SARAJI EAST MINING LEASE PROJECT

Environmental Impact Statement

Chapter 5
Land Resources

BHP

Contents

Saraji East Mining Lease Project

5 Land Resources

5.1 Introduction

This chapter provides an assessment of the Project on land based environmental values of the Project Site. The assessment considers the likely nature and extent of potential impacts from the Project and identifies, where appropriate, controls to avoid, mitigate and manage adverse impacts.

This chapter considers:

- potential land degradation and contaminated land
- geology and mineral resources
- land suitability and agriculture
- subsidence.

Related topics are discussed in separate chapters, including:

- Chapter 4 Land Use and Tenure
- Chapter 13 Scenic Amenity and Lighting.

Further detail on the assessments undertaken and summarised in this chapter are provided in:

- Appendix B-1 Land Resources and Soils Technical Report
- Appendix B-2 Subsidence Modelling
- Appendix K-1 Rehabilitation Management Plan
- Appendix K-2 Subsidence Management Plan.

5.2 Legislation and policy

5.2.1 Environmental Protection Act 1994

The primary environmental legislative requirements for the management of soils and contaminated land in Queensland are contained within the *Environmental Protection Act 1994* (Qld) (EP Act) and subsidiary regulations. The EP Act is administered by the Department of Environment and Science (DES).

In Queensland, activities that have been identified as likely to cause land contamination are known as notifiable activities. Notifiable activities are defined in Schedule 3 of the EP Act. Land parcels that have historically been used, or are currently used, for notifiable activities and are reported to the government are recorded on the Environmental Management Register (EMR). Inclusion of a land parcel on the EMR does not necessarily mean that the land is contaminated, as it may or may not pose a risk to human health and/or the environment.

Land parcels that are known to pose a risk to human health and/or the environment are included on the DES Contaminated Land Register (CLR). Land parcels are included on the CLR when an investigation has identified that contaminants are present at concentrations that represent a risk to human health.

As such, action is required to remediate or manage the land to prevent adverse environmental and/or human health impacts.

5.2.2 Regional Planning Interests Act 2014

The *Regional Planning Interests Act 2014* (RPI Act) seeks to manage the impact of resource activities on areas that contribute or are likely to contribute to Queensland's economic, social or environmental prosperity.

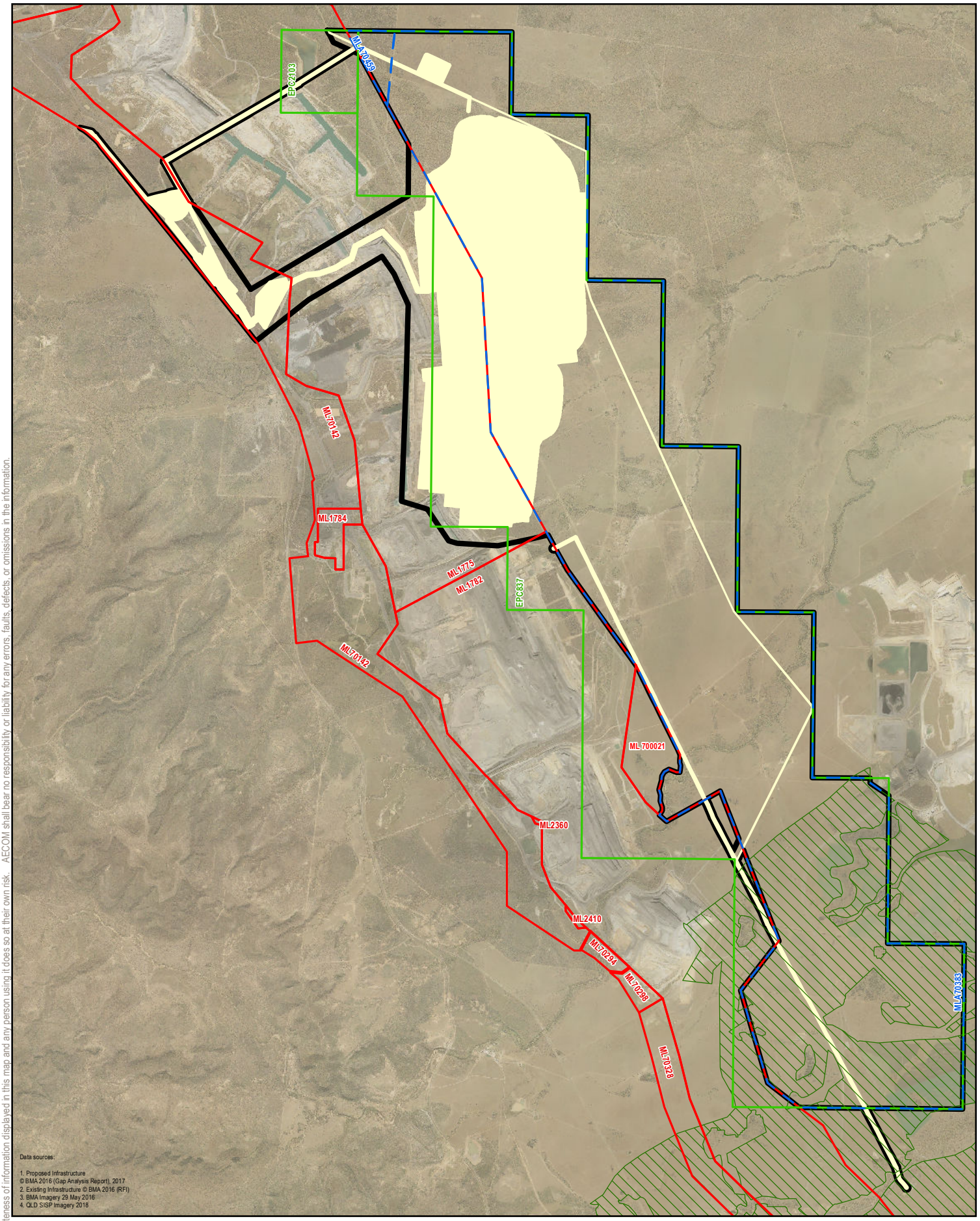
The RPI Act identifies and protects areas of regional interest from prescribed resource or regulated activities through the protection of:

- living areas in regional communities (Priority Living Area) (PLA)
- high-quality agricultural areas from dislocation (Priority Agricultural Area) (PAA)
- strategic cropping land (SCL) (Strategic Cropping Area) (SCA)
- regionally important environmental areas (Strategic Environmental Area) (SEA).

A Regional Interests Development Approval (RIDA) is required when a resource activity is proposed in an area of regional interest.

The SCA is an area of regional interest under the RPI Act and consists of the areas shown on the SCL Trigger Map as SCL. SCL is defined in the RPI Act as land that is highly suitable for cropping, or likely to be highly suitable for cropping, based on a particular set of soil, climate and landscape features. A review of the SCL Trigger Map identified that the southern extent of the Project Site encroaches SCA, as shown in Figure 5-1. This area is herein discussed as the SCL Assessment Area.

As the Project Site intersects land mapped as SCL, an assessment of the Project in accordance with the Department of Infrastructure, Local Government and Planning (DILGP) *RPI Act Statutory Guideline 01/14* was undertaken (DILGP, 2017a). Approval requirements regarding works within the regional interest area are discussed in **Appendix A-2 Approvals Framework**.



Data sources:

1. Proposed Infrastructure
© BMA 2016 (Gap Analysis Report), 2017
2. Existing Infrastructure © BMA 2016 (RFI)
3. BMA Imagery 29 May 2016
4. QLD SISP Imagery 2018

LEGEND

- Project Site
- Project Footprint
- Exploration Permit Coal (EPC)
- Mining Lease (ML)
- Mining Lease Application (MLA)
- Strategic Cropping Land Trigger Map

N

Figure 5-1
Strategic Cropping Land Trigger Map

Environmental Impact Statement
Saraji East Mining Lease Project

0 0.5 1 2
Kilometres

Scale: 1:110,000 (when printed at A4)

Projection: Map Grid of Australia - Zone 55 (GDA94)

BHP

DATE: 16/07/2020 VERSION: 2

Filename: \\aubne1fp003\Projects\605X\605070314. Tech Work Area\4.99 GIS\02_MXDs\06 Environmental Impact Statement\05 Land and Soil\60507031_G274_v1_A4P.mxd

5.2.3 Mined Land Rehabilitation Policy

The *Mineral and Energy Resources (Financial Provisioning) Act 2018* amends the EP Act, replacing the Plan of Operations and Financial Assurance (FA) with Estimated Rehabilitation Cost (ERC) and Progressive Rehabilitation and Closure Plan (PRCP). The Project will comply with the *Mineral and Energy Resources (Financial Provisioning) Act 2018* and a Progressive Rehabilitation and Closure Plan (PRCP) will be developed prior to construction commencing.

The *Mined Land Rehabilitation Policy* (DES, 2018a) is an outcome of the *Mineral and Energy Resources (Financial Provisioning) Act 2018*. The objective of the *Mined Land Rehabilitation Policy* is for land disturbed by mining activities to be rehabilitated to a safe and stable landform that does not cause environmental harm and is able to sustain a post mining land use which has been approved through a PRCP.

Further, it states that voids situated wholly or partially in a floodplain are to be rehabilitated to a safe and stable landform that is able to sustain an approved post-mining land use that does not cause environmental harm.

BHP has developed rehabilitation objectives and proposed measures in consideration of the *Mined Land Rehabilitation Policy*.

5.2.4 National Environmental Protection (Assessment of Site Contamination) Measure 1999

The soil investigation thresholds used in Queensland to evaluate whether land is contaminated are contained in the *National Environment Protection (Assessment of Site Contamination) Measure 1999* (amended in April 2013) (National Environment Protection Council (NEPC)). This document presents investigation and screening levels designed to ensure the protection of the environment and/or human health.

These investigation and screening levels are not intended for use as default remediation trigger criteria. Rather, they are intended to prompt an appropriate site-specific assessment when they are exceeded. Similarly, trigger levels nominated for the protection of ecosystem health should be developed on a regional scale, commensurate with land use (NEPC, 1999).

Developing trigger levels on a regional scale is a resource intensive process, therefore such trigger levels may not be developed for some time. In the interim, and for the purposes of this assessment, generic levels based on an assumed urban land use (comprising city, suburban and industrial areas) were adopted.

5.2.5 Mackay, Isaac and Whitsunday Regional Plan

The *Mackay, Isaac and Whitsunday Regional Plan 2012* provides future planning decisions for the region over the next two decades. It provides a framework to guide the long term sustainability of the region's communities, strengthen its economy, inform the delivery of social services and infrastructure, and protect its environment.

The plan recognises that the resources sector operates within specific legislation and supports the development of mining projects within the region. The plan also identifies the Bowen Basin as Australia’s largest coal deposit and one of the nation’s largest coal producers, with coal mining being the major industry in the region and the largest employer.

The plan outlines a number of desired regional outcomes (DROs), including the protection of regional landscape values and natural resource management.

An assessment of the DRO’s of the Mackay, Isaac and Whitsunday Regional Plan against the Project is presented in **Chapter 4 Land Use and Tenure.**

5.3 Methodology

5.3.1 Subsidence

A detailed mine subsidence assessment was undertaken and is presented in **Appendix B-2 Subsidence Modelling**.

All longwall panels across the Project Site will extract coal from the Dysart Lower (D14 and D24) seams.

Due to the size of the Project Site, the subsidence assessment was unable to model the entire area in a single model at a suitable resolution. Therefore, the northern and southern longwall panels were modelled separately.

The subsidence model was set up to include the major geological strata with properties which reflected the original pre-mining conditions. The model then stepped through the following stages to simulate the proposed mining operations:

- intact geology brought to equilibrium under applied in situ stress field and gravity
- open cut mining excavations cut into the model
- longwall panels excavated sequentially in down dip direction. At each stage the stresses and deformation were equilibrated
- roof rockmass allowed to collapse onto floor of longwall panel
- histories of displacement over the longwall panels were monitored
- changes in surface elevation were calculated to establish the post-mining topography.

5.3.2 Soils and land suitability

Soils

A detailed assessment of land resources and soil suitability for the Project was undertaken and is presented in **Appendix B-1 Land Resources and Soils Technical Report.**

This assessment included a review of existing soil and land suitability reports in the area to determine soil mapping units (SMUs) and identify their distribution within the Project Site.

Where appropriate, existing land suitability assessments were re-assessed against the *Guidelines for Agricultural Land Evaluation in Queensland* (GALE) (DSITI and DNRM, 2015). GALE (DSITI and DNRM, 2015) and regional land evaluation frameworks for various regions of Queensland give specific information for appropriate land uses and their associated limitations.

Following the review of the available assessments, data gaps were identified and additional field soil surveys were undertaken specifically targeting proposed infrastructure areas on the western side of the Project Site. Additional data was also obtained for the southern areas of the Project Site as part of a two stage SCL fieldwork assessment (GTE, 2018 and GTE, 2019).

The field investigation was based upon existing soil survey site locations (GTES, 2011) and free survey techniques (McKenzie et al. 2008 and Gunn et al. 1988) to verify soil types and assign boundaries to map units.

Laboratory analysis was undertaken in line with the Land Suitability Assessment Techniques (LSAT) outlined within the Department of Minerals and Energy (DME) (now Department of Natural Resources, Mines and Energy (DNRME)) guideline *Technical Guidelines for Environmental Management of Exploration and Mining in Queensland* (DME, 1995d). Information was also sourced from Queensland Department of Primary

Industry (DPI, 1991) *Guidelines for Agricultural Land Evaluation in Queensland* in Shields and Williams *Land Resource Survey and Evaluation of the Kilcummin area* and GALE (DSITI and DNRM, 2015).

Appendix B-1 Land Resources and Soils Technical Report provides a full description of the soils and land resources methodology.

Strategic cropping land

An overhead powerline proposed as part of the Project intersects land mapped as SCL (Figure 5-1). Therefore, an assessment of the site-specific soil conditions against the SCL criteria was required to confirm the actual extent of SCL at a local scale.

The SCL assessment was conducted in accordance with RPI Act Statutory Guideline 08/14 (DILGP, 2017b) which describes how to demonstrate that land in the SCA does not meet the criteria for SCL (Queensland Government, 2017). Additionally, the SCL criteria listed in Schedule 3, Part 2 of the RPI Act were assessed. The assessment comprised:

- a desktop study of relevant information, including satellite imagery, topographic information and regional soils information
- a field investigation to ground-truth the preliminary soil mapping and collect detailed information on soil distribution, topographic constraints, and physical and chemical soil conditions
- ground-truthed soil mapping at an appropriate scale for SCL assessment
- site-specific assessment of SCL map unit polygons against the relevant SCL criteria.

The relevant SCL criteria are presented in Table 5.1. To demonstrate that the land does not meet the SCL criteria, the assessment must demonstrate that it fails at least one of the eight criteria.

Table 5.1 Criteria to meet SCL in the Western Cropping Zone

Criteria	Thresholds for Western cropping zone
Slope	Equal to or less than 3 %
Rockiness	Equal to or less than 20 % for rocks greater than 60 millimetres (mm) in diameter
Gilgai	Less than 50 % of land surface being gilgai of greater than 500 mm in depth
Soil depth	Equal to or greater than 600 mm
Soil wetness	Has favourable drainage
Soil pH	For rigid soils, the soil at 300 mm and 600 mm soil depth must be within the range of pH1:5 5.1 to pH1:5 8.9 inclusive For non-rigid soils, the soil at 300 mm and 600 mm soil depth must be greater than pH1:5 5.0
Salinity	Chloride content is less than 800 milligrams per kilogram (mg/kg) at 600 mm soil depth
Soil water storage	Equal to or greater than 100 mm to a soil depth or soil physico-chemical limitation of equal to or less than 1,000 mm

5.3.3 Queensland Land Agricultural Audit

A desktop review of the Queensland Agricultural Land Audit and the Web-based Agricultural Land Information (WALI) was undertaken to understand the agricultural values within and surrounding the Project Site.

5.3.4 Contaminated land

An assessment of the potential contamination status of the Project Site was undertaken, including:

- Desktop review of the current and historical land uses associated with properties within, or adjacent to, the Project Site
- Desktop review of additional contamination sources (including Unexploded Ordinances (UXOs)) with the potential to impact the Project
- Review of properties potentially impacted by land contamination, focusing on the likelihood of these properties impacting the Project Site, based on their proximity and contaminants of concern.

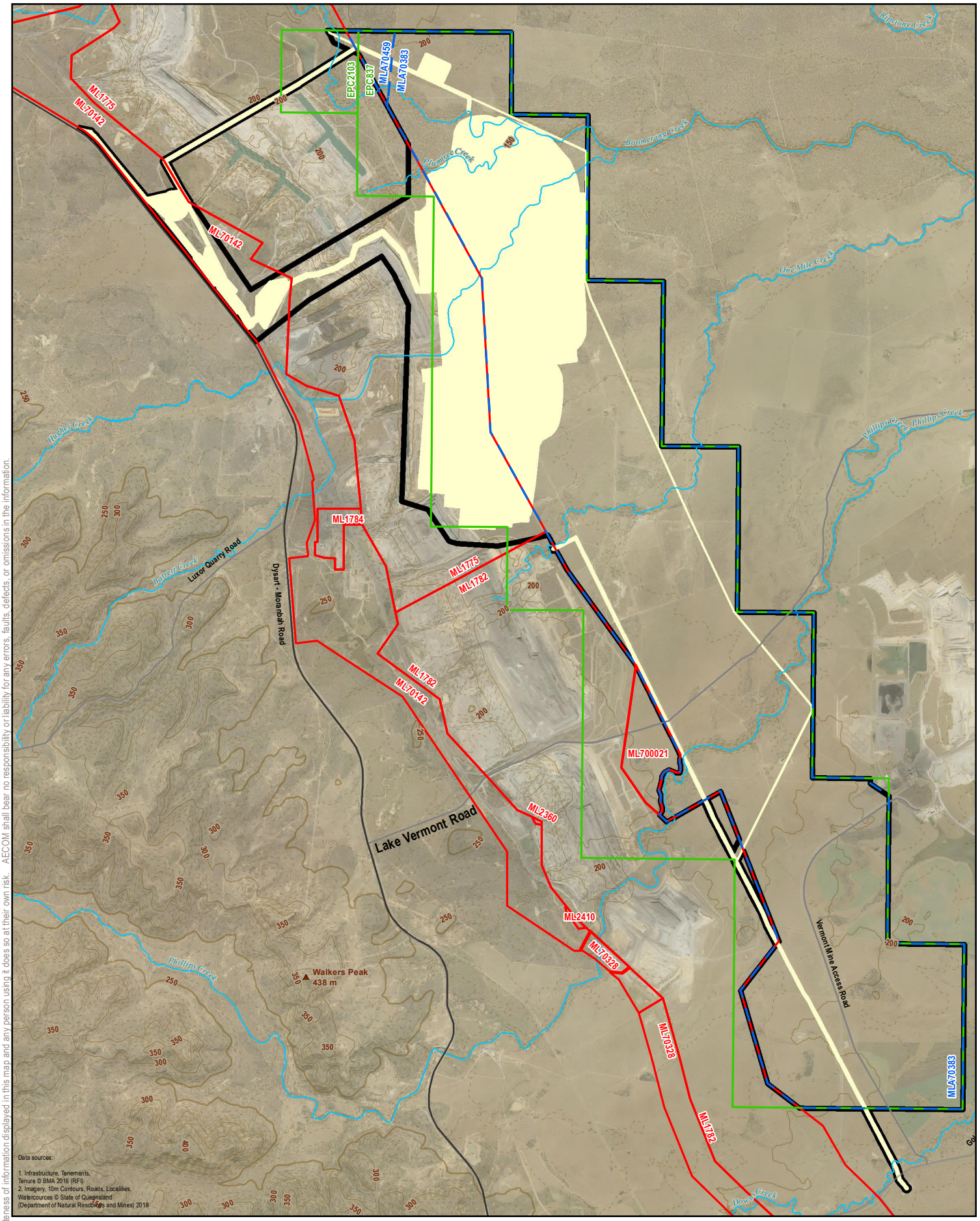
5.4 Description of environmental values

5.4.1 Biophysical

The topography of the Project Site is predominately flat, with channels associated with Phillips, Hughes, One Mile and Plumtree Creeks. The terrain within these catchments is undulating and land use is predominantly grazing and mining activities (Figure 5-2). In the upper reaches of the catchment, the terrain becomes steeper and possesses tracts of remnant vegetation.

Prior to land clearing for agricultural land uses, much of the area supported Brigalow and Belah vegetation on clay soils with tracts of Eucalypt woodlands on the alluvial and sand plains. The original Brigalow and Belah scrub communities have been heavily affected by clearing.

The ecological values of the Project Site are considered typical for the northern Bowen Basin with large areas of land historically cleared for grazing. Although some large areas of remnant vegetation remain, most have been modified to some extent by historical and current land management practices. The most common modifications across the Project Site have been the removal of the shrub and ground layers and replacement with pasture grass species, and the effects of cattle grazing. **Chapter 6 Terrestrial Ecology** provides a detailed discussion on the vegetation within the Project Site.



LEGEND

- Project Site
- Project Footprint
- Exploration Permit Coal (EPC)
- Mining Lease (ML)
- Mining Lease Application (MLA)
- Mountain Peak
- Major Contour (250m)
- Intermediate Contour (50m)
- Minor Contour (10m)

Figure 5-2
Local Landscape

Environmental Impact Statement
Saraji East Mining Lease Project

0 0.5 1 2
Kilometres

Scale: 1:110,000 (when printed at A4)

Projection: Map Grid of Australia - Zone 55 (GDA94)

BHP

DATE: 27/11/2020 VERSION: 1

Filename: \\aubne1fp003\Projects\605X\60507031\4. Tech Work Area\4.99 GIS\02_MXDs\06 Environmental Impact Statement\05 Land and Soil\60507031_G275_v1_A4P.mxd

5.4.2 Geology

The Project is located on the western limb of the northern Bowen Basin. The strata are relatively undisturbed with a gentle regional dip of 2 degrees (°) to 5° to the east. Faulting is common, though minor, producing local steepening of the coal seam dips to over 10°.

The Permian aged Moranbah Coal Measures (MCM) are the major economic coal resource in the region. Along with Fort Cooper Coal Measures (FCCM), they form part of a thick Permian sequence of regularly layered sedimentary rocks (siltstone, sandstone, mudstone and coal). Locally, the Permian strata are unconformably overlain by up to 57 metres (m) of unconsolidated to semi-consolidated Tertiary sediments and localised unconsolidated Quaternary sediments. The Quaternary alluvial sediments are thickest along the flanks of several of the creeks which traverse the Project Site.

The shallower Tertiary sediments consist of clay, sandy clay, clayey sand and gravel, but have been noted as consisting predominantly of clay. The clay-bound nature of the Tertiary sediments ensures that permeable lenses of sands and gravels are complex in distribution and irregular. In-filled Quaternary alluvial channels associated with the present-day creek courses are locally incised into the Tertiary Formation.

Table 5.2 provides a summary of the major geological units in the vicinity of the Project. The surface geology showing the distribution of the Quaternary alluvium and Tertiary sediments is presented as Figure 5-3. The Permian geology is shown in Figure 5-4.

Table 5.2 Geological units in the vicinity of the Project

Age	Unit	Description	Thickness	Occurrence
Quaternary	sand/gravel	clean quartz sand and gravel of alluvial origin	0 - 25 m	Associated with current watercourse channels such as Phillips Creek, Huqhes Creek and Isaac River
Tertiary	clay, clayey sand, sandy clay, sand	fluvial origin	up to 57 m	Covers whole of Project Site, regular distribution although individual units are discrete lenses and discontinuous
	basal sand		0 - 3 m	Very irregular distribution. Tends to occur where Tertiary sediments are thickest
Permian	Fort Cooper Coal Measures	sandstone, siltstone, mudstone, carbonaceous shale and coal.	up to 400 m	Eastern portion of Project Site dips to east at 3-6°
	Moranbah Coal Measures	sandstone, conglomerate, claystone, siltstone, carbonaceous clay and coal	250 – 350 m	Whole of Project Site, dips to east at 3-6°

LEGEND

- Project Site
- Underground layout (optimised)
- Existing Open-Cut Extent
- Exploration Permit Coal (EPC)
- Mining Lease (ML)
- Mining Lease Application (MLA)

Surface Geology

- Back Creek Group (Pb)
- Duaringa Formation (Tu)
- Fort Cooper Coal Measures (Pwt)
- German Creek Formation (Pbd)
- MacMillan Formation (Pbn)
- Moranbah Coal Measures (Pwb)
- Peak Range Volcanics (Tp)
- Qa-QLD (Qa)
- Qr-QLD (Qr)
- Qr\b-QLD (Qr\b)
- TQa-QLD (TQa)
- Tb-QLD (Tb)

N

Figure 5-3
Surface Geology
(1:100,000)

Environmental Impact Statement
Saraji East Mining Lease Project

0 1 2 4
Kilometres

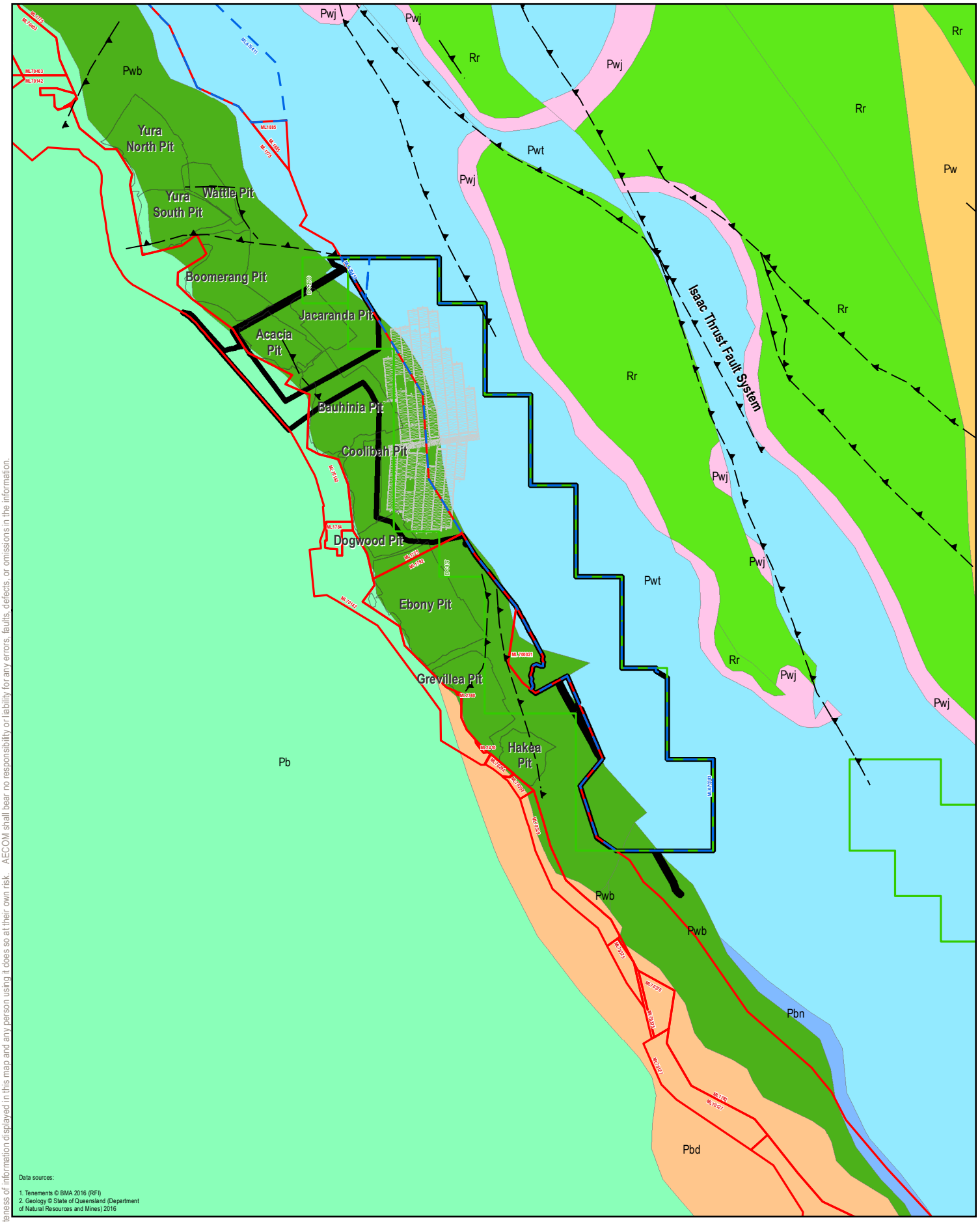
Scale: 1:200,000 (when printed at A4)

Projection: Map Grid of Australia - Zone 55 (GDA94)

BHP

DATE: 29/09/2020 VERSION: 0

Filename: \\aubne1fp003\Projects\605X\60507031\4. Tech Work Area\4.99 GIS\02_MXDs\06 Environmental Impact Statement\05 Land and Soil\60507031_G276_v2_A4P.mxd



Data sources:

1. Tenements © BMA 2016 (RFI)
2. Geology © State of Queensland (Department of Natural Resources and Mines) 2016

LEGEND

- Project Site
- Exploration Permit Coal (EPC)
- Mining Lease (ML)
- Mining Lease Application (MLA)
- Underground layout (optimised)
- Existing Open-Cut Extent
- Fault

Bowen Basin Basement Geology

- Pb - Permian Back Creek Group
- Pbd - Permian German Creek Formation
- Pbn - Permian MacMillan Formation
- Pw - Permian Backwater Group
- Pwb - Permian Moranbah Coal Measures
- Pwj - Permian Rangal Coal Measures
- Pwt - Permian Fort Cooper Coal Measures
- Rr - Triassic Rewan Group

N

Figure 5-4
Basement Geology
(1:500,000)

Environmental Impact Statement
Saraji East Mining Lease Project

0 1 2 4
Kilometres

Scale: 1:200,000 (when printed at A4)

Projection: Map Grid of Australia - Zone 55 (GDA94)

BHP

DATE: 29/09/2020 VERSION: 1

Mineral resources

The coal deposit to be mined by the Project is located in the northern part of the Permo-Triassic Bowen Basin, which principally comprises fluvial sediments with some marine sediments. The two major coal bearing regional geological formations of Permian age occur in the Project Site - FCCM and MCM. A Seam Correlation is shown in Figure 5-5.

Six coal seam groups exist within the Project Site. These comprise:

- The Dysart series (equivalent to Goonyella Lower and German Creek/Lilyvale seams)
- Harrow Creek group (Goonyella Middle seam/Aquila/Tieri equivalent)
- P seam
- Q seams (Goonyella Upper equivalent)
- R seam
- S seam (lower-most seam of the overlying FCCM).

The MCM are characterised by several laterally persistent, relatively thick coal seams interspersed with several thin minor seams. The major seams are the Dysart Lower (D24/D14) seams and the Harrow Creek Upper (H16). These major seams are potentially economic underground targets due to coking properties and the potential of high-quality pulverized coal injection resources that occur beyond the coking coal limit.

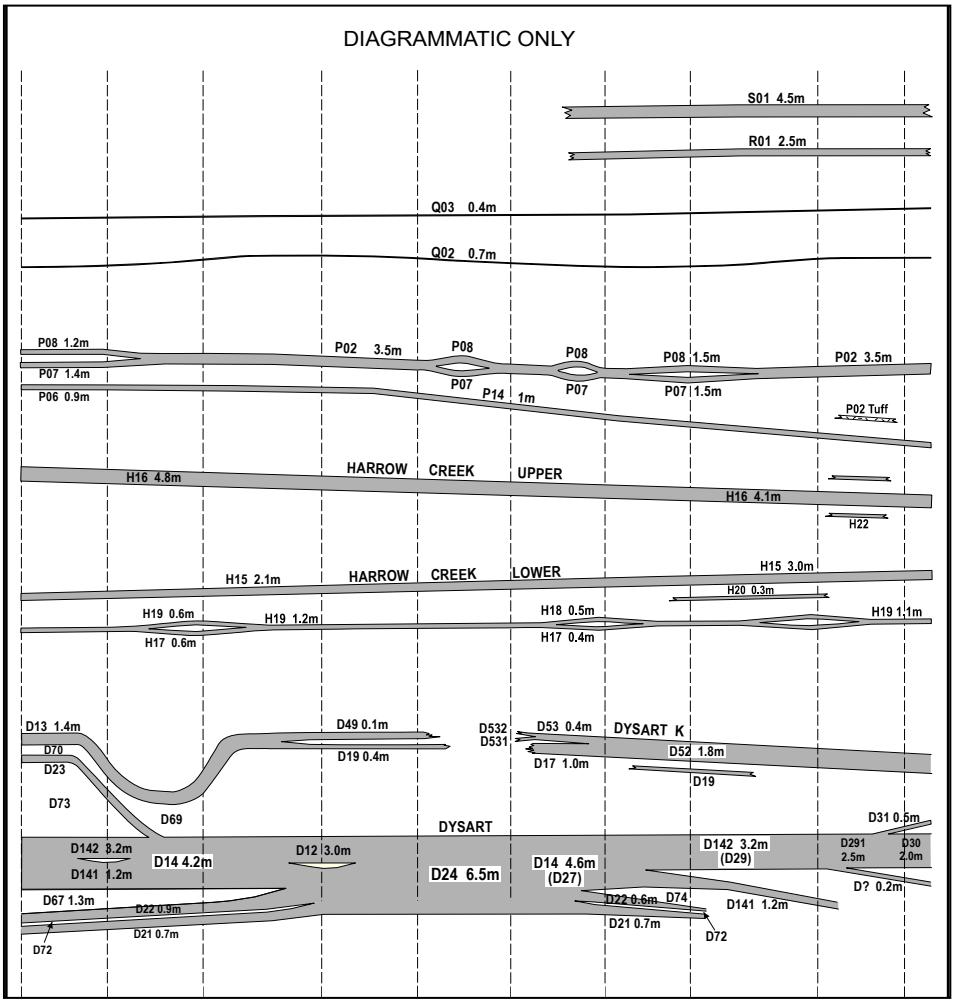


Figure 5-5 Regional stratigraphy

5.4.3 Soils and land suitability

Identification of soils

Twenty-six SMUs, including eleven variants, were identified across the Project Site on the basis of existing soil reports and the targeted soils assessment undertaken for the Project. This included 32 representative sites (of a total of 148 sites) recorded by Emmerton B. (2005) and 14 representative sites (of a total of 270 sites) recorded by GTES (2011). A soil variant may possess attributes that are somewhat different from the mainstream soil attributes but either cannot be mapped at scale or does not constitute any significant deviation from the agricultural suitability or basic soil morphology.

The Project Site includes areas of gently undulating plains with gradational to duplex sandy soils to uniform clays with microrelief to areas of drainage depressions near active alluvia areas.

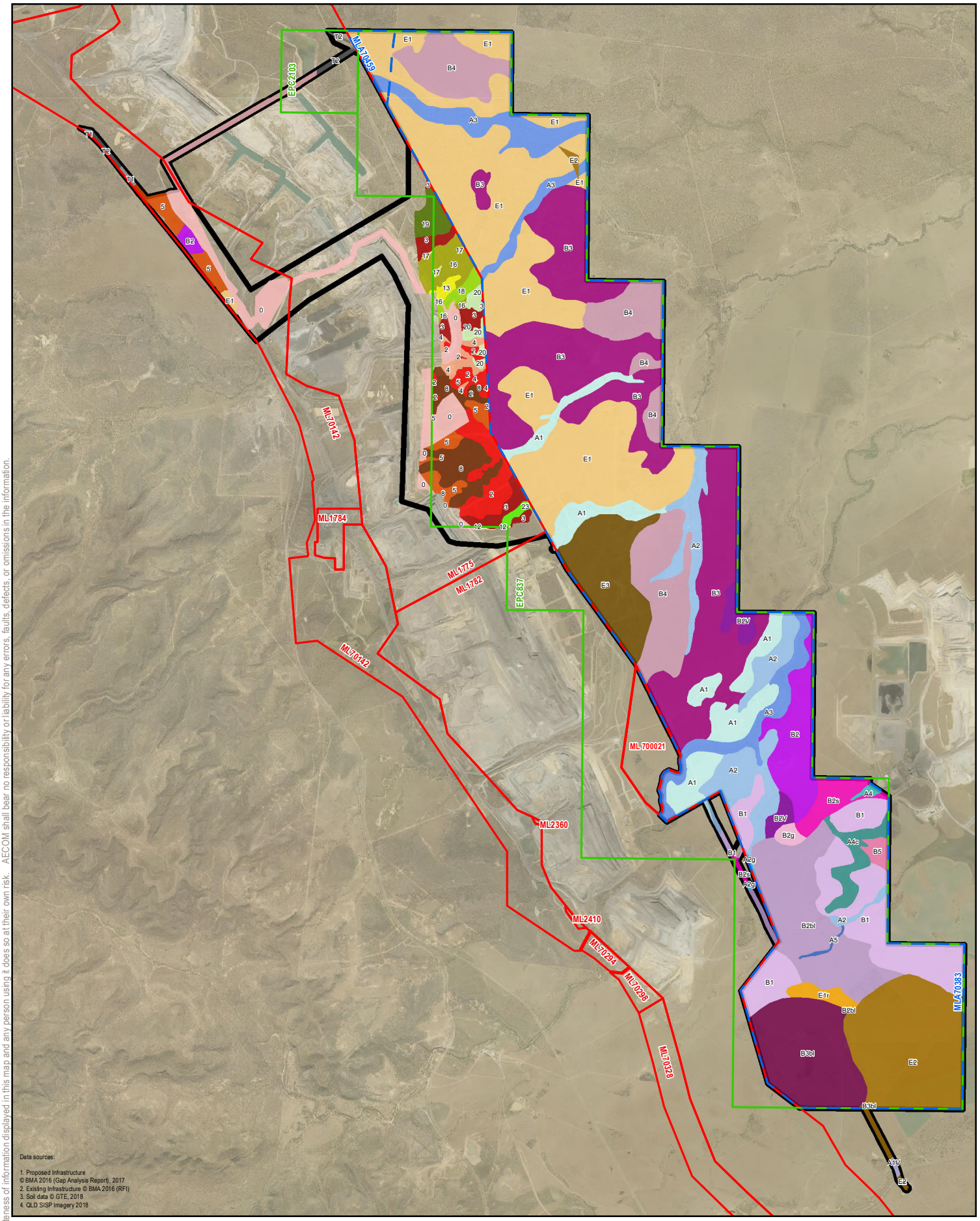
The SMUs are summarised within Table 5.3 and presented in Figure 5-6.

Table 5.3 Summary of SMUs

SMU and Variants	Concept	Representative sites
2/20	Light sandy clay loam duplex soils to non-cracking clays on unconsolidated cainozoic sediments	Site J4, S40 and 104 (Variant)
3	Sandy loam surfaced duplex soils on unconsolidated cainozoic sediments	S12, J31, 33 and 96
4	Cracking clays with minor gilgai supporting brigalow and dawson gum	S41, J27, J32 and 119
5	Cracking and non-cracking clays supporting dawson gum and brigalow on deep tertiary clays	S28 and 76
8	Clay loam duplex soils on sediments supporting dawson gum and brigalow (Breakaway areas)	S7 and 22 (scalded surface)
12	Sandy loam surfaced duplex soils on reworked cainozoic sediments supporting poplar box	J22 and 145
13	Hard-set silty duplex supporting mixed species (heavy shrub layer)	J23, 48, 134 and 138
16/23	Fine sandy loam to silt loam surfaced duplex and gradational soils (older alluvial duplex soils)	S17 (Variant), H32, 42 (Variant) and 60
17	Minor clay soils in anabranches	S32 and 57
18	Loamy sands, loams and gradational soils on stream banks and near stream levees	S51, H32 and 109
19	Loamy sand gradational soils present as relict alluvial levees	S49 and 142
A1 & A1V	Poplar box on deep duplex loams	38
A2	Alluvial brigalow clay drainage lines	21
A2g	Variant of SMU A2, colour of soil profile is grey	N1
A3	Alluvial loamy creek channels	52
A4	Dark brown sands with sandy loam subsoils near drainage lines	N17
A4c	Variant of SMU A4, texture includes higher clay percentage	N20

SMU and Variants	Concept	Representative sites
A5	Dark grey clay loams to grey brown clays within forested drainage line areas	N23
B1	Undulating clay plains under brigalow or belah	1
B2 & B2v	Mixed brigalow scrub on brown cracking clays	27
B2s	Variant of SMU B2, increase of salt content in subsoils	N13
B2g	Variant of SMU B2, colour of soil profile is black, with minor sub-dominant grey	N4
B2bl	Variant of SMU B2, colour of soil profile is black	91-SCL
B3	Cracking dark brigalow clays with gilgai	222 and 223
B3bl	Variant of SMU B3, colour of soil profile is black	5-SCL
B4	Melan holed brigalow clay plains	118 and 117
B5	Deep sandy clay loams with clay subsoils on gently undulating plains of tall woodlands	N28
E1	Eucalypt woodlands on deep sandy loams	173
E1r	Variant of SMU E1 over red clay (minor brown sub-dominant) subsoils on gently undulating plains	10-SCL
E2	Mt Coolibah on dark basalt soils	110
E3	Poplar box on shallower loams	169
T1	Sandy hard duplex poplar box	51
T2	Deep sandy duplex plains with poplar box and ironbark	21

A detailed description of each SMU is provided in **Appendix B-1 Land Resources and Soils Technical Report**.



Data sources:

1. Proposed Infrastructure © BMA 2016 (Gap Analysis Report), 2017
2. Existing Infrastructure © BMA 2016 (RFI)
3. Soil data © GTE, 2018
4. QLD SISP Imagery 2018

LEGEND

- Project Site
- Exploration Permit Coal (EPC)
- Mining Lease (ML)
- Mining Lease Application (MLA)

Soil Mapping Units

0	12	20	A3	B2V	B4	T1	
2	13	23	A4	B2bl	B5	T2	
3	16	A1	A4c	B2g	E1		
4	17	A1V	A5	B2s	E1r		
5	18	A2	B1	B3	E2		
8	19	A2g	B2	B3bl	E3		

**No SMU concept was identified due to disturbance observed within the area

Figure 5-6
Soil Mapping Units

Environmental Impact Statement
Saraji East Mining Lease Project

0 0.5 1 2
Kilometres

Scale: 1:110,000 (when printed at A4)

Projection: Map Grid of Australia - Zone 55 (GDA94)

BHP

DATE: 30/09/2020 VERSION: 3

Filename: \\aubne1fp003\Projects\605X\60507031\4. Tech Work Area\4.99 GIS\02_MXDs\06 Environmental Impact Statement\05 Land and Soil\60507031_G278_v3_A4P.mxd

Erosion potential

The erosion potential of the 26 SMUs and variants was identified using available laboratory analysis. Six SMUs (SMU 8, 12, 13, 17, 18 and 19) were considered to have high to very high attributes of erosion potential. All remaining SMUs ranged from low to moderate (SMUs 2/20, 4, 16/23, A1, A2, A3, A4, A5, B1, B2, B3, B5, E1, E2, E3, T1 and T2) and moderate to high (SMUs 3, 5 and B4).

Potential acid generating material

The review and assessment of SMUs for actual acid sulphate soils (AASS) and potential acid sulphate soils (PASS) included the indicators of field pH, jarosite in horizon observations, waterlogging and vegetation status.

Review of the SMUs and field indictors reported acidic to neutral pH as a field indicator for the majority except SMU E2. This SMU is strongly alkaline, though results were not below 4.0 pH for AASS. The remaining indicators were not reported or observed; therefore, the SMUs were assessed based upon the information presented as very low field indication of PASS with no indicators of AASS.

Land suitability

The land suitability and major limiting factors of each SMU for dryland broadacre grain cropping and grazing of improved pastures was assessed.

Data collected on the physical, chemical and nutritional characteristics of the soil was ranked according to a five-class system that applies to grazing, rainfed cropping and conservation as per DME (1995d), and Shields and Williams (1991) (Table 5.4).

Table 5.4 Land suitability classes

Class	Definition
1	Suitable land with negligible limitations which is highly productive requiring only simple management practices to maintain economic production.
2	Suitable land with minor limitations which either reduce production or require more than the simple management practices of Class 1 land to maintain economic production.
3	Suitable land with moderate limitations which either further lower production or require more than those management practices of Class 2 land to maintain economic production.
4	Marginal land with severe limitations which make it doubtful whether the inputs required to achieve and maintain production outweigh the benefits in the long term (presently considered unsuitable due to the uncertainty of the land to achieve sustained economic production).
5	Unsuitable land with extreme limitations that preclude its use for the proposed purpose.

Agricultural land classification (ALC) based on GALE (DSITI and DNRM, 2015) relates the suitability of land to specified agricultural uses. The classification rates the ability of land to maintain a sustainable level of productivity. The factors used to classify agricultural land suitability are the soil, topographic and climatic limitations. The classification ranges from A to D and the descriptions are detailed in Table 5.5.

Table 5.6 presents a summary of the land suitability for the Project Site.

Table 5.5 Agricultural land classes

Agricultural land class	Land suitability (cropping)	Land suitability (grazing)	Description
A	-	-	Crop land - land that is suitable for a wide range of current and potential crops with nil to moderate limitations to production.
A1	1-3	1-3	Suitable for a wide range of current and potential broadacre and horticultural crops.
A2	1-3	1-3	Suitable for a wide range of current and potential horticultural crops only.
B	3-4	1-3	Limited crop land - land that is suitable for a narrow range of crops. The land is suitable for sown pastures and may be suitable for a wider range of crops.
C	-	-	Pasture land - land that is suitable only for improved or native pastures due to limitations that preclude continuous cultivation for crop production. Some areas may tolerate a short period of ground disturbance for pasture establishment.
C1	4-5	1-2	Suitable for grazing sown pastures requiring ground disturbance for establishment; or native pastures on higher fertility soils.
C2	4-5	3	Suitable for grazing native pastures, with or without the introduction of pasture species, and with lower fertility soils than C1.
C3	4-5	4	Suitable for light grazing of native pastures in accessible areas, and includes steep land more suited to forestry or catchment protection.
D	5	5	Non-agricultural land - land not suitable for agricultural use, including land alienated from agricultural use.

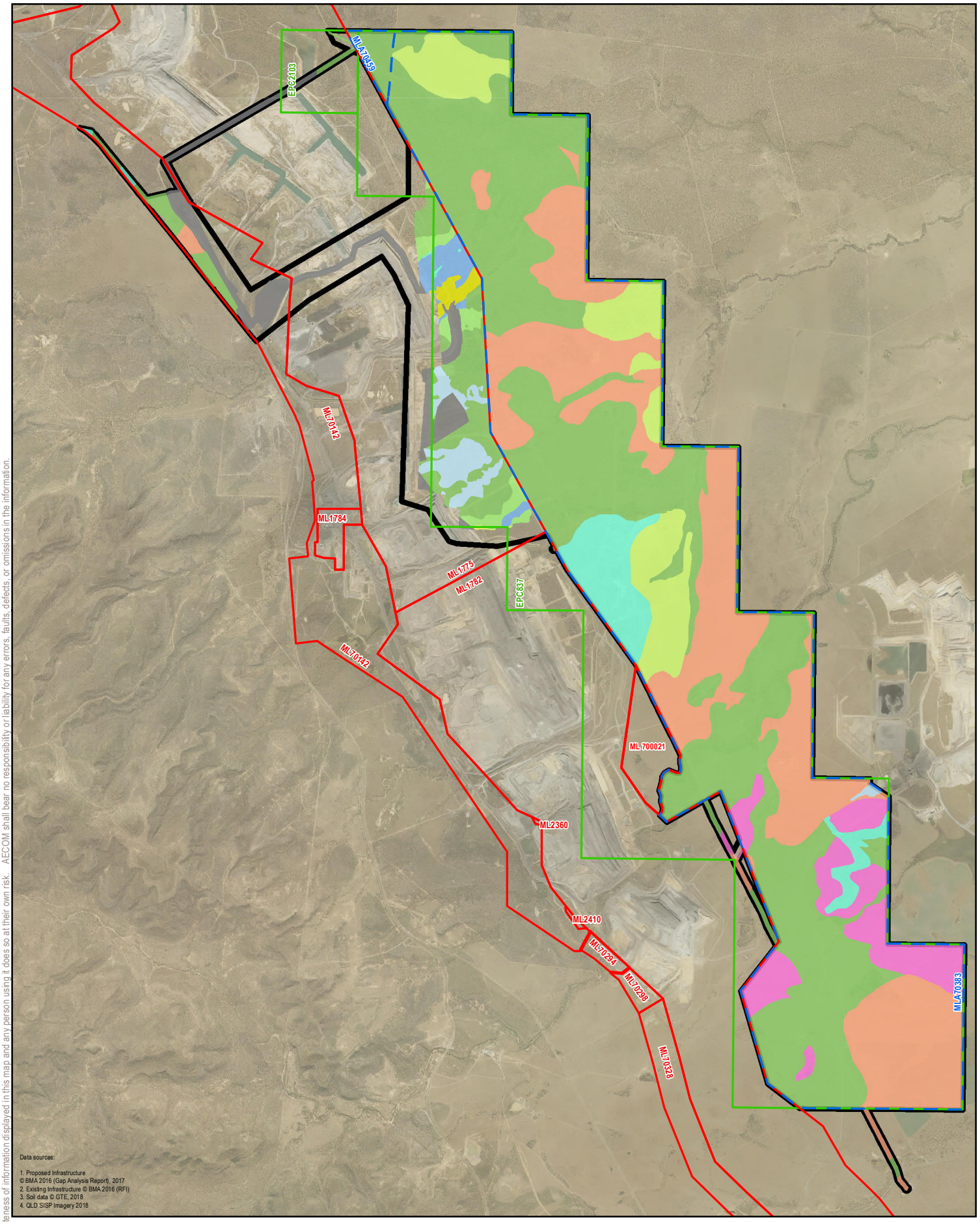
Table 5.6 Land suitability summary for the Project Site

SMU	Dryland cropping class	Beef cattle cropping class	ALC
2/20	4	3	C1
3	5	4, minor 5 in eroded or drainage areas	C2/C3
4	4	3	C1
5	4	3	C1
8	5	5	C3
12	5	4 levees, 5 on creek beds	C2/C3
13	4 levees, 5 on creek banks	3 levees, 5 on creek banks	C1/C3
16/23	4, minor 5 on stream banks	3, some 4 and 5 on stream banks and overlain banks	C1/C3
17	5	4	C2
18	4 levees, 5 on creek banks	3 levees, 5 on creek banks	C1/C2
19	4	3	C1
A1 & A1V	5	3	C2
A2	5	3	C2
A2g	-	2	A1
A3	5	3	C3
A4	-	5	C3
A4c	-	4	C3
A5	-	3	B
B1	2	1	A1
B2 & B2V	4	2	C1
B2s	-	2	A1
B2g	-	2	A1
B2bl	-	3	B
B3	4	2	C1
B3bl	-	3	B
B4	5	3/4	C2
B5	-	3	C1
E1	5	3	C2
E1r	-	3	B
E2	2	2	A1
E3	5	4	C3
T1	5	4	C3
T2	5	3	C2

Land management options for SMUs B1 and E2 (and variants A2g, B2s and B2g) were assessed as suitable to marginally suitable for cropping with soil water availability being the greatest limitation. This limitation was based upon the plant available water capacity (PAWC) attributes of 100 millimetres (mm) or more. Cropping land uses may include cotton, maize, mung bean, safflower, sorghum, soybean and sunflower. Marginal cropping land uses may include barley, chickpea, millet, oak and wheat. All other SMUs identified were considered suitable for beef cattle grazing activities either as simple or complex (consisting of two classes) units.

Figure 5-7 presents the pre-mine beef cattle grazing suitability results and Figure 5-8 presents the pre-mine rainfed cropping suitability results. ALC over the Project Site are shown in Figure 5-9.

In general, the topsoils for the majority of SMUs were assessed as suitable for rehabilitation activities, including as a growth medium for natural vegetation on flat to gently undulating plains.



Data sources:

1. Proposed Infrastructure
© BMA 2016 (Gap Analysis Report), 2017
2. Existing Infrastructure © BMA 2016 (RFI)
3. Soil data © GTE, 2018
4. QLD SISP Imagery 2018

LEGEND

- Project Site
- Exploration Permit Coal (EPC)
- Mining Lease (ML)
- Mining Lease Application (MLA)

Grazing Suitability

- Class 1
- Class 2
- Class 3
- Class 4
- Class 5
- Class 3 / 4
- Class 3 levees, class 5 on creek banks
- Class 4 levees, class 5 on creek banks
- Class 3, some class 4 and 5 on stream banks and overlain banks
- Class 4, minor class 5 in eroded or drainage areas
- Disturbance

N

Figure 5-7
Pre-mine Beef Cattle Grazing Suitability

Environmental Impact Statement
Saraji East Mining Lease Project

0 0.5 1 2
Kilometres

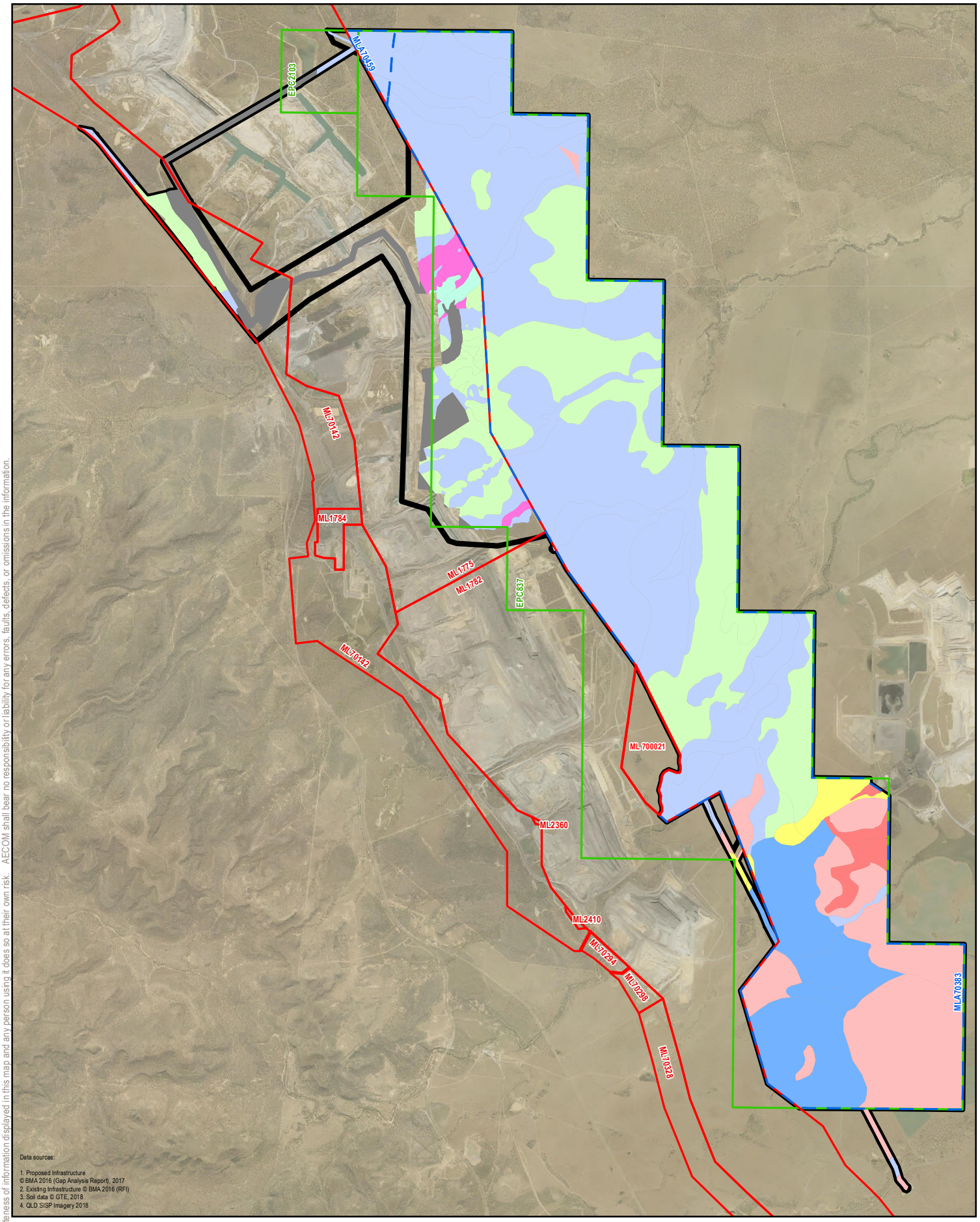
Scale: 1:110,000 (when printed at A4)

Projection: Map Grid of Australia - Zone 55 (GDA94)

BHP

DATE: 30/09/2020 VERSION: 1

Filename: \\aubne1fp003\Projects\605X\60507031\4. Tech Work Area\4.99 GIS\02_MXDs\06 Environmental Impact Statement\05 Land and Soil\60507031_G279_v1_A4P.mxd



Data sources:

1. Proposed Infrastructure © BMA 2016 (Gap Analysis Report), 2017
2. Existing Infrastructure © BMA 2016 (RFI)
3. Soil data © GTE, 2018
4. QLD SISP Imagery 2018

LEGEND

- Project Site
- Exploration Permit Coal (EPC)
- Mining Lease (ML)
- Mining Lease Application (MLA)

Cropping Suitability

- Regional Frameworks Class 3
- Regional Frameworks Class 4
- Regional Frameworks Class 5
- Cropping Class 2
- Cropping Class 4
- Cropping Class 5
- Class 4 on levees, Class 5 on creek banks
- Class 4, minor Class 5 on stream banks
- Disturbance

N

Figure 5-8
Pre-mine Rainfed Cropping Suitability

Environmental Impact Statement
Saraji East Mining Lease Project

0 0.5 1 2
Kilometres

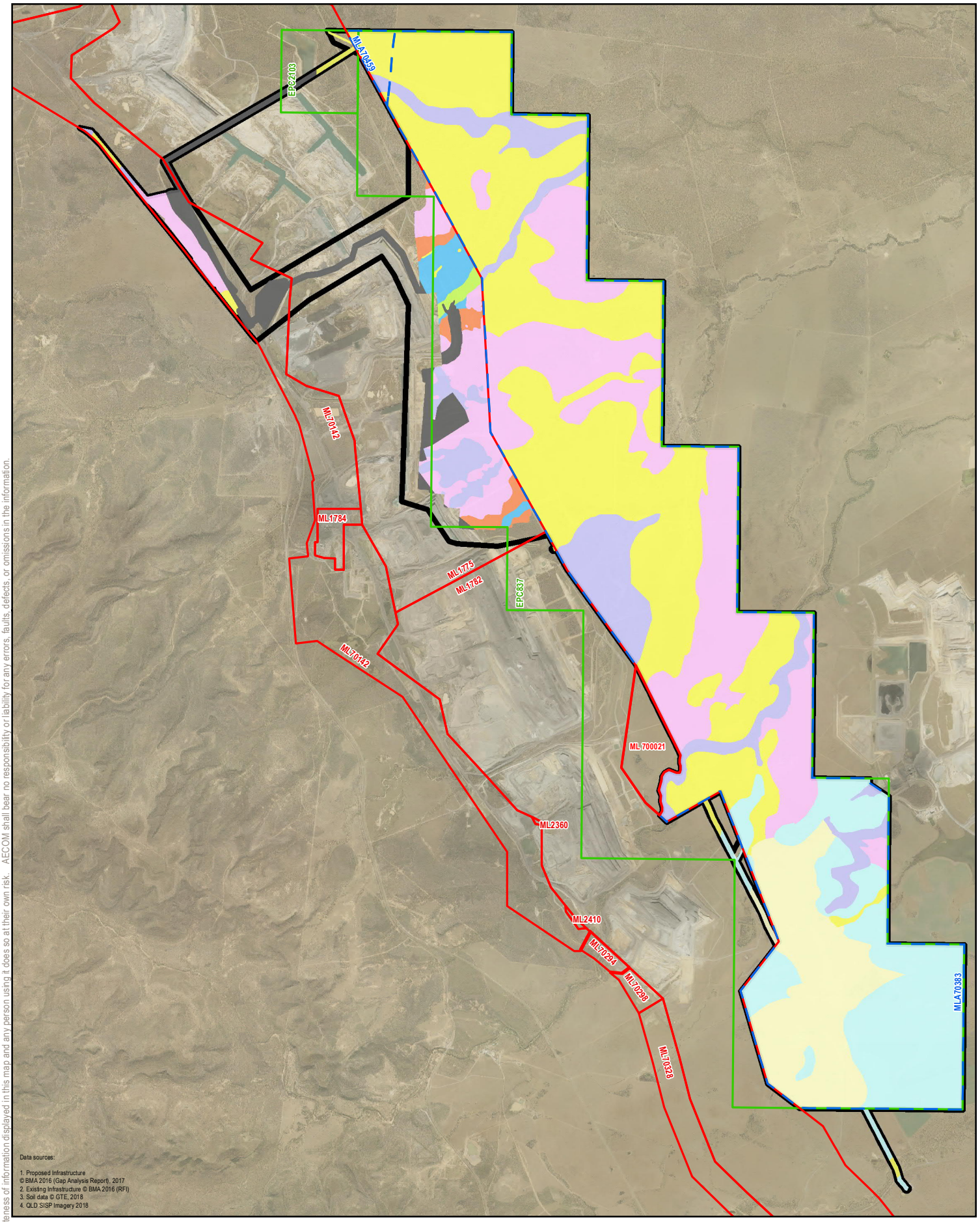
Scale: 1:110,000 (when printed at A4)

Projection: Map Grid of Australia - Zone 55 (GDA94)

BHP

DATE: 30/09/2020 VERSION: 1

Filename: \\aubne1fp003\Projects\605X\60507031\4. Tech Work Area\4.99 GIS\02_MXDs\06 Environmental Impact Statement\05 Land and Soil\60507031_G280_v1_A4P.mxd



Data sources:

1. Proposed Infrastructure
© BMA 2016 (Gap Analysis Report), 2017
2. Existing Infrastructure © BMA 2016 (RFI)
3. Soil data © GTE, 2018
4. QLD SISP Imagery 2018

LEGEND

- Project Site
- Exploration Permit Coal (EPC)
- Mining Lease (ML)
- Mining Lease Application (MLA)

Agricultural Land Class

- Class A1
- Class B
- Class C1
- Class C1 / C2
- Class C1 / C3
- Class C2
- Class C2 / C3
- Class C3
- Disturbance

Figure 5-9
Agricultural Land Classes

Environmental Impact Statement
Saraji East Mining Lease Project

0 0.5 1 2
Kilometres

Scale: 1:110,000 (when printed at A4)

Projection: Map Grid of Australia - Zone 55 (GDA94)

DATE: 22/07/2020 VERSION: 1

5.4.4 Queensland Agricultural Land Audit

An identification of agricultural values under the Queensland Agricultural Land Audit was undertaken. The following values were identified:

- The southern extent of the Project Site is mapped as Important Agricultural Areas (IAA), defined as 'land that has all of the requirements for agriculture to be successful and sustainable, is part of a critical mass of land with similar characteristics and, is strategically significant to the region or the state'. Section 5.4.3 further discusses the land suitability of the Project Site.
- The southern extent of the Project Site is mapped as SCA. See Section 5.4.5 for further assessment.
- There are no current sheep feedlots, poultry farms, piggeries or cattle feedlots mapped on the Project Site.
- Small areas in the south of the Project Site are mapped as current broadacre cropping. Section 5.4.3 further discusses the land suitability of the Project Site for broadacre cropping.

5.4.5 Strategic cropping land

The Project Site and surrounds continue to be used for cattle grazing where mining activity is not currently occurring. The southern extent of the Project Site is mapped within the SCL Trigger Map (refer Figure 5-1).

The SCL assessment (based on methods described in Section 5.3.2) identified SMUs within the SCL Assessment Area. Figure 5-10 shows the spatial distribution of these SMUs. The SCL map units were assessed against the SCL criteria outlined in Table 5.1. The findings of the assessment are summarised in Table 5.7.

Table 5.7 SCL assessment summary

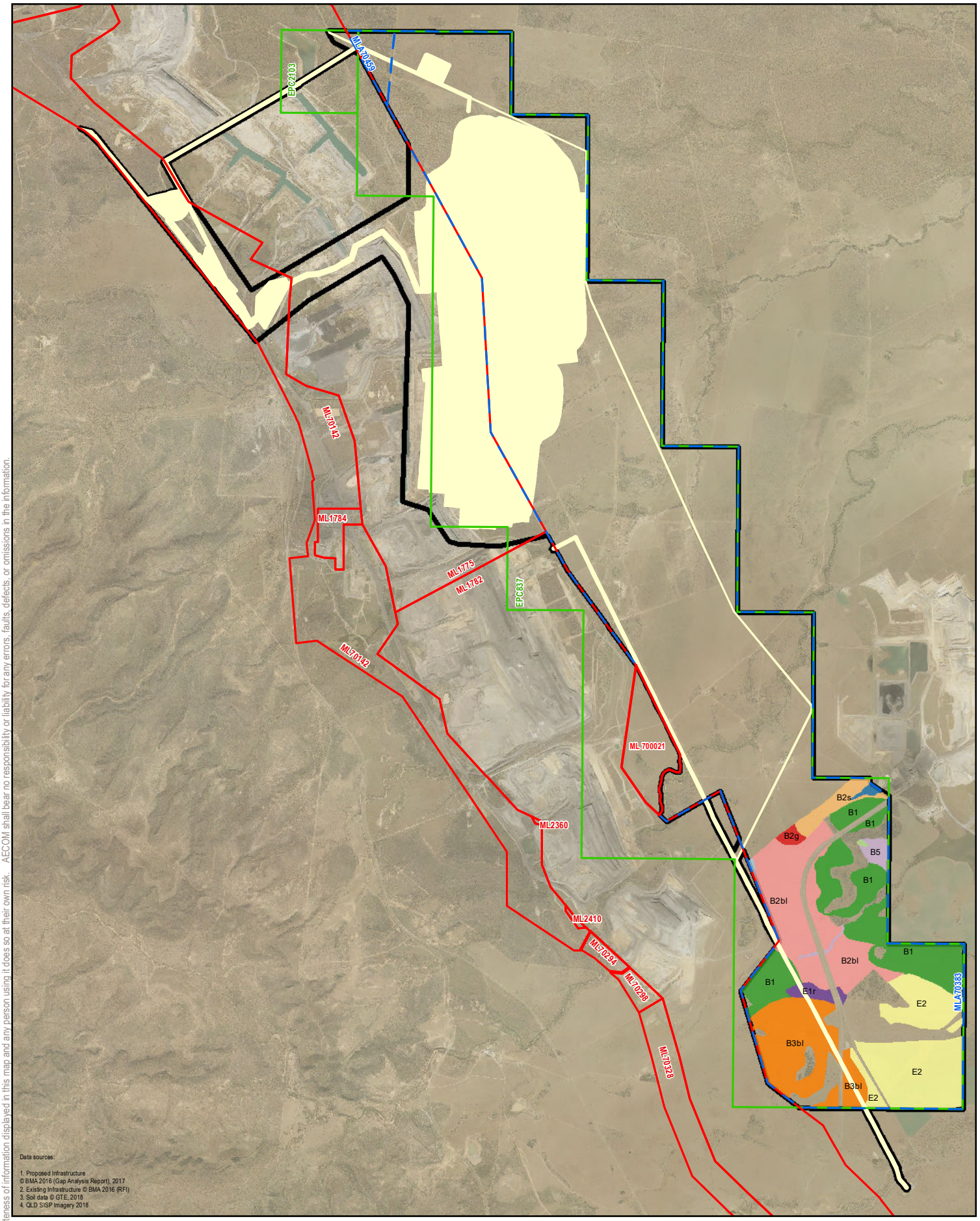
SMU	SCL map unit	SCL criteria exceedances	SCL status
B2s	1	pH – Sites N6-SCL, N7-SCL and N8-SCL	Not SCL
A4	2	pH – Sites N17, N18 and N19	Not SCL
B1	3	No SCL criteria exceedances reported	Likely SCL
A4c	4	pH – Sites N21 and N22 Chemical limitation for PAWC – Site N20	Not SCL
B2g	5	pH – Sites N4-SCL, N5-SCL and N9-SCL	Not SCL
B2bl	6	pH – Sites N26, N27, N32 and 80-SCL Soil water storage – Site 91-SCL	Not SCL
A2g	7	No SCL criteria exceedances reported	Likely SCL
B2s	8	No SCL criteria exceedances reported	Likely SCL
B1	9	No SCL criteria exceedances reported	Likely SCL
B5	10	pH – Sites N28 and N43	Not SCL
A5	11	pH – Sites N23, N24 and N25	Not SCL
B1	12	No SCL criteria exceedances reported	Likely SCL
B1	13	pH – Site 7-SCL Remaining two sites have no SCL criteria exceedances reported	Likely SCL
E1r	14	Soil water storage – Site 10-SCL, N41 and N42	Not SCL

SMU	SCL map unit	SCL criteria exceedances	SCL status
B1	15	No SCL criteria exceedances reported	Likely SCL
B3bI	16	No SCL criteria exceedances reported	Likely SCL
E2	17	No SCL criteria exceedances reported	Likely SCL

SCL map units 3, 7, 8, 9, 12, 15, 16 and 17 meet the SCL criteria as they did not exhibit any limitation relating to SCL. SCL map unit 13 exhibited limitations relating to SCL criteria soil pH; however, most of the analysed sites did meet the SCL criteria, therefore SCL map unit 13 is likely SCL.

Six SCL map units (1, 2, 4, 5, 10 and 11) do not meet the SCL criterion for soil chemistry as they exceed the relevant pH threshold limitation exceedance. SCL map unit 14 does not meet the SCL criterion for soil water storage and SCL map unit 6 does not meet the SCL criteria for both for soil water storage and for soil chemistry pH limitation exceedance.

Figure 5-11 presents the verified SCL soil types across the SCL Assessment Area.



LEGEND

- Project Site
- Project Footprint
- Exploration Permit Coal (EPC)
- Mining Lease (ML)
- Mining Lease Application (MLA)

Soil Mapping Units		
A2g	B2bl	B5
A4	B2g	E1r
A4c	B2s	E2
B1	B3bl	

N

Figure 5-10
Distribution of Soil Mapping Units in SCL Assessment Area

Environmental Impact Statement
Saraji East Mining Lease Project

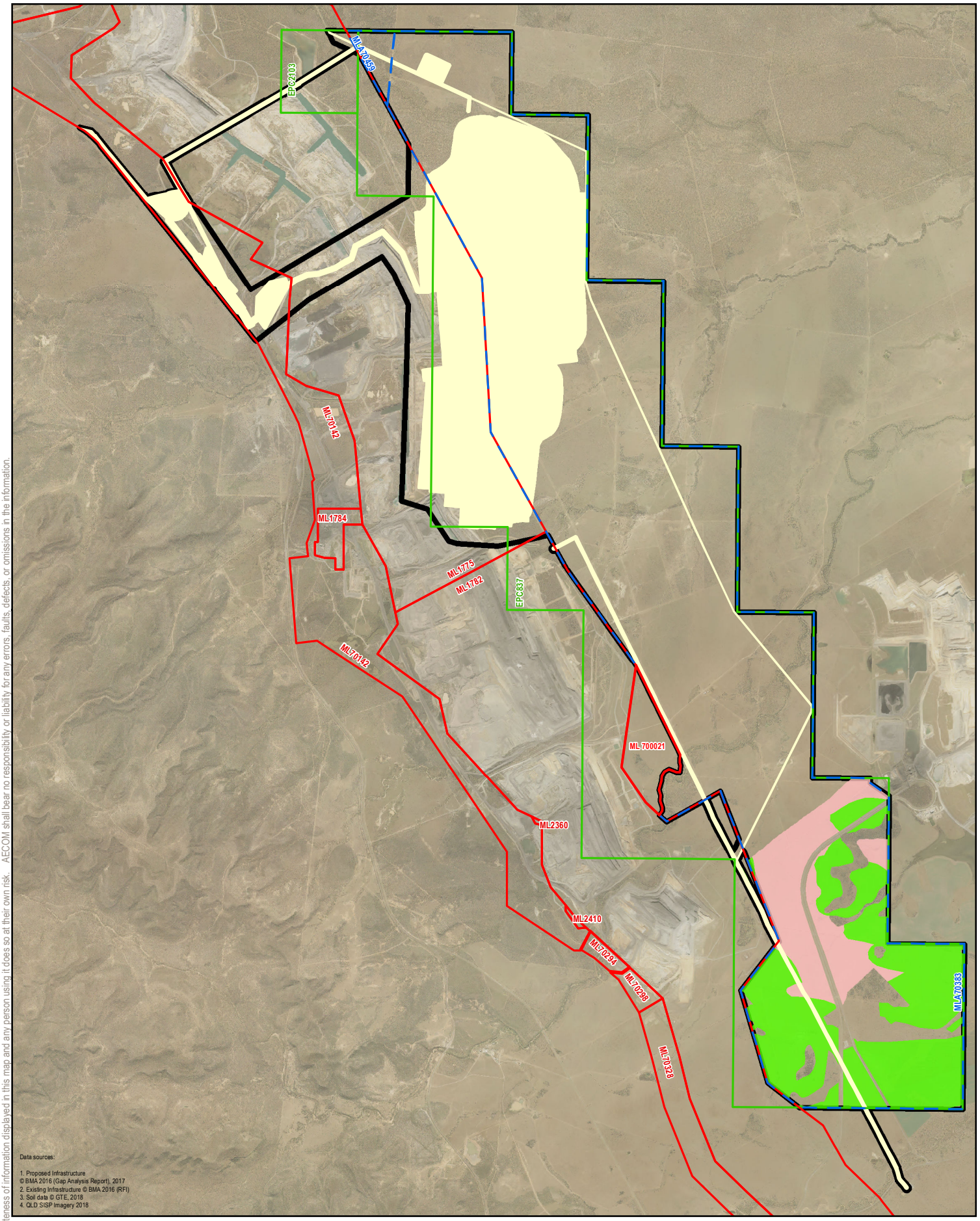
0 0.5 1 2
Kilometres

Scale: 1:110,000 (when printed at A4)

Projection: Map Grid of Australia - Zone 55 (GDA94)

BHP

DATE: 21/07/2020 VERSION: 2



Data sources:

1. Proposed Infrastructure
© BMA 2016 (Gap Analysis Report), 2017
2. Existing Infrastructure © BMA 2016 (RFI)
3. Soil data © GTE, 2018
4. QLD SISP Imagery 2018

LEGEND

- Project Site
- Project Footprint
- Exploration Permit Coal (EPC)
- Mining Lease (ML)
- Mining Lease Application (MLA)

Strategic Cropping Land

- SCL - Verified SCL
- SCL - Non - SCL Area

N

Figure 5-11

Verified Strategic Cropping Land

Environmental Impact Statement
Saraji East Mining Lease Project

0 0.5 1 2
Kilometres

Scale: 1:110,000 (when printed at A4)

Projection: Map Grid of Australia - Zone 55 (GDA94)

BHP

DATE: 8/07/2020 VERSION: 1

5.4.6 Contamination

Potential notifiable activities

Land contamination can arise from a range of land uses and activities. Potential contamination within the Project Site could be the result of previous activities associated with rural and agricultural land uses, such as homestead complexes, stockyards, agricultural infrastructure, equipment laydown areas and landfills. Potential contamination could also be the result of activities associated with the historical use of the Project Site for mining and mineral processing activities.

It should be noted that where a notifiable activity has been identified as potentially occurring:

- land contamination may not be a direct result of the notifiable activity
- the extent (lateral and vertical) of any contamination arising from a notifiable activity does not necessarily extend across the entire land parcel to which the notification relates.

Table 5.8 separates notifiable activities that have potentially occurred within the Project Site, from notifiable activities that are unlikely to have occurred within the Project Site.

Table 5.8 Notifiable activities likely or unlikely to occur within the Project Site

Notifiable activities that potentially occurred within the Project Site	Notifiable activities considered unlikely to have occurred within the Project Site
Abrasive blasting Aerial spraying Asbestos manufacture or disposal Chemical manufacture or formulation Chemical storage Electrical transformers Engine reconditioning works Explosives production or storage Landfill Livestock dip or spray race operations Metal treatment or coating Mine wastes Mineral processing Petroleum product or oil storage Railway yards Scrap yards Waste storage, treatment or disposal	Asphalt or bitumen manufacture Petroleum or petrochemical industries Smelting or refining Tannery, fellmongery or hide curing Wood treatment and preservation Battery manufacture or recycling Coal fired power station Coal gas works Drum reconditioning or recycling Dry cleaning Fertiliser manufacture Foundry operations Gun, pistol or rifle range Herbicide or pesticide manufacture Lime burner Paint manufacture or formulation Pest control Pharmaceutical manufacture Printing Service stations

Where DES has been advised that a notifiable activity has been, or is being undertaken, the land parcel where this activity has taken place is listed on the EMR or CLR. It is possible that notifiable activities have occurred, or are occurring, on properties within the Project Site without these properties being listed on the EMR or CLR.

Review of aerial photography

Recent aerial photography of the Project Site was reviewed to identify potential areas of concern with regards to land contamination. A summary of the identified activities is included in Table 5.9.

Table 5.9 Potential for pre-existing notifiable activities to occur within the Project Site

Activity	Activity details	Comment	Occurrences within the Project Site
Stockyard complex	Stockyards, holding yards, potentially including spray races or stock dips.	Potential for use of insecticides in spray races and/or dips.	The presence of stockyards was not identified in aerial photography; however, the resolution of the available imagery may not have been detailed enough to identify stockyards.
Equipment laydown areas	Cleared area where equipment is/may have been stored.	Potential for minor chemical/fuel/oil/ waste oil storage/spills.	Aerial imagery indicates multiple locations across the Project Site that have been used for equipment laydown associated with mining activities.
Farming infrastructure	Silos, above ground storage tanks, machinery storage.	Sheds, above ground storage tanks, silos with potential for minor chemical/ pesticide/fuel/oil/ waste oil storage/spills.	Aerial imagery indicates multiple locations across the Project Site that have been used as homesteads.
Dams	Dams, depending on how they were constructed, may have utilised imported fill, or minor fuel storage associated with pump mechanisms.	Potential for importing of previously contaminated soil, and/or for minor soil contamination associate with pumps etc.	Aerial imagery indicates multiple locations across the Project Site that have been, and are being, used as dams and water/waste storages.
Mining	Potential box cut/borrow pit/quarry.	Potential for minor fuel/chemical/oil/ waste oil storage.	Aerial imagery indicates multiple locations within the vicinity of the Project Site that are, and have been, subject to mining activities.

Unexploded ordinance search

A UXO is any sort of military ammunition or explosive which has failed to explode as intended.

Military ammunition is designed to explode at the time it is used, but for a variety of reasons some military ammunition fails to do so (Department of Defence, 2018a).

In Queensland, DES works with the Department of Defence to manage UXO contamination (NEPM 1999 as varied, NEPC). A review of Department of Defence UXO mapping identified that the Project Site does not contain any known UXO contaminated areas (Department of Defence, 2018b).

It is considered that any future Project works should not be impacted by any UXO. However, care will be taken, and advice from Defence sought and followed, if any potential devices are identified.

5.5 Potential impacts

5.5.1 Subsidence

A detailed mine subsidence assessment is presented in **Appendix B-2 Subsidence Modelling**. The subsidence modelling assessed the maximised underground layout.

The potential impacts as a result of subsidence include:

- surface depressions
- surface cracking - tension cracks will form above the longwall abutment edge and on either side of the chain pillars
- changes to surface water resources:
  - morphological stability of watercourses
  - the creation or alteration of riffle and pool sequences
  - changes to flood behaviour
  - incision processes
  - stream widening
  - lowering of creek bed and banks
  - reduced flow due to increased porosity and permeability
  - change of water quality due to a change in dissolved oxygen, salinity, iron oxides, manganese, and electrical conductivity
  - decrease in bank stability
- erosion and sedimentation until the bed profile is restored to a stable profile
- groundwater drawdown:
  - fractures in the Permian rock mass and overlying Tertiary sediments may provide pathways for drainage of groundwater resources
- ecological impacts:
  - dieback of riparian vegetation due to cracks beneath streams
  - changes to riparian community structure and composition due to water loss and disturbance of the root zone
  - reduction of creek stability due to the death of fringing vegetation and tree fall
  - vegetation stress from either mechanical disturbance or water table change
- aquatic ecological impacts:
  - lowering sections of stream bed with changes in bed level
  - alteration of natural water flow patterns
  - fish stranding in subsided areas due to restricted fish movement, especially during low flow conditions

- loss of fish due to fish passage blockage
- hydrological and biological disconnect between the Isaac River and upper catchment areas
- bank failure, in-filling of the channel and creation a barrier to fish caused by erosion.

Pre-mining land use in the Project Site is predominantly cattle grazing. Due to the gradual nature of the subsidence, it is expected that grazing activities will continue during mining operations but out of direct operational areas while any related subsidence occurs.

The modelled predicted subsidence impact can be seen in Figure 5-12.

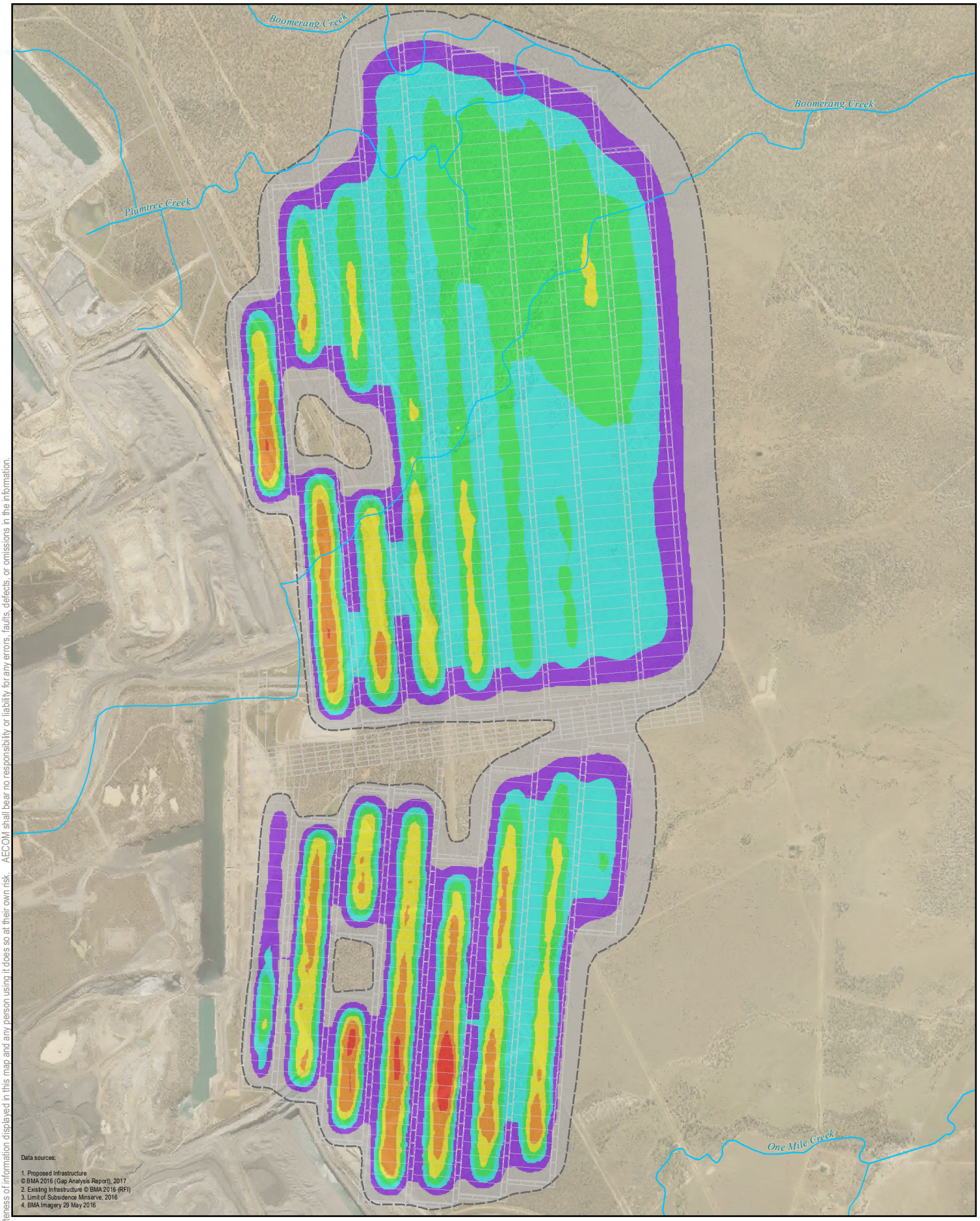
Over the northern panels:

- the maximum predicted subsidence is 3.2 m
- the deepest panel is 440 m below ground level
- Hughes Creek (maximum predicted subsidence of 2.5 – 3 m), Plumtree Creek (maximum predicted subsidence of 1.5 – 2 m) and Boomerang Creek (maximum predicted subsidence of 1 m) run through the northern panels.

Over the southern panels:

- the maximum predicted subsidence is 3.5 m
- the deepest panel is 350 m below ground level.

Existing infrastructure in the Project Site will be relocated outside of the subsidence boundary as part of the Project.



Data sources:

1. Proposed Infrastructure © BMA 2016 (Gap Analysis Report), 2017
2. Existing Infrastructure © BMA 2016 (RFI)
3. Limit of Subsidence Minserve, 2016
4. BMA Imagery 29 May 2016

LEGEND

- Underground Mine Layout (Maximised)
- Limit Of Subsidence

Subsidence Contour

- < 0.5m
- 0.5 - 1.0m
- 1.0 - 1.5m
- 1.5 - 2.0m
- 2.0 - 2.5m
- 2.5 - 3.0m
- > 3.0m

N

Figure 5-12
Predicted Subsidence

Environmental Impact Statement
Saraji East Mining Lease Project

0 0.25 0.5 1
Kilometres

Scale: 1:38,000 (when printed at A4)

Projection: Map Grid of Australia - Zone 55 (GDA94)

BHP

DATE: 8/07/2020 VERSION: 1

5.5.2 Soils and land suitability

Topsoil stripping associated with the Project may potentially impact future land use if not managed appropriately. Potential impacts may include but are not limited to:

- incorrect stripping depths of a SMU
- mixing of higher quality soil with low quality during stockpiling phase
- erosion of areas which have been stripped or stockpile areas
- identification of rehabilitation soils and their maintenance
- incorrect placement of soils.

The desktop, field and laboratory observations of existing soils shows very low field indication of PASS with no indicators of AASS across all 23 SMUs.

5.5.3 Contaminated land

Potential land contamination impacts within the Project Site may result from the disturbance of existing contaminated land, or contamination caused by activities associated with the Project. Impacts have the potential to harm human, surface water, groundwater and soil health, leading to degradation of the natural environment, and a reduction in the productive capability of the land and the sustainable use of natural resources.

Some Project activities have the potential to contaminate the Project Site as a result of the generation and handling of wastes, including mineral wastes. A discussion of the potential impacts associated with mineral waste can be found in **Chapter 10 Geochemistry and Mineral Waste**.

Disturbance of existing contaminated soils

Project activities have the potential to disturb existing contaminated land or groundwater during the construction, operation, decommissioning and rehabilitation phases. The disturbance of contaminated land or groundwater has the potential to contaminate previously unaffected soil or groundwater and affect human health through ingestion/dermal contact.

In the case that any existing (but unregistered) notifiable activities are positively identified during pre-construction works, in accordance with Section 320A(2) of the EP Act, landowners, or occupiers are required to notify DES so that the affected land parcels may be included on the EMR.

Project activities with the potential to cause land contamination

Project activities and areas within the Project Site with the potential to cause land contamination include:

- coal transportation
- coal handling facility, including conveyors
- refuelling areas
- chemical stores
- water treatment plants
- maintenance areas
- spoil and overburden storage and disposal
- haul roads.

Contamination sources from operations can include, but are not limited to, the following:

- spills of fuels, greases and lubricating oils which may cause localised contamination
- ineffective mineral waste disposal leading to soil and groundwater contamination as a result of leaching
- cargo spills during coal transportation on mine haul roads
- ignition of unprocessed coal releasing fly ash and other harmful emissions
- change in chemical or physical composition of natural soil in areas where mining has occurred, or overburden is dumped
- change in chemical or physical composition of natural soil in areas where dust suppression constitutes using water containing dissolved salts.

Demolition of buildings and infrastructure within the Project Site also has the potential to contaminate soils if not managed effectively. These activities have the potential to increase the risk of contaminants impacting human health and sensitive environmental receptors.

In consideration of the scale of the Project, significant environmental and/or health risks could occur if contaminated material is not identified prior to construction works, potentially exposing workers, members of the community and the environment to contaminants.

5.6 Mitigation and management measures

5.6.1 Subsidence

A Subsidence Management Plan (**Appendix K-2**) has been prepared for the Project. The proposed approach to managing subsidence is to use proactive measures to predict and potentially improve the overall condition of the potentially affected areas, so that any adverse effects of subsidence are minimised.

The order of controls for subsidence management is:

- mitigation (pre and post subsidence)
- monitoring and rehabilitation.

Monitoring

The Subsidence Management Plan (**Appendix K-2**) provides an overview of the monitoring requirements pre and post mining to ensure relevant data is captured for:

- landform
- surface water
- groundwater
- ecology
- infrastructure.

A pre-subsidence risk assessment will be conducted prior to Project commencement and will include a cross section of suitably qualified personnel. The findings of the risk assessment and monitoring will be used to identify suitable measures to mitigate the environmental risks. Monitoring of potential subsidence areas will be undertaken prior to any panel being subsided to ensure that any subsidence impacts are quickly identified and appropriate mitigations applied. Monitoring for surface subsidence parameters will commence after cessation of subsidence movements and will continue periodically. A summary of monitoring requirements is provided in Table 5.10.

Table 5.10 Summary of monitoring requirements

Subsidence impact	Parameters	Frequency
Landform	• Geomorphologic condition/status surveys including photographic recording of reach condition, including: – soils – sediment accumulation – watercourse stability • Land use related to water availability or quality (e.g. cattle grazing)	• Prior to mining / subsidence • Regular visual inspections will be conducted throughout the wet season and as required in the dry season • In accordance with Environmental Authority (EA) conditions • Aerial survey (LiDAR) to be flown annually
Surface water	• Creek flow monitoring – mean annual stream flow – peak discharge flow • Surface water quality	• Prior to mining / subsidence • Regular visual inspections will be conducted throughout the wet season and as required in the dry season • In accordance with EA conditions
	• Creek bed monitoring: – Instream ponding – Instream tension cracking – Overflow and flood points – Erosion points – Riparian vegetation conditions (foliar discoloration, defoliation, pathogenic attack, uprooting and tree mortality) – Bed and bank scour points – Sediment deposition areas – Entry points of other watercourses and localised tributaries – Any infrastructure located within the watercourse – Channel profile – Channel slope – Bank height – Erosion points – Ponding – Sediment deposition areas – Bed and bank scour points – Bed slope • Size of subsidence voids created within watercourse	• Prior to mining / subsidence • Ongoing monitoring in accordance with the Receiving Environment Monitoring Program (REMP) and EA conditions
Groundwater	• Water level measurement • Water quality field conductivity measurement • Chemical analysis of water samples to be taken annually • Groundwater level rebound • Groundwater flow patterns	• Prior to mining / subsidence • Ongoing monitoring at the completion of mining in accordance with the groundwater monitoring plan or the site closure management plan

Subsidence impact	Parameters	Frequency
Ecology	• Flora – Height class and life form of the dominant species within each strata (emergent, canopy, subcanopy, understory) – Foliage projective cover – Coarse woody debris – Groundcover composition – Native and introduced plant species richness – Native and introduced plant species relative abundance – Tree health parameters • Fauna – Intensive trapping • Microhabitat search program	• Flora and fauna monitoring prior to mining / subsidence • Flora annually during operations or as outlined in the EA
Infrastructure	• Photographic records of – Pipelines – Electricity transmission infrastructure – Watercourse related infrastructure – Dams and collection ponds – Bores • Windmills	• Prior to mining / subsidence • After the commencement of operations, monitoring will occur annually or as outlined in the EA

Management of subsidence

Potential mitigation measures for the management of subsidence are listed in Table 5.11. These measures will be applied as necessary to achieve the most practicable environmental outcomes. Progressive rehabilitation will be conducted as the mine advances and panels subside. Further detail regarding the implementation of rehabilitation is provided in Section 5.6.4.

Ongoing reporting will be conducted during the operation of the Project, in accordance with the EA and **Appendix K-2 Subsidence Management Plan**.

Table 5.11 Indicative mitigation techniques

Subsidence impact	Mitigation measure
Landform	• embankment arming • bed stabilisation such as pervious weirs • geomorphological modelling to predict high energy areas of the subsided landform • grazing access / controls to mitigate vegetation stripping and bank damage • channel re-profiling and construction of contour banks • vegetation planting • erosion control matting in high energy or erosive areas • construction of drop structures at head cut erosion features • ripping • tyning • grading • compaction • crack infilling with concrete or clay • progressive rehabilitation
Surface water	• embankment arming • bed stabilisation such as pervious weirs • geomorphological modelling to predict high energy areas of the subsided landform • grazing access / controls to mitigate vegetation stripping and bank damage • channel re-profiling and construction of contour banks • vegetation planting • erosion control matting in high energy or erosive areas • construction of drop structures at head cut erosion features • ripping • tyning • grading • compaction • crack infilling with concrete or clay • progressive rehabilitation
Ecology	• investigate and establish offsets • pump areas of persistent ponding • revegetate areas impacted • utilise dead vegetation in habitat creation • regrading to promote drainage
Infrastructure	• repair infrastructure as required • where possible, remove all infrastructure within the subsidence zone prior to the subsiding of any panel

5.6.2 Soils and land suitability

Post mining land use suitability is influenced by various factors including changes to physical, chemical and biological properties of soil, slope and slope length, soil depth and the quality of the underlying spoil. Given that Project involves underground mining, the extent of surface disturbance will be limited. The proposed rehabilitation for the Project is discussed in Section 5.6.4.

Topsoil management

Table 5.12 presents the recommended topsoil strip depth and use for topsoil.

Table 5.12 Recommended topsoil strip depth and recommended use

SMU	Recommended topsoil strip depth	Recommended topsoil use
2/20	0.00-0.30 metres below ground level (mbgl)	Strip the A horizon of the duplex soils (20 to 30 centimetres (cm)) avoiding the lighter coloured B horizon clays. Where clay soils are present, stripping should only take place to a maximum of 30 cm. Poorer surface structural characteristics are indicated and replacement should only be on relatively low slope angles.
12	0.00-0.40 mbgl	Strip the upper 40 cm, avoiding lower A2 or B horizon materials. Replacement should only be on very low slope angles as nutrition is low and structure is weak.
13	0.00-0.25 mbgl	Strip the A horizon (15 to 25 cm) avoiding B horizon clays which are generally dispersive. Only reuse the soil on almost flat areas (<0.5%) as the soil has very poor physical characteristics with low infiltration rates and is prone to surface sealing. If sufficient volumes of other soils are available for rehabilitation, the SMU may be better discarded.
16/23	0.00-0.25 mbgl	Strip the A horizon material (20 to 25 cm) avoiding bleached A2 material (where present) or B horizon clays. The material should only be used on flatter slopes as structural instability is indicated.
17	Nil	Generally nil, minor SMU with little seed source.
18	0.00-0.50 mbgl	Strip the surface 50 cm as soil in most areas, however close to the creek systems, around 90 cm of useable material (essentially a germination medium for flatter slopes) may be present. Avoid the inclusion of lower clay layers as some of these materials in the Hughes and Spring creek areas may be very dispersive. Overall structure is weak and the material should not be reused on steep slopes.
19	0.00-0.50 mbgl	Strip the surface 50 cm as better quality soil.
3	0.00-0.30 mbgl	Strip the upper A horizon (20 to 30 cm) avoiding the lighter coloured A2 or B horizon clays. Replacement should only be on very low slope angles as nutrition is low and structure is weak.
4	0.00-0.30 mbgl	For use as topsoil, limit stripping to the surface 30 cm in most areas (avoiding light brown subsoil materials). Patches of very dark clays containing carbonate could be taken to a total depth of 50 cm. The soils are suitable for replacement on elevated slopes as good nutrition and reasonable structural characteristics are evident. Initial plant establishment may be slowed by salinity.
5	0.00-0.20 mbgl	Strip the surface 20 cm as topsoil and a seed source in most areas. In occasional areas depth may be as little as 10 cm (structure is poor and the material should not be reused on steep slopes).
8	0.00-0.15 mbgl	The surface 10 to 15 cm (A horizon) may be useful on very flat areas (do not strip the scalded areas).
A1	0.00-0.40 mbgl	Topsoil may be retrieved for the major extent of the sandy A horizon. The material is suitable for use on all level to gently sloping rehabilitation areas.
A2	0.00-0.30 mbgl	Topsoil should only be retrieved from the upper 20 cm as salinity risk increases below this level. The material is suitable for use on lower sloping rehabilitation areas and should ideally be placed to a depth of 20 cm.

SMU	Recommended topsoil strip depth	Recommended topsoil use
A2g	0.00-0.10	
A3	0.00-0.50 mbgl	Topsoil strip depth may extend well past the nominated 50 cm strip depth although more intensive testing for EC and structural assessments should be conducted beforehand. The sandy loam topsoil may be taken until hard clayey subsoil is encountered. The material is suitable for use on most level to gently sloping rehabilitation areas and should ideally be placed to a depth of 20 cm or more.
A4	Nil	
A4c	0.00-0.10	
A5	0.00-0.10	
B1	0.00-0.50 mbgl	Excellent quality topsoil which could be taken deeper than the 50 cm nominated depth (up to 90cm) or double stripped. The material is suitable for use on all rehabilitation areas and should ideally be placed to a depth of 20 cm or more.
B2	0.00-0.30 mbgl	Topsoil should not be taken deeper than the 30 cm nominated depth as below this depth the subsoil is quite hard and coarse structured which would seal if placed on rehabilitation. The material is suitable for use on flatter rehabilitation areas as it tends to erode. It should ideally be placed to a depth of 20 cm or more.
B2bl	0.00-0.10	
B2g	Nil	
B2s	0.00-0.15	
B3	0.00-0.30 mbgl	These soils are traditionally variable in quality – particularly between mounds and depression positions. The mounds are better quality than many other melon hole situations and are not excessively saline or sodic above about 50 cm depth. Nevertheless, topsoil should not be taken deeper than the 30 cm because of the risk of contamination from saline subsoil. The material is suitable for use on flatter rehabilitation areas as it tends to erode. It should ideally be placed to a depth of 20 cm or more.
B3bl	0.00-0.10	
B4	0.00-0.20 mbgl (mound) and 0.00 mbgl (depression)	Melon hole soils often vary considerably between mounds and depression positions. The flat areas between depressions (mounds) offer rehabilitation potential however the dark crusting clay depressions should be avoided. It is important that stripping does not go too deep as useable topsoil will be contaminated. The material is preferred on flatter rehabilitation areas and should ideally be placed to a depth of 20 cm or more.
B5	Nil	
E1	0.00-0.50 mbgl	The loose surface topsoil for reuse in mine rehabilitation may be stripped moist or dry. These soils offer large quantities of good porous material with a variety of applications in mine rehabilitation. Stripping depth will normally exceed 60 cm. The material is

SMU	Recommended topsoil strip depth	Recommended topsoil use
		suitable for use on most rehabilitation areas as it tends to infiltrate water rapidly and remain loose. It should ideally be placed to a depth of 20 cm or more.
E1r	Nil	
E2	0.00-0.40 mbgl	These soils are high quality clay soils with a high moisture retention capacity however the establishment of permanent pasture cover on rehabilitation may take considerable time as problems occur with germination of fine seeded plants in the shrinking and swelling medium. The soils are often saline below 50 cm depth so a depth cut off of 40 cm is nominated. The material is more suited for use on flatter rehabilitation areas as it tends to erode and the establishment of a protective surface cover may take longer than expected. It should ideally be placed to a depth of 20 cm or more.
E3	0.00-0.20 mbgl	Stripping of these soils should not proceed into the clayey subsoil as the material is hard, impervious and generally dispersive. It is preferable to take less soil than risk contamination with the poor subsoil. Use should normally be limited to rehabilitation of level sites.
T1	0.00-0.20 mbgl	The upper sandy loam may be stripped to the harder pale coloured clay subsoil. In most cases 20 cm of soil would be available for stripping. The preferred rehabilitation application is flat sites only due to high erosion potential.
T2	0.00-0.20 mbgl	The T2 SMU at 10 – 20 cm horizon is a well-drained and higher quality soil which overlies very dense fine sandy loam. It is expected to set hard and seal if placed over rehabilitation. The preferred rehabilitation application is flat sites only due to high erosion potential.

5.6.3 Contaminated land

Where practical, the following measures will be implemented prior to commencing Project works:

- directing excavation works, spoil or topsoil storage during planned operations and remediation to avoid potentially contaminated areas
- design drainage to minimise the amount of run-off occurring near, or across, potentially contaminated land
- undertake an environmental assessment of potentially contaminated sites that will be impacted during the operational phase of the Project.

A preliminary site investigation will be undertaken if construction activities are to be undertaken in areas where potential for contamination is identified, or on land listed on the EMR or CLR. This preliminary investigation will identify the location and nature of any contamination that will potentially be encountered during Project works.

If the findings of the preliminary investigation identify that contamination is significant, a detailed site investigation will be undertaken in order to assess the health and environmental risks of the contaminants. A management and remediation plan will then be developed in order to minimise the impact of these contaminants.

5.6.4 Rehabilitation

A Rehabilitation Management Plan (RMP) has been developed for the Project (**Appendix K-1**). The RMP provides the framework within which progressive and final rehabilitation can be planned and executed for the Project. Post-mining rehabilitation as outlined in the RMP is detailed below.

Hierarchy

The rehabilitation hierarchy in the DES *Guideline – Application requirements for activities with impacts to land* (ESR/2015/1839, version 4.02) (DES, 2017) outlines the preferred methodologies to rehabilitate mining activities that minimise the risk of environmental harm. The DES Guideline states that strategies listed higher in the hierarchy should be adopted in preference to those listed lower, unless there are significant environmental, economic or social issues that override a higher selection. The rehabilitation hierarchy is summarised as follows, in order of decreasing preference:

1. avoid disturbance that will require rehabilitation
2. reinstate a “natural” ecosystem as similar as possible to the original ecosystem
3. develop an alternative outcome with a higher economic value than the previous land use
4. reinstate previous land use (e.g. grazing or cropping)
5. develop lower value land use
6. leave the Project Site in an unusable condition or with a potential to generate future pollution or adversely affect environmental values.

This rehabilitation hierarchy will apply differently to each of the post mining land uses described later in this section. In assessing the applicable goals of the hierarchy, BHP will consider the pre-mining land use, any compensation agreements regarding land including stakeholder values, the potential uses of the rehabilitated land and the surrounding environmental values.

Post mining land uses

BHP's *Queensland Coal Rehabilitation Completion Criteria* (BHP, 2018c) outlines the completion criteria for meeting satisfactory rehabilitation for post mining land uses. Post mining land uses across BHP's operations typically include:

- cattle grazing
- dryland cropping
- woodlands habitat
- watercourses
- water storages.

Queensland Coal Rehabilitation Completion Criteria notes that final voids are not considered a post mining land use as they are difficult to justify as an acceptable rehabilitation post mining land use. No voids are proposed as part of the Project (areas within the ML will be subject to rehabilitation as approved for the existing Saraji Mine).

Land suitability

Changes to the proposed land surface will occur progressively over the 20 year mine life. Where necessary to accommodate surface infrastructure (as discussed in Section 0), soil will be stripped and stockpiled to prepare for clearing, creating potential for erosion and acid sulphate soils. Clearing activities will be staged with the mining schedule of each longwall panel to minimise the exposure of disturbed areas and degradation of topsoil. With erosion and sediment controls, and setting aside of topsoil, these features should not affect long term land suitability.

The surface infrastructure including the coal handling and preparation plant (CHPP) and mining infrastructure area, water management infrastructure, roads and a construction village, will be installed during the construction phase as identified in Section 3.6.2 of the EIS. Previously disturbed areas will be utilised where possible. Vegetation removal will be limited to the footprint associated with surface infrastructure, where it cannot be avoided. Some earth works may be required to level the sites. These changes are not anticipated to affect the land use suitability for rehabilitation.

The most notable change to the landscape will come from subsidence. Prior to the underground mining, land within the Project Site is utilised for cattle grazing and mine associated infrastructure. Due to the gradual nature of the subsidence, it is expected that grazing activities will continue during mining operations but out of direct operational areas while any related subsidence occurs. This will result in impacts including a maximum surface depression of 3.5 m (refer **Appendix K-2 Subsidence Management Plan**). These areas will be monitored for signs of erosion.

As outlined in Section 5.4.3, the Project Site pre-mining land use is most suited to grazing practices and marginally suitable for cropping with soil water availability being the greatest limitation. The proposed post mining land use for the Project Site is expected to return to grazing land, consistent with the surrounding pastoral land use that dominates the region.

Native vegetation outside of the surface infrastructure footprint will be retained in a way that is compatible with the pre-existing land use for biodiversity values observed during the baseline ecological studies. However, where vegetation mortality occurs as a result of persistent ponding associated with subsidence, it will be revegetated with species that are tolerant of inundation (refer **Chapter 6 Terrestrial Ecology**).

Whether or not it is a previously mined area, grazing will cause damage to the soils and land suitability if not managed in accordance with the limits of the land suitability class. Required soil conservation practices include erosion and sediment control, stocking rate control and establishment or re-establishment of permanent pasture.

Mapping of pre-mine beef cattle grazing suitability, pre-mine rainfed cropping suitability and ALC is shown in Figure 5-7, Figure 5-8 and Figure 5-9 respectively.

Based on the lack of suitable land available and minimal water availability, dryland cropping is not proposed as a rehabilitation method except for areas verified as SCL to the south of the Project Site (Section 5.4.5 and Figure 5-11). These will be rehabilitated to suitable dryland cropping lands.

Strategic cropping land

State-mapped SCL is in the southern extents of the Project Site, in MLA 70383. As discussed in Section 5.4.5, the SCL assessment identified SMUs within the SCL Assessment Area. The SCL map units were assessed against the SCL criteria (Table 5.1).

SCL map units 3, 7, 8, 9, 12, 15, 16 and 17 meet the SCL criteria as they did not exhibit any limitation relating to SCL. SCL map unit 13 exhibited limitations relating to SCL criteria soil pH; however, most of the analysed sites did meet the SCL criteria, therefore SCL map unit 13 is likely SCL. The classification and assessment of SCL soil types is subject to change as part of the ongoing Regional Interests Development Approval (RIDA) process which is proceeding in parallel to the EIS.

Under the RPI Act, no more than 2% of SCL may be permanently impacted by a development. The total area of the mapped SCL is calculated as the area of a polygon that covers one or more lot and plans under the ownership of a single landholder. The area of impact is the area of mapped SCL which will potentially be impacted by the Project, whether or not the land can be restored to its pre-activity condition after the activity ceases. An overhead 66 kilovolt (kV) powerline is proposed to extend off-lease and connect to the Dysart Substation, south of the Project Site. Within the verified SCL, impacts under the ownership of a single landholder are less than 2% of the property area.

BHP will reinstate the SCA to pre-disturbance condition as soon as practical and no later than six months after the decommissioning of the resource activities. Rehabilitation will involve dryland cropping within the impacted areas. Methodologies of restoration are outlined in Table 5.16.

Rehabilitation of utilised pre-existing Saraji Mine Infrastructure

The Project will utilise existing infrastructure as part of the existing Saraji Mine operations where practical, including:

- use of the Saraji Mine CHPP for processing Project coal in years where run of mine (ROM) tonnes exceed 7 Million tonnes per annum (Mtpa)
- use of an integrated power supply network for Saraji Mine and the Project
- use of the existing open cut pit for mine access and highwall entry to minimise the environmental impacts, costs, time and risks involved in construction of a new mine portal
- haul roads and trucks for the transportation of ROM coal from the proposed CHPP to the existing Saraji Mine CHPP
- use of open-cut spoil dumps to distribute and dispose of rejects from the Project's CHPP.

Where possible, above-ground infrastructure will be located within previously disturbed areas on the existing Saraji Mine. Rehabilitation of the above infrastructure will be in accordance with the existing Saraji Mine RMP. The Saraji Mine RMP establishes site-wide strategies to achieve rehabilitation by prioritising stability of the final landform, and the return of land use to grazing, where appropriate. This approach recognises the challenging nature of the spoil material, the climate, the elevated spoil landforms and significant change in local topography, and the scarcity of topsoil resources. In accordance with the existing Saraji Mine RMP and existing approved EA conditions, rehabilitation of disturbed land will commence within two years of the mined area becoming available.

Rejects management

All rejects (including tailings that are dewatered) will be trucked to the Saraji Mine's existing in-pit spoil dumps for disposal. No new tailing and coarse rejects management facilities are required for the Project. Rejects that have been dewatered by the belt press filters will be co-disposed with rejects (coarse), which will be placed into existing spoil dumps by truck or conveyor and buried in spoil. Rehabilitation of in-pit spoil dumps at the existing Saraji Mine will be undertaken as per the existing commitments in the Saraji Mine RMP.

In the unlikely event that reject haulage falls behind, the rejects bin will overflow to the designated bunker. The bunker will provide access for a loader to remove rejects material as required.

The scope of the Project will not change the rehabilitation objectives for the existing mine. Existing approved EA conditions do not need to change as a result of the Project to allow rehabilitation to progress when areas become available for rehabilitation. Existing approved EA conditions for the Saraji Mine will apply to the area of open cut that overlaps the Project Site.

Landform design and planning

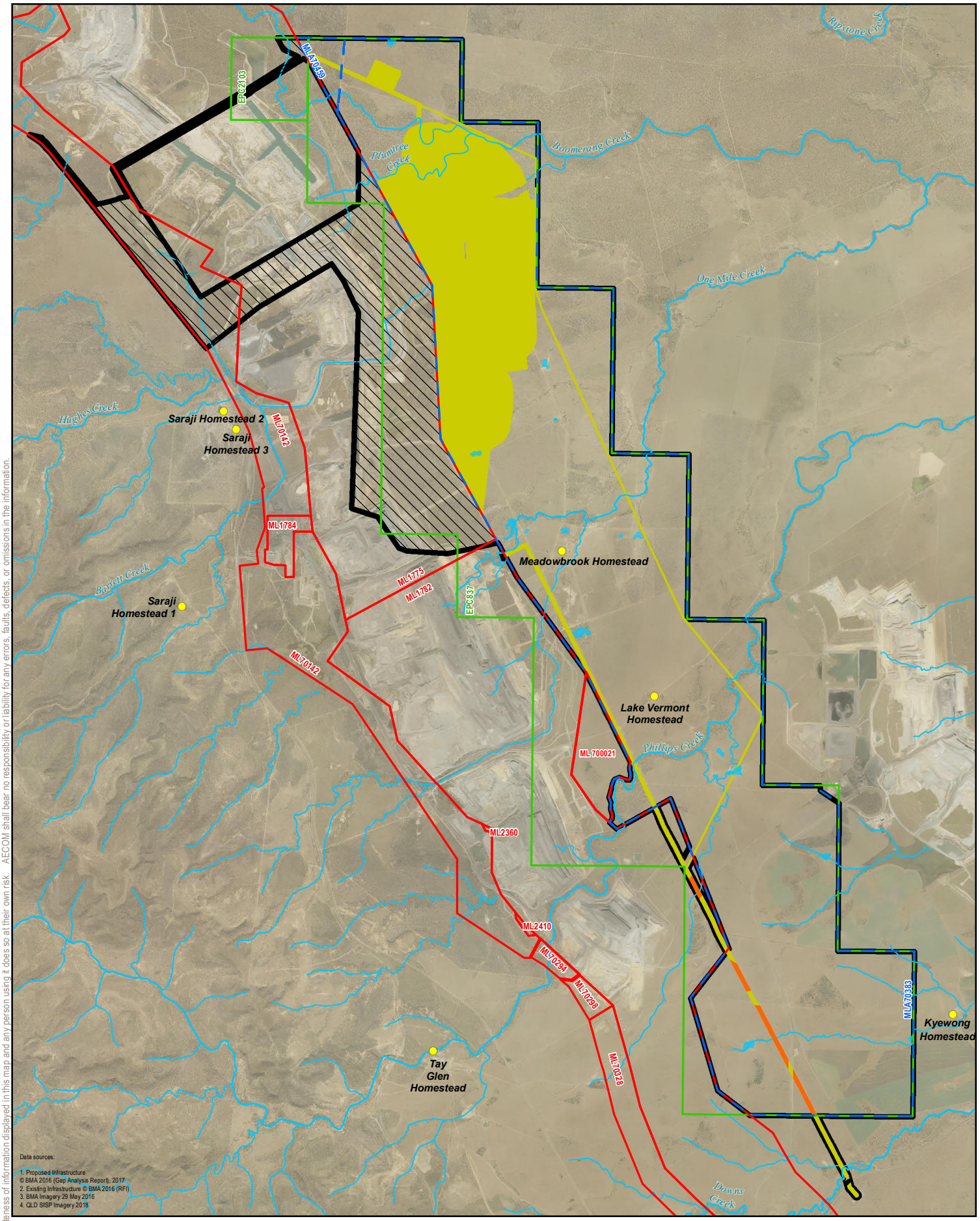
The proposed post mine landform is suitable for rehabilitation of cattle grazing, with dryland cropping where SCL is verified and potential for riparian rehabilitation. This approach is in accordance with level one and two of the rehabilitation hierarchy.

The domains and proposed post mining land use areas are summarised in Table 5.13. The current landform and predicted subsidence are illustrated in Figure 5-12. The rehabilitation strategy for each individual domain is discussed in **Appendix K-1 Rehabilitation Management Plan**.

Table 5.13 Post mining land for each domain

Domain	Post mining land uses				
	Grazing land	Woodland habitat	Watercourse	Water storage	Dryland cropping
Subsided riverine and remnant vegetation areas	X (if present pre-disturbance)	X (if present pre-disturbance)	X		
Subsided non-riverine areas	X (if present pre-disturbance)	X (if present pre-disturbance)			
Surface infrastructure	X (once decommissioned)			X	X
Future subsidence areas	X	X			

Indicative post mining land uses proposed for the Project are illustrated in Figure 5-13.



LEGEND

- Project Site
- Exploration Permit Coal (EPC)
- Mining Lease (ML)
- Mining Lease Application (MLA)
- Homestead

Post Mine Land Use

- Water storage
- Cattle grazing
- Dryland cropping
- Rehabilitation subject to development of Saraji Mine

N

Figure 5-13
Indicative Post Mine Land Use

Environmental Impact Statement
Saraji East Mining Lease Project

0 0.5 1 2
Kilometres

Scale: 1:110,000 (when printed at A4)

Projection: Map Grid of Australia - Zone 55 (GDA94)

BHP

DATE: 21/07/2020 VERSION: 0

Filename: \\aubne1fp003\Projects\605X\60507031\4. Tech Work Area\4.99 GIS\02_MXDs\06 Environmental Impact Statement\05 Land and Soil\60507031_G368_v0_A4P.mxd

Success criteria

In accordance with the *Mined Land Rehabilitation Policy* (DES, 2018a), the general rehabilitation goals and success criteria for areas disturbed by mining include that sites are:

- safe to humans and wildlife
- non-polluting and does not cause environmental harm
- stable
- able to sustain an agreed post mining land use.

The rehabilitation methods detailed in **Appendix K-1 Rehabilitation Management Plan** are designed to address these general rehabilitation goals.

The objectives, completion criteria, and indicators detailed in Table 5.14 have been drawn from BHP's *Queensland Coal Rehabilitation Completion Criteria* (BHP, 2018). The criteria, objectives and goals outlined in Table 5.14 are preliminary and expected to undergo further development and refinement in line with any further regulatory guidance that may be provided by DES associated with the finalisation of the Project's EA.

Table 5.14 Indicative completion criteria, objectives and indicators (BHP, 2018)

Post mining land use	Goal	Objective	Indicator	Criteria
Cattle grazing	Safe to humans and wildlife	Safety hazards in rehabilitation are not significantly different to surrounding unmined landscapes subject to the same land use	Hazard assessment	No significant difference
	Stable	Rehabilitation is geotechnically stable	Factor of safety	≥1.5
		Rehabilitation is erosionally stable	Extent, slope gradient and groundcover	Groundcover >50% 70% of slopes ≤20%
	Non-polluting	Rainfall runoff from rehabilitation achieves relevant water quality objectives for receiving waters	pH Electrical conductivity (EC) Turbidity	Not significantly different to upstream values
		Deep drainage from rehabilitation achieves relevant water quality objectives for groundwater	EC	Not significantly different to: (a) the EPP (Water) schedule documents water quality objectives for relevant groundwater chemistry zones; or, (b) local water quality objectives developed in accordance with the Queensland Water Quality Guidelines.
	Able to sustain an agreed post-mining land use	Rehabilitation is suitable for sustainable cattle grazing	Land suitability assessment for cattle grazing	Land suitability class ≤3 or not different from pre-mining class if ≥4
			Leucaena stem density	<250 stems >2m height per ha (1 per 40m^2), mean total area
Woodland habitat	Safe to humans and wildlife	Safety hazards in rehabilitation are not significantly different to surrounding unmined landscapes subject to the same land use	Hazard assessment	No significant difference
	Stable	Rehabilitation is geotechnically stable	Factor of safety	≥1.5 unless an alternative is justified by an appropriately qualified engineer
		Rehabilitation is erosionally stable	Groundcover (steep slopes, >15%)	80%

Post mining land use	Goal	Objective	Indicator	Criteria
			Groundcover (lesser slopes, ≤15%)	50%
	Non-polluting	Rainfall runoff from rehabilitation achieves relevant water quality objectives for receiving waters	pH EC Turbidity	Not significantly different to upstream values
		Deep drainage from rehabilitation achieves relevant water quality objectives for groundwater	EC	Not significantly different to: (a) the EPP (Water) schedule documents water quality objectives for relevant groundwater chemistry zones; or, (b) local water quality objectives developed in accordance with the Queensland Water Quality Guidelines.
	Able to sustain an agreed post-mining land use	Some native bushland characteristics	Species richness Trees Shrubs Grasses	 ≥2 ≥3 ≥4
			Tree canopy cover	≥16%
Water storage	Safe to humans and wildlife	Safety hazards in rehabilitation are not significantly different to surrounding unmined landscapes subject to the same land use	Hazard assessment	No significant difference
	Stable	Rehabilitation is geotechnically stable	Factor of Safety	≥1.5
		Rehabilitation is erosionally stable (banks and immediate surrounds)	Groundcover	>50%
	Non-polluting	Rainfall runoff from rehabilitation achieves relevant water quality objectives for receiving waters	pH EC Turbidity	Not significantly different to upstream values

Post mining land use	Goal	Objective	Indicator	Criteria
		Deep drainage from rehabilitation achieves relevant water quality objectives for groundwater	EC	Not significantly different to: (a) the EPP (Water) schedule documents water quality objectives for relevant groundwater chemistry zones; or, (b) local water quality objectives developed in accordance with the Queensland Water Quality Guidelines.
	Able to sustain an agreed post-mining land use	Rehabilitation retains water that is a potential resource for cattle grazing, with quality according to ANZECC guidelines version October 2000	TDS Calcium Magnesium Nitrate Nitrite Sulphate	≤5,000mg/L ≤1,000mg/L ≤2,000mg/L ≤400mg/L ≤30mg/L ≤1,000mg/L
Watercourse	Safe to humans and wildlife	Safety hazards are not significantly different to surrounding unmined landscapes subject to the same land use	Hazard assessment	No significant difference
	Stable	Rehabilitation is erosionally stable	Geomorphic index (IDC method)	Greater or equal to upstream or downstream values.
	Non-polluting	Rainfall runoff from rehabilitation achieves relevant water quality objectives for receiving waters	pH EC Turbidity	Not significantly different to upstream values
	Able to sustain an agreed post-mining land use	Riparian vegetation	Riparian vegetation index (IDC method)	Greater or equal to upstream or downstream values
Dryland cropping	Safe to humans and wildlife	Safety hazards in rehabilitation are not significantly different to surrounding unmined landscapes subject to the same land use	Hazard assessment	No significant difference
	Stable	Rehabilitation is geotechnically stable	Factor of safety	≥1.5

Post mining land use	Goal	Objective	Indicator	Criteria
		Rehabilitation is erosionally stable	Percentage of cultivation at >1% slope gradient with functional contour banks	100% of rehabilitated areas
	Non-polluting	Rainfall runoff from rehabilitation achieves relevant water quality objectives for receiving waters	pH EC Turbidity	Not significantly different to upstream values
		Deep drainage from rehabilitation achieves relevant water quality objectives for groundwater	EC	Not significantly different to: (a) the EPP (Water) schedule documents water quality objectives for relevant groundwater chemistry zones; or, (b) local water quality objectives developed in accordance with the Queensland Water Quality Guidelines.
	Able to sustain an agreed post-mining land use	Rehabilitation is suitable for sustainable dryland cropping	Land suitability assessment for dryland cropping	Land suitability class ≤3 or not different from pre-mining class if ≥4

Rehabilitation phasing

A conceptual rehabilitation program will be implemented using progressive rehabilitation based on current objectives for the Project and current anticipated dates of mine closure. An indicative summary of rehabilitation phases to achieve the rehabilitation program throughout the life of the Project is detailed in Table 5.15. As the life expectancy of the Project is expected to align with the existing Saraji Mine, no changes to the existing RMP timing are anticipated.

An indicative summary of the rehabilitation program to be implemented throughout the life of the Project is detailed in Table 5.15.

Table 5.15 Indicative summary of the rehabilitation program

Phase	Year rehabilitation starts	Year progressive rehabilitation ends
Phase 1 - Progressive rehabilitation of subsidence areas	2024	2043
Phase 2 - Decommissioning – removal of surface infrastructure including buildings, contaminated materials and hazardous materials	2043	2045
Phase 3 - Landform establishment - incorporates gradient, slope, aspect, drainage, substrate material characterisation and morphology	2045	2046
Phase 4 - Ecosystem establishment - corporates revegetated lands and habitat augmentation	2046	2048
Phase 5 - Ecosystem sustainability - incorporates components of floristic structure, nutrient cycling recruitment and recovery, community structure and function which are the key elements of a sustainable landscape	2048	2052
Phase 6 – Rehabilitation complete	-	2052

Rehabilitation methods

Rehabilitation will be undertaken to meet the post mining land use objectives (Table 5.14). Where land clearing is required for the development of the incidental mine gas network, roads and other infrastructure, topsoil will be stripped and stockpiled in accordance with the Project Topsoil Management procedure (to be developed prior to construction). Table 5.16 provides a summary of the proposed mitigation measures for rehabilitation.

Table 5.16 Indicative rehabilitation mitigation measures

Mitigation measure	Description
Weed suppression	
Weed suppression during operations	While the Project is operational, weed suppression will occur in accordance with a site Weed and Feral Animal Management procedure. As the most likely source of a new weed infestation is through a freshwater system or infected machinery, weed suppression efforts will focus on waterways, hardstand areas, drill sites, along the sides of haul roads, and the incidental mine gas network footprint.
Water quality management	
Waterway management	Suitable drainage will be incorporated into the rehabilitation design to ensure the final landform can safely shed surface runoff without giving rise to erosion. Particular attention will be given to ensuring that the hydraulic properties of the impacted waterways are maintained. Where practical, riverbed earthworks will be undertaken to re-profile waterways to a natural state.
Bank stabilisation	Where required, rock chutes and embankment armouring will be implemented in waterways to: • reduce the velocity of surface flow • prevent erosion and scouring • reduce sediment entrainment • capture large woody debris. Other mitigation measures, which may be used (as required) to stabilise waterways prior to impacts occurring, include installation of weirs, channel re-profiling, vegetation planting or erosion control matting on embankments.
Pumping of persistent ponding	It is recommended that either pumping is undertaken to prevent ponding or planting of tolerant species occurs where there is an opportunity to do so.
Drainage establishment for large and persistent ponding	Where vegetation which is tolerant of inundation fails to establish, or where establishing this kind of vegetation cover is inappropriate, there is potential to mitigate the possible loss of flow through Boomerang, Plumtree and Hughes Creeks by installing permanent drainage works to drain, or partially drain, voids created by subsidence.
Subsidence management	
Minimisation of surface disturbance	Land surface disturbance associated with longwall mining will be limited to the minimum required for operational success. Disturbed areas exhibit significantly greater impacts from subsidence and cracking due to the typically unstable nature of these areas. Limiting disturbance is therefore a primary control to reduce impacts.
Soil management	
Topsoil stripping	Once the Project Site has been decommissioned, the compacted areas such as the incidental mine gas network footprint and haul roads that are no longer required for operations or to be retained will be progressively rehabilitated by: • deep ripping/rock raking • applying stockpiled topsoil where it has been removed • sowing with species outlined in **Appendix K-1 Rehabilitation Management Plan**. The recommended topsoil strip depth and recommended use are outlined in Table 5.12.

Mitigation measure	Description
Topsoil stockpiling	Stockpiles will be low mounds at a maximum height of 3 m over the maximum surface area, with a greater number of lower mounds preferable. Stockpiles will remain for an extended period of time and will be sown with species selected for revegetation.
Erosion and sediment controls	Sediment and erosion controls that may be employed include: • minimising erosion of exposed land by restricting clearing areas, minimising soil exposure, and diverting potential runoff from undisturbed layers. • preventing exposed subsoils through minimising length of time subsoils are exposed and using erosion control measures such as gravelling, mulching, sediment fencing, and erosion control blankets. • contour ripping.
Topsoil application process	There are three options for topsoil application: • business as usual topsoil application - by applying topsoil to 20 cm depth across the largest area possible, taking into account topsoil availability and alternative options. • low intensity application of topsoil with other ameliorants - using 10 cm topsoil as an inoculant, or applied in strips with ameliorants and growth media substitution on competent waste material. • revegetate directly on spoil material - with minor use of alternative ameliorants in place of topsoil on competent waste material.
Revegetation	
Biodiversity offsets	While mitigation and management measures for impacts on terrestrial ecology focus on maximising retention of vegetation across the Project Site, offsets may be required where residual impacts upon conservation significant species are realised. Offsets will be undertaken in accordance with **Appendix C-2 Offsets Strategy**.
Species selection	Appropriate seed mix will be selected based on the post mining land use. Where the post mining land use is grazing, the species composition will aim to include a suitable mix of palatable, perennial and productive (3P) grasses and legumes. Where vegetation impacts have occurred as a result of recurrent ponding, the area will be revegetated with species that are tolerant of periodic inundation. All seed suppliers must be accredited and where possible, guarantee that seed supplied is free from declared weed seed.
Seeding rate	Seeding rate will be based on the number of each species per gram, factoring in viability information about each species if known. If seed quality information is unknown, rates will factor in an assumption of 90% mortality/non-viability. Groundcover species will be over sown relative to rates observed in the analogue sites, especially where rehabilitation is within 20 m of a waterway.
Seed delivery	Suitable seeding methods include: • direct drill air seeding after ripping • hydro seeding using a custom slurry.

In addition to the rehabilitation measures as discussed above, the RMP (**Appendix K-1 Rehabilitation Management Plan**) provides guidance on weed and pest control, and the use of burning to support and promote rehabilitation.

Demolition and decommissioning

In order to undertake all aspects of rehabilitation, decommissioning of infrastructure is likely to be required. Decommissioning may include the removal of hard stand areas, the incidental mine gas network, construction accommodation facility, contaminated materials and hazardous materials from the Project Site. Monitoring equipment will be decommissioned when no longer in use. Groundwater bore casings will be removed, bores will be filled in and the impacted footprint will be rehabilitated as required. BHP will consult with post mining landholders to determine the need for any infrastructure to remain.

Post closure and monitoring

Rehabilitation monitoring will be undertaken in accordance with the BHP monitoring program current at the time of rehabilitation. The purpose of rehabilitation monitoring is to collect sufficient data to identify any potential design non-conformances and issues affecting the rehabilitation that will require future maintenance and monitoring. Monitoring will focus on the following rehabilitation factors:

- erosion
- vegetation
- soil
- landform.

The data from the monitoring program will be used to determine whether the final rehabilitation outcomes have been met. Monitoring is proposed to be split into four phases:

1. Initial monitoring - conducted within 12 months of the establishment of a newly rehabilitated site to establish baseline conditions and comprising:
    a. Monitoring plot establishment
    b. Soil and spoil profile characterisation
    c. Soil laboratory analysis for an extended suite of analytes
    d. LiDAR analysis of rehabilitation design, erosion features and sediment loss
    e. Field survey for erosion features.
2. Event-based monitoring – conducted on an as-needs basis, targeting the structural performance of land features after rainfall or other disturbance events.
3. Minor monitoring – conducted on alternate four-yearly cycles with major monitoring and consisting of a subset of the methodologies used in the major monitoring.
4. Major monitoring – conducted two years after initial monitoring and then every four years, providing a detailed assessment of the current state of rehabilitation and comprising:
    a. Desktop review of previous monitoring reports
    b. LiDAR analysis of rehabilitation design, erosion features, sediment loss and persistent bare ground
    c. Field based assessment including soil and spoil, erosion and vegetation monitoring.

5.7 Summary and conclusions

The assessment of potential impacts to land resources and soils included consideration of subsidence, geology, mineral resources, contamination and rehabilitation.

Reviews of previous reports and a field assessment identified that there are 26 SMUs and 11 variants within the Project Site. Two SMUs and two variants were assessed as suitable to marginally suitable for cropping. All other SMUs identified were considered suitable for beef cattle grazing activities. The remaining SMUs were assessed as suitable for grazing either as simple or complex (consisting of two classes) units.

The southern extent of the Project Site (the location of the proposed overhead powerline) is mapped as SCL as regulated under the RPI Act. A field assessment of these mapped areas identified 17 SCL map units within the Project Site, of which nine (SCL map units 3, 7, 8, 9, 12, 13, 15, 16 and 17) meet the SCL criteria.

Subsidence modelling undertaken for the Project predicted maximum subsidence is 3.5 m over the southern panels.

During the operation of the mine, existing land uses such as grazing may be able to continue within the proposed mining lease in areas not directly impacted by the mine and supporting infrastructure.

A Subsidence Management Plan (**Appendix K-2**) has been prepared for the Project. The proposed approach to managing subsidence is to use proactive measures to predict and potentially improve the overall condition of the potentially affected areas, so that any adverse effects of subsidence are minimised.

BHP has prepared a Rehabilitation Management Plan (**Appendix K-1**) in line with the Mined Land Rehabilitation Policy (DES, 2018a) and BHP's *Queensland Coal Rehabilitation Completion Criteria* (BHP, 2018c).

The proposed post mining land use will be an undulating landscape that could be used as grazing land, consistent with the surrounding pastoral land use that dominates the region. Native vegetation outside of the surface infrastructure footprint will be retained in a way that is compatible with the pre-existing land use for biodiversity values. However, where vegetation mortality occurs as result of persistent ponding, associated with subsidence, it will be revegetated with species that are tolerant of inundation. A mix of native and non-native species may be implemented.

Disturbed land will be developed to a condition that is self-sustaining or to a condition where maintenance requirements are consistent with an agreed post mining land use.