is called the exchangeable sodium percentage (ESP). Topsoils with low sodicity are preferred for mined land rehabilitation in central Queensland. Generally, topsoils with an ESP <6 % are suitable, while topsoils with ESP >6 -14 % are less suitable and typically require amelioration with gypsum to ensure aggregate stability.

4.2 Quality

Soils at Ensham have been comprehensively characterised and summarised in six major soil groups, as described briefly in Section 3.1. Most soils are highly weathered, chemically, and physically poor, and can be saline and sodic at depth. In addition, some mine spoils (overburden) can also be high dispersive and/or saline.

Useable topsoil resources are mainly confined to the surficial A horizon (and locally on the upper part of the subsurface B1 horizon, which contain seed-stock, micro-organisms and nutrients necessary for plant growth. Soil microbial activity, organic matter content and other parameters affecting soil fertility tend to decrease with depth.

Table 4-2 provides a summary of topsoil suitability and availability for rehabilitation at Ensham.

Table 4-2 Soil quality in rehabilitation at Ensham

Major Soil Group	Soil Type	Description	Suitability and use for rehabilitation
1 - Shallow Rocky Soils	1	These soils are shallow (<0.5m), exhibit very little profile development and contain gravel and rock cobbles from various geological formations.	Soil types 1, 2.1, 2.2 and 3.1.
2 – Moderately Shallow Gravelly Sands, Loams or Clay Soils	2.1	These soils are shallow to medium depth and comprise uniform or weakly gradational sands, loamy sands or sandy loams, loams or clayey soils with varying amounts of ferruginous and siliceous gravel or stone. These soils exhibit low soil fertility and water storage capacity.	Apart from recovering the surface (A horizon) soil for its seed stock and organic content, this material is not considered suitable for use as topsoil due to the predominantly coarse texture, stoniness and lower water storage capacity.
	2.2		
	2.3		
3 – Gradational Red and Yellow Earth Soils	3.1	These soils are present on the elevated dissected and eroded Tertiary plateau remnants and undulating plains associated with the Tertiary Emerald Formation. These soils include sandy, sandy loam or loamy surface soils grading to red, reddish brown or yellowish-brown sandy loam to light to medium massive or structured clay subsoils often with appreciable amounts of ferruginous gravel.	Soil types 3.2 and 3.3, apart from the often sandy or sandy loam texture of the surficial soil horizons, are generally acceptable in terms of physical and chemical properties to depths of 0.4 to 0.6m. Below 0.6m they tend to have some to appreciable fine to medium size ferruginous gravel within or distributed throughout the profile. The low nutrient status of this soil requires addition of suitable fertilizer and in places tend to be moderately strongly acidic. However texturally and structurally, and in terms of chemical and physical soil properties the deeper horizons are considered to be marginal for use as topsoil but acceptable for subsoil use.
	3.2		
	3.3		
	3.3		
4 – Texture Contrast (Duplex) Soils	4.1	These soils are sandy, silty or loamy on the surface with a clear to abrupt change to a clayey subsoil horizon.	The surficial soil horizons of soil types 4.1, 4.2 and 4.3, which are typically between about 0.2-0.3m thick, are useable as a topsoil for rehabilitation areas. It is noted that in places, this soil type can be mildly dispersive, and sampling prior to use is recommended. The deeper subsoil horizons tend to become strongly sodic, strongly alkaline and/or saline with depth.
	4.2		
	4.3		
5 – Uniform Fine-textured (Non-cracking) Clay Soils	5.1	These soil types are present on erosional plains, levees and high terraces along stream systems, undulating alluvial plains and	In term of acceptable soil properties and extent of occurrence, the most suitable sources of topsoil occur in soil groups 5 and 6. More specifically soil types 5.1, 5.3, 6.1 and 6.2.
	5.2		
	5.3		

		associated with cracking clays of Soil Group 6. These soils exhibit uniform profiles or weakly gradational profiles where clay content may increase slightly with depth.	Soil layers are typically between 0.15 to 0.25m thick and are the most suitable in term of soil physical and chemical properties.
6 – Cracking Clay Soils	6.1	Group 6 soil types form the dominant soil type within the alluvial plains associated with the Nogoa River and its tributaries.	However subsoil B1 horizons which occur at depths between 0.2 to 0.5m below the surface are usually lesser quality and in places are unsuitable for use as topsoil due to increasing alkalinity, sodicity and adverse soil structure.
	6.2	These soils have uniform medium to high clay content and pronounced swelling and shrinkage properties	

4.2.1 Suitability of topsoil

Suitable topsoils for rehabilitation at Ensham have the following characteristics;

- pH <8.5 preferably and 8.5 – 9.0 if no other soil resources are available.
- $EC_{SAT} \leq 4$ dS/m; and
- ESP <6% preferably and $ESP \leq 14$ % with amelioration if no other soil resources are available.

Topsoil resources have been characterised based on salinity and dispersion potential and classified into four categories from very good to poor, as outlined in Table 4-3.

Table 4-3 Topsoil Classification Criteria

Topsoil Classification	Criteria		
1 – Very good	$ECe < 4dS/m$, and	$ESP < 6\%$, and	Emerson class > 6
2 - Good	$ECe < 4dS/m$, and	$6\% < ESP < 15\%$, or	Emerson class < 3
3 - Marginal	$4 < ECe < 8dS/m$, or	$ESP > 15\%$	-
4 - Poor	$ECe > 8dS/m$	-	-

4.2.2 Suitability of other materials

Several assessments have also considered the suitability of overburden material to support the rehabilitation, effectively being placed as an alternate growth media with a view that these materials will be remediated into a topsoil over time.

Previous waste material characterisation assessments include CMLR (2005), Loch (2015), URS (2005), URS (2015), and RGS (2018). This is further detailed in Section 5.3.2 of the main PRCP. In summary, the assessments demonstrate that the spoils and soils are typically sodic and saline to varying extents, and non-acid forming (Ensham Resources 2021).

In particular, it is noted that Permian spoil materials are generally non-saline to saline and sodic, and thus has some potential for use as a growth media surrogate. This is further considered in Section 8 of this report.

4.3 Quantity

Table 4-4 below shows the latest inventory of topsoil materials held in stockpiles at Ensham. It can be seen that the majority of stockpiles are very good (1) to good (2) in quality. It is notable that no further surface disturbance is planned for the Ensham site, and the remaining operations will be underground in nature. Therefore, this inventory represented the total volume of salvaged topsoil material available for use in rehabilitation.

Table 4-4 Inventory of topsoil materials available, by classification

Location	1 – Very Good	2 – Good	3 – Marginal	4 – Poor	Total (m ³)
Pit AB	797,258	572,461	500,732	-	1,870,451
Pit CDE	15,630	61,182	67,487	1,157	144,456
Pit F	265,097	217,126	-	-	482,223
Yongala	91,079	122,493	8,934	19,972	242,278
Infrastructure	42,656	14,513	-	-	57,169
Total	1,211,719	987,776	577,153	21,129	2,797,777

From the table above, a total of 2,199,495m³ of good / very good topsoil is available for use, with a further 577,153m³ considered to be of marginal, but usable, quality. It has been assumed that the poor quality topsoil will require amelioration to be used.

Table 4-5 provides a summary of the remaining surface areas to be rehabilitated for the Ensham site, with detail provides to show the volume of topsoil resource required for a range of re-spreading depth, informed by typically rehabilitation practices for Central Queensland mine sites.

Table 4-5 Demand for topsoil materials, by area, for a range of depth profiles

Location	Topsoil volume available (m ³)	Type of disturbance	Area (ha)	Volume required @ 150mm re-spread (m ³)
Pit AB	2,740,608	Spoil emplacement**	1,755	2,632,500
Pit CDE		Borrow pits	6	9,000
Pit F		Cleared and topsoil stripped	108	162,000
Yongala		Haul road	134	201,000
		Access tracks	66	99,000
	57,169	Camp	13	19,500
		Laydown area	75	112,500
Infrastructure		Water storages	12	18,000
		Process plant	15	22,500
		Process water storage	27	40,500
Total	2,797,777		2,212	3,317,765

*** Note that part of the spoil emplacement areas have been designated as flat benches without topsoil (cattle shelterbelts) and excluded from the total area of disturbance requiring topsoil*

From a comparison between Table 4-4 and Table 4-5, it can be seen that Ensham do not have available suitable material to re-spread 150mm across all areas.

5 LOCATION OF SOIL AND CAPPING MATERIALS

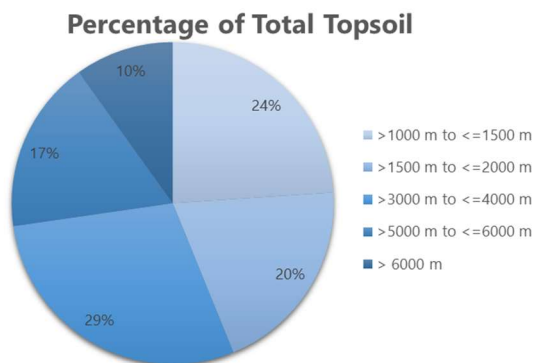
Stockpiles are strategically located across multiple areas of the Ensham site, as presented in Figure 5-1. This does not account for topsoil which has been stripped off the Boggy Creek Diversion area which will be placed back over the area, as this work will have been completed at the time of ERC submission.

The haul distances as outlined in Table 5-1 (and used within the 2021 Estimated Rehabilitation Cost (ERC) calculator) are derived utilising the Spry Model, in conjunction to various site-based inputs. In identifying the haul distances, the model also schedules the hauling of topsoil. The Spry model contains a set of destination topsoil solids - that is, areas that need to have topsoil placed onto them. The model also contains source solids, representing the existing topsoil stockpiles.

As part of the scheduling process, the Spry model simulates hauling topsoil from the stockpiles to the rehabilitation destination, recording information about the haulage including truck hours, total haul distance, etc. The Spry model uses a set of defined haul paths, and chooses the best route. By identifying the best route, this therefore identifies but also optimises haul distances for topsoil. It can be seen that the majority of topsoil resources are located relatively close to the intended use location.

Table 5-1 Topsoil volume, inventory and haul distance

Topsoil Location	Percentage of Total Topsoil	Haul Distance
A Pit	16%	>1000 m to <=1500 m
B Pit	25%	>3000 m to <=4000 m
C Pit	17%	>5000 m to <=6000 m
D Pit	10%	> 6000 m
E Pit	4%	>3000 m to <=4000 m
F Pit South	6%	>1500 m to <=2000 m
F Pit North	8%	>1000 m to <=1500 m
Y Pit	14%	>1500 m to <=2000 m



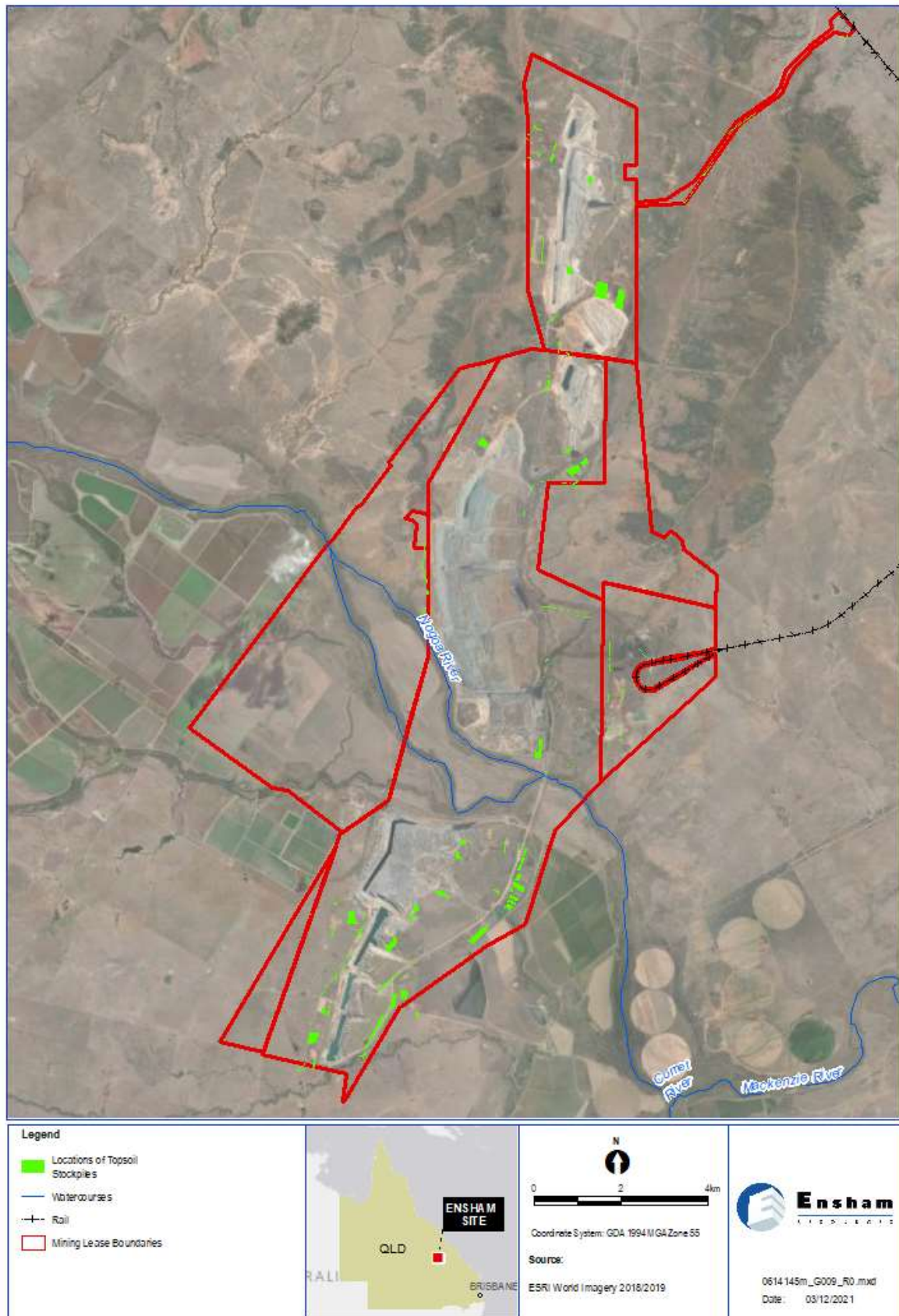


Figure 5-1 Locations of topsoil stockpiles

6 MANAGEMENT PRACTICES USED IN PROGRESSIVE REHABILITATION

The saline and sodic nature of much of the mine spoil is noted, along with the scale of rehabilitation works required at Ensham. Coupled with limited and variable topsoil resources, it is highlighted that effective and targeted soil management is essential for Ensham to achieve rehabilitation success.

In recognition of this importance, a number of trials have been conducted, as well as dynamic adjustment of rehabilitation prescriptions over time. Most rehabilitation requires creation of new soil profiles (or solum) with A, B and C horizons, which is a complex and multifaceted process that requires time for soil maturation. These new soil profiles are called Anthrosols (Isbell, 2016).

6.1 Past topsoil application rates

To date, most rehabilitation at Ensham has been completed by placing a thin 'A horizon' of topsoil over overburden in the following general composition:

- A horizon (0 – 20 cm depth) of topsoil; and
- B/C horizon of overburden.

The new solum i.e., A and B horizons, has an assumed depth of 90 cm as most plant roots, plant-available nutrients and accessible water, and other plant-soil interactions and soil fauna, are contained within this depth limit. New B horizons provide anchorage for plants and contribute to soil nutrition; however, the principal role of subsoil is to store moisture for plant use. Understanding spoil characteristics and potential subsoil limitations that restrict root proliferation and access to stored water is essential in achieving satisfactory rehabilitation. Common limitations at Ensham are subsoil salinity and sodicity.

Therefore, maintaining appropriate ground and soil cover is paramount, which can be achieved through appropriate depth soil application rates, minimum ground cover requirements, and adequate pasture residue. These measures provide some protection of both the soils and overall landforms from erodible forces.

6.2 Past topsoil management practices

In the past, Ensham have managed the scarce topsoil resources so to preserve and extend its value as much as possible. These practices as outlined below can demonstrate rehabilitation success (as evidenced by a long and consistent history of annual rehabilitation monitoring, and further explored within the complementary monitoring summary report and PMLU context documents. This has essentially been in line with current practices, with the management strategy employed to strategically and preferentially use topsoil to promote rapid groundcover establishment and stabilisation of outer slopes that drain to the broader environment.

Depending on availability and requirement, Ensham has applied fertilisers, gypsum, hay or composted feedlot manures in a range of ways and rates, to successfully improve topsoil quality. The aim of these trials and dynamic experimentation of rehabilitation practices has been to understand and explore what prescriptions will ensure favourable seed germination and vegetation

establishment, and ultimate rehabilitation success. Such measures are applied variably across the rehabilitation landform, based on agronomic interpretation of material chemical and physical characterisation and plant growth limitations. Unsuccessful rehabilitation constructed prior to 2004 has been redone to current methodology.

Ensham also have typically had a strong site history of utilising experienced rehabilitation practitioners who stay up to date with trials, research and changed practices within Central Queensland, and have adopted these practices as they have been demonstrated locally or regionally. The interaction between end land use (and in particular the establishment of trees and shrubs) and growth media application has been demonstrated successfully at Ensham since 2004. This has also occurred with the benefit of the nearby Curragh mine that has successfully demonstrated the technique for perhaps 25 years.

It is noted that topsoil management is considered to be a continuum, whereby the topsoil depth can be varied down to being entirely absent whilst still ensuring successful rehabilitation outcomes, provided the land use outcomes are consistent with the expected rehabilitation that will be successful. And indeed, such an approach requires reduced slope gradients and potential for erosion, and may well result in longer timeframes to achieve success criteria. However, for Ensham, it is considered that the landform arrangement and gentle slopes does support such approaches.

6.2.1 Rehabilitation without topsoil

Techniques that promote tree and shrub establishment, without topsoil, have been demonstrated successfully at Ensham since 2004. This technique provides little groundcover and is typically used only on areas with reduced slope gradient and erosion potential, where rapid grass cover for erosion hazard control is not the primary goal of vegetation, e.g. flat areas in the rehabilitation landscape, for tree benches

In addition to evidence provided by rehabilitation monitoring data, Ensham have also undertaken formalised and long-term trials considered the success of native trees planted in different types of Ensham spoil (termed the NEDO forestry planting trial). The outcome of the trial indicated successful performance in growth and health over a number of years from commencement in 2000 (AXM Environmental, 2010). This demonstrated that trees can be successfully grown on benches without topsoil to provide shelterbelts for cattle.

7 ASSESSMENT OF CAPPING MATERIALS

Capping is not generally required for progressive rehabilitation or closure at Ensham, as there are no high risk features such as Tailings Storage Facilities which require a cover system to be installed. Typically, clay materials would be utilised which can be compacted to form a low permeability layer, however, there are no features where this would be necessary for the Ensham site.

Topsoil materials, as discussed throughout this document, do form a 'cover' of erosionally stable materials over more dispersive materials. This has been discussed throughout, with the intent of the soil assessment and management strategy to provide a stable and successful remediated topsoil layer that prevents the exposure of underlying sodic and or saline spoil materials.

Further, given the low slope gradients adopted across the site, structures such as contour banks and rock lined chutes are avoided to prevent concentrating water flow and necessitating ongoing maintenance. As a result, landforms have a more natural appearance. The absence of conventional drainage features also enhances the ability to move cattle and farming equipment across the site, which further enhances the proposed PMLU of low intensity grazing.

8 ONGOING GROWTH MEDIA MANAGEMENT REQUIREMENTS

8.1 Current management strategy for soils

Prior to rehabilitation, topsoil is collected and stockpiled in advance of mining activities and preserved for future use in rehabilitation (Ensham, 2021). As noted in Section 4.3, the site has transitioned from an open cut to an underground operation, therefore, no further land clearing or associated topsoil harvesting is anticipated. The current and future planned topsoil practices are broadly consistent with that used historically, and as detailed in Section 6. In summary, current and future planned topsoil rehabilitation practice at Ensham is as follows:

- Strategically using salvaged topsoil to promote rapid groundcover establishment and stabilisation of outer slopes that drain to the broader environment; and
- Ameliorating overburden to create a plant growth media by additions of organic matter, gypsum and/or fertiliser as required.

8.1.1 Remediation of topsoil materials

Future and planned rehabilitation at Ensham will continue to be completed by placing a thin 'A horizon' of topsoil over B and C horizons of overburden in the following composition:

- A horizon (0 – 15 cm depth) of topsoil
- B/C horizon of overburden

As explained above, the new solum i.e., A and B horizons, has an assumed depth of 90 cm as most plant roots, plant-available nutrients and accessible water, and other plant-soil interactions and soil

fauna, are contained within this depth limit. The new B horizons (15-90 cm depth) are intended to primarily store moisture for plant use.

Maintaining appropriate ground and soil cover is paramount, which can be achieved through appropriate depth application rates, minimum ground cover requirements, and adequate pasture residue. These measures provide some protection of both the soils and overall landforms from erodible forces. The addition of mulch provides additional erosion protection whilst awaiting vegetation establishment.

Ensham will ameliorate all growth media materials as needed, with the goal to ensure the plant growth medium can support the required rehabilitation as a 'topsoil substitute'. Amelioration will be applied to both the A and B horizon materials as appropriate.

Additional ameliorants and surface treatments, such as Hydromulch, may also be considered in the future, where it can be shown to result in satisfactory rehabilitation outcomes. However, this will likely be coupled with, rather than replacing, an approach whereby growth media materials are remediated through amelioration.

8.1.2 Topsoil free rehabilitation areas

It is planned for rehabilitation areas where the primary goal of rehabilitation is to result in a native bushland community to be topsoil free. Further to this, there are areas within other land use areas where enhancement of tree and shrub coverage may also be desirable, such as for cattle shelterbelts and to improve visual amenity. Topsoil is also not required to be placed on disturbed/cleared areas where topsoil was not stripped.

As justified in Section 6.2.1, this prescription will actually increase the likelihood of ensuring suitable tree and shrub establishment, as opposed to alternate prescriptions where topsoil material is used. This has also been demonstrated successfully at Ensham since 2004.

There is also significant research to provide complementary support to the strong site evidence as to rehabilitation success for native bushland (or flat areas comprising tree and shrub coverage) where no topsoil is placed. A key outcome of research into relevant rehabilitation practices, completed by The University of Queensland, is that not using topsoil and sowing directly into overburden or spoil material improves tree and shrub germination proportional to groundcover and grass species. The research also shows, provided the rehabilitation landform is otherwise stable and non-polluting, that a 'no topsoil' approach increases native species richness by reducing the competitive impacts of grasses (DISER, 2016).

8.2 Remediation of spoil materials

Conservative slope gradients have been adopted for Tertiary spoils to control erosion. The common approach is to limit slope gradients to not more than 10%. Key additional criteria that are adopted includes ensuring slope lengths do not exceed 200 m, not using contour banks or rock-lined waterways, and applying a surface treatment for erosion control (such as hay mulch and deep ripping) at the time of seed sowing.

Ensuring waste rock dumps or spoil piles of Tertiary overburden do not exceed 10% is the critical requirement for ensuring rehabilitation success on these landforms. However, by adopting such gentle slope angles, Ensham are also afforded much flexibility in terms of placement and management of soil materials and the need for erosion control.

As per the current EA (*EPML00732813*), all outward facing overburden slopes will achieve 0 to 10% slopes for tertiary materials, and 0 to 15% slopes for Permian materials. Further to this, at least 90% of the inward facing slopes will achieve 0 to 10% slopes for tertiary materials, and 0 to 15% slopes for Permian materials. Up to 10% of inward facing slopes may exist between 15% to 25%, and would be fully contained within the areas of 0 to 15% slopes.

Permian spoil material is considered to be relatively benign, and is about 50% less saline and less sodic than Tertiary overburdens. It is therefore favoured for use as a B horizon surrogate growth media material in rehabilitation because it is less hostile to the establishment and growth of plants, and is more erosion resistant, due in part to its variable content of coarse sandstone fragments.

The key requirement for B horizons materials is to store moisture for plant use, and available local information suggests that the Plant Available Water Capability (PAWC) for spoil in the region is around 150mm/m. The minimum PAWC in Ensham's rehabilitation criteria is <45-30mm for Class 4 beef cattle grazing, so there appears to be potential for mine spoil to meet these criteria (Premise Environment 2017).

In order to prove up a method of generating a growth media capable of being used as a substitute topsoil, a METS trial was carried out at Ensham. The METS trial was funded jointly by Idemitsu and METS with support from the Australian Government. METS Ignited is part of the Australian Government's Industry Growth Centres Initiative from the Department of Industry, Science, Energy and Resources.

The objectives of the trial included:

- Amelioration of a range of spoil material on site to produce a substitute growth media instead of topsoil; and
- Determine if pit water or a freshwater / pit water shandy could be used for initial pasture germination and establishment.

Typical Tertiary and Permian spoil was ameliorated using a range of additives to reduce soil pH levels, increase exchangeable calcium, increase exchangeable potassium, increase soil carbon and boost soil biology. A trommel was used to incorporate the ameliorants into the spoil and aerate the mixture. The trial plots and controls were seeded with grazing pasture species in February 2021.

A number of the trial plots were irrigated with either pit water with an electrical conductivity of approximately 10,000 $\mu\text{S}/\text{cm}$ or a shandy mix of approximately 5,000 $\mu\text{S}/\text{cm}$. Watering was carried out for a period of 10 weeks. Seedlings germinated in the irrigated plots, but due to ongoing drought conditions, there was limited germination on the unirrigated plots. As was expected, germination and seedling development performed best with the lower conductivity water. Testing

has revealed that the ameliorated spoil was not unduly affected by the short term watering with high conductivity water.

One of the completion criteria for the grazing PMLU is >50% persistent groundcover for 0-15% slopes and >80% persistent groundcover for >15% slopes. Within 2 months, the criteria for <15% was easily exceeded and by 4 months, there was 100% groundcover with estimated biomass of 3,000 kg/ha.

Further monitoring will be required over a longer timeframe to determine if other completion criteria of surface water runoff and land suitability are achieved to prove that this is a successful method of ameliorating spoil as a growth media to be able to achieve rehabilitation certification. Similar results were achieved for Tertiary spoil and Permian spoil.



Figure 2 March 29th 2021 with shandy water on Tertiary spoil



Figure 3 April 7th 2021 with shandy water on Tertiary spoil



Figure 4 April 21st 2021 with shandy water on Tertiary spoil



Figure 5 May 6th 2021 with shandy water on Tertiary spoil



Figure 6 July 13th 2021 with shandy water on Tertiary spoil

9 AMELIORATION AND FERTILISER ASSESSMENT

It is noted that sampling of stockpiled material will occur prior to use to guide exact application rates, as well as selection and specifications of ameliorants and fertilisers. The high dispersive and/or saline nature of mine spoil, limited topsoil resources and the scale of rehabilitation works required at Ensham requires creation of new soil profiles. As a result, most rehabilitation areas (where topsoil reapplication will occur) will require amelioration or fertiliser application.

Understanding and correcting soil limitations ensures revegetation success. Regular soil and spoil testing ensures the correct fertilisers and ameliorants are applied, which thus promotes revegetation success. Addressing soil limitations within Ensham soils has historically included the application of fertiliser and hay-mulch where needed. Recently, gypsum has been used, and even lime, as more rehabilitation is undertaken in areas with poor soils. Past detailed amelioration and fertiliser assessment have informed the following sections.

9.1.1 Gypsum

Sodium concentration and ratios in the soil can be adjusted through the application of gypsum. Analysis of topsoil types to determine the expected range of gypsum required to improve soil properties at Ensham has occurred. The lower range given is to reduce sodium levels below the sodic soil threshold ($ESP < 6\%$) and the upper value is to reduce sodium for optimal plant growth ($ESP < 1\%$). The rate to achieve this was based on the 90th percentile values for stockpiles in the different categories. The results are shown in the Table 9-1.

Table 9-1 Recommended Gypsum Application Rate (T/ha), as per Premise Environment, 2017)

Soil Classification	Minimum	Optimum
1 – Very Good	0	2
2 – Good	4	8
3 – Marginal	25	NA
4 – Poor	NA	NA

9.1.2 Fertiliser

The main constraints to pasture establishment and sustainability at Ensham are nitrogen, phosphorous and carbon. Other nutrient and trace elements are within acceptable ranges.

9.1.2.1 Nitrogen

Nitrogen levels are variable, and in some cases extremely high, where samples taken from stockpiles have been in-situ for some time. The required urea application can be determined at the time of application by additional testing, however it is considered that appropriate application rates are likely to be around 200kg/ha.

A follow-up or maintenance application of urea (spread onto the completed rehabilitation pasture areas) may also be completed once pasture is established, or when legumes begin to be succeeded

at Yongala and Pit CDE. Rehabilitation at Pit F indicates extremely high levels of nitrate, thus is unlikely to require nitrogen application for many years (Premise Environment, 2017).

9.1.2.2 Phosphorous

Colwell Phosphorus (P) levels are highly variable and are a critical nutrient required for good pasture production. As at the last audit (Premise Environment, 2017) approximately one third of sites have extremely low values (<5mg/kg), one third had low values (<10mg/kg), and the remainder had adequate to good levels of P (>10mg/kg)

For those areas where analysis suggests it is required, an initial application of mono-ammonium phosphate (MAP) would suffice to ensure adequate P was available. This could be applied during final land preparation i.e. during ripping, to incorporate P into the topsoil rather than placed on the surface.

9.1.2.3 Organic Carbon

Organic carbon, as with other factors, was also considered to be variable, although not as much as other nutrients. The following classifications for organic carbon content (%) were determined - <0.5 – Very low; 0.5-1.0 – Low and 1 – Adequate. The majority of topsoil site had very low to low OC content. The addition of hay mulch, as well as the pasture, helps to increase organic carbon levels over time.

9.1.3 Deep Ripping

Ripping of newly created Anthroposols to the depth of the solum (90 cm) is essential for achieving satisfactory rehabilitation at Ensham (Ensham, 2021), which has several advantages for rehabilitation. The single greatest advantage is creation of macro-porosity that increases rainfall infiltration and furrows that reduce runoff and erosion (Gardner 2001; Koch 2007). Other benefits include the following:

- Reducing soil bulk density (Henderson 1989) caused by equipment compaction of subsoil (spoil) during landform construction.
- Increases profile recharge and plant available water (Kew et al. 2007).
- Facilitates deeper rooting by establishing vegetation, improves root architecture and increases use of deep subsoil moisture (Szota et al. 2007; Lardner and Tibbett 2013).
- Can be used to mechanically incorporate gypsum into subsoils (spoils), lessening the time required for gypsum to dissolve and react with the subsoil solid phase.
- Creates a surface seedbed for seed germination with good soil-seed contact (also provided by shallow ripping) (Lardner and Tibbett 2013).

To improve ripping outcomes and achieve greater tillage at depth, a wing-like structure is fitted to the shank of the tyne.

This action lifts and tills the soil profile across a broad front. Deep ripping is typically enough to create a friable seed bed into which seed is sown, however a secondary lighter rip is also commonly used.

10 SUITABILITY OF MATERIALS TO SUPPORT PMLU OUTCOMES

Given the limiting factors of topsoil quality and quantity at Ensham, the revegetation prescriptions are strongly influenced by land systems and soil types and ensuring the soil and spoil materials will suit the PMLU requirements and outcomes.

Reference sites have been established on and around Ensham for the purpose of comparing with rehabilitated areas, this is further discussed in Appendix 9.3 – Progressive Rehabilitation Monitoring Summary. Consideration is given to plant species selection with attention given to the regulatory constraints of the approvals, the surrounding PMLU context, and the capacity of the available topsoil resources at the time of revegetation to support the selected species, determines the successfulness of the rehabilitation.

The extent and location of the PMLUs at Ensham which are relevant to this soils assessment, are presented in Figure 10-1 and include the following domains;

Domain area	PMLU	Relevant to soils assessment
Mine domain 1	Cattle grazing on overburden / infrastructure areas	Yes
Mine domain 2	Landholder retained infrastructure	No
Mine domain 3	Watercourse bed, banks and riparian vegetation of the Boggy Creek diversion	No – rehabilitation is completed, with in-situ topsoil materials replaced
Mine domain 4	Native bushland corridor	Yes
Mine domain 7	Flood protection landform	No – requirements are consistent with Mine domain 1

More than 90% of rehabilitation by area at Ensham has a target PMLU of beef cattle grazing. Determination of rehabilitation suitability requires evaluation of soil and landform attributes based on the requirements for beef cattle grazing using current technology and management. This is also considered within the main PRCP, as well as within Appendix 9.3 – Progressive Rehabilitation Monitoring Summary and Appendix 9.2 – PMLU context document.

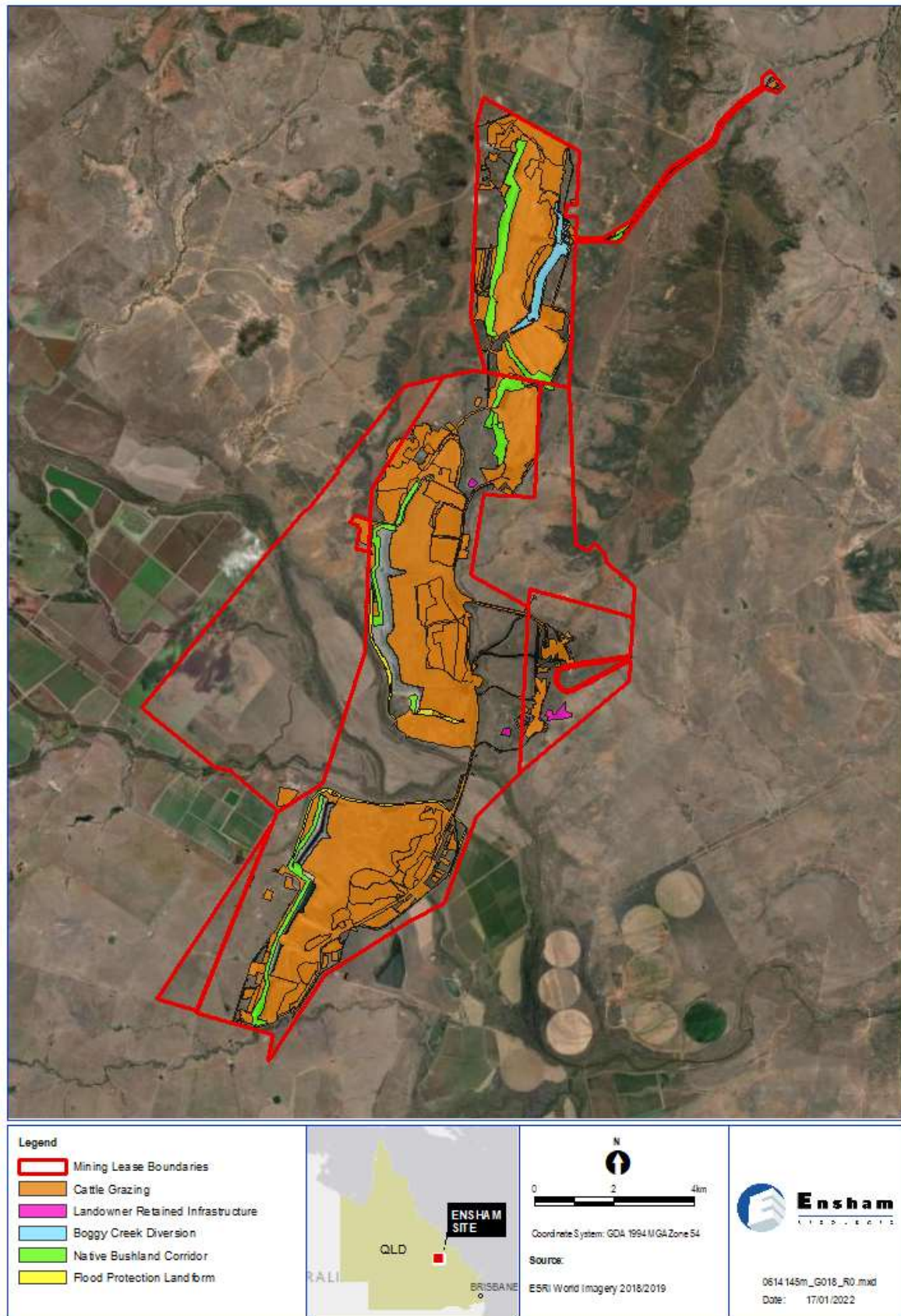


Figure 10-1 Location and extents of PMLUs

10.1 Soils and initial vegetation cover

Revegetation has two primary aims, both initial vegetative cover for stabilisation, and also longer-term vegetative establishment which is reflective of the desires PMLU. Use of hay mulch also provides initial soils cover and seed germination protection, thus supporting revegetation aims.

Initial rapid vegetation establishment is required to achieve a transitional groundcover greater than 50 % to control soil loss by water erosion to sustainable levels. The seeding mixture includes both fast establishing annual grasses as well as perennial, longer-lived grasses, legumes and some forbs. Review of past rehabilitation performance indicates that the seed mix is adequate for achieving the require groundcover rates, as further detailed in Appendix 9.2 PMLU context report as well as Appendix 9.3 Monitoring summary report.

10.2 Soils and PMLU Outcomes

10.2.1 Cattle Grazing PMLU

While an extensive list of species is seeded at Ensham including improved desirable perennials, native grasses, native and introduced legumes, shrubs and native tree species, rehabilitation monitoring has identified and characterised four rangeland systems/ areas which dominate the rehabilitation landscape. They include;

- **G1** – Rhodes dominated improved pastures
- **G2** – Buffel dominated improved pastures
- **G3** – Mixed Buffel and Rhodes pastures
- **G4** – Mixed Acacia and Eucalypt with improved pastures

Both Buffel (*Cenchrus ciliaris*) and Rhodes (*Chloris gayana*) are drought tolerant, persistent, deep rooted and tufted perennials (3P Grasses). They are suited to tropical and semi-tropical conditions and are quick to respond to light falls of rain, ideally suited to 300mm – 900mm rainfall areas. The pastures and vegetation above are suited to soils with salinity and fertility issues typically encountered at Ensham.

Furthermore, by employing appropriate construction techniques such as resspreading topsoil as available, deep ripping, applying fertilizer and hay mulch, this improves bedding elements. In turn, this enhances the ability of improved pastures to establish, thus protecting landforms from erodible forces and providing a basis for a sustainable grazing end land use.

10.2.1.1 Suitability for grazing

The suitability classification for grazing evaluates soils in terms of the potential to graze and finish cattle on improved pastures (QDME 1995, Shields and Williams 1991).

Typically, grazing systems in inland Central Queensland aim to produce young, finished, grassfed, export quality cattle without inputs other than pasture development. Most production is based around improved grass-legume pastures. Improved pasture development in many areas is

dominated by Buffel grass, although Rhodes grass, introduced Bluegrasses (Indian Bluegrass, Creeping Bluegrass), Purple Pigeon Grass and Panic species all have a role in certain situations. Legume establishment and species vary significantly depending on soil characteristics and microclimates. Commonly used legumes include Shrubby Stylo species, Burgundy Bean and Butterfly Pea (clay soils). Buffel is no longer used in Ensham's seed mix, but due to prevalence in surrounding areas, the rehab areas contain significant amounts of buffel

In order to sustain the largest PMLU for Ensham (Mine Domain 1 – grazing on 92% of all PMLUs) the soil quantity and quality characterisation of growth media material focuses on sustaining Class 3 – 4 classification. This is considered to be consistent with the underlying soil materials and treatments. Further, grazing assessments have been completed at Ensham, which indicate no detrimental effect on soil, pasture and landform (Greenfield 2017; 2018), and grazing outcomes that are consistent with or improved from regional expectations.

10.2.2 Native Bushland Corridor PMLU

Native Bushland Corridor rehabilitation areas will be located on the western side of the rehabilitated open cut mining areas, connecting Corkscrew Creek with the Nogoa River floodplain and the escarpment country, as well as connecting with Boggy Creek. The corridor will be located on areas of battered down highwall, that are expected to represent a unmined landform, where, apart from surface preparations, the landforms are not comprised of waste rock or otherwise placed material.

Rehabilitation will reflect the function of the PMLU, which is threefold:

- provide corridors that increase the available vegetation cover, and associated foraging opportunities in the locality. This is expected to be beneficial for native fauna species as well as increasing fauna movement opportunities across the landscape;
- prohibit vehicle access onto the rehabilitated highwall slopes. This sustainable control measure is seen as better practice than the conventional practice that includes constructing a berm, and, fencing of the highwall; and
- to reduce any visual impacts that may be associated with the rehabilitated open cut mining areas. The corridor will be consistent with, and blend into, the regional escarpment landscape.

As such, this PMLU is highly functional in nature, and the key aspect of concern is the establishment of trees and shrubs to provide the required vegetation structure to support the bushland corridor function. Although the selection of tree and shrub species is expected to reflect that which occurs within the Central Highlands area, the species assemblage is considered secondary to the function, which would be provided by any tree and shrub species.

The proposed soil management strategy to be applied to this PMLU has been established as successful at Ensham, and is expected to increase the likelihood of ensuring suitable tree and shrub establishment, as detailed extensively in Sections 6.2.1 and 8.1.2. The ecosystems to be emulated are typically rocky and void of topsoil.

11 REFERENCES

- AXM Environmental (2010). NEDO Forestry Trial: Summary of 2010 Monitoring Results. Emerald, prepared for Ensham Resources.
- CMLR (2005). Ensham Coal Mine Rehabilitation Resource Survey. Centre for Mined Land Rehabilitation. The University of Queensland. Australia
- Department of Industry, Science, Energy and Resources (DISER) (2016). Leading Practice Sustainable Development Program for the Mining Industry, Mine Rehabilitation (pp 51-52). Commonwealth of Australia, September 2016.
- Ensham Resources (2021). Rehabilitation Management Plan. Environmental Impact Management Plan (EIMP). Revision 3. January 2021
- Greenfields Agricultural and Environmental Services (2017). Ramp 22 - Grazing Assessment and 2017 Report, Ensham Mine.
- Greenfields Agricultural and Environmental Services (2018). Ramp 10, 22 and 82 – 2018 Grazing Assessment, Ensham Mine.
- Hansen Consulting (2006). Terrain, soils and land capability assessment. Ensham Central Project. Hansen Consulting, Brisbane.
- Hazelton and Murphy (2007). Interpreting soil test results, what do all the numbers mean? CSIRO Publishing. Melbourne.
- Hollingsworth Dames and Moore (1990). Ensham Coal Project Impact Assessment Study. Reference HOB449, Brisbane.
- Isbell and the National Committee on Soil and Terrain (2016). The Australian soil classification. CSIRO Publishing. Second edition.
- Kew G, Mengler F and Gilkes F (2007). *Regolith Strength, Water Retention, and Implications for Ripping and Plant Root Growth in Bauxite Mine Restoration*. Restoration Ecology. Vol 15, Issue s4, pp 54-64.
- Koch, J.M. (2007). Alcoa's mining and restoration process in South Western Australia. Restoration Ecology, Vol. 15, pp. s11–s16.
- Lardner, T.D. and Tibbett, M. (2013). Chapter: Deep ripping after topsoil return affects root proliferation and floristic diversity in a restored biodiverse forest after bauxite mining. Publisher: Australian Centre for Geomechanics. Editors: Mark Tibbett, Andy Fourie, Caroline Digby, pp.363-376.
- Premise Environment (2017). Ensham Resources Topsoil Review. Report No: 1701643/R01. Revision A.
- Queensland Department of Mines and Energy (1995) Technical Guidelines Index, Queensland Government via Department of Mines and Energy, Brisbane.

RGS 2018, Material Characterization and source term development for the Ensham Coal Mine Final Void Plan, September 2018.

Shields P and Williams, B 1991, 'Land resource survey and evaluation of the Kilcummin area, Queensland'. QDPI bulletin QV 91001.

Story R, Galloway R W and Gunn R H (1967). Land systems of the Isaac-Comet area. CSIRO Publishing. Melbourne

Szota C, Veneklass E, Koch J and Lambers H (2007). Root Architecture of Jarrah (*Eucalyptus marginata*) Trees in Relation to Post-Mining Deep Ripping in Western Australia. Restoration Ecology. Vol 15, Issue s4, pp s65-s73.

9.6 Landform Design Report



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Idemitsu Australia
Resources Pty Ltd
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APPENDIX 9.6 – LANDFORM DESIGN REPORT

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1 INTRODUCTION

The purpose of this report is to address the requirements of the PRCP by reviewing and assessing existing knowledge and data related to the landform design process for Ensham Mine. Detail of the landform design details are also essential for understanding what the post mining footprint will look like and how it will interact with surrounding areas. This document considers the landform design aspects relevant to rehabilitation and closure of Ensham Mine. It is noted that a rehabilitation landform concept has been in development for Ensham mine since 2018, and has been an iterative process. This report further describes the development and investigation of the landform design and discusses final outcomes.

This document covers all operational areas of Ensham Mine, which is an open-cut and underground coal mine located 40 kilometres (km) northeast of Emerald, near Comet, in Central Queensland. The open-cut mining operations comprised of Pits A, B, C, D, E, F, and Y Pit.

2 DEVELOPMENT OF LANDFORM DESIGN CONCEPT

Ensham operates the mine under the most current environmental authority (EA EPML00732813), dated 3 September 2020, under which condition H1 requires all surface areas significantly disturbed by mining activities to be rehabilitated to a safe, stable and non-polluting landform, with self-sustaining vegetation cover. Condition H2 also requires for all residual voids from open-cut mining activities must not cause any serious environmental harm to land, surface waters or any recognised groundwater aquifer, other than the harm constituted by the existence of the residual void itself in accordance with Ensham rehabilitation success criteria.

Historic versions of the EA also required for a detailed residual void study to be completed to inform the strategy around retained voids, and by extension, surface landforms to be retained at the end of mine life for Ensham. Extensive landform design for the overall Ensham site was completed to inform this study, and understand the subsequent performance of the residual voids proposed. The current EA is representative of the agreed outcomes from the residual void study.

Development of this landform design concept commenced with a collation of design criteria and literature review of regulatory publications, best practice guidelines, ACARP research reports, site documentation and historical information, , and previous landform studies completed. Relevant information on the rehabilitation and landform design from similar mine sites in Central Queensland was also utilised where available, and coupled with an understanding and review of site conditions. This process developed a range of landform and residual void design options which were subsequently investigated.

2.1 Option assessment process

Three main options were identified as part of the rehabilitation strategy for the Ensham Mine, as progressed through the residual void study for investigation. The options were developed after extensive consultation with stakeholders and community. The options are as summarised below:

- Option 1: Development of a Landform Levee - This option converts the existing maintained levee structures into permanent landforms capable of providing a 1:1000-year annual exceedance probability (0.1% AEP) flood immunity to residual voids in the floodplain. Landforms including waste rock dumps/spoil piles and highwalls, would be left as long-term stable structures, and the area inside the landform levee would primarily be returned to grazing use.
- Option 2: Provision of Flood Mitigation and Beneficial Use – Engineered intake structures are constructed through existing levee embankments to capture a small fraction of flood event flows from the Nogoia River, to feed water from the river to remaining open cut voids within the floodplain, providing both flood attenuation but also future use of retained water. Waste rock dumps/spoil piles and highwalls would be left as long-term stable structures. Existing levees would be retained as operational or engineered structures requiring inspection and maintenance, and the area not required for water storage would be returned to grazing use.
- Option 3: Backfill to Probable Maximum Flood (PMF) - Voids occupying the pre-mining floodplain would be backfilled to approximately original (pre-mining) ground levels. Parts of those pits straddling the boundary of the floodplain, would also be backfilled, whilst parts lying outside of that boundary would remain unfilled. Remaining waste rock dumps/spoil piles and highwalls would be left as long-term stable structures. Significant volumes of fill material would have to be sourced from other areas of the mine and significant areas of established rehabilitation redisturbed to enable this option.

2.2 Preferred option selection

After extensive investigation of the nature of, and potential impacts associated with all three options, a preferred option was selected and agreed between Ensham and Department of Environment and Science (DES).

Proposed Option 2 was not supported by government stakeholders, including Department of Agriculture and Fisheries (DAF), Department of Natural Resources, Mines and Energy (DNRME) and DES. While it was supported by local government and other local stakeholders, proposed Option 3 was not preferred by Ensham or downstream stakeholders, and was considered unfeasible.

The adopted preferred outcome was therefore a modified Option 1, where existing levee structures were to be retained and converted into permanent flood protection landforms. The modification was for the retention of high walls to maximise the area of land suitable for grazing on the low walls. It is noted that there was no agreement to provide for future beneficial use of the residual voids as water storages.'

The preferred option has the following key benefits:

- Eliminates afflux impacts for upstream landholders in a greater than 0.1% AEP event
- Eliminates any potential increased impacts on downstream landholders associated with widening the river floodplain.
- Eliminates the need to realign the Nogoanabranch.

Further, a native bushland tree corridor was agreed to be developed along the highwall side of the rehabilitated pits to provide connectivity between Corkscrew Creek and the Nogoanabranch floodplain.

3 KEY FACTORS OF RELEVANCE TO DESIGN CONCEPT

3.1 Landform areas to be rehabilitated

The extent of the pits and associated landform areas to be rehabilitated are as shown in Figure 3-1.

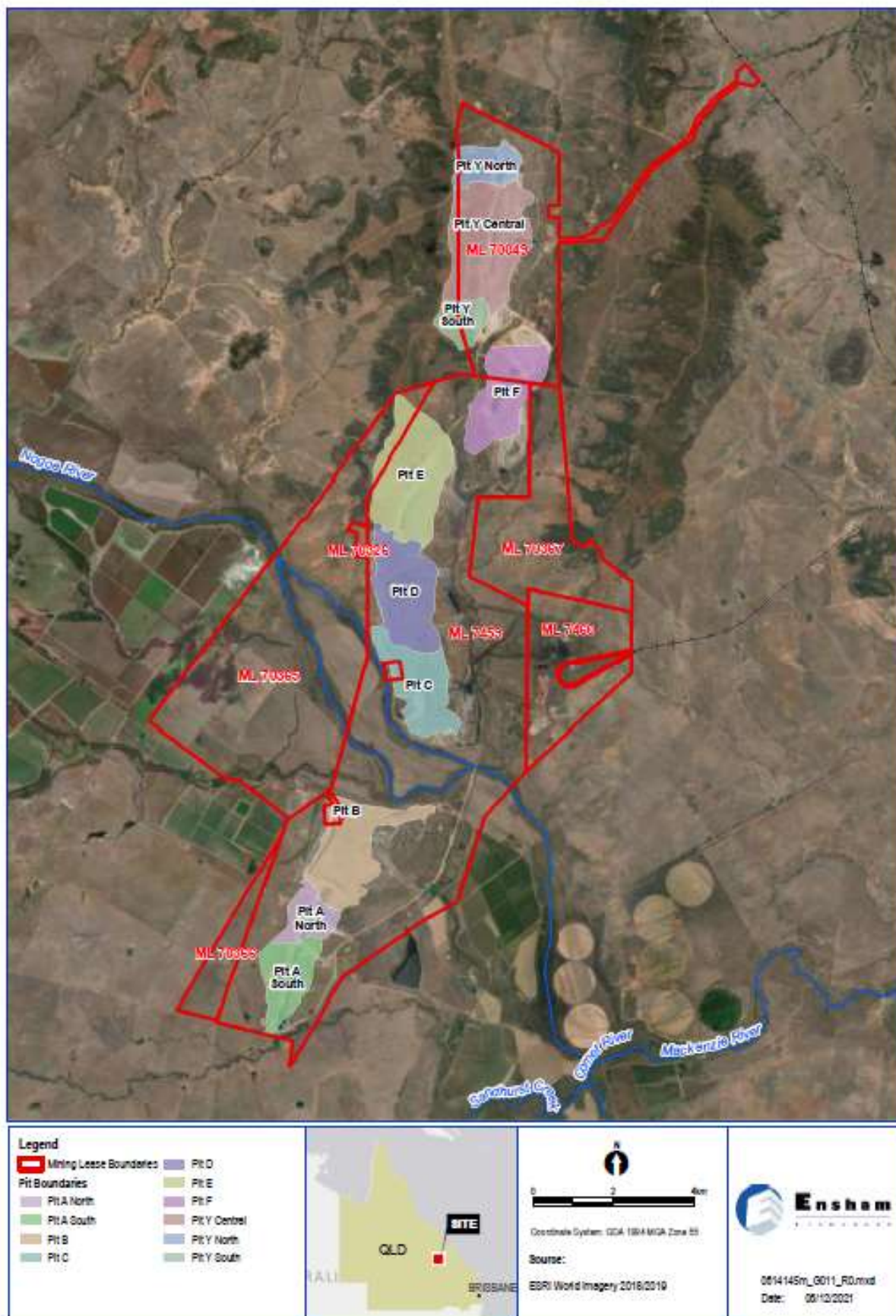


Figure 3-1: Location of landform rehabilitation areas and pits

3.2 Overall design principles

The Ensham EA requires all surface areas significantly disturbed by mining activities to be rehabilitated to a safe, stable and non-polluting landform, with self-sustaining vegetation cover. Residual voids must not cause any serious environmental harm to land, surface waters or any recognised groundwater aquifer. The implications of these requirements, as they can be managed or influenced by landform design, are described in the sections below.

3.2.1 Safety and stability

Altering natural ground shape invariably introduces a degree of instability, with a tendency for readjustment by way of mass soil movement, either by rapid catastrophic failure such as slumping, sliding; or gradual erosion and deposition through surface processes. Catastrophic failure can be remedied by reducing slopes or loading the toe of cuttings (buttressing), whilst erosional stability is dependent on several factors, including land slope, surface preparation and vegetation cover, which can be managed by landform design.

For the purposes of the landform design, the rehabilitation outcomes will adopt batter slopes on all landforms that exhibit a low risk of failure and consider the long term weathering properties of exposed materials. Possible future scenarios and fluctuations of water levels in the residual void and adjacent ground water have been considered. An assessment of geotechnical stability of landform levee structures has been completed as part of the design development process completed for the residual void project, which found the levee structures to be stable in the long-term (WSP, 2018).

The geotechnical assessment undertaken for the highwall and lowwalls, as part of the Residual Void project (WSP, 2018) completed an assessment of the long-term stability of Ensham landform features, and made recommendations as to maximum landform slopes, that have been adopted at Ensham. Limit equilibrium slope stability analyses were carried out to assess the overall slope factor of safety (FOS) of representative sections through the highwalls and spoil piles at Ensham. The results have informed landform slope and gradient design criteria, as detailed in Section 4.

3.2.2 Non-polluting

For the final landform to achieve an outcome of being non-polluting, water quality runoff must conform with EA completion criteria. Typical sources of pollutants after mine closure are:

- elevated levels of sediment from erosion of outward facing rehabilitated spoil dumps,
- overflow of residual void water with high levels of salinity into watercourses during periods of high rainfall; and
- leachate from spoil dumps that potentially contain acid forming (PAF) minerals or with elevated EC.

Material characterization of spoils at Ensham have indicated that these are benign, and do not contain PAF materials. The landform results in residual void catchments that are sufficiently small to

result in a low risk of spills to the surrounding watercourses for the adopted option. Erosion is a key consideration of concern, and has been detailed further in Section 3.3.

For the purposes of the landform design, the rehabilitation outcomes will minimise erosion potential of outward facing landforms comprising spoil material by adopting conservative slope gradients, as well as through topsoiling and revegetating slopes. The residual voids will result in a reporting catchment, with storage capacity that poses a low risk of spillage during wet weather events. Rehabilitation runoff samples are collected from outer facing slopes to demonstrate the final landform is non-polluting.

3.2.3 Able to sustain agreed PMLU

The final topography or landform of the site is dependent not only on the pre-mining topography but also by the mining method, and reshaping strategy adopted. Ensham has identified a reshaping strategy that promotes land capability. Slope characteristics are planned to be sufficiently gentle to prevent erosion of replaced soils at greater than sustainable rates.

To permit the revegetation of rehabilitated areas and undertake maintenance operations of pastures, slopes will be kept below a maximum slope (as outlined for each aspect of the site in the current EA (EPML00732813)) to permit the operation of agricultural equipment. All slopes will be suitable for grazing as the post-mining land use with relevant ongoing maintenance in the event of erosion caused by cattle activity on the slopes. Further, there are many existing rehabilitation paddocks on site that provide evidence of the capability and sustainability of the landforms designed for use of cattle, as further detailed in Appendix 9.2- PMLU Context Report and Appendix 9.3 – Monitoring Summary Report.

For the purposes of the landform design, Ensham will maximise potential land capability and minimise erosion potential by reducing batter grades where possible. The adoption of the supporting rehabilitation strategy has proven successful in prevention of erosion.

3.3 Environmental factors

Development of the landform design for rehabilitation and closure has required the synthesis of a wide range of technical and environmental factors, as well as constraints, into a cohesive design concept. This concept has addressed any underlying factors through design, but also responds to the specific requirements present for Ensham to ensure long-term environmental control and adequate performance. In many cases, the environmental factors have driven the design concept outcomes, including the following key parameters:

- spoil type
- appropriate slope criteria for each spoil type
- disturbed material and land
- the location and performance of adjacent watercourse
- floodplain interactions and protection

- rehabilitation drainage

As detailed in Section 3.2 above, the key environmental factor of relevance relates to the erosive potential of materials at Ensham. This has been further explored below.

3.3.1 Erosive stability

3.3.1.1 Achieving sustainable rates of soil loss (erosion)

Erosion is the greatest risk to any post-mining landscape in Central Queensland. Though historical rates of soil loss up to 40 t/ha/y were considered acceptable (for example see DME, 1995), the contemporary view is that erosion rates from rehabilitated landforms should be analogous to surrounding unmined areas. This must be demonstrated by monitoring of surrounding unmined areas, which is difficult in practice. Williams (2000) summarised variously estimated soil losses and found for mixed pasture and woodlands, rates have a maximum of around 4 t/ha/y.

Coincidentally, Grigg *et al.* (2001) conclude the rate of soil loss in mine rehabilitation should not exceed the rate of soil renewal, which is less than 4 t/ha/y. It is well established that high vegetation percentages reduce erosion in rehabilitation, even on steep slopes (Carroll *et al.* 2000; Loch 2000). So *et al.* (1998) studied erosion of 16 spoils and 16 soils from 15 coal mines throughout Queensland and found the potential impact of vegetation on erosion from rehabilitated soils was “enormous”. Under vegetation, infiltration capacities increase greatly, soil structure is improved, and erosion can be greatly reduced. So *et al.* (1998) suggest 30 to 40 % vegetation cover will be required to reduce erosion to acceptable levels.

For sloping rehabilitation, rates higher than 50 % were recommended by Grigg *et al.* (2001). Carroll *et al.* (2001) found rates of erosion from 10 % and 20 % gradient spoil rehabilitation were reduced to <1 t/ha/y with groundcover >50 %.

Other research shows that high levels of vegetative cover reduce erosion to minimal levels, even on very steep slopes (Carroll *et al.* 2000; Carroll and Tucker 2000; Loch 2000). Loch (2000) studied erosion at Meandu mine and found, as simple rule of thumb, a level of 50 % vegetative cover was adequate to control erosion.

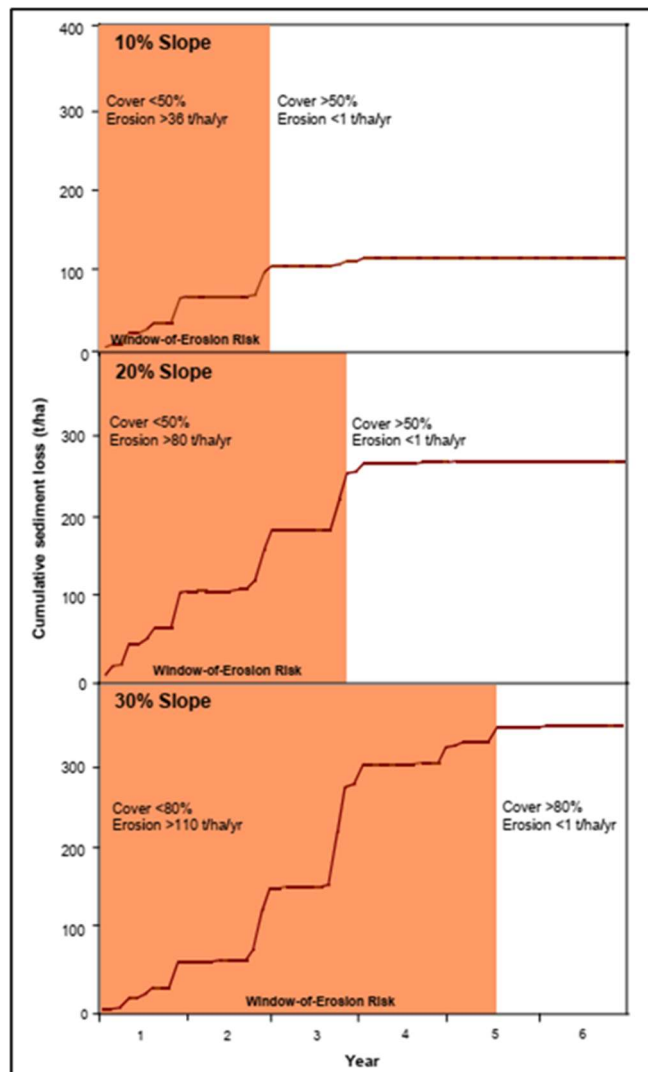
The period when soil is unvegetated and vulnerable to erosion and unsustainably high rates of soil loss presents a significant *window of erosion risk* for rehabilitation (Carroll *et al.* 2000; Carroll and Tucker 2000; Loch 2000).

Carroll *et al.* (2001) studied runoff and erosion in field experiments at three Central Queensland coal mines and demonstrated that groundcover takes longer to establish on steeper slopes (

Figure 3-2), thus extending the window of erosion risk when the landform can fail.

Figure 3-2 Window of erosion risk and cumulative soil loss for different slope gradients (Carroll *et al.* 2001)

So *et al.* (1998) measured the rate of erosion-derived sediment delivery from 32 bare soils and overburdens in Central Queensland at slope gradients from 5 to 30%. Unremarkably, sediment delivery rates increased linearly with slope (Figure 3-3) and with slope length. The effect of increasing slope gradient from 5% to 30% was a 12-fold and 4-fold increase in sediment delivery rates for soils and spoils, respectively.



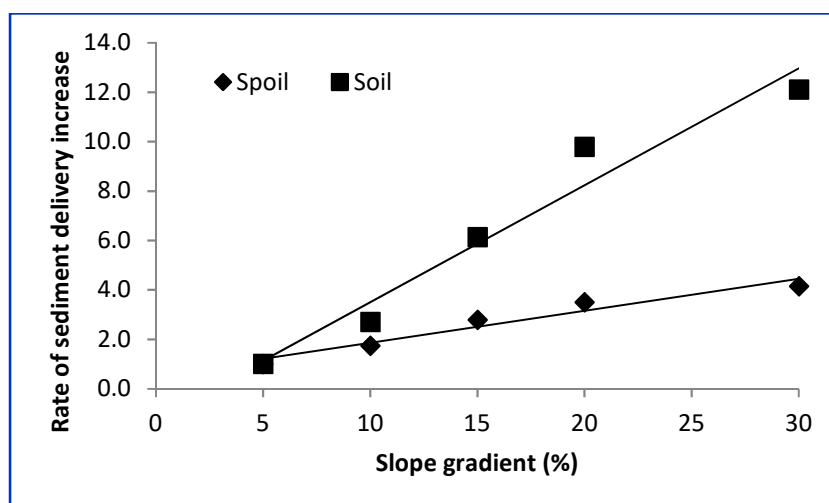


Figure 3-3 Effect of slope gradient on the rate of sediment delivery (So *et al.* 1998)

With consideration of material characteristics and more than 40 years of industry-led research and practice, Ensham has determined the following typical design objectives to control erosion on slopes, which is also reflected within the conditions of the current EA.

- 1 Tertiary overburden slopes, regardless of soil type, will typically have:
 - Gradients $\leq 10\%$, and
 - Lengths $\leq 200\text{m}$, variable depending on the size of the contributing upper catchment, then construction of a bench of minimum width of 10m.
- 2 Permian overburden slopes, regardless of soil type, will typically have:
 - Gradients $\leq 15\%$, and
 - Lengths $\leq 100\text{m}$, variable depending on the size of the contributing upper catchment, then construction of a bench of minimum width of 10m.

There is considerable variation in the spoil composition with higher sandstone component spoils being more competent than those with higher mudstone / siltstone composition.

3.3.2 Suitability requirements for PMLU

3.3.2.1 Land suitability requirements for beef cattle grazing

More than 90 % of rehabilitation at Ensham has a target PMLU of beef cattle grazing, which is in keeping with the historic "Duckponds" property being primarily a grazing property. Determination of rehabilitation suitability requires evaluation of soil and landform attributes based on the requirements for beef cattle grazing using current technology and management.

Five land suitability classes are defined for use in Queensland, with land suitability decreasing progressively from class 1 to class 5. These classes are used to describe an area of land in terms of suitability for a particular land use which allows optimum, sustainable production using current technology, while minimising degradation to the land resource in the short, medium or long term.

Land is considered less suitable as the severity of limitations for a specified land use increase, reflecting:

- reduced potential for production.
- increased inputs required to achieve an acceptable level of production.
- increased inputs required to prepare the land for successful production.
- increased inputs required to prevent land degradation.

The five land suitability classes are summarised and described in detail in Table 3-1.

Table 3-1 Land suitability classes (from DNRM/DSITIA 2013)

Class	Suitability	Limitations	Description
1	Suitable	Negligible	Highly productive land that is well suited to the proposed use.
2	Suitable	Minor	Land with limitations that either constrain production, or require more than the simple management practices of class 1 land to maintain sustainable production.
3	Suitable	Moderate	Land with limitations that either further constrain production, or require significant inputs to ensure sustainable use.
4	Marginally suitable	Severe	Land which is marginally suited for a proposed use and would require major inputs to ensure sustainability; often the inputs required may not be justified in terms of the benefits to be gained from using the land for a proposed use and the land is considered presently unsuitable for that use.
5	Not suitable	Extreme	Land with extreme limitations that preclude any possibility of successful sustained use of the land in the proposed manner.

Classes 1 to 3 are considered suitable for a specified land use because the benefits from using the land (for that particular use) outweigh the inputs required to initiate and maintain production. Class 4 is also used in situations where reducing the effect of a particular limitation may indicate production is possible, but additional studies are needed to determine the feasibility of such actions, e.g. fertilisation.

In contrast, there is no doubt regarding the long-term suitability of Class 1–3 lands or the overall unsuitability of Class 5 land. If the majority of an area is considered Class 5, the land is considered to have limitations that in aggregate are so severe that the benefits do not justify the inputs required to initiate and maintain production. Many Class 5 lands have physical characteristics that totally preclude any form of development, e.g. mountains, and will always remain unsuitable for agriculture.

It is however noted that areas of Class 5 land do occur naturally within grazing paddocks on the 'Duckponds' property, and in aggregate, so not result in overall limitations to the usability of the land for grazing.

4 ENSHAM FINAL LANDFORM

Guided by the abovementioned principles and criteria, Ensham have designed a final landform in adherence to the objectives, domains and the indicative plan in the land outcome document to achieve the rehabilitation objectives. Development of the landform took into consideration limitations, criteria and rehabilitation strategies to enable the development of successful rehabilitation.

Table 4-1 provides a summary of design treatments adopted for each of the main parts of the Ensham site as relevant. Visualisation of the overall post-mining landform is provided as Figure 4-1.

Table 4-1 Adopted overarching landform design criteria

Landform Feature	Treatment
All areas	- Inward facing slopes of rehabilitated open cut mining areas to be free draining to approved water areas - A South, E, F South, F North, Y South, Y Central and Y North are to be partially backfilled such that no groundwater will daylight - All slope designs must be equal to or exceed a Factor of Safety of 1.5 - Maximum dimensions for groundwater daylighting areas as per EA requirements
All waste rock dumps/spoil piles landforms/ landform levees	- Free draining landform with no water damming behind the landform toe, Drainage incorporated into the design, particularly from highwalls to groundwater daylighting areas - All watercourse facing slopes to be 1V:6.7H (15%) and constructed from suitable compacted levee building material, finished with topsoil and grass - Void facing embankments to be 1V:6.7H (15%) where space permits, where constrained by the proximity of void regrade extents, batter slopes to be reduced to 1V:4H - Landform slopes - Tertiary material – slopes between 0 – 10% - Weathered Permian material – slopes of 0 – 15% - A bench of at least 10 m will be provided separating the inward toe embankment of the landform and adjacent edge of void stabilization regrade - Minimum of 2km width in the floodplain (between B & C pit). Landform based on 0.1%AEP flood modelling surfaces + 0.5m freeboard - Raising of landform to be undertaken based on a central raising where space permits, where constrained by proximity of a residual void, raising to be undertaken from the watercourse side - Line the river facing embankments at sharp changes in alignment, where turbulence could occur, with hard, durable rock rip rap.
Outward facing spoil slopes	- Regrade to a slope of 10% for Tertiary spoil rehabilitation , with a bench every 200m - Regrade to a slope of 15% for Permian spoil rehabilitation , with a bench every 200m
Inward facing low wall slopes	Maximum of 25% slopes

	• Maximum of 10% inward facing slopes in Domain 1 between 15-25% slopes (and encased by slopes 0-15%) • Incorporate a 10m bench at approximately every 75m of 25% slope length
Highwalls and endwalls	• Highwall slopes assesses as stable by a suitably qualified person, as follow: ○ Tertiary material – maximum slope 1V:3H (18° or 33%) ○ Weathered Permian material – maximum slope of 1V:3H (18° or 33%) ○ Fresh Permian material – Competent highwalls maximum slope of 275%, incompetent maximum 50% slopes. ○ minimum of 5m bench at interface between Weathered and Fresh Permian • Endwalls are to be treated the same as highwalls. ○ The exception is B Pit Northern endwall which will be filled at a 15% slope (as buttressing to reduce the slope of the residual void adjacent to the Nogo River) ○ A South, F & Y pits highwalls must be reshaped to a maximum of 25% slope.
Land bridges/ ramps	• E pit land bridge dozed down, partially backfilling E pit to the point that E pit will drain into D pit. • Ramp batters are to be treated the same as the inner facing low wall slopes.

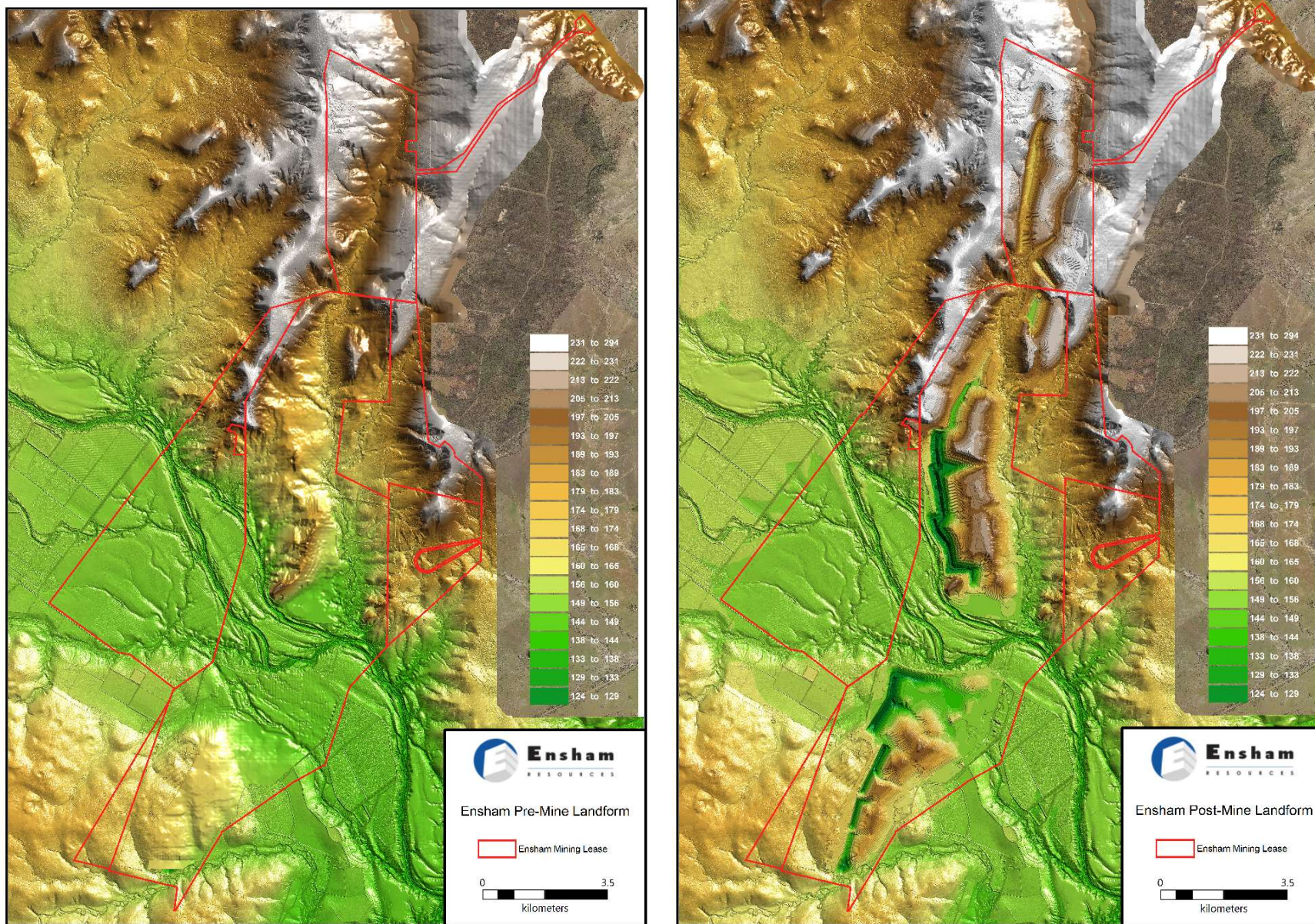


Figure 4-1 Ensham visualisation of pre-mining (to left) Vs final landform (to right)

4.1 Summary of key features

Landform design characteristics have been shown for Ensham in Figure 4-2. Key features of each of the main rehabilitated landforms is as identified, including footprint and height (including lift heights), as well as other relevant factors.

4.1.1 AB Pit

Table 4-2 details the key features of each part of the AB pit area, including each of the key landform features.

Table 4-2 Landform features for AB pit area

Landform footprint (excluding completed rehabilitation)	Pit A South – 224.4 ha Pit A North – 143.3 ha Pit B – 394.7 ha
Landform height	Pit A South – 188 m AHD, 30 m high from natural ground Pit A North – 199 m AHD, 35 m high from natural ground Pit B – 196 m AHD, 29 m high from natural ground
Landform slope gradient & typical length	Pit A South – up to 15% linear, 30-50m long Pit A North – up to 10% linear, 30-60m long Pit B – up to 10% linear, 30-60m long
Lift height	~10 m
Void footprint	Pit A South – 2.6 ha Pit A North – 13.5 ha Pit B – 31.8 ha
Highwall depth	Pit A South – 120m AHD, 50 m below natural ground Pit A North – 117m AHD, 53 m below natural ground Pit B – 85m AHD, 70 m below natural ground
Surface water philosophy	Water shedding
Surface treatment	Revegetated
Relevant PMLUs	Mine domain 1 – Cattle grazing Mine domain 4 – Native bushland corridor Mine domain 7 – Flood protection landform
Relevant NUMAs	Mine domain 5 – Groundwater daylighting water areas Mine domain 6 – Highwalls

4.1.2 CDE Pit

Table 4-3 details the key features of each part of the CDE pit area, including each of the key landform features.

Table 4-3 Landform features for CDE pit area

Landform footprint (excluding completed rehabilitation)	Pit C – 308.9 ha Pit D – 384.7 ha Pit E – 507.5 ha
Landform height	Pit C – 215 m AHD, 55 m high from natural ground Pit D – 215 m AHD, 50 m high from natural ground Pit E – 230 m AHD, 60 m high from natural ground
Landform slope gradient & typical length	Pit C – up to 10% linear, 50-70m long Pit D – up to 10% linear, 30-60m long Pit E – up to 10% linear, 40-70m long
Lift height	~10 m
Void footprint	Pit C – 42.6 ha Pit D – 58.3 ha Pit E – N/A
Highwall depth	Pit C – 65 m AHD, 85 m below natural ground Pit D – 75m AHD, 80 m below natural ground Pit E – 155m AHD, 20 m below natural ground (backfilled)
Surface water philosophy	Water shedding
Surface treatment	Revegetated
Relevant PMLUs	Mine domain 1 - Cattle grazing Mine domain 4 – Native bushland corridor Mine domain 7 – Flood protection landform
Relevant NUMAs	Mine domain 5 – Groundwater daylighting water areas Mine domain 6 – Highwalls

4.1.3 FY Pit

Table 4-4 details the key features of each part of the FY pit area, including each of the key landform features.

Table 4-4 Landform features for FY pit area

Landform footprint (excluding completed rehabilitation)	Pit F- 338.9 ha Pit Y South – 123.3 ha Pit Y Central – 535.9 ha Pit Y North – 149.4 ha
Landform height	Pit F - 230 m AHD, 45 m high from natural ground Pit Y South – 225 m AHD, 10 m high from natural ground Pit Y Central – 235 m AHD, 20 m high from natural ground Pit Y North – 240 m AHD, 35 m high from natural ground
Landform slope gradient & typical length	Pit F – up to 10% linear, 40-60m long Pit Y South – up to 10% linear, 20-30m long Pit Y Central – up to 10% linear, 30-55m long Pit Y North – up to 10% linear, 15-40m long
Lift height	~10 m
Void footprint	Pit F – N/A Pit Y South – N/A Pit Y Central –N/A Pit Y North – N/A
Highwall depth	Pit F – 152m AHD, 40 m below natural ground (backfilled) Pit Y South – 175m AHD, 25 m below natural ground (backfilled) Pit Y Central – 170m AHD, 60 m below natural ground (backfilled) Pit Y North – 210m AHD, 30 m below natural ground (backfilled)
Surface water philosophy	Water shedding
Surface treatment	Revegetated
Relevant PMLUs	Mine domain 1 - Cattle grazing Mine domain 4 - Boggy Creek diversion Mine domain 4 – Native bushland corridor
Relevant NUMAs	N/A

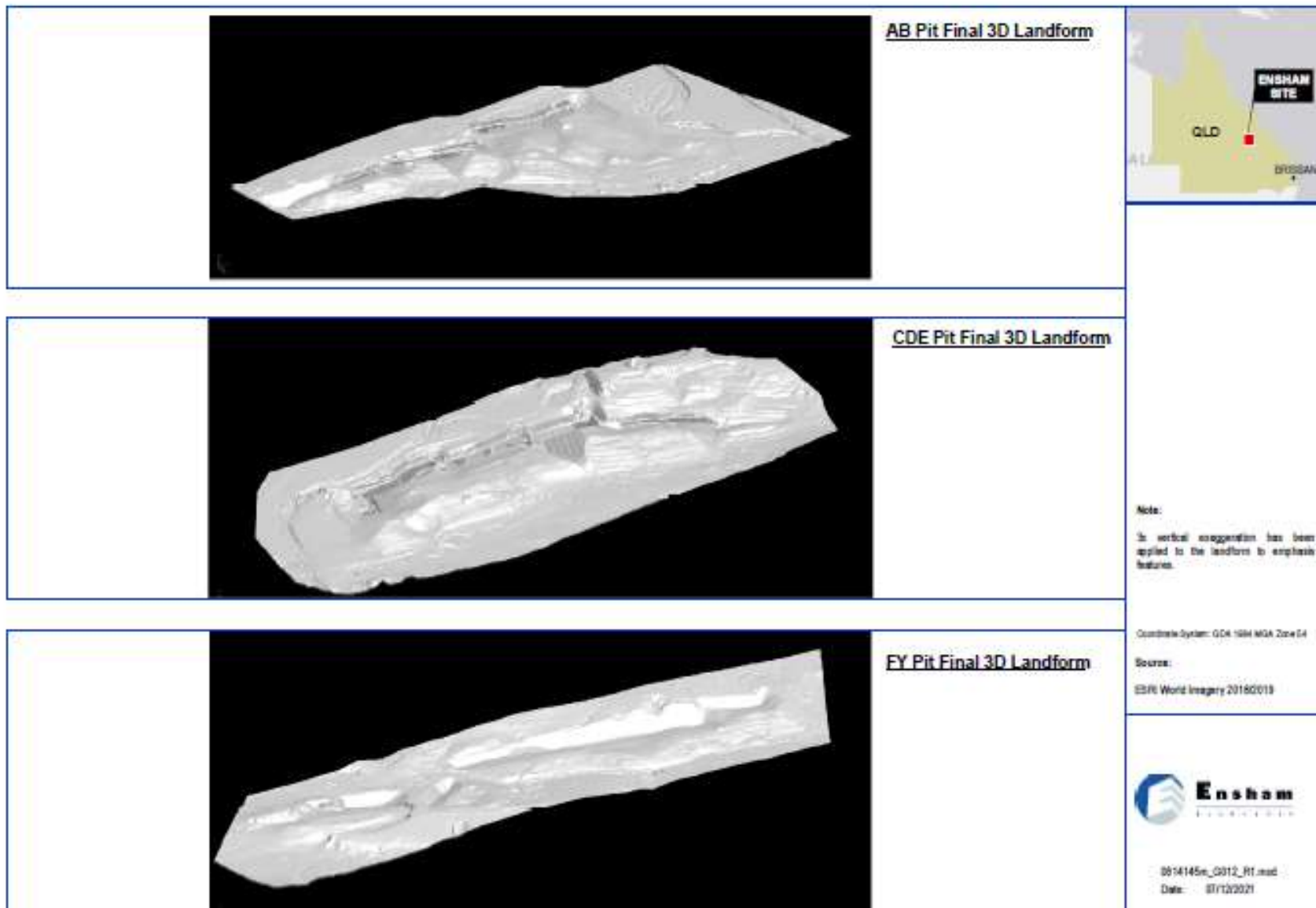


Figure 4-2 Ensham Final 3D Landform

5 LANDFORM PERFORMANCE ASSESSMENT

5.1 Geotechnical stability

A geotechnical investigation was undertaken as part of the residual void study to explore stability requirements for the final landform design, in terms of final landform geometry. Slope stability analyses were carried out to assess the overall slope factor of safety (FOS) of representative sections through the exposed highwalls at Ensham (WSP, 2018). The analysis was carried out using SLOPE/W considering ACARP Rehabilitation of Highwalls, November 2006, Pells et al, 2015; Pells et al, 2007 and Pells et al, 2005.

Geotechnical stability considers sudden and catastrophic surface failures such as gross rock failures, major landslips and highwall collapses. The following key recommendations were made and have subsequently informed the landform design as detailed below:

- Outward facing spoil slopes – analysis identified that slopes of 1V:4H (25%) would be considered stable over the long-term under all envisaged conditions, however based on experience learnt from rehabilitation practices on site to prevent erosion, the spoil slope criteria were set as 10% (1V:10H) or 15% (1V:6.7H) depending on whether the spoil is Tertiary or Permian based material, which is represented in final landform topography. These slopes are flatter than those recommended for geotechnical stability, and hence will have a low risk of failure.
- Inward facing spoil slopes – sloped at 10 or 15% were considered geotechnically stable over the long term.
- Highwall – geotechnical analysis indicated that highwall materials be set-back at angles of 1V:1H for fresh Permian, 1V:2H for weathered Permian, and 1V:3H for Tertiary materials to allow for long-term weathering of exposed materials with associated geotechnical weakening. Final landform profiles also incorporate partial backfilling of all voids to accommodate surplus spoil material generated by reducing spoil slopes, effectively buttressing fresh Permian profiles. Those surfaces not buttressed have been set back to 1V:1H to comply with geotechnical recommendations. Any material above the bottom line of weathering profile provided by Ensham, will be regraded at 1V:3H, which is flatter than geotechnical recommendations for weathered Permian rock, and in compliance with that recommended for Tertiary materials.

A FOS of 1.5 was adopted as the minimum required for long-term stability for final landforms. The modelling results for representative highwall sections typically encountered in A to E-pits have an overall FOS of >1.5 and are expected to be long-term stable in their current condition based on limit equilibrium analyses.

For F-Pit, model results indicate Tertiary clay soils in their current configuration have a FOS of 1 to <1 and require regrading for long-term stability. Weathered Permian materials exposed in the pit

walls in Y-pit also require regrading of Permian and Tertiary materials to improve their short-term and long-term stability.

The Slope/W results indicate that the weathered Permian and fresh Permian materials exposed in the highwalls and endwalls of the open cut voids at Ensham have an overall FOS of >1.5 to 3 and would therefore be considered long-term stable in their current state and under conditions expected in the longer-term. Pits which have exposures of weathered Tertiary clay or steeply cut weathered Permian have FOS of <1.3 to <1 and thus, have required regrading.

It is noted that the highwall and lowwall criteria contained within the current EA (EPML00732813) were developed on the basis of these findings, and on assessment of a range of highwall options, and are consistent with this PRCP.

5.2 Erosional stability

In addition to geotechnical stability, the landform must also exhibit stability against longer term, more gradual erosion. Slope angle, length of slope, and vegetation cover are important factors in the control of erosion, and can be incorporated in landform design to manage erosion characteristics of the final landform. Site practices for spoil rehabilitation have been developed over years considering the erosional stability of rehabilitated areas

Ensham has had success rehabilitating Tertiary spoil dumps with 10% slope regrades, coupled with maximum slope lengths of 200m and 10m wide benches as slope breaks. Permian spoil has been found to be erosionally stable at regraded slopes of 15% with 100m slope lengths.

Rehabilitation construction practices include topsoiling, deep ripping, grass seeding, and hay mulching. Benches are not topsoiled, but are seeded with tree and shrub seed stock as the absence of soil reduces competition between fast establishing grasses and the desired tree/shrub community.

The distribution of typical spoil material has been used to guide landform design (as per Figure 5-1 below). As can be seen, spoil dumps for A-pit through to E-pit have void facing slopes comprising mostly Permian material, and hence inward facing slopes have been regraded to a maximum slope of 15% in these areas. Spoil dumps at the northern F and Y pits are characterised by a higher proportion of Tertiary material, and hence for these pits a maximum spoil regrade slope of 10% has been adopted. Quaternary spoil adjacent to A-pit has also been regraded at 10%, as review of rehabilitated slopes in this area has shown that 10% has been used previously and is performing well.

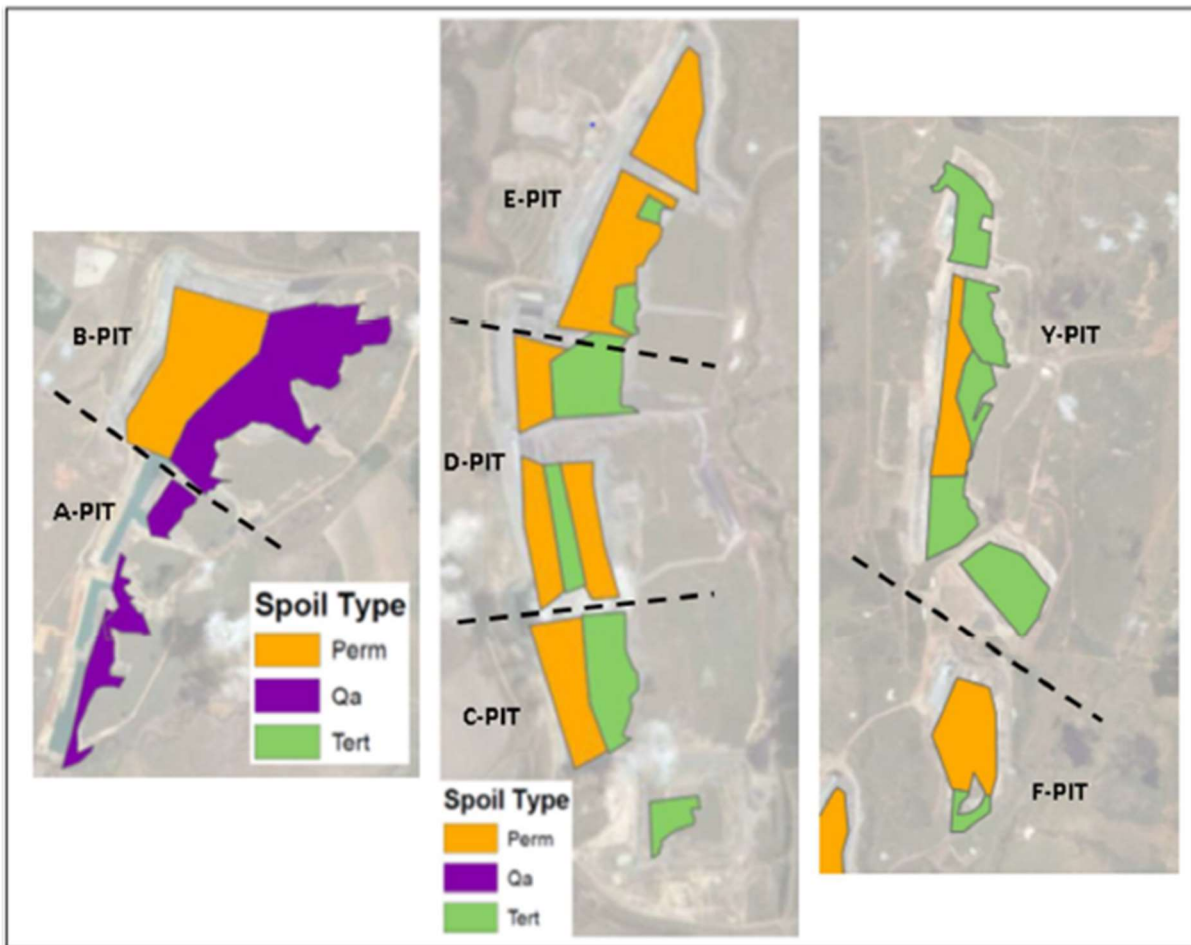


Figure 5-1 Approximate surface spoil characterisation by pit

5.3 Landform evolution modelling

5.3.1 Assessment methodology

The stability of final void and landform shaping options was assessed, with associated inspection of site materials and typical vegetation cover levels achieved on rehabilitated areas (Landloch, 2016). Sampling of key site materials (for topsoils and wastes), chemical and physical characterisation of the materials, as well as the measurement of key erodibility parameters for topsoils was completed.

This information was subsequently used to inform both SIBERIA and WEPP models, to in turn provide slope design rules for the mine planning process. Modelling considered and predicted erosion over a 500-year period, considering the range of topsoil available on the site (Landloch, 2016).

5.3.2 Benchmarking

An assessment of long-term erosion rates has been conducted, and it is noted that although there are no agreed standards or guidelines for acceptable erosion rates, there is an extensive body of literature and scientific practices that can be used for benchmarking. There is also a regulatory expectation that erosion will be minimised, and vegetation cover established.

In this way, it is expected that the erosional performance of the landform will ultimately approach an acceptable reference point or benchmark from the surrounding area. Based on the available data, identification of a singular value, or acceptable range, is not available and it is highlighted that landform performance overall must be taken as a matter of judgement.

However, a holistic approach is valuable whereby a range of values relevant to the local environmental factors can be applied to Ensham. Relevant measured values for acceptable rates of erosion range from 0.75 t/ha/yr (Waters, 2004) to 8 t/ha/yr (Bowen et al. 1998). Based on information around gully development, it was also recognised that there would be a ceiling to selected values. Significant gully and rill development is a metric of slope stability and long term performance. Studies by Klingbiel and Montgomery (1961), and Howard and Loch (2019), suggest an erosion rate cap of 10 t/ha/yr, as acceptable, to mitigate the formation of rills and gullies.

Therefore, a range of erosion rates of approximately 5-10 t/ha/y have been adopted as the benchmark against which modelled outcomes are compared. This is consistent with observed rates within the Bowen Basin, which is expected to also meet the PRCP Guideline requirements.

5.3.3 Outcomes of modelling

SIBERIA modelling considered general areas of predicted erosion over 50 and 500 year periods considering two vegetation scenarios, with grazed and ungrazed pastures. Models were set up for various pits with topsoil parameters that are representative of one of three typical topsoil types encountered on site.

Reporting was based on typical control areas in the landform, including steep sections of spoil reporting to the void, saddles between higher areas in the landform, and batter slopes on re-shaped

landform (existing rehabilitated landform). No comment was made regarding highwall erosion. Results were provided for each typical control section for each pit, for grazed and ungrazed vegetation conditions, with predictions of the change in ground level (mm) due to erosion or deposition, and erosion rates (t/ha/y).

The results predicted that erosion of “landform batter slopes” in the A and B pit areas where black, cracking clay is the prevalent topsoil used for rehabilitation, would be the most extensive and severe outcome for the Ensham site, with a predicted landform erosion of 52 mm in 500 years for grazed conditions and 15 mm for ungrazed. This equated to erosion rates of 1.3 to 0.4 t/ha/y for grazed or ungrazed conditions respectively, which is deemed as acceptable and within the proposed benchmark values. This is not considered to be a high amount of erosion over the modelled timeframe, and the rates are quite sustainable, indicating that the batter slopes are at a gradient that is stable to erosion (Landloch, 2016).

It is also notable that there is no visual evidence of erosion on existing areas of rehabilitated spoil during site visits conducted to complement the SIBERIA modelling, and it is therefore concluded that spoil landform with rehabilitated slopes of between 10 – 15%, combined with topsoiling and revegetation as is currently practiced, will yield an erosionally stable final landform.

5.3.4 Model limitations

SIBERIA is a computer model for simulating the evolution of landscapes under the action of runoff and erosion over long times scales. Due to SIBERIA being a model, it can only work as accurately as the input data utilised as it cannot discriminate between good or poor data. Landscape evolution models (LEMs) such as SIBERIA require a digital elevation model (DEM) to represent the landscape surface. The DEM needs to be accurate and reliable, as well as at a resolution that represents the landform feature of interest adequately.

It is also noted that the level of elevation is held as consistent across the whole model timeframe, which is not likely to occur in the real world. The surface elevation cannot be modified in the model, as the slope is altered in response to erosion. Therefore, SIBERIA should be taken as an extreme ‘worst case’ scenario because it does not account for weathering, surface armouring and soil maturation over time, all of which would likely result in attenuation of erosion as it occurs. It also cannot consider gully and tunnel erosion from interactions between the underlying overburden and cannot account for ‘non-typical’ environmental conditions such as the effects of climate change.

Similarly, the model assumes the entire catchment has the same hydrology parameter values. As a result, the simulation results cannot be considered to be an entirely reliable indication of the erosion and deposition likely to occur on the landform, particularly on the disturbed areas.

No model is a perfect representation of field processes and the reliability of any predictions made using LEM are open to question. SIBERIA is the worst case scenario model provided, and any external altering factors such as the erosion altering the hillslope means that once constructed the landform design is likely to have reduced erosion impacts due to unaccountable factors that the model simply cannot incorporate or consider.

5.4 Highwall erosional stability

Investigations in Central Queensland have considered and assessed the long-term erosion of pit walls that may occur. A recent study assessed erosional stability of highwalls and the consequential effects on final void stability and footprint (Henderson, 2018). The results indicate that highwalls could retreat horizontally between 10 m for moderately weathered overburden, and 30 m for highly erodible Tertiary overburden over the 200-year period of study, and hence if no highwall stability treatment is applied, long term erosion at pit walls could impact adjoining land in most cases.

The proposed landform design incorporates high and endwall treatment by way of flattened slopes (or laybacks) to account for material weathering and weakening, with 1V:3H in the weathered zone, including Tertiary Clays, and 1V:1H in fresh Permian material.

These measures will reduce the retreat of highwall over time.

6 LANDFORM REHABILITATION PROCESS

6.1 Rehabilitation construction methodology

Ensham have a long history of completing rehabilitation and the following construction process has been developed from these proven rehabilitation methodologies. The key steps for the completion of rehabilitation (as it pertains to rehabilitation works) for all PMLU areas, is as follows:

- 1 Remove infrastructure if required
- 2 Spoil and soil laboratory testing
- 3 Undertake a contaminated land assessment where required
- 4 Reshape overburden (earthworks) as required to achieve landform design parameters paired to land suitability requirements and spoil types. A deep rip may be completed on the spoil profile after reshaping is completed
- 5 Apply ameliorants and surface treatments as required
- 6 Respread topsoil to minimum prescribed depth
- 7 Rip profile to minimum prescribed depth, with a lighter ripping typically completed here to disturb the topsoil surface as well as add contour lines for erosion control and seed/water capture
- 8 Apply seed and fertiliser
- 9 Apply hay mulch as required

Rehabilitation and landform design at Ensham occurs throughout the rehabilitation planning processes. Concept design is a high level design intended to address whole landforms and is largely

intended to align with site planning activities and timelines. The mine then takes the design concept and develops an understanding of the operational scheduling constraints and requirements to determine when areas will become available.

Annual rehabilitation programs are then defined, with detailed landform and drainage design progressed for these areas at a higher resolution. The intent is to develop design outputs which can support construction, whilst still remaining true to the design principles and philosophy as established for Ensham. However, these general principles may be modified with appropriate justification during the detailed design phase to ensure the most appropriate outcome is achieved.

The following sections provide more detail of the key processes steps for completing rehabilitation.

6.1.1 Earthworks to reshape overburden

Ensham reshape overburden/spoil using available operational mining equipment (e.g. haul trucks for spoil placement and track dozers for shaping landforms) and will progressively shape available areas into suitable final landforms. Slope specific designs will be developed for each rehabilitation slope and will align with the design concept.

A conformance to design process will be used to meet Quality Assurance / Quality Control (QA/QC) requirements, whereby survey of bulk push areas are tracked and reviewed to highlight any variations to design and targets. Where small discrepancies / variations to design are identified during the conformance to design process, remediation of the areas of concern will typically be completed using more refined equipment such as a grader as needed.

Post-mining landforms at Ensham are designed to not concentrate overland flow and therefore, do not require contour banks or rock-lined waterways to transport overland flow downslope and off rehabilitation. Rather, landform design is sympathetic to natural geo-fluvial processes.

Slope lengths are broken by benches to slow runoff velocities without concentrating flow and to encourage infiltration and soil profile wetting. This limits the volume and velocity of runoff and encourages revegetation. Therefore, the constructed landforms can be considered to be 'water-retaining' rather than 'water shedding' landscape features.

6.1.2 Amelioration

Appropriate machinery will be used to incorporate ameliorants into rehabilitation areas. The type of machinery application, as well as timing and process of application, will be strongly driven by the underlying purpose of amelioration. The nature of the product to be incorporated will also likely influence the construction or application methodology. Amelioration application will likely occur subject to advice of specialised soil science practitioners and will be based on laboratory analysis of the soil type and underlying spoil type for the specific rehabilitation area.

6.1.3 Deep ripping

Deep ripping of newly created Anthrospols to the depth of the rooting depth for perennial plants (90 cm) is essential for achieving satisfactory rehabilitation at Ensham. Deep ripping has several

advantages for rehabilitation. The single greatest advantage is creation of macro-porosity that increases rainfall infiltration and furrows that reduce runoff and erosion (Gardner 2001; Koch 2007). Other benefits include the following:

- Reducing soil bulk density (Henderson, 1989) caused by equipment compaction of subsoil (spoil) during landform construction.
- Increases profile recharge and plant available water (Kew et al, 2007).
- Facilitates deeper rooting by establishing vegetation, improves root architecture and increases use of deep subsoil moisture (Szota et al, 2007; Lardner and Tibbett, 2013).
- Can be used to mechanically incorporate gypsum into subsoils (spoils), lessening the time required for gypsum to dissolve and react with the subsoil solid phase.
- Creates a surface seedbed for seed germination with good soil-seed contact (also provided by shallow ripping) (Lardner and Tibbett, 2013).

Practice at Ensham is to use a single or double tyne and rip at close intervals with overlapping track lines. To improve ripping outcomes and achieve greater tillage at depth, a wing-like structure is typically fitted to the shank of the tyne directly behind the point. This lifts and tills the soil profile across a broad front. Deep ripping is typically enough to create a friable seed bed into which seed is sown.

6.1.4 Topsoiling

Suitable available machinery will be used to relocate topsoil from stockpiled locations, and place onto the rehabilitated surface, at an average depth in accordance with the requirements for each PMLU. Topsoiled areas will be lightly ripped (following a similar process to that detailed in Section 6.1.3) immediately prior to seed spreading, to prevent surface soil sealing and crusting and to encourage establishment of vegetative cover. This shallower ripping 'keys' the topsoil into the underlying spoil and creates micro-topography that assists with moisture harvesting and creation of a suitable surface for seed lodgement.

If any opportunities exist for direct placement of topsoil material, this will be prioritised so as to retain the natural seed bank, organic matter and soil micro-organisms within the topsoil source. Prior to the commencement of mine rehabilitation, soil sampling will occur to determine amelioration and fertiliser requirements (if any).

Potentially weed infested topsoil stockpiles may also be "scalped" of the outer layer of the topsoil dump to limit the spread of weeds in rehabilitated areas. Equally, if a tree seed PMLU cover mix is being applied to a rehabilitation areas, the heavily grassed outer layer of topsoil dumps may be scalped to limit competition between tree and grass establishment. As described in section 5.2, topsoil may not be placed on benches where tree and shrubs are planted to reduce competition from fast-establishing pasture species.

6.1.5 Revegetation

The initial priority for the majority of rehabilitation is to establish a dense, vigorous and sustainable cover to stabilise the final landform. As such, it is recommended that fertilisers are spread prior to seeding to increase soil fertility again based on advice from soil science practitioners. Timing of seeding works should consider the local and expected short-term climatic conditions.

Seed will be sourced from reliable suppliers with evidence of appropriate seed analysis and quality control reports, with certificates available for seed purity and germination levels.

6.1.6 Erosion control

It is well established that high cover percentages, above 50 % groundcover, reduce erosion in rehabilitation, even on steep slopes (Carroll, 2000; Loch, 2000). However, the period when the soil is bare and vulnerable to erosion by surface runoff presents a significant window of erosion risk (Loch 2000; Carroll and Tucker 2000; Carroll et al. 2001). For typical rehabilitation with slope gradients ≤ 15 %, this window of erosion risk exists from the time of sowing until >50 % groundcover is established. It is during this period, which may be weeks or months depending on rainfall and other factors that affect plant establishment and growth, that Ensham will actively control erosion to prevent unacceptable soil loss and potentially severe gully erosion and landscape failure.

Ensham typically applies hay mulch immediately after seed sowing to provide instant groundcover and close the window of erosion risk (as shown in Figure 6-1). Hay mulch applied at a minimum rate of 5 t/ha (20 round bales/ha) is a quick, cheap, and effective erosion hazard control. It also promotes germination and establishment of sown species by assisting to retain soil moisture through reducing evapotranspiration and lowering soil temperatures in the hotter months. The mulch cover is particularly effective in minimising erosion arising from raindrop impact and also serves to retain moisture within the upper soil profile to assist with seed germination and vegetation establishment.



Figure 6-1 Spreading hay mulch for erosion control in rehabilitation at Ensham

6.2 QA/QC processes

6.2.1 Conformance to design

Ensham will adopt a conformance to design review process to ensure the landform bulk earthworks is constructed in a manner that is consistent with the design concept. For this process, bulk push areas completed will be surveyed and progression tracked over time to highlight any variations to design and short-term rehabilitation targets. Where discrepancies and variations fall outside the range of tolerance, the area will be flagged for rework or remediation as appropriate. This may require further bulk earthworks, or additional trim using more refined equipment as needed.

6.2.2 Annual rehabilitation inspections and monitoring

After completion of each year of planned rehabilitation works, a suitably qualified person will undertake an inspection of the rehabilitation works that have been completed. This will review the rehabilitation outcome and ensure all expected activities have been implemented as expected and with minimal variation from the design standards. Review of rehabilitation works requires a combination of survey control, physical inspection, and verification of actual rehabilitation works at specific stages.

The inspection may also cover rehabilitation completed in previous years, not just the preceding year. A summary of this inspection can document the completion of rehabilitation activities, as well as the inspection completed, and may include actions to address any observed deficiencies. It is expected that these actions will then be monitored and progressed over time.

6.2.3 Rehabilitation performance reporting

To ensure that the performance of rehabilitation is measured and reported, monitoring of the previous year's rehabilitation areas will be conducted by a suitably qualified person(s).

An annual report is prepared to include recommendations to manage any identified areas of concern, with this report provided to DES on an annual basis as per EA condition H7. Older rehabilitation may also be monitored from time to time. If older rehabilitation in a particular area is not trending towards (or has not met) the completion criteria listed in the EA, a review will be undertaken on what additional works of interventions may be required to achieve the completion criteria. This recognises that rehabilitation can be an iterative process heavily influence by climatic conditions/ weather cycles and enables sufficient time for assessment of rehabilitation performance and any necessary changes well prior to relinquishment.

6.3 Trials

Given that Ensham is a transitional PRCP site, with a strong operational history of completing progressive rehabilitation (with more than 1500 ha of progressive rehabilitation already completed), much is understood about what is required to produce high quality rehabilitation. A number of trials and reviews of rehabilitation practices have been conducted in the past, considering establishment

of tree and shrub species, different soil arrangements, assessing fire treatments, as well as investigating the impact of grazing within rehabilitation areas.

Additional research is continuing into pasture dieback for the region, via ACARP funded projects undertaken through the University of Queensland. Further, there are ongoing trials investigating the treatments required to complete rehabilitation using overburden as a growth media, as further detailed in the main PRCP (Section 6.3). As such, further trials are not considered essential to verify the predicted success of the final landform design. The actual performance of the quality and nature of progressive rehabilitation are evidence to Ensham's ability to rehabilitate so as to achieve a stable condition.

Each year, the rehabilitation progression is reviewed, and from there Ensham carefully modifies the rehabilitation practices moving forward, to improve rehabilitations outcomes, and verify the success of rehabilitation. Rehabilitation trials may be conducted from time to time as a component of continuous improvement. This approach is expected to identify any issues with rehabilitation early on and facilitate more targeted monitoring if appropriate, or allow for early intervention for more significant concerns.

6.4 Limitations and assumptions

The key assumptions and limitations of the Ensham landform design concept relate to the performance of the flood protection levees. These landform levees have been designed to exhibit long-term geotechnical stability, and so that seepage below and through the structures during flood events are of a magnitude that represents a very low risk of destabilisation of highwall materials adjacent to the levees. The following key assumptions have been made in developed of the design concept relating to these specific structures:

- Landform levees will result in a free draining landform, with runoff captured behind the structures directed to residual voids.
- These landforms will incorporate the existing levee structures wherever possible, and additional earthworks embankment construction required to raise the levees shall be founded on natural ground, with no part of the levee structure founded on backfill.
- The landform levees will resemble a landform in nature, rather than the existing engineered levees, with embankment batters of 15% (1H:6.7V) for all embankments where space permits. It is noted that void facing embankments of 1H:4V have been adopted at a few locations.
- New earthworks for the landform levees will be constructed from typical levee construction materials (low permeability, low dispersivity clay materials), with full engineering compaction to eliminate preferred seepage paths and high porosity associated with uncompacted materials.
- The landform levees will be inspected and certified as 'fit for purpose' by a suitably qualified and experienced person.

7 REFERENCES

- Carroll C, Merton L and Burger P (2000) Impact of vegetative cover and slope on runoff, erosion, and water quality for field plots on a range of soil and spoil materials on central Queensland coal mines, *Australian Journal of Soil Research* 38:313-327.
- Carroll C and Tucker A (2000) Effects of pasture cover on soil erosion and water quality on central Queensland coal mine rehabilitation, *Tropical Grasslands* 34:254-262.
- Carroll C, Tucker A, Merton L, Burger P and Pink L (2001) Sustainability Indicators for Coal Mine Rehabilitation, ACARP project C7006, Queensland Department of Natural Mines and Resources, Brisbane.
- Cohen, Willgoose and Hancock, 2009; Welivitiya et al., 2016. Sustainable mine rehabilitation – 25 years of the SIBERIA landform evolution and long-term erosion model.
- Queensland Department of Environment and Science (DES) (2021). Progressive Rehabilitation and Closure Plans (PRC Plans) Guideline (ESR/2019/4964) – Version 2.00
- Queensland Department of Mines and Energy (DME) (1995). Technical guidelines for the environmental management of exploration and mining in Queensland. Handbook developed between DME and Queensland Mining Council.
- Ensham Resources, 2021. Rehabilitation Management Plan.
- Ensham Residual Void Project Stage 2 Environmental Values Workshop Report (March, 2018)
- Ensham Residual Void Project - Geotechnical Design Report (WSP, 2018. PS107225-RESREP- 004 Rev J)
- Grigg AH, Emmerton BR and Callum NJ (2001) The development of draft completion criteria for ungrazed rehabilitation pastures after opencut coal mining in central Queensland, ACARP project C8038, The University of Queensland, Brisbane.
- Henderson, S (2004). Rehabilitation of Dispersive Tertiary Spoil in the Bowen Basin – Project C12031. Australian Coal Association Research Program (ACARP).
- Howard and Loch, 2019. Acceptable erosion rates for mine waste landform rehabilitation modelling in the Pilbara, Western Australia.
- Kew G, Mengler F and Gilkes F (2007) *Regolith Strength, Water Retention, and Implications for Ripping and Plant Root Growth in Bauxite Mine Restoration*, *Restoration Ecology*, Vol 15, Issue s4, pp 54-64.
- Klingebiel, A.A., Montgomery P.H., 1961. Land Capability Classification. Agriculture Handbook N. 210. U.S.D.A., Soil Conservation Service, Washington.
- Landloch Pty Ltd, 2016. Assessment of Stability of Final Void and Landform Shaping Options, Ensham Coal Mine.
- Lardner, T.D. and Tibbett, M. (2013) Chapter: Deep ripping after topsoil return affects root proliferation and floristic diversity in a restored biodiverse forest after bauxite mining, Publisher: Australian Centre for Geomechanics, Editors: Mark Tibbett, Andy Fourie, Caroline Digby, pp.363-376.
- Loch R (2000) *Effects of vegetation cover on runoff and erosion under simulated rain and overland flow on a rehabilitated site on the Meandu Mine, Tarong, Queensland*, *Australian Journal of Soil Research* (2000), vol 38, pp 299-312.

- So HB, Sheridan GJ, Loch RJ, Carroll C, Willgoose G, Short M and Grabski A (1998) Post Mining Landscape Parameters for Erosion and Water Quality Control, ACARP project C4011, The University of Queensland, Brisbane.
- Szota C, Veneklass E, Koch J and Lambers H (2007) *Root Architecture of Jarrah (Eucalyptus marginata) Trees in Relation to Post-Mining Deep Ripping in Western Australia*, Restoration Ecology, Vol 15, Issue s4, pp s65-s73.
- Waters, D., 2004. Enhancing pasture stability and profitability for producers with *Aristida Bothriochloa* pastures under Eucalypt Woodland, Queensland Department of Natural Resources & Mines, Toowoomba.
- Williams DJ (2000) Assessment of Embankment Parameters, Pages 275-284 in W. A. Hustrulid, M. K. McCarter, and D. J. A. V. Zyl, editors. Slope stability in Surface Mining. Society for Mining, Metallurgy, and Exploration, Inc, Littleton, Colorado.
- WSP, 2019 Stage 3 Landform Design
- WSP, 2018 Stage 3 Geotechnical Design Report.