NEW HOPE GROUP

FINAL LAND USE & REHABILITATION PLAN

New Acland Coal Mine Stage 3 Project

New Acland Coal Pty Ltd

April 2020

PREPARED BY

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BASIS OF REPORT

This report has been prepared by SLR Consulting Australia Pty Ltd (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with New Hope Group (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

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DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
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1 Introduction

New Acland Coal Pty Ltd (NAC) is the proponent of the New Acland Coal Mine Stage 3 Project (Project), which involves the proposed extension of the operating life of the New Acland Coal Mine (Mine) by up to 15 years.

NAC has received initial approval for the Project from the Coordinator-General, under the *State Development and Public Works Organisation Act 1971*, through the release of an evaluation report on the environmental impact statement for the Project dated 19 December 2014 (the Coordinator-General's Report). In addition, NAC was granted amended Environmental Authority EPML00335713 (EA) for the Project, under the *Environmental Protection Act 1994* (EP Act), by the Department of Environment and Science on 12 March 2019.

This Final Land Use and Rehabilitation Plan (FLURP) has been developed for the life of mining to address Imposed Conditions 7 and 8 of the Coordinator-General's Report and EA Condition H10.

2 Project Description

NAC has operated the Mine since 2002. The Mine's operations are currently authorised under Mining Lease (ML) 50170 and ML 50216 and EA EPML00335713. At present, the Mine has approval to produce 5.2 million tonnes per annum (Mtpa) of product coal as an open cut coal mine. The Project will allow the continuation of open cut mining operations on ML 50232 and will provide an opportunity for the Mine to expand production up to 7.5 Mtpa of product coal if economic and operational circumstances permit (**Figure 1**).

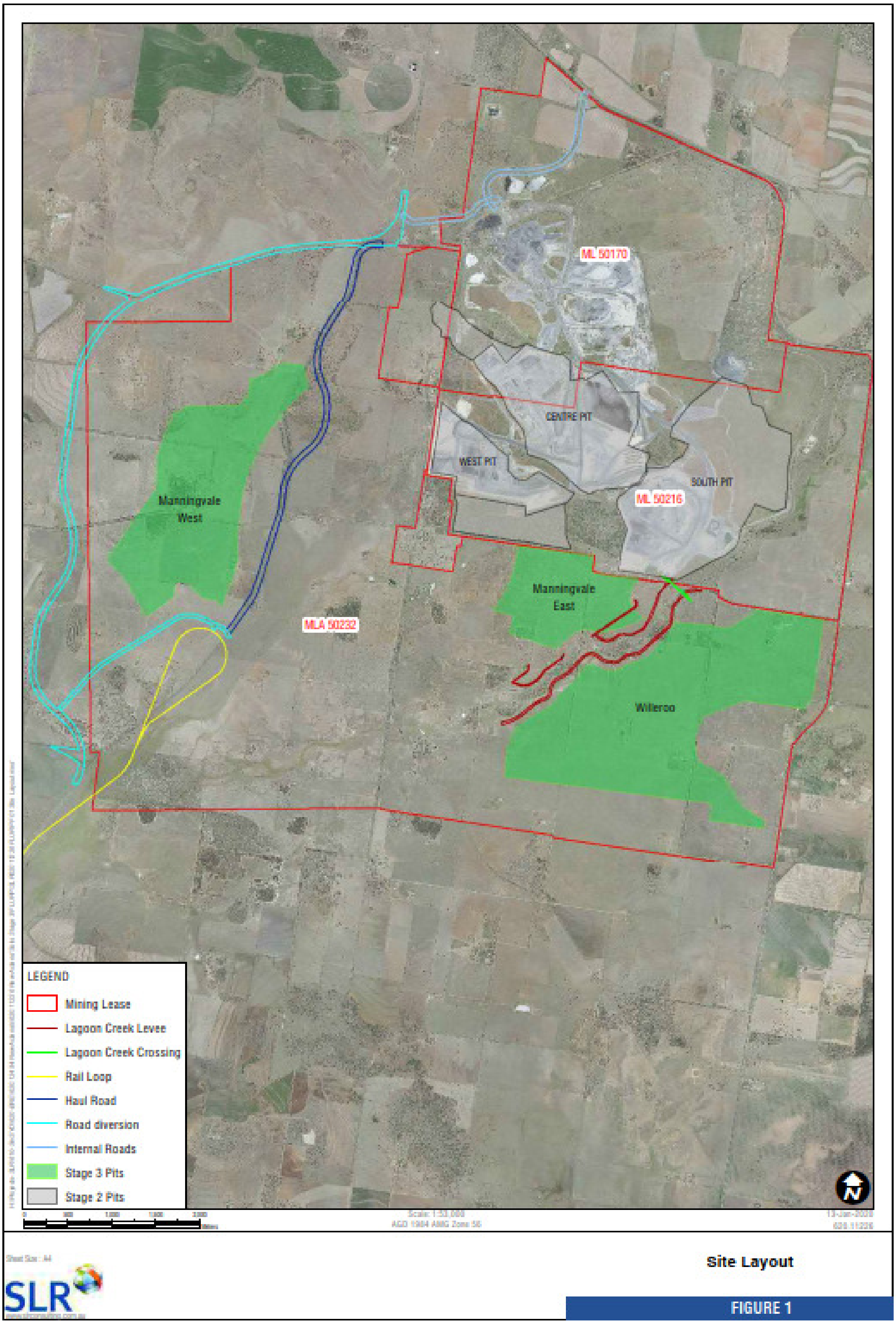
The Project proposes the extension of the Mine's operating life through the inclusion and progressive development of three new resource areas within ML 50232 as three new pits, construction of a rail spur and balloon loop from Jondaryan within ML 700002 and ML 50232, construction of a new train loading facility on ML 50232, and the development of associated operational infrastructure (e.g. roads). The mining activities for the Project's new resource areas will involve the same open cut mining method used for the existing operations.

The Project's coal will be sourced from the Manning Vale West, Manning Vale East and Willeroo Pits on ML 50232. The key rehabilitation elements of the Project are the:

- completion of mining and the continued progressive rehabilitation of the West Pit;
- continued progressive rehabilitation of South Pit;
- continued management of the rehabilitated surfaces of Tailings Storage Facility (TSF) 1 and the TSF 1 Extension;
- ongoing capping and rehabilitation works of inactive In-Pit Tailings Dams (IPT) 1, 2/1 and 2/2;
- completion of fine tailings disposal within IPT3 and its preparation for capping and rehabilitation works;
- development of a new tailings disposal facility within the Centre Pit;
- disposal of coarse reject within active spoil dumps, and use of coarse reject for road sheeting, and tailings capping;

- continued and progressive development of the mine surface water management system involving various water management structures;
- continued grazing of rehabilitated land (including on-going cattle trials);
- development, mining and eventual progressive rehabilitation of the Manning Vale West, Manning Vale East, Willeroo Pit.

Figure 1 Site Layout



3 Statutory Requirements

3.1 State Development and Public Works Organisation Act 1971

As a statutory requirement of the Coordinator-General's Report, NAC has received a number of 'Imposed Conditions (IC)' that are prescriptive about the Project's rehabilitation outcomes from an agricultural perspective (i.e. about maintaining a certain level of land capability post-mining). **Table 1** details IC 7 which outlines the Coordinator-General's key rehabilitation requirements for the Project.

Table 1 Imposed Condition 7 – Coordinator General's Report

Condition 7. Rehabilitation of disturbed land

(a) Rehabilitation is to be undertaken so as to establish discrete land units (that is, no unjustified mixing of soil material from different land units) in the disturbed areas to be rehabilitated ('rehabilitation area'), each capable of ultimately being assigned a specific post-disturbance land use suitability.

(b) The rehabilitation of disturbed land is to result in the affected land units being able to support the best post-disturbance land use possible. The post-disturbance land suitability of each land unit is to:

(i) represent that achievable on an ongoing basis;

(ii) be obtainable without the use of irrigation; and

(iii) be such that collectively at least 50 per cent of the total area of disturbed land originally meeting or exceeding the criteria for either Class 3 grazing land or Class 4 cropping land still meet or exceed those classifications.

(c) Prior to commencement of mining operations, the project proponent must:

(i) identify parcels of land, unaffected by mining operations (the land can be land owned by the proponent/associated company), that are able to provide at least three separate reference sites for each land suitability class to be represented in rehabilitated areas; and

(ii) Undertake investigations at each reference site, consistent with the requirements in Condition 6(b): Land resource survey, and sufficient to demonstrate that each reference site satisfies the criteria for the applicable suitability class.

(d) Within nine months of the commencement of project operations, the proponent is to submit for approval by the Coordinator-General a set of rehabilitation success criteria.

(e) The set of rehabilitation success criteria is to include elements specific to each land suitability class identified in the land resource survey undertaken in accordance with Condition 6: Land resource survey.

(f) Rehabilitation success criteria should include measures related to the following:

(i) landform;

(ii) soil physical and chemical attributes;

(iii) erosive soil loss (estimated using the Revised Universal Soil Loss Equation (RUSLE))

(iv) vegetative cover;

(v) plant density;

(vi) dry matter yield of harvestable material; and

(vii) botanical composition (pasture) or weed population characteristics (crops).

(g) The rehabilitation and restoration of the disturbed land is to be subject to ongoing and regular monitoring. At a minimum, the monitoring program is to:

(i) require monitoring twice in a calendar year (in spring and autumn in areas sown to pasture and at early flowering and at harvest in cropped areas)

(ii) provide a statistically valid sampling intensity for assessing compliance with the rehabilitation success criteria in each land unit (note: a sampling intensity providing 95 per cent confidence level that the sample mean values reported for a land unit are within ±20 per cent of the true mean for that unit.)

(iii) Include relevant climatic data, including rainfall, for both the rehabilitation and reference sites; and

(iv) by way of comparison with the corresponding reference sites, determine progress in meeting restoration success criteria, including identifying any failings; and proposing means to rectify those failings.

The Coordinator-General is to have jurisdiction for this condition.

In addition, IC 8 requires NAC to submit a FLURP to the Coordinator-General for approval before the Project can commence operations.

3.2 Environmental Protection Act 1994

A FLURP is required to be developed and implemented within 12 months of the Project's EA taking effect, which is upon grant of MLs 50232 and 700002. **Table 2** outlines the FLURP's requirements under *Agency Interest: Land and Rehabilitation – Condition H10* of the EA and the corresponding section references within this FLURP.

Prior to 1 April 2019, the FLURP was managed through NAC's Plan of Operations. Since 1 April 2019, the statutory requirement for a Plan of Operations was removed and replaced by an 'Estimated Rehabilitation Cost' decision.

Importantly, from 1 November 2019, all Queensland mines will gradually transition to the implementation of a 'Progressive Rehabilitation and Closure Plan (PRCP)'. As a consequence of this regulatory change, in the future the FLURP and all other rehabilitation-related conditions of the EA will be incorporated into a PRCP for New Acland Coal Mine.

Table 2 EA Condition H10 – Details and FLURP Reference

Condition H10 Details	FLURP Reference
Final Land Use and Rehabilitation Plan *Within twelve (12) months upon the grant of ML50232 and ML700002 the holder of this environmental authority must develop and implement a Final Land Use and Rehabilitation Plan to ensure that all areas disturbed by mining activities will be suitably rehabilitated in accordance with* ***Table H1 – Final Land Use and Rehabilitation Approval Schedule – ML50170 and ML50216****,* ***Table H2 - Landform design criteria for New Acland Coal Mine – ML50170 and ML50216****,* ***Table H3: Residual Void Design – ML50170 and ML50216****,* ***Table H4: Rehabilitation Requirements Stage 3 New Acland Mine Project****,* ***Table H5: Rehabilitation Acceptance Criteria — Grazing Lands Stage 3 New Acland Mine Project*** *and* ***Table H6: Rehabilitation Acceptance Criteria — Treed Areas Stage 3 New Acland Mine Project****.*	
The Plan must include, but is not limited to the following:	
(a) disturbance type	Section 4
(b) disturbance area	Section 4
(c) pre- and post-mine land descriptions & *(d) pre- and post-mine land capability*	Sections 6.2, 6.3, 7
(e) analogue site(s) identification	Sections 10.2, 10.2.1, 10.2.2, 10.2.3, 10.2.4
(f) a description of rehabilitation management techniques incorporating works and monitoring programs and timetables	Sections 9.4, 9.7, 9.7.1, 9.7.2, 9.7.3, 9.7.4, 9.7.5, 9.7.6, 9.7.7, 9.8, 12.1, 12.2
(g) indicators for success;	Sections 11, 11.1.1, 11.2, 12.1, 12.2, 12.3
(h) keeping of appropriate records or rehabilitation measures implemented including taking of photographs demonstrative of rehabilitation achieved and the preparation of annual rehabilitation progress reports.	Sections 12, 12.1, 12.2, 12.3

4 Area and Type of Disturbance

4.1 Mining Sequence

Mining activities in North Pit commenced during late 2002 and ceased in 2008 and is now fully rehabilitated, with 349 hectares of this land parcel 'certified' as progressive rehabilitation by the Department of Environment and Science. Mining activities in South Pit commenced during early 2008 and ceased in late 2018. In the Centre Pit, mining activities commenced in 2012 and are scheduled to cease during 2020. West Pit mining commenced during early 2016 and are scheduled to cease in late 2020. The Manning Vale West Pit is scheduled to commence in 2021 and cease in 2031. The Manning Vale East Pit is scheduled to commence in 2020 and cease in 2029. The Willeroo Pit is scheduled to commence in 2020 and cease in 2031. The Project's projected pit lives are subject to changes based on when the final primary approvals are granted, noise management requirements, alterations to planned mining rates and the continued refinement of the economic mining models for each pit as mining progresses. The proposed mine development sequence is illustrated in **Figure 2**.

4.2 Mining Methods

The open cut mining method employed for the Project will continue to be a conventional open cut strip-mining process using excavator, truck, dozer and loader operations. The current mining method allows removal of multiple coal seams from benches at varying depths, based on coal seam quality, depth and thickness until the maximum depth (economic limit) of mining is reached.

Overburden (the strata above the coal seams) and interburden (the strata between the coal seams) is either dumped in the active pit, if pit development has progressed sufficiently, or in previously mined pits or an out-of-pit dump. A portion of the overburden from active pits will be utilised for final rehabilitation of the TSFs. In addition, the Project's spoil will be used to help backfill the existing Mine's pits. For example, spoil from the Willeroo Pit (Stage 3) will be used to help backfill the South Pit void (Stage 2).

Dump construction comprises a series of progressive 10-20 metre lifts placed from the toe to the final height (allowing for profiling for final slope grade) to a maximum height of 30 metres above natural ground level as per NAC's FLURP. Surface drainage infrastructure associated with the dumps are constructed with due consideration of the slope angles, slope lengths, the erosion potential of topsoil and overburden, and hydrological factors.

To provide adequate coal access and opportunities for coal blending, multiple blocks operate at any one time in each pit. The block size is typically 150 by 150 metres. The mining fleet facilitates the production profile. Equipment used includes surface miners, excavators, front-end loaders, scrapers, dozers, graders, rear dump trucks, light vehicles, service trucks, and water trucks.

For the existing Mine, NAC's EA permits a final void area of 55 hectares, to be located within the Centre and South Pits. In reality, this void area will be backfilled by spoil from the Project's Willeroo and Manning Vale East mining areas, which will also remove the requirement for out-of-pit dumps to be constructed within these mining area.

For the Project, NAC has committed to re-contouring the three planned voids at the end of mining to the following landforms:

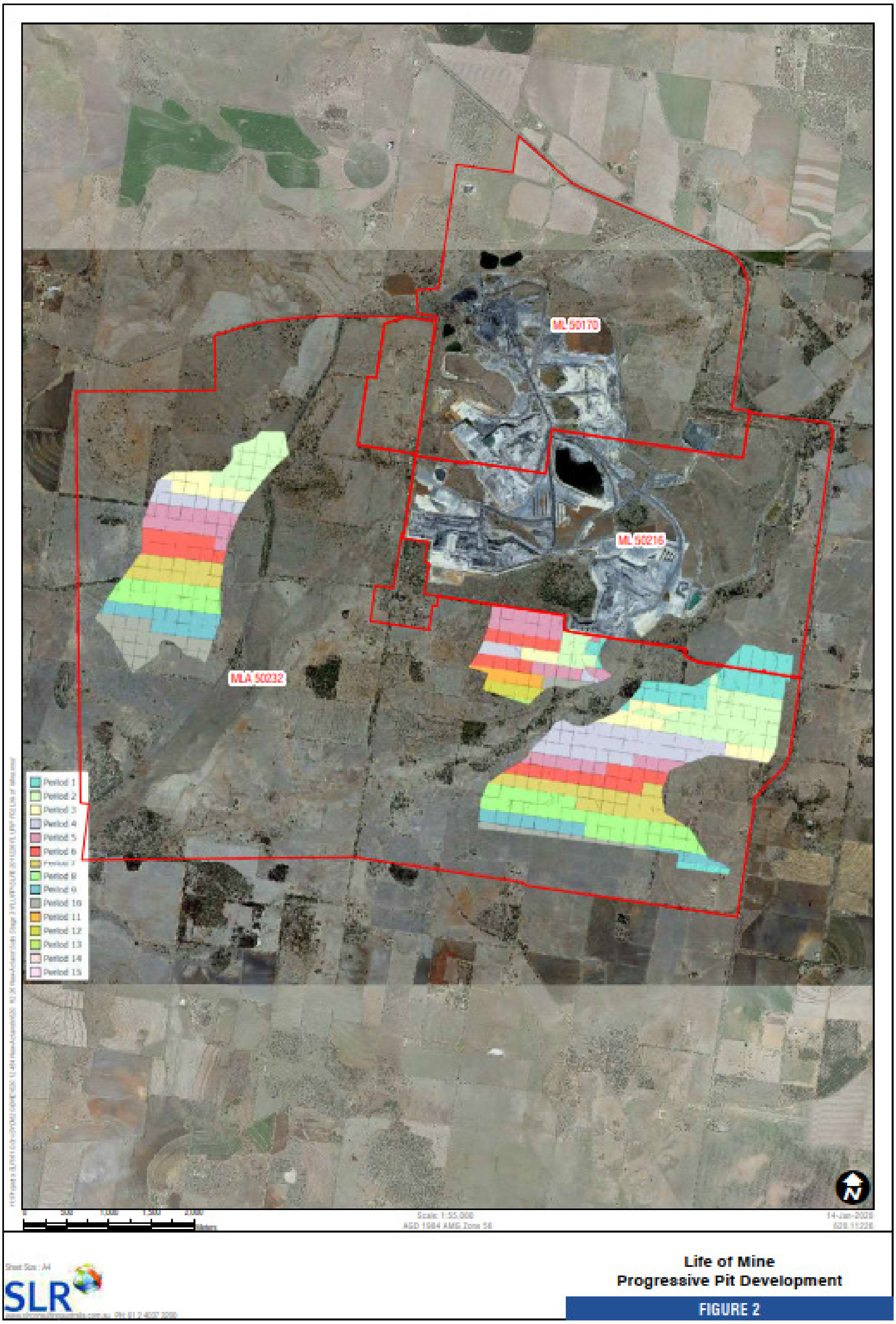
- 163 hectares depressed landform area to be located in the Manning Vale West Pit area;
- 154 hectares depressed landform area to be located in the Manning Vale East Pit area; and
- 213 hectares depressed landform area to be located in the Willeroo Pit area.

The depressed landform concept is a rehabilitation strategy for the Project's final voids that was originally provided within the 'Land Resources Chapter' of the Project's EIS. The full details of the concept were described in the 'Final Landform Technical Report (NHG 2014)' located within 'Appendix G1 Land Resources' of the Project's EIS.

In summary, NAC proposes that the final voids' in-pit dump/low wall and high wall slopes will be battered down to an angle of 8.5 to 17 degrees. This slope from current available geotechnical information is identified as being safe and stable long term, and following the re-application of topsoil, will allow the establishment of grass and legume species to stabilise the surface layer from erosion and permit the future use of the land for grazing (beef production) purposes.

NAC has made this commitment to ensure the Project's final landforms are safe, stable and non-polluting once fully rehabilitated. The final areas of the depressed landforms may vary slightly at the end of mining depending on the operational variables experienced over the life of the Project.

Figure 2 Life of Mine – Progressive Pit Development



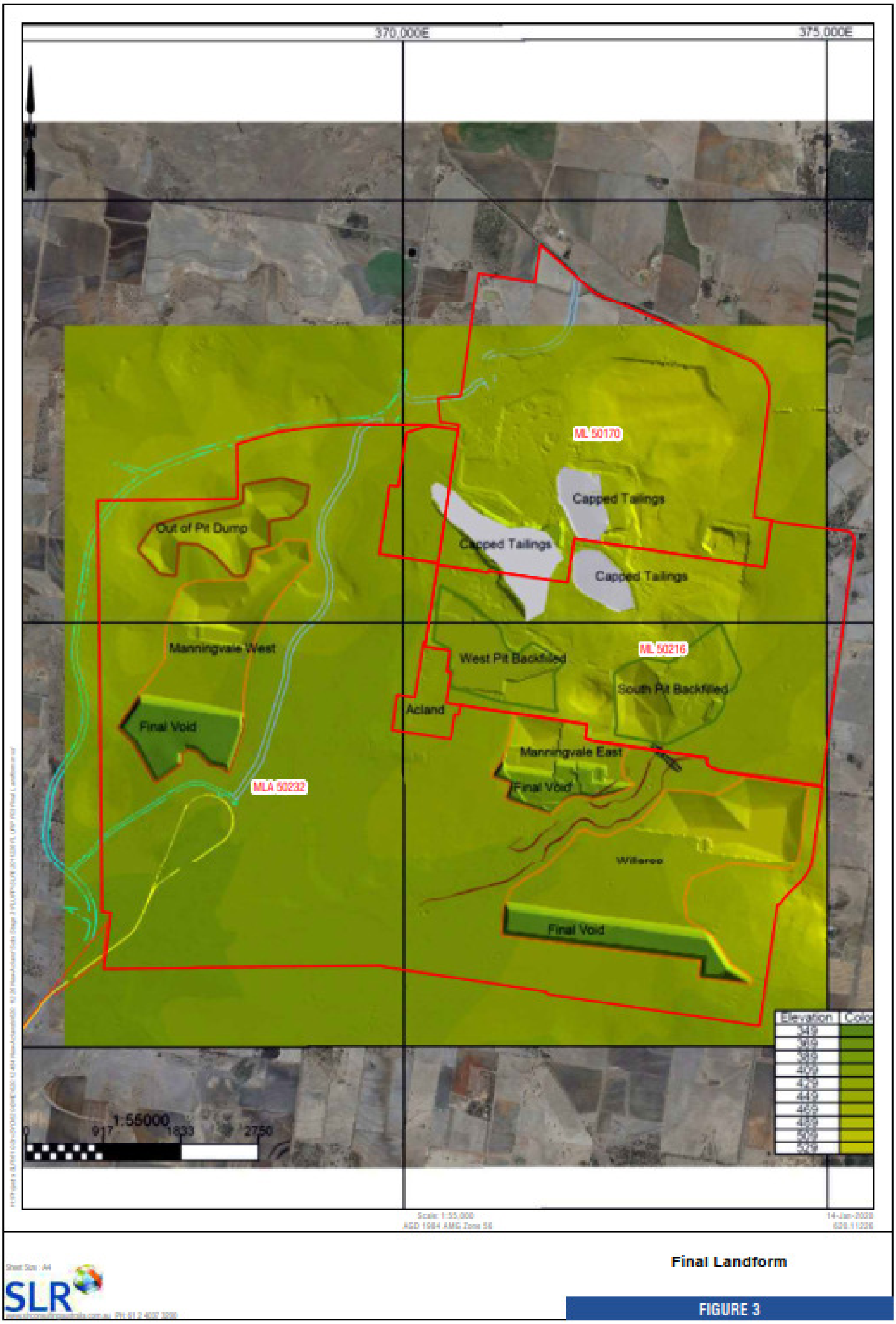
4.3 Progressive Rehabilitation

The rehabilitation of mining areas will utilise a variety of topographical features to complement the post mine land use. Landforms may be designed in a variety of ways, including but not limited to:

- reshaped landform – a reshaped area of previously mined land supporting vegetative cover on a grade that does not promote erosion;
- basin catchment – a reshaped area of previously mined land that is designed in such a way to capture and direct rainfall runoff:
  - to a depressed landform (former residual void); and/or
  - along a drainage path to a water management structure or a series of water management structures;
- contour banks – contour banks may be used on the final landform to reduce catchment areas and slope lengths, increase water infiltration and direct water:
  - to a depressed landform (former residual void); and/or
  - along a drainage path to a water management structure or a series of water management structures;
- drainage networks – a drain or a network of drains may be used on the final landform to direct water:
  - to a depressed landform (former residual void); and/or
  - along a drainage path to a water management structure or a series of water management structures.

The Project's final rehabilitated landform is shown on **Figure 3**.

Figure 3 Final Landform



5 Soils

General soil investigations have been completed for the existing Mine as part of impact assessment activities undertaken for the approval of ML 50170 (Stage 1) and ML 50216 (Stage 2), respectively. This soils information has been used to define the land suitability, soil erosion potential, rehabilitation requirements and storm water runoff quality for the existing Mine.

During investigations for the Project, sampling and profile inspection points have been completed across the proposed disturbance areas to characterise all landform elements and geological units. The surveys were designed to provide sufficient information on land resources to allow the determination of land suitability, soil erosion, rehabilitation potential, and storm water runoff quality consistent with the methods set out by the following documents.

For the Mine:

- Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland – Land Suitability Assessment Techniques (DME, 1995); and
- Shields and Williams (1991).

For the Project,

- Australian Soil and Land Survey Field Handbook 3rd Edition (NCST 2009);
- The Australian Soil Classification Revised Edition (Isbell 2002); and
- Regional Land Suitability Frameworks for Queensland (DNRM, DSITIA, 2013).

A detailed outline of previous soil assessment methodologies and soil mapping units for the current Mine are outlined in **Appendix A**. The *Soil and Land Resource Assessment New Acland Mine Stage 3 (NAC03) Project* (SLR, 2015) provides details of assessment methodologies and soil types. The extent of the soil mapping units for the current Mine and the NAC03 Project are outlined on **Figure 4** and **Figure 5**, respectively.

Figure 4 Current Mine Soil Types

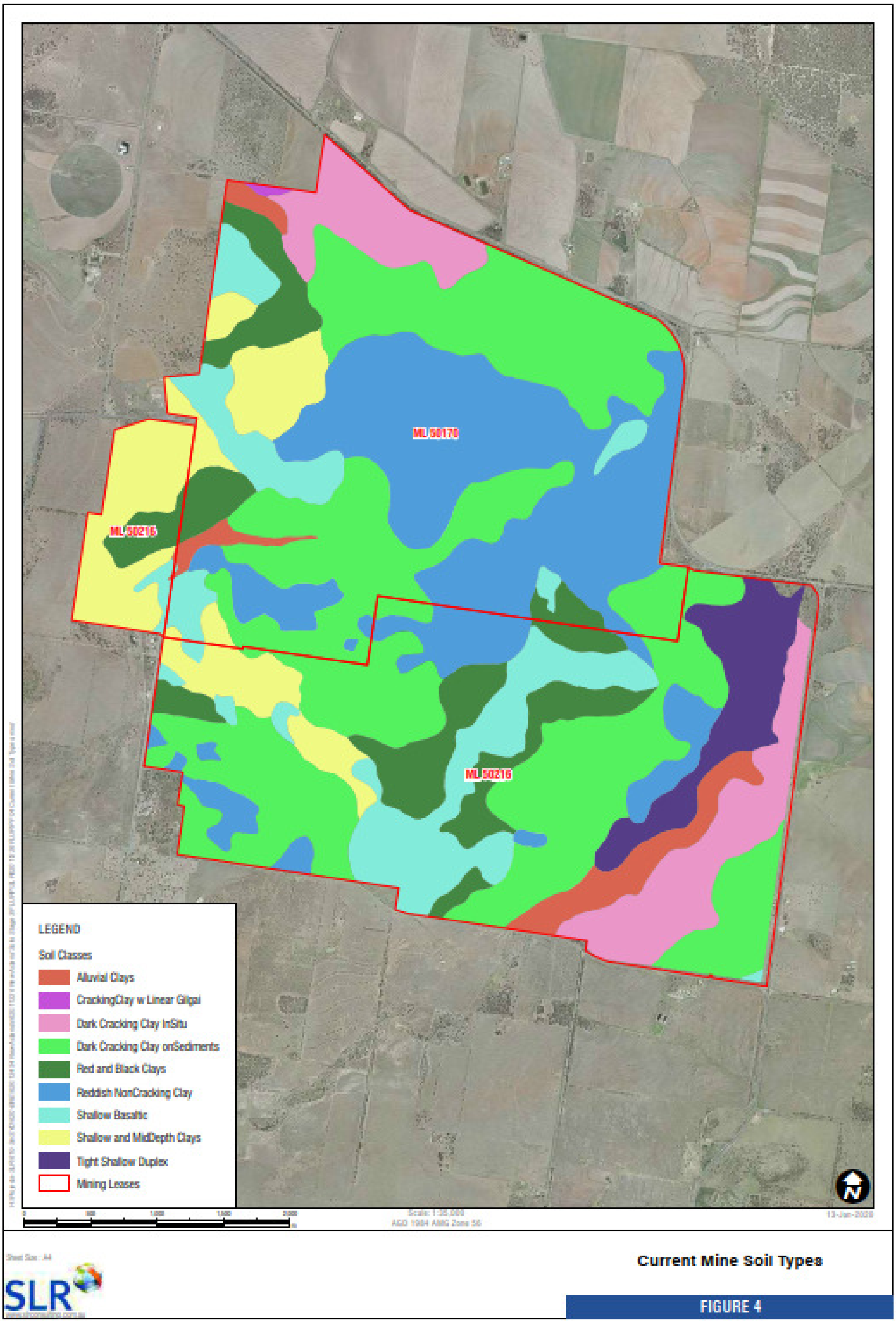
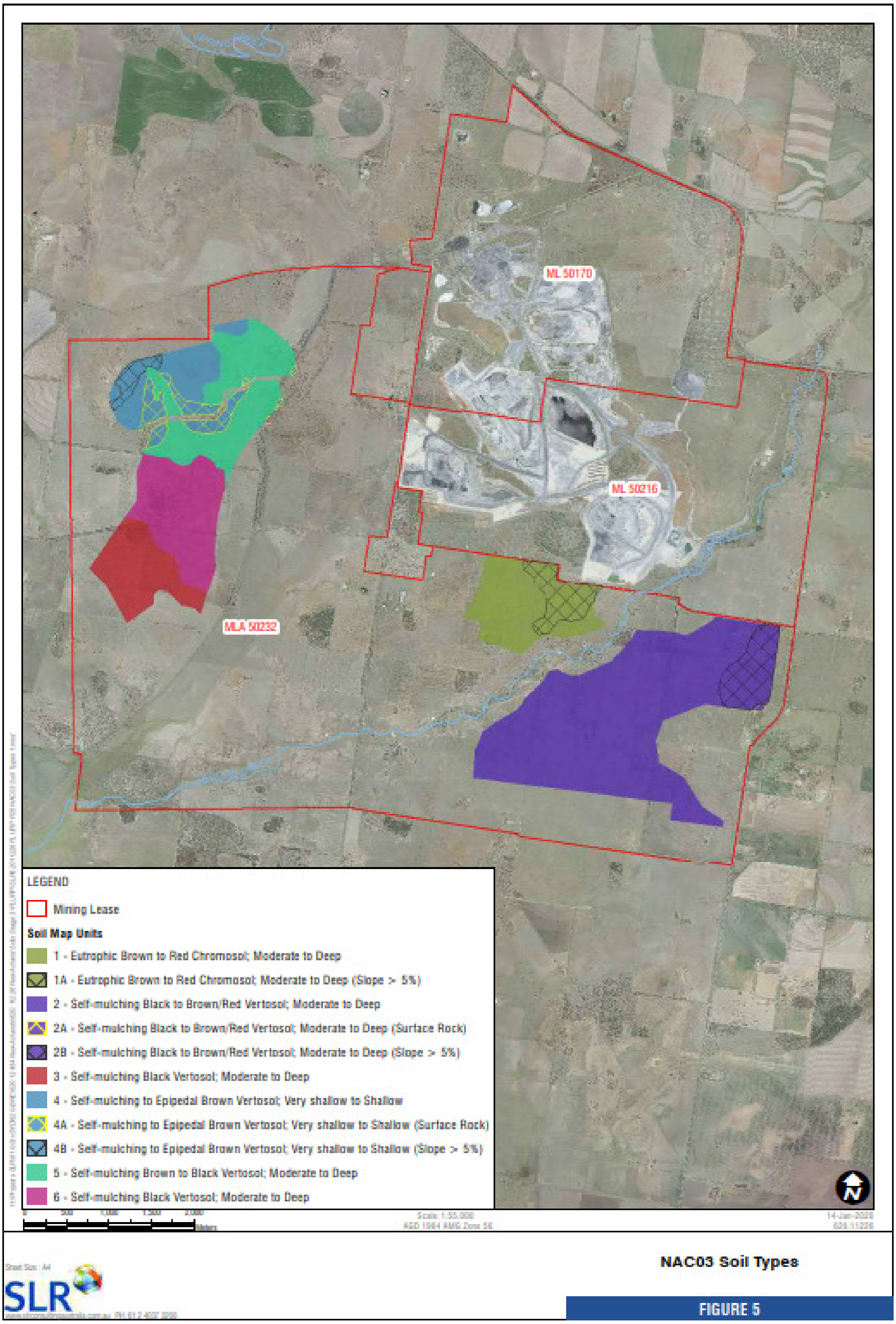


Figure 5 NAC03 Soil Types



6 Current Mine Land Suitability Assessment

The Land Suitability Assessment was undertaken pre-mining for the current Mine's disturbance areas under the Land suitability classification, based on the *Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland* (DME, 1995). These technical guidelines were revised and updated for the assessment of land suitability in Queensland in 2013 with the introduction of the *Regional Land Suitability Frameworks for Queensland* (DNRM, DSITIA, 2013). The Project was assessed pre-mining using the updated Framework. The two methodologies and associated results are outlined separately in the sections below

6.1 Current Mine Assessment Methodology

Land suitability assessment is a means to consider the type of land use activity which is appropriate on a particular area. This section discusses the pre-mining and post-mining land suitability assessment of areas within the current Mine. Pre-mine land use suitability for beef cattle grazing and dryland cropping were determined for the majority of the current Mine area. These two land uses have been considered within the context of the pre-mining and post-mining land suitability.

Land suitability classification is based on the Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland (DME, 1995) and identifies limitations of the different soil types at the Project site and identifies suitable uses.

Information provided in Vandersee and Mullins' (1977) and personal communications with Mr Andrew Biggs (DNRM Land Management Manual author for the area) were also utilised during the land suitability assessment. The Project site was assessed, as part of previous EIS processes, for suitability for dryland cropping and grazing land uses and assigned land suitability classes as defined in Shields and Williams (1991) and DME (1995).

The soils present in the area were generally suitable for cropping on the less steep areas and away from drainage lines. All soils are considered to be suitable for cattle grazing on improved pastures with the exception of some of the upper slope areas where clearing should not take place. Land suitability classifications are outlined below:

- Class 1 - Suitable land with negligible limitations and is highly productive requiring only simple management practices;
- Class 2 - Suitable land with minor limitations which either reduce production or require more than simple management practices to sustain the use;
- Class 3 - Suitable land with moderate limitations - Land which is moderately suited to a proposed use but which requires significant inputs to ensure sustainable use;
- Class 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; and
- Class 5 - Unsuitable land with extreme limitations that precludes its use.

The Project site was also assessed for Good Quality Agricultural Land (GQAL) in accordance with the Planning Guidelines: the identification of Good Quality Agricultural Land (DPI/DLGP, 1993). Agricultural land is defined as land used for crop or animal production, excluding intensive animal uses. GQAL is land which is capable of sustainable use for agriculture, with a reasonable level of inputs, and without causing degradation of land or other natural resources.

The DPI/DLGP (1993) guidelines were introduced to provide local authorities and development proponents with a system to identify areas of GQAL for planning and project approval purposes. GQAL classification descriptions are summarised below:

- A – Crop land that is suitable for a wide range of current and potential crops with nil to moderate limitations to production;
- B – Limited crop land that is suitable for a narrow range of current and potential crops. Land that is marginal for current and potential crops due to severe limitations but is highly suitable for pastures. Land may be suitable for cropping with engineering or agronomic improvements;
- C – Pasture land that is suitable only for improved or native pastures due to limitations which preclude continuous cultivation for crop production. Some areas may tolerate a short period of ground disturbance for pasture establishment; and
- D – Non-agricultural land and land not suitable for agricultural uses due to extreme limitations. This may be undisturbed land with significant conservation or catchment values, land that may be unsuitable because of very steep slopes, shallow soils, rock outcrop, poor drainage, salinity, acidic drainage, or is an urbanised area.

6.2 Current Mine Pre Mining Land Suitability

A summary of the pre-mine land suitability assessments undertaken over the current Mine site to date is provided in **Appendix B** and **Appendix C**. The extent of pre- mine land suitability for Dryland Cropping is outlined on **Figure 6** and the extent of pre- mine land suitability for Improved Pasture is outlined on **Figure 7**.

Figure 6 Current Mine Pre Mine Land Suitability Map for Dryland Cropping

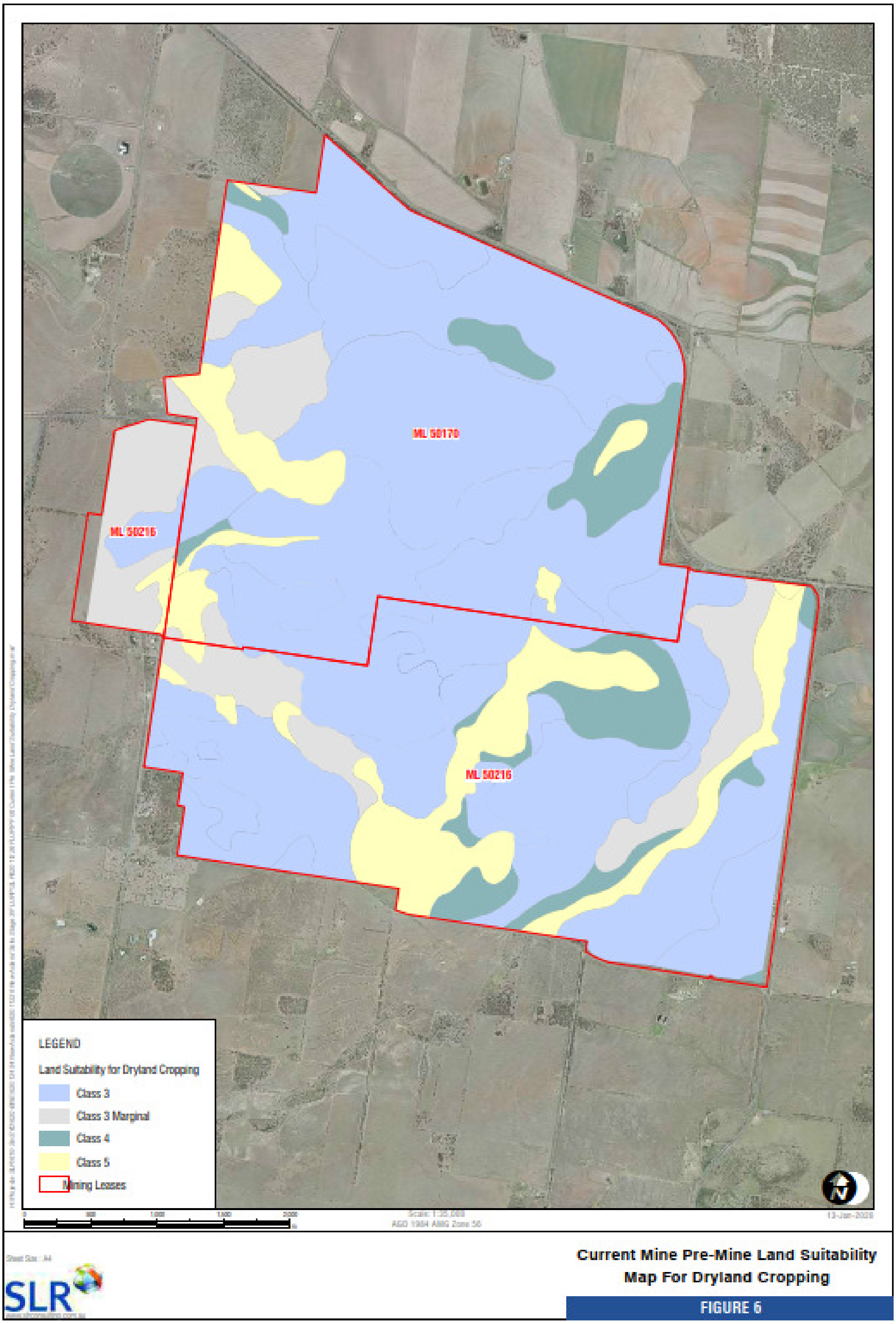
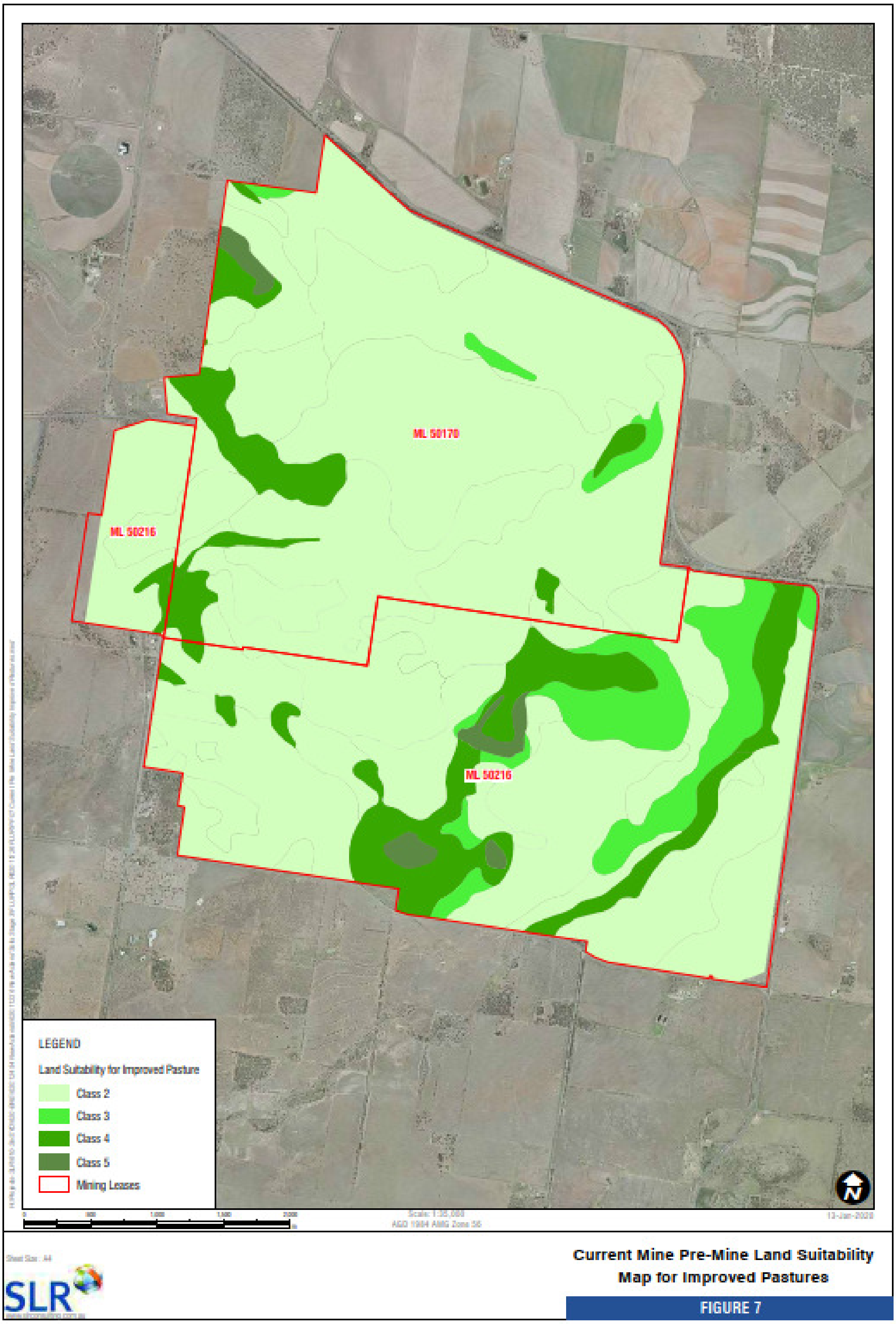


Figure 7 Current Mine Pre Mine Land Suitability Map for Improved Pastures



6.3 Current Mine Post Mine Land Suitability

This section outlines the implications of the activity on the suitability of areas for determined pre-mine land use (dryland cropping and cattle grazing) as mining activities are expected to change the physical, chemical and biological properties of soil, slope and slope length, and suitability of the land for intended post mine land use.

The suitability of the waste rock dumps for cropping and grazing is constrained by slope angle, soil cover, and altered moisture profile. These constraints would increase the risk of erosion significantly if cropping were undertaken.

The plateau of the final waste dump landforms is not considered suitable for rainfed cropping as it would require the replacement of a black cracking clay profile of approximately 900 millimetres depth and the installation of suitable soil conservation works, which is considered not practical.

The erosion stability of the waste rock dump may present a severe to extreme limitation to sustainable grazing. Moisture availability for a 30 centimetres deep topsoil would also be a severe limitation. Therefore, suitability on the waste rock dumps would be marginal land at best.

The extent of post-mine land suitability for Dryland Cropping is outlined on **Figure 8** and the extent of post-mine land suitability for Improved Pasture is outlined on **Figure 9**.

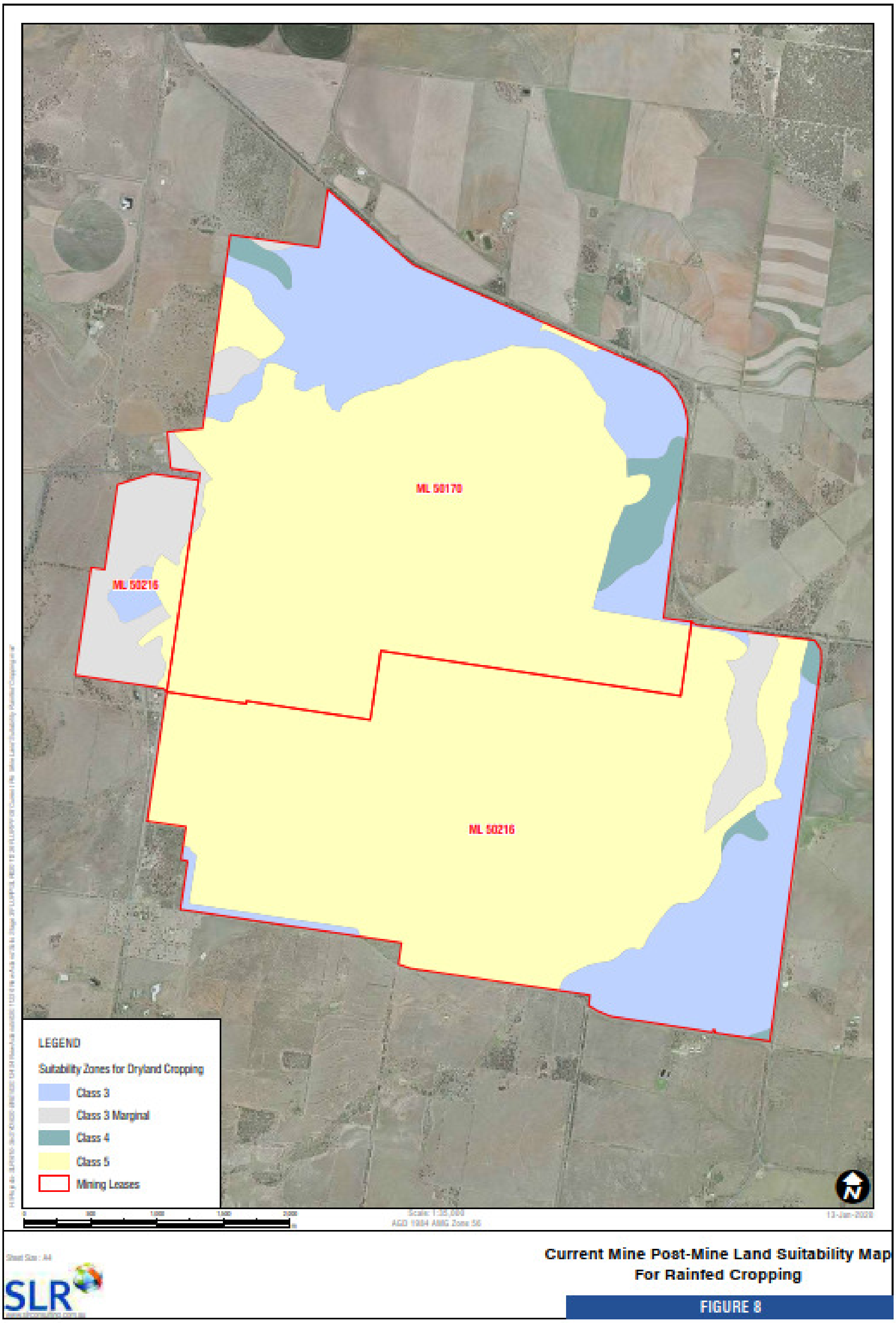
6.3.1 Dryland Cropping

Approximately 84% of the pre-mined area within ML 50170 (Stage 1) and 74% of the pre-mined area within ML 50216 (Stage 2) is suitability Class 3 and is suitable for rainfed cropping. This feature is consistent with existing land use, although some potential cropping land currently supports native pastures. The post-mining landscape suitable for rainfed cropping comprises approximately 24% of ML 50170 (Stage 1) and 25% of ML 50216 (Stage 2). Overall, the post-mine land suitability classes for dryland cropping of the area are unlikely to be suitable without extreme limitations. The pre-mine and proposed post-mine areas of land suitability for rainfed cropping is outlined in **Table 3**.

Table 3 Current Mine Dryland Cropping Pre Mine and Post Mine Land Suitability

Land Suitability Class	Area within ML50170 (ha)		% of Total ML50170 Area		Area within ML50216 (ha)		% of Total ML50216 Area	
	Pre-Mining	Post-Mining	Pre- Mining	Post-Mining	Pre-Mining	Post-Mining	Pre- Mining	Post-Mining
3	923	269	83.8	24.4	856	288	74.1	24.9
4	81	40	7.4	3.6	100	9	8.7	0.8
5	99	794	9.0	72.0	199	858	17.3	74.3
Total	**1,103**	**1,103**	**100**	**100**	**1,155**	**1,155**	**100**	**100**

Figure 8 Current Mine Post Mine Land Suitability Map for Rainfed Cropping



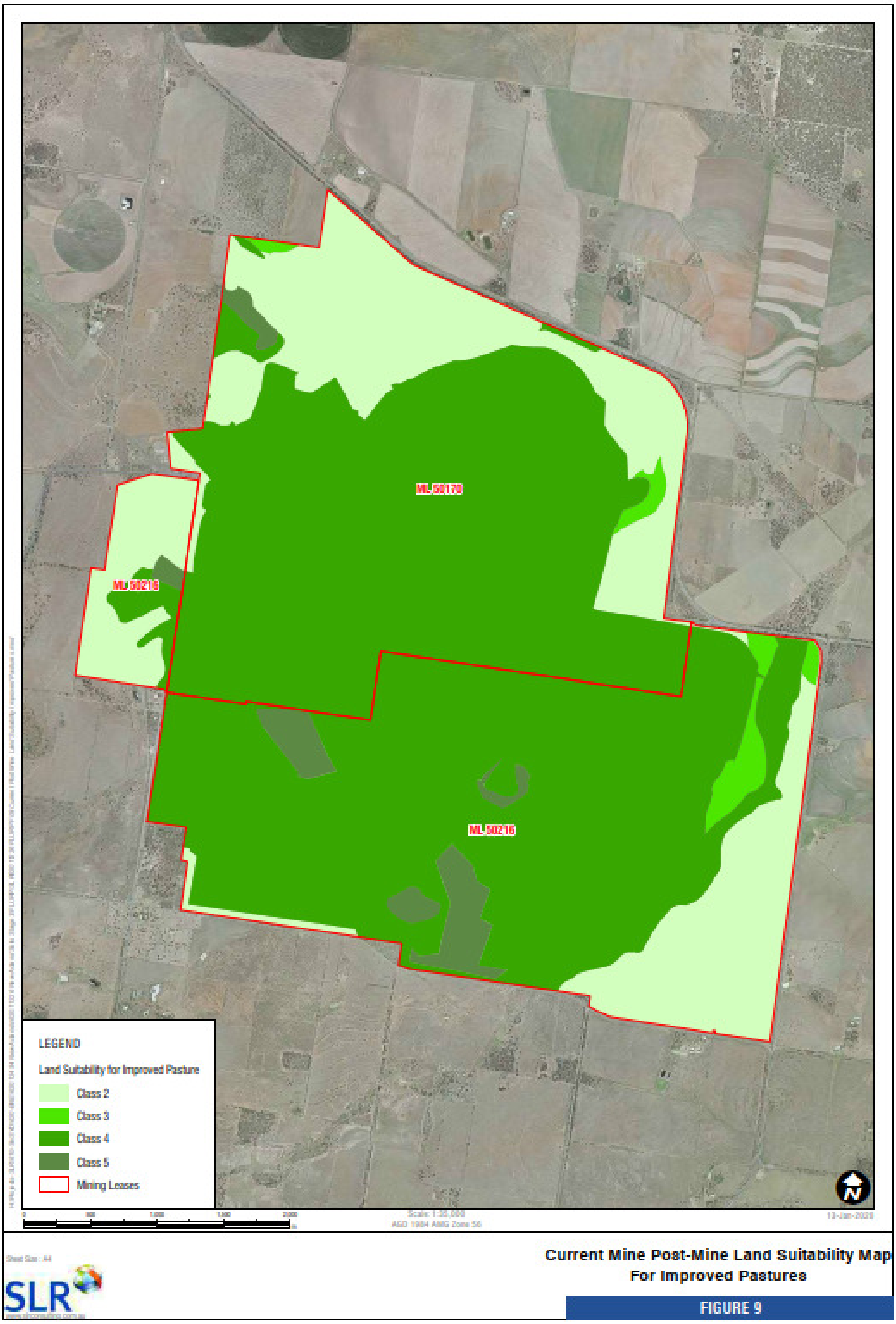
6.3.2 Grazing

The largest change in post-mining land suitability for cattle grazing occurs in Class 4 which increases from 8% to 71% within ML 50170 (Stage 1) and 15% to 71% within ML 50216 (Stage 2). Other land areas downgraded are mostly Class 2 and Class 3 land suitability. However, overall post-mine land suitability for grazing is substantially greater than that for dryland cropping. The pre-mine and proposed post-mine areas of land suitability for grazing are outlined in **Table 4**.

Table 4 Current Mine Cattle Grazing Pre Mine and Post Mine Land Suitability Extents

Land Suitability Class	Area within ML50170 (hectares)		% of Total ML50170 Area		Area within ML50216 (hectares)		% of Total ML50216 Area	
	Pre- Mining	Post-Mining	Pre-Mining	Post-Mining	Pre-Mining	Post-Mining	Pre-Mining	Post-Mining
2	981	303	89	27	816	250	71	22
3	19	10	2	1	140	27	12	2
4	88	782	8	71	178	816	15	71
5	15	8	1	1	21	62	2	5
Total	**1,103**	**1,103**	**100**	**100**	**1,155**	**1,155**	**100**	**100**

Figure 9 Current Mine Post Mine Land Suitability Map for Improved Pastures



7 NAC03 Land Suitability Assessment

This Land Suitability assessment has been conducted in accordance with the Regional Land Suitability Frameworks for Queensland (DNRM, DSITIA, 2013) for the Eastern Downs Region. The suitability framework provides the detail for assessing which crops are suitable for individual mapped areas of land or soil.

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

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

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

The five land suitability classes are defined as follows.

Class 1 – Suitable land with negligible limitations. This is highly productive land requiring only simple management practices to maintain economic production.

Class 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.

Class 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.

Class 4 – Marginal land, which is presently considered unsuitable due to severe limitations. The long term significance of these limitations on the proposed land use is unknown or not quantified. The use of this land is dependent upon undertaking additional studies to determine whether the effect of the limitation(s) can be reduced to achieve sustained economic production.

Class 5 – Unsuitable land with extreme limitations that preclude its use.

The first three classes of land are considered suitable for the specified land use, as the benefits from using the land for that land use in the long term should outweigh the inputs required to initiate and maintain production. Decreasing land suitability within a region often reflects the need for increased inputs rather than decreased potential production. There are many occasions where there is no land assessed as Class 1 (or other suitable classes) in a study area for a particular land use.

Class 4 land is regarded as marginal land, currently unsuitable for a particular land use due to the severity of one or a number of limiting factors. It is doubtful that the inputs required to achieve and maintain production outweigh the benefits in the long-term. This land may possibly be upgraded to a suitable class if future agronomic, soil or engineering studies show it to be economically viable and environmentally sustainable. Changes in climate, economic conditions, or technology may alter the level of management inputs required to achieve satisfactory productivity.

Six Soil Map Units (referred to as Unique Map Units within the Framework) and five Soil Map Unit variants were mapped with the NAC03 Study Area, with Vertosols comprising the dominant soil type. The Land Suitability Assessment for each Soil Map Unit has been completed on the soil and land properties identified from Analysed Sites.

The outcomes of the Land Suitability Assessment include:

- The entire Study Area has been assessed as either Land Suitability Class 3 or Class 4 for all Land Uses, including dryland cereal and grain crops (i.e. wheat, oats, barley and sorghum), sunflower and chickpeas (**Table 5**).
- The major limitations for Soil Map Units identified as Class 3 are Erosion Hazard (Es) and Surface Condition (Ps) (**Table 6)**.
- The major limitations for Soil Map Units identified as Class 4 are Soil Water Availability (M), Erosion Hazard (Es) and Rockiness (R) (**Table 6**).

Table 5 NAC03 Overall Land Suitability Results

Land Suitability Class	Major Limitation(s)	Area (Ha)
3	Es – Erosion Hazard Ps – Surface Condition	696
4	Es – Erosion Hazard M – Soil Water Availability R - Rockiness	316
	Total	**1,012**

Table 6 Land Suitability Assessment Results Summary

Soil Map Unit	Major Limitation(s)	Overall Land Suitability Class
1	Es – Erosion Hazard, Ps – Surface Condition	Class 3
1A	Es – Erosion Hazard	Class 4
2	Es – Erosion Hazard	Class 3
2A	R - Rockiness	Class 4
2B	Es – Erosion Hazard	Class 4
3	Es – Erosion Hazard	Class 3
4	M – Soil Water Availability	Class 4
4A	M – Soil Water Availability, R – Rockiness	Class 4
4B	M – Soil Water Availability, Es – Erosion Hazard	Class 4
5	Es – Erosion Hazard	Class 3
6	Es – Erosion Hazard, M – Soil Water Availability	Class 4

Full details of the NAC03 Land Suitability Assessment for each Soil Map Unit is provided in (SLR, 2015).

The post mining landforms and soil profiles are modified from pre mining classes, generally due to changes in slope steepness and length, soil profile depth and layering. These changes result in a modified land suitability for the site to that shown in **Figure 10**. The proposed post mining land suitability for the disturbance areas for NAC03 are as follows.

- Cropping Land Suitability Class 3 – 541 hectares, suitable for use as SCL with standard soil profile depths of 0.6 metres to 1.2 metres. These areas are located within the mining areas. However, they avoid the out-of-pit emplacements and final depressed areas.
- Grazing Land Suitability Class 4 – 471 hectares, suitable for use as grazing land with soil profile depths of 0.3 metres to 0.5 metres. These areas are located within the out-of-pit emplacements and final depressed areas, which are typically steeper slopes than the backfilled mining areas.

Where infrastructure areas are not required for the ongoing use by APC (i.e. water infrastructure such as dams or access tracks) they will be rehabilitated to a minimum of Grazing Suitability Class 4 (as per IC7). Prior to the commencement of any infrastructure works soil sampling will be undertaken to determine topsoil stripping depth, stockpiling requirements and rehabilitation requirements.

Figure 10 NAC03 Pre Mine Land Suitability Map for Improved Pastures

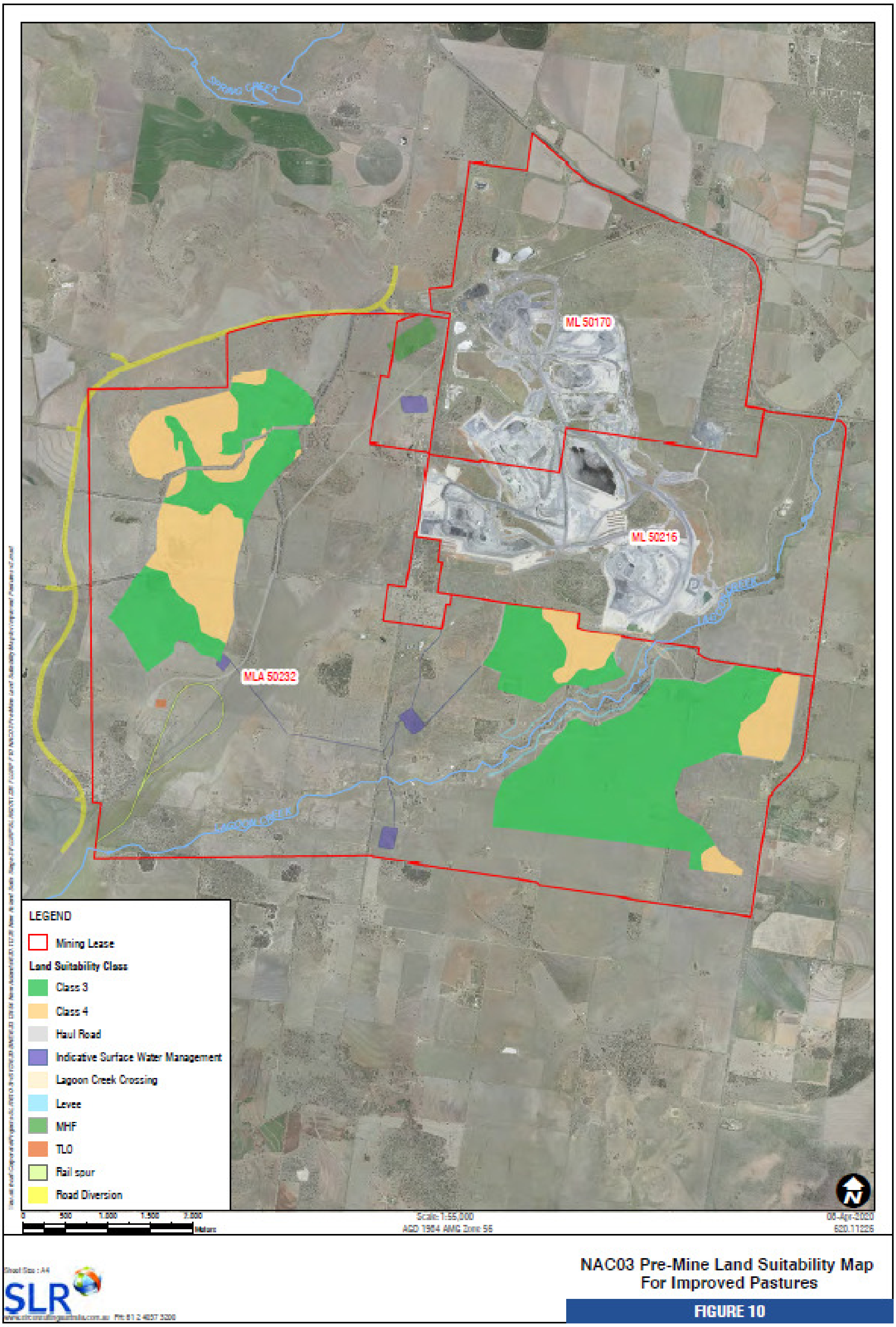
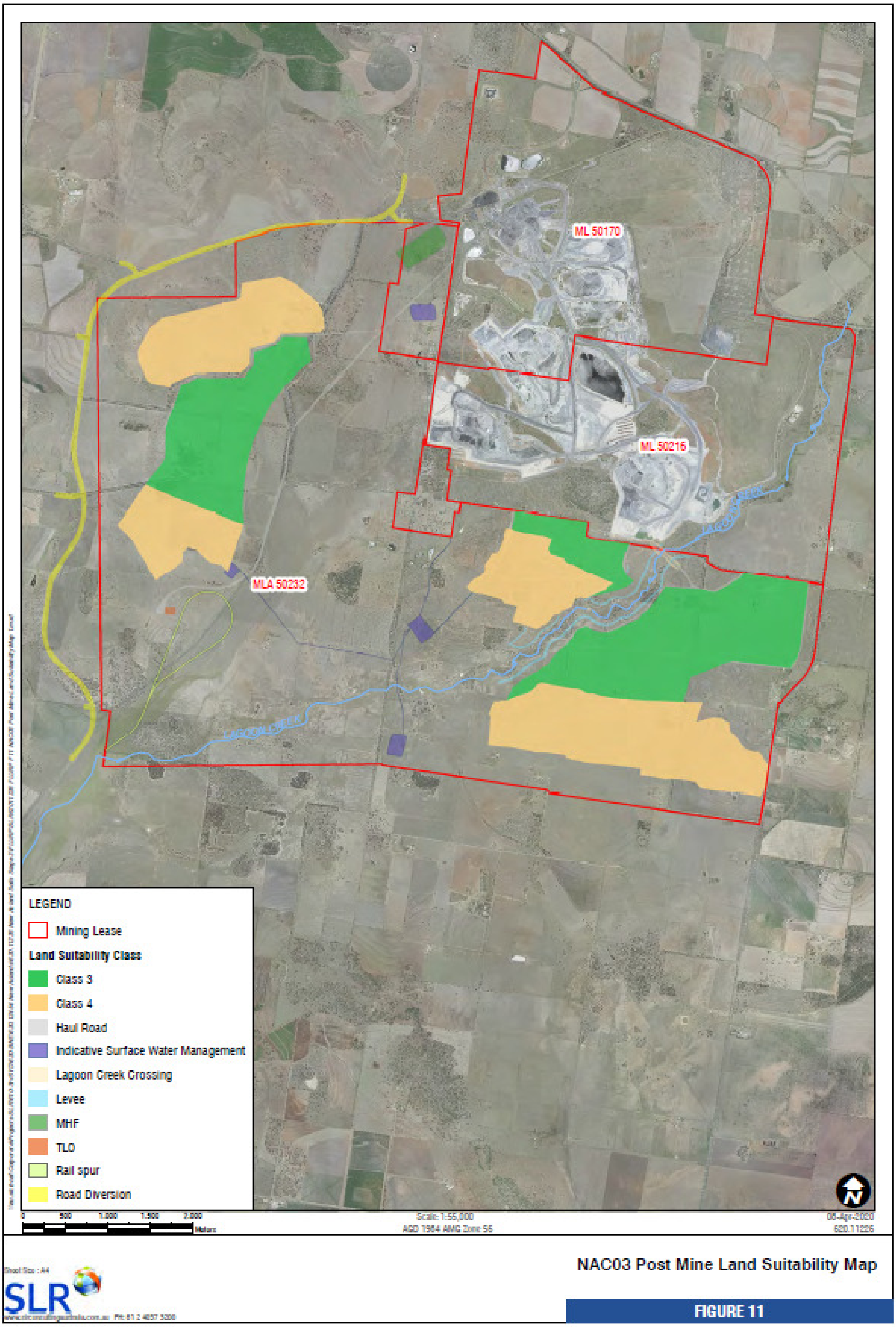


Figure 11 NAC03 Post-Mine Land Suitability Map



8 Erosion Potential and Control

8.1 Erosion Hazard

Open cut mining activities involve land disturbance that can pre-dispose an area to erosion risks. Typical mining activities that require use of erosion mitigation strategies include:

- topsoil stripping ahead of mining development and for infrastructure development such as haul roads, hard stands and access tracks;
- drainage line crossings for pipes and roads;
- spoil dump placement, as spoil is a fractured mix of earthen fines that possess a considerable erosion potential;
- newly rehabilitated areas prior to vegetation establishment; and
- topsoil stockpiles.

8.2 Erosion Control

Progressive rehabilitation will continue over the life of the Project until all areas disturbed by mining are safe, stable, non-polluting and able to support the proposed post-mining land use. In general, this approach will ensure disturbed areas are stabilised as quickly as practical to limit the risk of erosion.

Erosion and sediment control measures will be employed as per the practices described in the *Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland* (DME 1995).

The design parameters for the construction of erosion control work such as rock armoured or grass lined waterways will be in accordance with established principles for engineering and soil conservation earthworks. A number of variables are included such as time of concentration, rainfall intensity, erosivity, gradient, scour velocities and flow estimations.

The erosion control measures to be employed at the Project site are summarised in **Table 7**.

Table 7 Erosion Causes and Control – Mining Activities

Area	Control Measure
Cleared Land	• restrict clearing to areas essential for the works • windrow vegetation debris along the contour • minimise length of time soil is exposed • divert run-off from undisturbed areas away from the works • direct run-off from cleared areas to sediment dam • monitoring and/or inspection at an appropriate interval, and as required, prompt remediation actions based on risk

Area	Control Measure
Exposed Subsoils	• minimise length of time soil is exposed • direct run-off from exposed areas to sediment dams • monitoring and/or inspection at an appropriate interval, and as required, prompt remediation actions based on risk
Active Pit	• divert run-off from undisturbed areas away from the active pit(s) • pump rainfall run-off capture within pit areas to the environmental dams for future water recycling purposes
Active Waste Rock Dump (out-of-pit and in-pit)	• direct all run-off from dumps to sediment dams • avoid placement of sodic waste material on final external batters • control surface drainage to minimise the formation of active gullies • commence rehabilitation activities as soon as operationally possible • monitoring and/or inspection at an appropriate interval, and as required, prompt remediation actions based on risk
Rehabilitation	• re-contour waste rock dumps progressively to landform criteria • install drainage control works • replace topsoil, rip on the contour and seed • direct run-off from rehabilitated areas to sediment dams • revegetate rehabilitated areas as soon as practical • monitoring and/or inspection at an appropriate interval, and as required, prompt remediation actions based on risk
Mine Infrastructure (including water)	• provide protection in drains where water velocity may cause scouring (e.g. rip rap, grass) • confine traffic to maintained tracks and roads • install sediment traps, silt fences, hay bales where necessary to control sediment • rehabilitate disturbed areas no longer required for operational purposes as promptly as possible • monitoring and/or inspection at an appropriate interval, and as required, prompt remediation actions based on risk

9 Post Mining Land Use and Rehabilitation

9.1 Introduction

Rehabilitation studies at the existing Mine and for the Project have examined soils, landforms, the nature of waste materials, drainage and vegetation. These studies have demonstrated the successful use of conventional rehabilitation techniques on a range of materials excavated at the Mine and in the future for the Project. The knowledge gained from the existing Mine has been adapted and used in the progressive rehabilitation of the site and will continue throughout the Project.

Importantly, NAC has achieved a high standard of progressive rehabilitation at the existing Mine, which resulted in 349 hectares being 'certified' as progressive rehabilitation, under the EP Act, by DES on 1 November 2018. NAC will continue to build on the knowledge gained from this achievement to help its rehabilitation outcomes for the Project meet regulatory standards and community expectations.

Rehabilitation strategies at the site include all areas of disturbance and are reviewed on a regular basis in order to take into account any changes to mine operations, changes in legislative requirements and/or results of ongoing studies and monitoring.

The rehabilitation strategies have been developed after consideration of the Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland (DME, 1995), the Department of Environment and Heritage Protection (DEHP, now DES) Guideline: Rehabilitation Requirements for Mining Projects (DEHP 2014), the Mined Land Rehabilitation Policy (QLD Government 2018) and the Mineral and Energy Resources (Financial Provisioning Act (QLD Government 2019). Importantly, the following considerations have been applied:

- *Land Suitability Assessment Techniques* - which addresses the applicability and use of land suitability assessment techniques in determining pre-mining land capability and post-mining land use potential;
- *Determination of Post-Mining Land Use* - which describes the identification and selection of suitable post-mining land use options;
- *Progressive Rehabilitation* - which describes the advantages of and opportunities and strategies for progressive rehabilitation;
- *Assessment and Management of Acid Drainage* - which addresses the identification, evaluation and management of solid waste materials with potential to generate acid drainage and/or heavy metal toxicity;
- *Open Pit Rehabilitation* - discusses the criteria to be applied in the design and rehabilitation of open pits having regard to geophysical aspects, sealing of strata, water accumulation and safety issues;
- *Erosion Control* - which addresses the prediction, control and measurement of soil erosion on mining lease areas;
- *Growth Media Management* - which outlines the selection, handling, storage, treatment and replacement of soils and other media to be used for establishing and growing vegetation on land following mining;
- *Mine site Decommissioning* - which addresses the closure and decommissioning of areas, works and facilities used for mining, including the In-Pit Tailings Storage Facility;

- *Site Water Management* - which discusses the management of water on mine sites so as to reduce the amount of contaminated water that may need to be handled; and
- *Water Discharge Management* - which addresses the management of water discharged from mine sites to ensure compliance with statutory requirements and protection of downstream uses.

9.2 Rehabilitation Principles and Hierarchy

The overriding principle for the rehabilitation program at the Mine and for the Project is that the land should be returned to a post-mine land use that will be stable, self-sustaining and require minimal maintenance. The post-mine land use for areas disturbed by mining at the site will be a self-sustaining vegetation community using appropriate pasture grasses and scattered plantings of native tree and shrub species. The attainment of this land use will stabilise the landform and protect the downstream water quality.

In assessing the rehabilitation objectives and completion criteria, the Mine Rehabilitation Hierarchy outlined by the Guideline Rehabilitation Requirements for Mining Projects (DEHP 2014) have been considered as well as the Sustainable Final Land Use Outcomes outlined in the EA. The most practical, achievable and sustainable rehabilitation strategy for the site is to reinstate the dominant previous agricultural land use of grazing.

In addition, the Project's rehabilitation requirements for mining disturbance on ML 50232 has been conditioned by the Coordinator-General to ensure:

1. rehabilitation is undertaken in a manner that does not allow unjustified mixing of soil material from different soil map units;
2. each rehabilitated land unit is capable of being assigned a specific post-disturbance land use suitability; and
3. a rehabilitation outcome that achieves at least 50 per cent of the total area of disturbed land originally meeting or exceeding the criteria for either Class 3 grazing land or Class 4 cropping land being able to still meet or exceed those classifications.

9.3 Post Mining Rehabilitation Goals

The core rehabilitation goal is to achieve the final land use of grazing at the Mine site and in the future for the Project site by:

- creating stable rehabilitated landforms that are safe to humans and wildlife and are non- polluting;
- ensuring rehabilitated landforms can support productive and sustainable grazing activities;
- implementing and monitoring measurable standards to assess the success of rehabilitated landforms to the agreed grazing post-mining land use;
- ensuring progressive rehabilitation of disturbed land over the life of the Project is incorporated into mine planning to minimise the amount of land disturbed at any one time and to reduce the rehabilitation burden prior to mine closure;

- undertaking rehabilitation within ML 50232 in a manner that establishes discrete land units in the disturbance areas, so that each rehabilitated land unit is capable of being assigned a specific post-disturbance land use suitability (i.e. to achieve the best possible post-disturbance land use);
- ensuring a rehabilitation outcome for ML 50232 that achieves at least 50 per cent of the total area of disturbed land originally meeting or exceeding the criteria for either Class 3 grazing land or Class 4 cropping land being able to still meet or exceed those classifications; and
- achieving a rehabilitation standard that will permit regulatory approval for surrender of MLs 50170, 50216, 50232 and 700002 to allow complete mine closure.

9.4 Strategies to achieve Rehabilitation Goals

The rehabilitation strategies for each of the four domains of solid waste disposal areas (spoil, waste dumps and reject dumps), tailings dams, infrastructure areas and depressed landforms at the Mine/Project site are summarised in **Table 8**. The rehabilitation acceptance criteria outlined under Section 9.2 relates to all four domains as they are classified as "disturbed by mining" and will receive the same rehabilitation treatment.

Infrastructure areas will generally not require spoil placement or capping. However, they will receive topsoil and seeding treatments similar to the solid waste disposal and capped tailings dams. Please note, by agreement some of the former mining infrastructure will remain for use by the New Hope Group subsidiary company, Acland Pastoral Company Pty Ltd (APC).

Each of the Project's depressed landforms (former voids) will require reshaping of its void's 'high' and 'low' walls to a maximum of 20 and 15 degrees, respectively. The reshaped slopes will receive a final layer of subsoil and topsoil suitable to promote re-vegetation to allow grazing to be conducted in a safe and sustainable manner.

Table 8 Strategies to Achieve Rehabilitation Goals

Domain	Rehabilitation Goals			
	Safe	Non-Polluting	Stable landform	Sustains Agreed Land Use
Solid Waste Rock Disposal	Appropriate geotechnical design will be used for solid waste disposal structures.	Only geochemically benign material will be placed at or near the surface of solid waste disposal structures. Adequate vegetation cover will be established to minimise erosion. Runoff and seepage associated with solid waste disposal structures will be controlled by water management (e.g. dams).	Appropriate geotechnical design will be used for solid waste disposal structures. Adequate vegetation cover will be established to minimise erosion.	The re-establishment of vegetation will be monitored against the performance indicators for a successful grazing outcome. As required, grazing trials will be conducted to evaluate grazing performance within rehabilitation areas.
Tailings Dams	Tailings dams will be decommissioned and rehabilitated as defined by the In-pit Tailings Storage Management Plan.	Tailings dams will be decommissioned and rehabilitated as defined by the In-pit Tailings Storage Management Plan. Appropriate capping material will used for rehabilitation. Adequate vegetation cover will be established to minimise erosion. Runoff and seepage associated with tailings dams during rehabilitation will be controlled by water management (e.g. dams).	Tailings dams will be decommissioned and rehabilitated as defined by the In-pit Tailings Storage Management Plan. Appropriate capping material will used for rehabilitation. Adequate vegetation cover will be established to minimise erosion.	The re-establishment of vegetation will be monitored against the performance indicators for a successful grazing outcome.

Domain	Rehabilitation Goals			
	Safe	Non-Polluting	Stable landform	Sustains Agreed Land Use
Mine Infrastructure Areas (including Linear Infrastructure Areas)	Contaminated land investigations and remediation will be conducted as required. All non-required infrastructure will be appropriately decommissioned and removed off site.	Contaminated land investigations and remediation will be conducted as required. Runoff and seepage associated with Mine Infrastructure areas during rehabilitation will be controlled by water management (e.g. dams). Adequate vegetation cover will be established to minimise erosion.	All non-required infrastructure will be appropriately decommissioned and removed off site. By agreement some of the former mining infrastructure will remain for use by the New Hope Group subsidiary company, APC. Adequate vegetation cover will be established to minimise erosion.	The re-establishment of vegetation will be monitored against the performance indicators for a successful grazing outcome.
Depressed Landforms (Former Voids)	Each final void will have its high and low walls reshaped to an appropriate geotechnical design that allows efficient rehabilitation activities, and longer term facilitates safe grazing of the internal slopes.	Adequate vegetation cover will be established to minimise erosion.	Appropriate geotechnical design will be used for depressed landforms. Adequate vegetation cover will be established to minimise erosion.	The re-establishment of vegetation will be monitored against the performance indicators for a successful grazing outcome.

To achieve the rehabilitation goals set by the Coordinator-General for the Project, NAC has completed a detailed soil survey of the proposed disturbance areas within ML 50232 and developed a Revised Soil Management Plan based on the detailed soil survey to ensure that the Project's topsoils and subsoils are selectively managed (stripped and returned) to minimise the risk of mixing soil types and to promote the opportunity to achieve the best possible rehabilitation outcome from an agricultural perspective.

9.5 Post Mining Land Use

The proposed post-mine land use for the existing Mine's and Project's disturbed areas will be grazing, using native and pasture (exotic) grass species combined with smaller areas of local native tree and shrub species. This nominated land use will ensure that the land remains agriculturally productive, is consistent with the surrounding land uses, and can be re-incorporated into the New Hope Group's agribusiness through its subsidiary company, APC.

To help satisfy community expectations, the Coordinator-General has conditioned the Project to ensure that all efforts are made by NAC to return the Project's disturbed areas to a high standard of agricultural production.

9.6 Post Mining Landform

The existing Mine and its continuation under the Project will change the land use and land suitability of the site. From a regulatory perspective, the Project's disturbed areas (including the existing Mine) will be rehabilitated in accordance with:

- Agency Interest: Land and Rehabilitation – Table H1 and Table H2 of the EA for the existing Mine;
- Table H4: Rehabilitation Requirements Stage 3 New Acland Mine Project, Table H5: Rehabilitation Acceptance Criteria — Grazing Lands Stage 3 New Acland Mine Project and Table H6: Rehabilitation Acceptance Criteria — Treed Areas Stage 3 New Acland Mine Project of the EA for the Project; and
- the requirements of Imposed Conditions 6 and 7 of the 'New Acland Coal Mine Stage 3 project Coordinator-General's evaluation report on the environmental impact statement (December 2014)'.

The primary design objective is the creation of a stable final landform that is compatible with the proposed final agricultural land use. NAC will use experience gained at the current Mine and other mines in the region, specialist consultants and relevant research findings to meet this objective and the requirements specified in the EA's *Agency Interest: Land and Rehabilitation* and the Coordinator-General's evaluation report.

Stable landforms will continue to be progressively established as part of the mining process using integrated mine planning, proven earthmoving techniques and appropriate water management design. The final slopes will be engineered to ensure geotechnical stability and designed to incorporate the required water management structures to manage storm runoff.

Established topsoil and revegetation techniques will be applied to create a self-sustaining vegetation community capable of supporting grazing. Advanced soil management (topsoil and subsoil) will be used within the Project's disturbance areas to help achieve an even higher standard of rehabilitation outcome.

Rehabilitation monitoring and grazing trials (as required) will be conducted to establish rehabilitation success and to capture the required data for further progressive rehabilitation certification and/or eventual surrender of the mining tenure.

9.7 Rehabilitation Strategy

A rehabilitation strategy has been developed to restore and re-establish disturbed areas resulting from mining operations. The rehabilitation strategy for the current Mine and the Project comprise the following integrated measures.

- Appropriate pre-disturbance preparation will be conducted, such as topsoil recovery and management plans, and integrated mine planning to efficiently coordinate mining activities.
- Practical landform designs will be developed and implemented to prevent erosion and establish final landform stability.
- Development of the proposed post-mine agricultural land use will consider local environmental constraints.
- All efforts will be made to ensure sodic/dispersive materials are not placed near the surface of the dumps or within the plant root zone.
- Tailing dams will be managed in accordance with the current in-pit tailings dam management plan and all other applicable statutory requirements.
- As required, revegetation trials will be conducted to assist the selection of appropriate revegetation species and methodologies.
- Progressive rehabilitation of disturbed areas will continue using appropriate rehabilitation procedures.
- A rehabilitation monitoring program to assess rehabilitation success will continue.
- A corrective action program to address identified areas of unsatisfactory rehabilitation will continue.
- Progressive rehabilitation, monitoring and remediation activities will be focussed on increasing the amount certified progressive rehabilitation over time.
- Advanced soil management activities through the Revised Soil Management Plan will be integrated into the Project's mine planning and operations.

9.7.1 Progressive Rehabilitation

A program of progressive rehabilitation is conducted at the current Mine and will continue over the life of the Project, and eventually will become a statutory requirement of a PRCP for the site (i.e. upon implementation of the process by DES). The main features of NAC's progressive rehabilitation process are as follows.

Final shaping of slopes and landforms involving a variety of topographical features are designed to complement the post mined land use. Landforms may be designed in a variety of ways, including but not limited to:

- reshaped landforms – reshaped areas of previously mined land supporting vegetative cover on a grade that does not promote erosion;
- basin catchment – reshaped areas of previously mined land that are designed in a way to capture and direct rainfall runoff;
- depressed landform (former residual void);

- drainage pathways to water management structures;
- contour banks – contour banks may be used on final landforms to reduce catchment areas and slope lengths, increase water infiltration and direct water; and
- leeward aspects – provide protection from the dominant wind direction and enhances vegetation growth.

Establishment of final landforms, spreading of topsoil and subsoil, seeding with appropriate pasture species, and livestock activity are progressively conducted on rehabilitation areas.

9.7.2 Soil Management

For the current Mine, soil is recovered prior to disturbance from all planned disturbance areas for eventual use in rehabilitation. Recovered soil is either purposefully stockpiled until suitable re-contoured areas are available for re-spreading or is directly returned to re-contoured areas to achieve a sustainable final landform. Currently, stockpile recovery processes are implemented per site-based Work Instruction documents (i.e. NAC documents: WI-ENV-11 Topsoil and Rehabilitation Work).

The soil resources present at the current Mine and to be recovered for the Project are adequate for the rehabilitation of current and proposed disturbed areas, and to achieve the proposed post- mining land suitability classes and post mining land uses. The soil resources allocated for rehabilitation at the current Mine are adequate to provide a soil profile depth of approximately 250-300mm.

The Project's soil resources (topsoil and subsoil) have been thoroughly assessed to ensure adequate post mining soil profiles and depths are achieved to establish the required amount of targeted land suitability classes and the planned post mining land uses.

9.7.3 Revegetation

The revegetation methods for disturbed areas generally comprise the following actions:

- respreading of stockpiled or freshly stripped soil;
- contour ripping;
- application of appropriate fertiliser for plant establishment (after soil chemical analysis, if required); and
- seeding with an appropriate seed mix to establish a post mining agricultural land use.

Where available, competent materials such as basalt are placed on steeper slopes to aid stability. Contour ripping is used as an erosion control measure immediately after surface preparation and before revegetation to improve infiltration. A seed mix containing a sterile cover crop for fast establishment, pasture grass and local native shrub and tree species is used to establish a sustainable vegetation cover in a one pass operation. The revegetation of disturbed areas normally occurs prior to the commencement of the wet season (October-December) to maximise the benefits of subsequent rainfall or following the heat of Summer (February-March). This practice occurs at the existing Mine and will continue as part of the Project's mining operations.

9.7.4 Rehabilitation Maintenance

Rehabilitated areas are monitored in order to identify any areas in need of maintenance and to capture data to confirm the success of rehabilitation against key performance indicators (i.e. for future rehabilitation certification and tenure surrender applications). Rehabilitated areas that have not achieved the designated acceptance criteria will be repaired. Supplementary plantings or seeding may be used to increase species diversity and/or groundcover. Maintenance work will be performed to repair any areas exhibiting excessive soil erosion. Excessive erosion will be investigated to identify appropriate methods for repair. As required, weed control activities are conducted.

9.7.5 Maintenance of Non-Mined Areas

Non-Mined Areas – Grazing Activities

APC will continue to manage those non-mining areas where grazing can be conducted (i.e. where access allows, and safety requirements can be met). APC is responsible for the management of these areas and will continue to liaise with NAC in relation to the management of this land.

Non-Mined Areas – No Grazing Activities

NAC will continue to manage non-mining areas where grazing cannot be conducted by APC in accordance with the most current version of its Pest and Weed Management Plan. Periodic site inspections of non-mining areas will also continue, and as required, any damage to the land from erosion or feral animals (e.g. wild pigs) will be repaired in accordance with the principles of Section 9.7.4.

NAC believes the maintenance of an appropriate vegetation cover, the control of feral animals and significant weed species, the management of erosion, and avoidance of unauthorised disturbance are the key drivers to preventing land degradation and ensuring that the pre-mined land capability of non-mining areas is retained for the life of the Project.

Non-Mined Areas – Lease Arrangements

NAC will also continue to lease by agreement certain non-mining areas to near neighbours for farming purposes (i.e. mainly within ML 50170 – Stage 1). Under the agreement, the neighbour leasing the land from NAC/APC is responsible for its proper management.

Non-Mined Areas – Unauthorised Disturbance Control

NAC possess a ‘permit-to-disturb’ system to minimise the risk of unauthorised land disturbance. NAC also continuously undertakes detailed short-medium mine planning to control disturbance on-site, which also defines its current ERC (and eventually its PRCP requirements). These practices will continue for the Project. For the Project, NAC intends to erect signage to delineate conservation zones, no disturbance areas and non-access areas (i.e. for safety reasons).

9.7.6 Grazing Trials

NAC has been undertaking a formal grazing trial within the eastern extent of the rehabilitation area of the North Pit's Elevated Landform within the Stage 1 area of the current Mine. The grazing trail program ceased in 2018 and has demonstrated the effectiveness of rehabilitation at the site. Details of the grazing trial are outlined under **Appendix C**.

9.7.7 Groundwater

During 2018, NAC produced an updated groundwater model to support the Project's Associated Water Licence application. The outputs from the groundwater modelling have been combined with other relevant variables (e.g. climatic inputs) to generate preliminary pit lake water balance models and preliminary contaminant modelling within the pit lakes of each depressed landform (former void) (SLR, 2018).

The coupled groundwater/surface water model for the final voids was also used to assess the salt balance associated with the voids as a means of assessing any long-term water quality (salinity) risks. As reported in SLR (2018), the results indicate as follows.

- Salinities in the void lakes are predicted to generally increase over time primarily as a result of evaporation from the void lakes, with cyclical fluctuations in the longer term due to the effect of rainfall (and therefore runoff) variability based off the historic rainfall record.
- The Manning Vale East void lake salinity stabilises at approximately 10,000 to 12,000 mg/L in the long term.
- The Manning Vale West and Willeroo void lake salinities reach approximately 20,000 to 25,000 mg/L in the long term.

The lower predicted lake salinity in the Manning Vale East void as compared to the Manning Vale West and Willeroo void lakes is considered to be a result of the reduced groundwater inflow volume to the Manning Vale East void in comparison to the other two voids. This leads to the predicted salinity in the Manning Vale East void lake increasing in concentration at a lower rate than the Manning Vale West or Willeroo void lakes (SLR, 2018).

Since all three void lakes are predicted to form groundwater sinks in the long term at rates of between 0.01 and 0.11 ML/day, the voids will continue to collect groundwater post-mining, and therefore, any local changes to the quality of groundwater that might occur as a result of mining are unlikely to migrate away from the residual voids (SLR, 2018).

From an acid rock drainage perspective, it is unlikely that any water captured in the Project's final voids will become acidic from oxidation of pyrites in the Walloon Coal Measures aquifer because of the neutralising effect of the surrounding sediments which are naturally alkaline. To date, NAC has not experienced any occurrences of acid rock drainage at the Mine (SLR, 2018).

As a requirement of specific State and Commonwealth approvals for the Project, the pit lake water balance models and contaminant modelling will continue to be refined over time with each mandatory update of the Project's groundwater model. NAC will be able to improve its predictions for the 'pit lake' scenarios for each of the three depressed landforms (former voids) and further investigate final landform design, which will eventually be incorporated into the Project's mine closure process at the cessation of mining.

NAC has recommended regarding post-mining modelling within SLR (2018), which formed part of the Project's Associated Water Licence application, that during future detailed mine closure planning, as a minimum the following matters should be considered as a priority.

- The incorporation of diversion bunds adjacent the eastern sides of the Manning Vale West void and the Manning Vale East void should be considered as part of the final landform design to divert surface water runoff away from the voids.
- Groundwater model grid discretisation revisions adjacent the voids should be considered to allow better representation of the detail of the final land surface in the groundwater model.
- The simulation of long-term void lake levels for both the base case climate scenario and the climate change scenario should be undertaken.
- Redesign of the land surface should be considered to have a minimum elevation between 405 mAHD and 410 mAHD at Manning Vale East.
- The incorporation of the groundwater modelling results into a feedback loop with the final landform design should be undertaken to provide the most optimum solution with regards to limiting potential long-term groundwater quantity and quality impacts (i.e. via ensuring the floor of the depressed landforms are above the final predicted groundwater level).

9.7.8 Decommissioning

A Life of Mine (LoM) Plan will be developed for the Mine to allow eventual surrender the EA. This LoM Plan will inform the mine closure planning process and establish a basis for final landform design and management. The LoM Plan will be based on economic, geological and engineering factors. As a result of the planning process a competent Mine Closure Plan will be prepared and will ultimately be incorporated into a PRCP for the Project.

A Mine Closure Plan will be submitted to the Administering Authority at least five years prior to the surrender of the EA. The decommissioning and final rehabilitation of the site will occur on a staged basis over several years. A contaminated land assessment will be carried out as part of the Final Rehabilitation Report. On completion of the Project's mining, infrastructure will be treated as follows.

- Under an agreement with APC, certain mine roads and other infrastructure will be left behind for use as farm roads, or if not required, they will be rehabilitated.
- Under an agreement with APC, specific dams will remain and approved by regulators. Otherwise, the dams will be rehabilitated.
- Most buildings, plant and equipment will be removed and the surface rehabilitated, including the Coal Handling and Preparation Plant, certain hard stands and coal handling facilities (e.g. conveyors, bins, etc.).
- Concrete pads will be covered with benign waste rock, topsoiled and revegetated or removed and disposed to the nearest landfill or in-pit (depending on the timing of the activities).
- Contaminated land management will be completed as required under the EP Act.
- All TSFs will be capped with a competently engineered final cover system, topsoiled and grassed.

- The final voids remaining at the end of the mine life will be re-shaped into depressed landforms so that all their slopes are safe, stable and able to be revegetated to facilitate grazing activities.

A Final Rehabilitation Report and Compliance Statement will be produced as a statutory requirement under the EP Act for the surrender process for environmental authorities and their associated mining tenures.

9.8 Rehabilitation Timetable

Scheduling and reporting of the Project's (including the current Mine's) rehabilitation will be outlined in each subsequent ERC/PRCP. Changes and updates to the Project's mine plan and rehabilitation schedule must be capture by amendment of the ERC/PRCP or during submission of a new ERC/PRCP. These new processes once fully implemented for the Project will make the FLURP a redundant document.

In general, over the life of the existing Mine, NAC has rehabilitated on average 40 hectares per year. This amount of completed rehabilitation is influenced by a range of operational, climatic and other factors, and therefore, may vary from year to year. This annual quantum of completed rehabilitation is likely to remain consistent for the Project.

The Department of Environment and Science 'certified' 349 hectares of progressive rehabilitation during November 2018. At the time, the area certified was the largest single area of certified rehabilitation on an open cut mine in Queensland. NAC will continue to seek certification of its rehabilitated land for the Project.

10 Selection and Description of Analogue Sites

10.1 Methodology for Selecting Analogue Sites for the current Mine

Analogue sites were selected to represent Grazing Land Suitability Classes 2, 3, 4 and 5. Analogue sites are used as a means of providing baseline data against which future land use rehabilitation can be measured. Analogue sites are intended to represent a typical example of that Land Suitability Class within the Project area and provide an opportunity for meaningful monitoring to occur.

Based on the substantial body of information available in relation to soil properties and landscapes, land classes and productivity, no replication of previous survey work was required. The information provided in the NAC FLURP (2008) and the Mine Rehabilitation Monitoring report (Jacobs, 2017) has been utilised to update this section. The locations of the analogue sites are illustrated in **Figure 12**.

Figure 12 Current Mine Analogue Site Locations

10.2 Description of Analogue Sites

10.2.1 Class 2 Analogue Site

The analogue site chosen for Land Suitability Class 2 has been updated since the NAC FLURP (2008) due to access issues. As a result, the Mine Rehabilitation Monitoring report (Jacobs, 2017) surveyed an updated analogue site for Land Suitability Class 2. The 2008 FLURP Class 2 analogue site vegetation cover has been retained as the basis for the vegetation cover targets discussed in **Section 11**. The 2008 FLURP vegetation cover at the original Class 2 analogue is outlined in **Table 9**.

Table 9 2008 Class 2 Analogue Site Description

Class 2						
Location: 375262, 6981253						
Sub plot	**1**	**2**	**3**	**4**	**5**	**Average**
% Grass Cover	5	10	10	40	20	17
% Herb/forb Cover	25	40	10	10	30	23
% Total Cover	30	50	20	50	50	**40**

The updated Class 2 analogue site is located on a plain (slope gradient <1%), is moderately well- drained, possesses no rock outcrop, and has no evidence of erosion (stable). The soil is a medium heavy clay (0- 350 mm depth) gradually increasing to heavy clay (350-900+ mm depth). The soil has a strong sub-angular or polyhedral throughout. Soil consistence is firm (moist) (0-100 mm), grading to very firm (moderately moist) (100-700 mm). The vegetation cover at the updated Class 2 analogue site is described in **Table 10** and demonstrated in **Photo 1**.

Table 10 Class 2 Analogue Site Description

Class 2						
Location: 374121, 6978662 (Site ID: *R06_2016*)						
Sub plot	**1**	**2**	**3**	**4**	**5**	**Average**
% Vegetation Cover (Grasses only)	95	95	95	95	95	**95**

Notably, the vegetation cover at the Class 2 analogue site in the Jacobs (2017) survey (95%) is significantly higher than that of the original survey of the Class 2 analogue site (40%). This difference is likely due to seasonal variability and/or survey technique changes and is not considered a reasonable vegetation cover target for rehabilitation.

Photo 1 Typical Vegetation at Class 2 Analogue Site

10.2.2 Class 3 Analogue Site

The analogue site chosen for Land Suitability Class 3 is located at a mid-slope (slope gradient 3%), which is well-drained and has no visible rock outcrop or erosion. The soil profile consists of a clay loam (sandy) (0-100 mm depth) abruptly increasing to medium clay (350-800 mm depth). Light clay (sandy) from 800+ mm. The soil has weak to moderate sub-angular or polyhedral structure between 0-600 mm depth, and is apedal from 600+ mm. The current vegetation cover across the Class 3 analogue site is outlined in **Table 11**, and the typical vegetation found across at the site is a *Eucalyptus populnea* (Poplar Box) woodland with a grassy understorey (**Photo 2).**

Table 11 Class 3 Analogue Site Description

Class 3						
Location: 375271, 6980962 (Site ID: *R02_2013*)						
Sub plot	**1**	**2**	**3**	**4**	**5**	**Average**
% Grass Cover	0	5	5	5	30	9
% Herb/forb Cover	40	25	45	20	40	34
% Total Cover	40	30	50	25	70	**43**

Photo 2 Typical Vegetation at Class 3 Analogue Site

10.2.3 Class 4 Analogue Site

The analogue site chosen for Land Suitability Class 4 has been updated since the FLURP (2008) as the original location was mined through by the current Mine's Centre Pit. The Mine Rehabilitation Monitoring report (Jacobs, 2017) outlines the updated analogue site for Land Suitability Class 4. The 2008 FLURP Class 4 analogue site vegetation cover has been retained as the basis for the vegetation cover targets discussed in **Section 11**. The 2008 FLURP vegetation cover at the original Class 4 analogue is outlined under **Table 12**.

Table 12 2008 Class 4 Analogue Site Description

Class 4						
Location: 372169, 6979878						
Sub plot	**1**	**2**	**3**	**4**	**5**	**Average**
% Grass Cover	50	65	15	80	70	56
% Herb/forb Cover	0	0	0	0	0	0
% Total Cover	50	65	15	80	70	**56**

The analogue site chosen for Land Suitability Class 4 is located on the crest of a tributary bank (slope gradient 0%), is moderately well-drained and possesses no visible rock outcrop or erosion (stable). The soil profile consists of light clay (0-50 mm depth) abruptly increasing to light medium clay (50-900 mm). Refusal at 900 mm. The soil has strong to moderate polyhedral structure grading. Notably, the vegetation cover at the Class 4 analogue site in the Jacobs (2017) survey (67%) is higher than that of the original survey of the analogue site (56%). This difference is likely due to seasonal variability and/or differences between survey methods. The current vegetation cover across the Class 4 analogue site is outlined in **Table 13** and the typical vegetation found at the site is a Poplar Box woodland with a grassy understorey (**Photo 3)**.

Photo 3 Typical Vegetation at Class 4 Analogue Site

Table 13 Class 4 Analogue Site Description

Class 4						
Location: 375142, 6980991 (Site ID: *R01_2013*)						
Sub plot	**1**	**2**	**3**	**4**	**5**	**Average**
% Vegetation Cover (Woody vegetation and grasses)	90	70	25	80	70	**67**

10.2.4 Class 5 Analogue Site

The analogue site chosen for Land Suitability Class 5 was located in an area of Shallow basaltic soils (clay loam and non-cracking clay, outcrop soils). The current vegetation cover across the Class 5 analogue site is outlined in **Table 14** and the typical vegetation found across the transect was *Eucalyptus orgadophila* (Mountain Coolibah) woodland with *Brachychiton rupestris* (Narrow-Leaved Bottletree) (**Photo 4**).

Table 14 Class 5 Analogue Site Description

Class 5						
Location: 372231, 6979083 (Site ID: *R04_2013*)						
Sub plot	**1**	**2**	**3**	**4**	**5**	**Average**
% Grass Cover	1	15	30	15	5	13.2
%Herb/forb Cover	59	35	5	15	45	31.8
% Total Cover	60	50	35	30	50	**45**

Photo 4 Typical Vegetation at Class 5 Analogue Site

Current analogue sites are being used to determine composition of the desired rehabilitation outcomes i.e. groundcover, species diversity and nil declared weeds. Analogue site methodology and monitoring results are detailed in the *New Acland Coal Mine Rehabilitation Monitoring Program – April 2019* (SLR, 2019a).

11 Proposed Rehabilitation Acceptance Criteria

11.1 Review of Major Research Project

11.1.1 Sustainability Indicators for Coal Mine Rehabilitation

The Research Project Sustainability Indicators for Coal Mine Rehabilitation (DNRM, 2001) was completed under the Australian Coal Association Research Program (ACARP). The Research Project's objectives were to:

- monitor the long-term impact of open cut mine rehabilitation on erosion and water quality under natural rainfall conditions;
- evaluate physical and biophysical indicators for sustainable rehabilitation; and
- use the monitoring sites as an educational resource to promote the outcomes from the study to the industry and the wider community.

In particular, this research assessed runoff, erosion and water quality from rehabilitated land at Curragh, Goonyella Riverside and Oaky Creek mines at two scales - plot (0.01 ha) and catchment (0.4ha to 0.9ha) - and three slope gradients – 10 percent, 20 percent and 30 percent. Pasture and tree vegetation treatments were imposed on topsoil and spoil materials and a number of topsoil and spoil plots at each site were left bare to compare with the vegetative treatments.

Pasture establishment on spoil was poor at all mine sites, especially where the spoil was hard setting and dispersive. Annual erosion rates from spoil remained unacceptably high throughout the study.

The key findings of this research were as follows.

- Rainfall is the major limiting factor associated with successful rehabilitation. It is critical that pasture cover is established rapidly in order to maximise rainfall infiltration.
- A rehabilitated landscape is at greatest risk of erosion before grass cover is established. The window-of-erosion risk occurs before vegetative growth reaches 50 percent ground cover.
- Pasture establishment to 50 percent cover should be a minimum target indicator for coal mine rehabilitation. Further increases in pasture cover (greater than 80 percent) and biomass are required to reduce erosion rates on 30 percent slopes to negligible levels.
- Topsoil erosion rates declined between slopes once a dense sward of grass cover established (greater than 80 percent cover).
- Vegetative cover reduces the risk of salt movement on-site and off-site through runoff.
- The development of a hard-dispersive crust on the spoil material reduced infiltration, produced very poor pasture and tree establishment and resulted in unacceptably high runoff and erosion.
- Surface ripping of slopes greater than 20 percent should be used to improve infiltration and reduce runoff and erosion losses.
- Supplementary irrigation should be used to assist rapid pasture establishment during periods of low rainfall.

11.2 Rehabilitation Acceptance Criteria for the Project

11.2.1 Grazing Land

Proposed rehabilitation acceptance criteria have been developed to monitoring the progress of rehabilitation efforts for the Project. Drawing on the findings of Grigg, Emmerton and McCallum (2007) it is considered appropriate to focus on several key criteria to determine rehabilitation success, namely:

- 'Vegetation Cover', measured as a percentage;
- 'Species Diversity', determined from analogue sites;
- 'Slope';
- 'Erosion';
- 'Absence of Declared Weeds';
- 'Exchangeable Sodium Percentage (ESP)' (as a measure of soil dispersion);
- 'Cation Exchange Capacity (CEC)' (as a measure of nutrient availability); and
- 'Root Zone Salinity (RZS)'.

Exchangeable Sodium Percentage (ESP), Cation Exchange Capacity (CEC) and Root Zone Salinity (RZS) have been incorporated into the monitoring and reporting framework outlined in **Section 10**. Vegetation cover, species diversity, slope angle, erosion and the absence of declared weeds have been incorporated into the acceptance criteria for land suitability class. The acceptance criteria do not apply to conservation areas at the Project as these are considered in the Project's Conservation Zone Management Plan. Proposed rehabilitation acceptance criteria for disturbed areas is outlined under **Tables 15** and **16**.

Table 15 Rehabilitation Acceptance Criteria – Grazing Land

Indicator	Acceptance Criteria
Ecological	
Vegetation cover	≥70%
Grass species diversity	≥4 pasture species
Prohibited or Restrictive invasive plants (Qld)	Absent
Geomorphological	
Slope[1]	17° (maximum)
Active rill/gully erosion[2]	Rill/gully erosion will be managed to be consistent with surrounding in-situ landforms. Identification and repair of areas of concern (e.g. large scale rill/gully erosion)
Geotechnical stability	Stable surface, no subsidence
Physical	
Field texture	Sandy loam to light clay (rigid soils i.e. duplex soils) Clay loam to heavy clay (non-rigid soils i.e. Vertosols)
Bulk density (BD)	1.1 – 1.8 gm/cm3
Emerson dispersion test	Class 2, 3, 4, 5 or 6
Depth of effective root zone (ERZ)	250 – 1000 millimetres
Chemical	
pHCa	pH_w 6.5 – 9.5, pH_{ca} 6.0 – 8.0
Electrical Conductivity (EC/se)	**EC1:5$_W$** 120 – 240 µS/cm for low salinity in sandy soils 90 – 300 µS /cm for low salinity in clay soils **EC_{se}** 950-1900 µS/cm for low – moderate salinity in all soils
Cation Exchange Capacity (CEC)	9 – 45 meq/100 gm
Exchangeable Sodium Percentage (ESP)	<10
Total metals –Cu, Zn	*Risk Based Ecological Levels* Zn – 190 mg/kg, Cu – 90 mg/kg *Typical Background Levels* Cu – 3-412 mg/kg, Zn – 5-92mg/kg,
Total Organic Carbon (TOC)	>1% for total organic carbon

1. This criterion has been developed to meet the standards set in the EA (*Schedule H Table H5*). Maximum slope will be 17° as authorised but consideration will be given to the lower slope angles.
2. Should active rill/gully erosion be identified, erosive soil loss will be estimated using RULSE.

A further 22 reference (analogue) sites have been assessed in the *New Acland Stage 3 Project Land Resource Survey Establishment of Soil Reference Sites* (SLR,2019b) to satisfy IC 6(c)(i)(ii), 6(e)(i)(ii), and 7(c)(i)(ii) of the Coordinator-General's Report. This includes reference sites for rehabilitation that are required to be established under two conditions, 6(c) and 7(c), within areas of land that have not, and will not, be disturbed by mining activities. Condition 6(c) requires three reference sites be established for each soil map unit identified in the land resource survey, including detailed soil profile descriptions and laboratory analysis.

Table 16 Rehabilitation Acceptance Criteria – Treed Areas

Land Suitability Class	Acceptance Criteria						
	Non-Polluting	Stability and Sustainable Land Use					
	Active Rill/Gully Erosion	Vegetation Cover	Native & Exotic Grass Species[1]	Slope[2]	Geotechnical Stability	Active Rill/Gully Erosion	Prohibited or Restrictive Invasive Plants (Qld)
2-5	Absence (<10t/ha/yr)	≥50%	*Eucalyptus sp.* ≥2; *Acacia sp.* =≥2; Other tree/shrub sp. ≥2; Grass= ≥ 3	Maximum 17°	Stable	Rill/gully erosion will be managed to be consistent with surrounding in-situ landforms. Identification and repair of areas of concern (e.g. large scale rill/gully)	Absence

1. The majority of the rehabilitated land will be returned to grazing with exotic pastures established. Where pockets of trees/shrubs have been established the diversity criteria will apply taking into account the limited diversity of some remnant communities near the Mine.
2. This criterion has been developed to meet the standards set in the EA (*Schedule H Table H6*). Maximum slope will be 17° as authorised but consideration will be given to the lower slope angles

11.2.2 Agricultural Production

The Project has been strictly conditioned to ensure that the rehabilitated mined land achieves a higher standard of rehabilitation from an agricultural perspective. As explained earlier, the Queensland Coordinator-General has conditioned the Project to achieve the following rehabilitation outcome.

"The rehabilitation of disturbed land is to result in the affected land units being able to support the best post-disturbance land use possible. The post-disturbance land suitability of each land unit is to:

(i) represent that achievable on an ongoing basis;

(ii) be obtainable without the use of irrigation; and

(iii) be such that collectively at least 50 per cent of the total area of disturbed land originally meeting or exceeding the criteria for either Class 3 grazing land or Class 4 cropping land still meet or exceed those classifications."

To achieve the Project's agricultural based rehabilitation outcome, the Queensland Coordinator-General has also conditioned the Stage 3 Project to undertake selective handling and return of topsoils and sub-soils within the proposed mining areas.

In addition prior to the commencement of the Project, an extensive land resource (soil) survey has been completed to establish the soil types and soil profiles for future soil management purposes and to refine land suitability classifications within the proposed mining areas. Reference sites have also been established for each of the identified soil types to assist with future monitoring of rehabilitation performance.

11.3 Seed Mix

Seed mixes for the Grazing Lands used for rehabilitation have been refined and will continue to be applied to the rehabilitation works for the Project. The seed mix and seed rates applied since 2014 are outlined in **Table 17**.

Table 17 Seed Mix – Grazing Lands from 2014-2017

Common Name	2014 Seed rate (kg/ha)	2015 Seed rate (kg/ha)	2016 Seed rate (kg/ha)	2017 Seed rate (kg/ha)
Japanese Millet	4	6	5	5
Bisset Creeping Blue Grass (Coated)	4	2	3	3
Qld Blue Grass (Coated)	2	2	3	3
Katambora Rhodes Grass (Coated)	6.5	4	4	4
Gatton Panic (Coated)	4.5	4	4	4
Woolly Pod Vetch	5	4	3	3

12 Reporting Framework

12.1 Monitoring Rehabilitation Works

Monitoring activities for the Project will involve the continuation of the methodology applied to the current Mine's monitoring program, which was developed using reference site data to establish rehabilitation targets to monitor changes over time at monitoring sites. Ongoing monitoring of reference sites serves as a control for environmental variability in the assessment and allows rehabilitation success to be determined over time against success criteria.

In terms of establishing permanent rehabilitation monitoring points, at the commencement of rehabilitation works in a new area, permanent photograph points are established and delineated with a star picket or similar. The geographic location and bearing of the photograph are recorded using a GPS.

12.2 Revegetation Monitoring Program

In summary, formal revegetation monitoring will be conducted by a competent person, annually. New rehabilitation areas will be added as necessary and subject to establishment success which may be affected by rainfall, seedling establishment and other seasonal factors. This formal monitoring program will continue for the current Mine areas and will apply until all rehabilitated areas are deemed successful via the surrender of the associated mining tenure. During this monitoring the revegetation will be compared against the rehabilitation success criteria proposed in **Tables 15** and **16**. The following information will be collected for rehabilitation areas during the biennial monitoring surveys at the end of the wet season:

1. a minimum of 8 permanent monitoring sites, plus any additional analogue sites;
2. photographs of existing and new rehabilitation areas from permanent photographic points;
3. record of treatments used for each new rehabilitation, including seeding rates, soil treatment, topsoil source;
4. botanical description of the rehabilitation area, including percentage cover and species diversity;
5. selective measurement of pH, ESP, CEC and RZS;
6. Emerson Aggregate Test, soil texture or particle size analysis, and bulk density or penetrometer resistance;
7. presence and abundance of weed species;
8. landform monitoring, including slope angle, contour bank spacing, waterways, presence/absence of active rill/gully erosion; and
9. any failure of rehabilitation works and maintenance conducted or proposed to be conducted for these areas.

Full details of the revegetation monitoring program are provided in the *New Acland Coal Mine Rehabilitation Monitoring Program – April 2019* (SLR, 2019a).

12.3 Identification of Remediation Works

Remedial works may be required during the rehabilitation process, including the following actions.

- Soil remediation may be required prior to the seeding/planting of rehabilitation areas. This requirement will be based on the soil type, stripping depths applied, and if applicable, the residence time in storage;
- Failure to achieve the desired levels of vegetation cover and species diversity will require supplementary seeding and/or planting;
- Weed infestation will require treatment to an appropriate standard or as defined by legislation; and
- Erosion damage may require repair depending on the level of severity. The potential for erosion will be controlled by the establishment of a good ground cover (i.e. ≥50%) and through the correct design of water management structures.

13 References

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APPENDIX A

Current Mine

Soil Assessment Details and Description of Soil Mapping Units

Background

During previous investigations for NAC01 and NAC02, sampling and profile inspection points spread across the Project area to characterise all landform elements and geological units were undertaken. The surveys were designed to provide sufficient information on land resources to allow the determination of land suitability, soil erosion, rehabilitation potential and storm water runoff quality consistent with the methods set out by the following documents:

- Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland – Land Suitability Assessment Techniques (DME, 1995); and
- Shields and Williams (1991).

In addition, information regarding local production systems, land suitability and flooding was obtained from the Department of Natural Resources and Mines (DNRM) through direct communications and soil mapping data.

In summary, soil profile descriptions were consistent with the Australian Soil and Land Survey Field Handbook (McDonald et al, 1998), the Australian Soil Classification (Isbell, 1996) and Munsell Soil Colour Charts.

Methodology of Previous Assessments

The land resource information presented is based on two previous surveys. The first study was conducted in 1996 and involved 13 samples on MDL 244 over the areas currently overlayed by NAC01 and NAC02. The following study was conducted in 1999 as part of an Impact Assessment for a proposed coal mine and power station for Shell Coal Australia Ltd. The 1999 survey was carried out using a 1:1000 map of the area and a 1:1000 digitised photo mosaic (1998) of the area. The survey was carried out using the map and aerial photograph provided and marking investigation sites and soil boundaries according to surface features and vehicle odometer readings. The 1999 investigation involved an additional 96 holes and included detailed profiles and samples to determine soil boundaries and provided:

- Delineation and mapping of soil types present on the site;
- Broad descriptions of soil profiles;
- Data on the chemical and physical properties of soils for use in topsoil stripping and rehabilitation;
- A brief land contamination study; and

- A land suitability assessment of soils for dryland cropping and grazing

The 1999 survey contained over 750 samples that were tested for pH and electrical conductivity on a 1:5 (soil:water) basis. The soils were categorised into 11 soil groups. From these soil groups, samples were selected from a total of 35 profiles for analysis. Profiles were analysed to characterise their physical and chemical conditions with additional fertility environment analyses for surface samples. Analyses undertaken on all samples included:

- pH, electrical conductivity, chloride and sulphate;
- Exchangeable calcium, magnesium, potassium and sodium;
- Cation exchange capacity;
- Particle size analysis and RI dispersion index; and
- 15 bar moisture content.

Additional analyses on surface samples from the soil profiles included:

- Organic carbon;
- Nitrate and total nitrogen;
- Extractable and total phosphorous; and
- Copper, manganese and zinc.

Plant available water was assessed for 29 profiles as a guide to land suitability, in terms of moisture retention for cropping.

Soil Characteristics

The soils described in this section are those that occur within the NAC01 and NAC02 area. Topsoil was examined using soil and chemical properties including pH, electrical conductivity, phosphorus and exchangeable sodium percentage (ESP). Physical properties such as permeability and drainage characteristics were inferred from profile morphological characteristics such as concretions, depth to rock, observed root depth, colour and mottling.

Typical depths of primary and secondary topsoil were determined using the DME (1995) guideline, site data and experience with similar soil types used in rehabilitation by the Project.

Primary topsoil is the uppermost layer of soil used in site rehabilitation. It is salvaged from the surface horizons of areas to be disturbed, is relatively fertile and contains seeds and micro-organisms. Secondary topsoil (subsoil), if used is placed directly in contact with waste rock and may be obtained from subsurface soil horizons, including weathered rock

Soils on Upper and Midslope

Soils in mid and upper slope positions are either associated with basalt or are formed purely on sediments. Soils formed on or associated with basalt, range from: 'Shallow basaltic soils' on upper slopes and steeper basaltic outcrops; through 'Shallow and mid depth cracking clays on basalt' on less steep slopes (<6%) through to 'Red and black clays' which are deeper soils influenced by basalt from above but are formed on colluvium or on in-situ sediments.

Soils formed on sediments are primarily cracking clay soils. They are mainly comprised of closely associated and often intermixed areas of 'Reddish non cracking and lesser cracking clays on sediments' and 'Dark cracking clays on sediments'. These soil types were originally vegetated by brigalow and softwood scrubs with minor eucalypt vegetation but have been extensively cleared for farming (Ison Environmental Planners, 1999). The soil descriptions are as follows, and have been sourced from Ison Environmental Planners (1999).

Soils in Upslope and Midslope Positions associated with Basalt Shallow Basaltic Soils (clay loam and non-cracking clay, outcrop soils)

This soil type is present in association with elevated ridges and caps and basalt outcrops throughout the area. These soils have been partially cleared and are generally grazing lands. Limited pasture improvement has taken place in less steep areas.

A range of soil types are present ranging from silty clay loams to medium clays over basalt (which may contain substantial rock on steeper basalt slopes), to skeletal non- cracking soils. All soils are shallow with the skeletal cracking soils less than 10 cm deep on steep slopes up to 15%.

Natural vegetation tends to be mountain coolibah, wilga and softwood scrub remnants. Slope is generally in the order of 2 to 5%, but may be up to 15% on some rocky outcrop areas. Rock exposure may be up to 70% in some steeper outcrop areas. The soil surface is friable and appears to be non-cracking. The thin soil surface is immediately underlain by weak to friable silty clay loam to medium clay that is dark reddish brown to dark brown (5YR to 7.5YR3/2) in colour. Broken decomposed basalt is found increasing down the profile below 10 cm to 25 cm, depending on slope and the amount of basalt.

Salinity (EC and chloride) is generally low throughout the profile, and the soil reaction trend is generally neutral.

Sodicity (Exchangeable sodium percentage -ESP) is low throughout the profile. Calcium magnesium ratios are high down the profile and are considered favourable to the maintenance of good structure. The low ESP's and favourable Ca/Mg ratios are reflected in the low RI dispersion indices throughout the profile which indicates good stable structure (although sometimes reaching higher RI levels in the decomposed basalt under the soil proper). The clay content of the soil is moderate to high and the clay activity ratio indicates some activity, although no cracking was observed in the field.

The soil generally has good levels of organic carbon in the surface. Cation exchange capacity is good down the profile (although probably slightly overestimated) indicating a good ability to hold nutrients. The levels of extractable phosphorus and total phosphorus present are high. Nitrate nitrogen levels are high in the surface while the levels of total nitrogen present are also generally high, indicating good nitrogen reserves.

Sulphate levels are low to medium while levels of other major nutrients would be considered adequate. Levels of micronutrients are also adequate.

In the profiles analysed, plant available water capacity (PAWC) would be approximately 40 to 50 mm for a soil 30 cm deep over parent rock. In isolated areas where the soil is deeper, PA WC levels may reach around 90 mm.

Shallow and Mid Depth Cracking Clays on Basalt

This soil type occurs extensively on slightly elevated areas in association with and below the 'shallow basaltic soils'. These soils are mainly cleared and are either cropped or for forage production. Boundaries between these soils and the 'Red and black cracking clays (basaltic influenced soils on colluvium or in situ sediments)' should be regarded as indicative.

Natural vegetation is scattered mountain coolibah bloodwood and wilga with mid height grassland below, but much of the area has been cleared and cultivated. Slope is generally, approximately 2%, but extending up to 4% in some isolated areas. Occasional basalt floaters may be present on the surface in the darker soil types, however are generally minor in occurrence.

The soil surface is a light to medium clay in the more reddish soil types and heavy clay in the darker soil types. The soil is strongly cracking and self-mulching with the mulch (1 to 3 cm) being fine to medium in the redder soil types and becoming coarser and deeper in the darker soil types. Colour is dark reddish brown to black (5YR3/2 to 10YR2/1).

In areas where surface colour is darker, colour tends to be maintained down the profile and texture increases slightly. Where the soils are lighter (redder), colour lightens below 10 to 30 cm and texture becomes slightly heavier. Below 30 to 50 cm some hard calcium carbonate ($CaCO_3$) may be encountered. Soil depth is generally between 45 to 80 cm below which parent material is encountered. Parent material may be hard basalt, decomposed basalt, calcareous basaltic material or on some occasions basaltic clays. Site 54 is a darker heavier profile and shows decomposed basaltic material under 80 cm, which is deeper than average for this soil type.

Salinity is low in the soil surface and may increases slightly down the profile, still maintaining low levels at depth. The soil has a neutral to alkaline soil reaction trend. Sodicity is low in the surface and usually remains low with depth. Calcium to magnesium ratios are high throughout the profile (they may decline in the underlying basalt) and are considered favourable to the maintenance of good structure.

The generally low ESP's and favourable Ca/Mg ratios are reflected in the low RI dispersion indices indicate good, stable structure throughout the profile. In some cases there may be slight elevation in some surface soils and the dispersion indices may also be elevated in underlying basaltic materials. The clay content of the soil is high and the clay activity ratio indicates the presence of active clays. The soil generally has moderate levels of organic carbon in the surface. Although organic carbon may be lower in some of the more marginal cropped sites, possibly leading to the higher levels of dispersion.

Cation exchange capacity is medium-high down the profile indicating a good ability to hold nutrients. The levels of extractable phosphorus and total phosphorus are high. Nitrate nitrogen levels are moderate to high, while the levels of total nitrogen are only moderate, thus indicating moderate nitrogen reserves with some nutrient run-down from cropping. Levels of major nutrients are adequate, except for sulphate sulphur levels which are low. Levels of micronutrients also appear adequate with the exception of zinc which may be marginal in some areas.

In the profiles analysed, PAWC would be considered to be 80 to 120 mm for a soil 50 to 80 cm deep over decomposed basalt parent rock. In areas where basaltic clays are present, PAWC levels may be higher.

Red and Black Clays (basaltic influenced soils on colluvium or in situ sediments)

This soil type occurs in association with the basaltic soils and occurs below those soils, which are present on slightly elevated areas. The soils have been cleared and are either cropped or utilised for forage production. In most instances the soil type is only distinguishable from the 'Shallow and mid depth cracking clays on basalt' by more intense survey.

The natural vegetation was probably occasional mountain coolibah and poplar box woodlands. These soils have been extensively cleared for agriculture. Slope is generally low between 1 to 3% and occasionally increasing to over 8%. Occasional basalt floaters may exist on the soil surface and occasional silcrete may also be present. But, in general, deeper soils such as these have only minor stone occurrence, being predominantly confined to the steeper areas on and below the basalt outcrops.

The soil surface tends to be a heavy clay which is strongly cracking and self-mulching. The surface colour is dark reddish brown to black (5YR3/2 to 10YR2/1). The surface 2 to 5 cm has a strong generally medium self-mulch. Below 5 cm, the soil is firm to the base of the plough zone, below which it is a hard, coarse blocky structure. Colour generally lightens below 20 to 50 cm and texture increases slightly.

Some slight hard CaC03 may exist throughout the profile and occasionally high concentrations of soft CaC03 may exist below 30 to 60 cm where the colluvial material is from basaltic origin. Parent colluvium or decomposed sediments may be encountered anywhere below 50 to 190 cm and where colluvium is encountered at relatively shallow depths, sediments are often encountered at deeper depths below this. Plant rooting depths are generally considered to be deep.

Salinity levels are variable at depth but are low in the surface soil. In some profiles, salinity increases down the profile, in some instances reaching high levels which may restrict crop rooting depth by 80 to 90 cm. Other profiles still have low salinity levels at depth. The soil generally has an alkaline soil reaction trend, however it is occasionally neutral.

The pH of the profiles analysed tend to be alkaline in the surface and become increasingly alkaline with depth. Exchangeable sodium percentage is low in the surface becomes sodic with depth (generally below 50 to 90 cm). The subsoil clays although sodic are not considered highly sodic (>15%). Calcium to magnesium ratios are reasonable in the soil surface and decline with depth to levels which are unfavourable to the maintenance of structure below 30 to 60 cm. The low surface ESP's and favourable Ca/Mg ratios are reflected in the low RI dispersion indices, while dispersion indices tend to increase to elevated levels below 30 to 60 cm. The clay content of the soil is high and the clay activity ratio indicates the presence of clays with some activity.

The soil generally has moderate levels of organic carbon in the surface, indicative of cropped sites. Cation exchange capacity is high down the profile indicating a good ability to hold nutrients. The levels of extractable phosphorus and total phosphorus are moderate to high. Nitrate nitrogen levels are generally moderate (sometimes low) in the surface while the levels of total nitrogen present are only medium indicating moderate nitrogen reserves and some nutrient run-down from cropping. Sulphate levels are relatively low in the surface while levels of other major nutrients would be considered adequate. Levels of micronutrients also appear adequate with the exception of zinc which may be marginal in some areas

In the profiles analysed, PAWC would be considered to be around 170-180 mm for an analysed rooting depth of 120 cm which appears to be available in most cases (or around 150 mm where salinity restricts rooting depth to around 90 cm).

Soils in Upslope and Midslope Positions Formed on Sediments Reddish Non Cracking and Lesser Cracking Clays on Sediments

This soil type occurs in close association with and on similar materials to the 'Dark cracking clays on sediments'. The soils have mainly been cleared and are usually cropped or to a lesser degree utilised for forage production. These soils were originally poplar box and softwood scrub with lesser brigalow vegetation.

Slopes are generally low, 2 to 3%, but occasionally increase above 5%. No large stones are present in these soils. The soil surface tends to be a light clay (or occasionally a clay loam) which is normally non cracking or very slightly cracking. Colour is dusky red to dark reddish brown (2.5YR3/3 to 5YR3/4). Significant surface ironstone is present and the surface forms a slight crust with occasional surface structural problems indicated. Colour may darken slightly down the profile before lightening below 20 to 50 cm to dark reddish brown to yellowish red (5YR3/4 to 4/6), while texture generally increases down the profile to a heavy clay by around 50 cm.

Some soft $CaCO_3$ may be present below 30 to 60 cm. Parent sediments or less commonly deeper colluvium may be encountered below 70 to 130 cm and ironstone or limestone bands may be encountered in the parent material. Site 16, considered to be a deeper profile, shows parent material under 120 cm.

Salinity is generally low in the soil surface and increases to varying degrees down the profile, but does not reach high levels which would be considered to restrict crop rooting depth. The soil has an alkaline soil reaction trend.

Structural characteristics are variable and exchangeable sodium percentage is low in the surface and may increase only slightly with depth to levels which are still non- sodic in the parent material, or may increase to levels which are considered to be highly sodic (ESP> 15%) below 60 cm.

Calcium to magnesium ratios are good for the maintenance of soil structure in the surface and may be maintained at good levels with depth or may decline to unfavourable levels below 60 to 80 cm. The RI dispersion indices in the surface layers vary between 0.30 and 0.55 and this indicates that in some profiles slight surface structural problems are evident. Depending on the sodicity trend, dispersion may remain relatively low down the profile, increasing only slightly at depth or may rise to relatively high levels with depth. The clay content of the soil is high and the clay activity ratio indicates the presence of clays with low activity.

The soil generally has slightly low levels of organic carbon in the surface, indicative of cropped sites. Cation exchange capacity is moderate throughout the profile indicating a reasonable ability to hold nutrients. The levels of extractable phosphorus are moderate to high and the levels of total phosphorus are relatively high. Nitrate nitrogen levels are generally moderate (sometimes low) in the surface while the levels of total nitrogen present are slightly less than medium indicating moderate nitrogen reserves and some nutrient run-down from cropping. Sulphate levels are relatively low in the surface (sometimes higher at depth) while levels of other major nutrients would be considered adequate. Levels of micronutrients appear adequate.

In the profiles analysed, PAWC is approximately 130-150 mm for an estimated rooting depth of 100 to 110 cm.

Dark Cracking Clays on Sediments (upper slopes)

This soil type occurs in close association with, and on similar materials to the 'Reddish non cracking and lesser cracking clays on sediments'. These soils have mainly been cleared and are usually cropped or to a lesser degree utilised for forage production. This soil type was originally vegetated with brigalow and softwood scrub with lesser poplar box emergents. The two soil types are closely associated and often form a mosaic, however for the purposes of this study an attempt has been made to map them separately.

Slopes are generally 2 to 3% and occasionally increasing to above 5%. No large stones are present in these soils apart from a small steep area where metamorphosed siltstone is present.

The soil surface tends to be a medium clay which is cracking and has a weak medium self-mulch. Colour is dark brown to very dark grey (7.5YR3/2 to 10YR3/1). Significant surface ironstone is present and some silcrete. The soil becomes very tight and hard below the plough zone and texture generally increases to a heavy clay. Colour is generally maintained down the profile before lightening and becoming slightly mottled below 20 to 40 cm. Subsoil colours range widely from dark reddish brown to yellowish brown (5YR3/3 to 10YRS/4). Soft $CaCO_3$ may be present below 30 to 60 cm, decreasing where parent material is encountered generally by 90 to 120 cm. Salinity levels are variable at depth but are low in the soil surface. In some soil profiles salinity increases with depth, reaching high levels, which could be considered to restrict crop rooting depth by 80 to 90 cm. Some soil profiles still have low salinity levels at depth. The soil normally has an alkaline reaction trend, however, occasionally acidic sediments may be encountered at depth.

The pH of the profiles analysed tend to be alkaline in the surface and become increasingly alkaline with depth, although in one instance acidic parent sediments are encountered at depth.

Structural characteristics are variable. Sodicity levels are variable with some non-sodic soils, others that are sodic in the parent material, or others that are highly sodic below 60 cm. Calcium to magnesium ratios are favourable for the maintenance of soil structure in the surface and may be maintained at good levels with depth or may decline to unfavourable levels below 50 to 80 cm.

The R1 dispersion indices in the surface layers vary between 0.35 and 0.54 and this indicates that in some profiles slight surface structural problems are evident. Dispersion generally increases down the profile rising to relatively high levels with depth. The clay content of the soil is high and the clay activity ratio indicates the presence of clays with low to moderate activity.

The soil has low to moderate levels of organic carbon in the surface, common of cropped sites. Cation exchange capacity is moderate to high in the surface and down the profile indicating a good ability to hold nutrients. The levels of extractable phosphorus are moderate to high and the levels of total phosphorus are relatively high. Nitrate nitrogen levels are moderate to high in the surface while the levels of total nitrogen present are medium to high indicating reasonable nitrogen reserves. Sulphate levels are relatively low in the surface (often higher at depth) while levels of other major nutrients would be considered adequate. Levels of micronutrients also appear adequate.

In the profiles analysed, PAWC is approximately 130 mm in some areas where crop rooting depth is restricted to 90 cm. However, PAWC is more common approximately 160 mm where crop rooting depth is around 120 cm.

Soils on Mid and Lower Slope

Soils in mid and lower slope positions are formed mainly on colluvium and to a lesser degree on alluvium. In the south eastern portion and also in the northern area, two relatively small areas of 'Dark cracking clays on in situ sediments or colluvium' are present below the other mixed cracking and non-cracking clays on sediments which previously supported softwood scrub. An area of 'Tight shallow surfaced duplex soils on deep colluvial material' in the south east also occurs below the scrub soils. In the northwest an area of 'Deep heavy clays on clay colluvium' occurs, while small areas of 'Alluvial clays in drainage ways' occur in drainage lines that drain or cross the site (Ison Environmental Planners, 1999). The soil types mapped follow.

Dark Cracking Clays on In Situ Sediments or Colluvium (lower slopes)

This soil type occurs at lower slope angles below the 'Dark cracking clays on sediments' upper slopes' in relatively confined areas in the south east and north of the study area. The soils have mainly been cleared and are cropped. The original vegetation was brigalow. Slopes are generally less than 2%. No large stones are present in these soils apart from minor small ironstone and silcrete pebbles on the surface.

The soil surface tends to be a medium to heavy clay which is cracking and has a well-developed medium to coarse self-mulch. Colour is very dark grey to very dark greyish brown (10YR3/l to 3/2). Slight surface ironstone is present and some silcrete. Colour is maintained down the profile and texture increases slightly with some soft CaCO3 being present below 20 to 50 cm. Below 50 to 60 cm some colour lightening and slight mottling may occur with colour becoming reddish brown to brown (5YR4/4 to 7.5YR5/4) by 90 to 100 cm. Below 100 to 130 cm parent colluvial clays are present.

Salinity is relatively low in the soil surface and increases down the profile, sometimes remaining relatively low down the profile but occasionally reaching high levels, which could be considered to restrict crop rooting depth below 120 to 150 cm. The soil has an alkaline reaction trend.

The pH of the profiles analysed tend to be alkaline in the surface and become increasingly alkaline with depth. Exchangeable sodium percentage is low in the surface and with depth soils becoming sodic by 50 cm and highly sodic by 80 to 110 cm.

Calcium to magnesium ratios are generally favourable for the maintenance of soil structure in the surface and may be maintained at good levels with depth to below 30 cm or may decline more rapidly. The dispersion indices in the surface layers vary between 0.35 and 0.56 and this indicates that in some profiles slight surface structural problems are evident. Dispersion generally increases down the profile rising to high to extreme levels at depth (below 60 cm). The clay content of the soil is high and the clay activity ratio indicates the presence of clays with low to moderate activity.

The soil has low to moderate levels of organic carbon in the surface, common of cropped sites. Cation exchange capacity is moderate to high in the surface and down the profile indicating a good ability to hold nutrients. The levels of extractable phosphorus are moderate to high and the levels of total phosphorus are medium. Nitrate nitrogen levels are moderate to high in the surface while the levels of total nitrogen present are relatively low to medium indicating some nutrient run-down. Sulphate levels are relatively low in the surface (higher at depth) while levels of other major nutrients would be considered adequate. Levels of micronutrients also appear adequate, except zinc, which may be deficient at some sites.

In the profiles analysed, PAWC is often restricted at depth by high sodicity (rather than chloride) and would be around 130 to 150mm at a rooting depth of 100 to 110 mm or occasionally reaching 160 mm where sodicity is lower.

Tight Shallow Surfaced Duplex Soils on Deep Colluvial Material

This soil type occurs in only one location in the south east of the investigation area. The soils have been largely cleared and some areas out of drainage lines are cropped. The remnant vegetation that exists is predominantly poplar box. Slopes are low and generally between 1 to 2%.

The soil surface tends to be hardset loam (massive where not cultivated), fine sandy and surface structural problems are indicated. Some silcrete and ironstone gravel is present. The surface is very dark greyish brown (10YR3/2) in colour. There is an abrupt boundary to the B horizon at around 10 cm and this is a tight medium to heavy clay which is very dark grey to very dark greyish brown (10YR3/1 to 3/2) in colour and becomes mottled below 20 to 30 cm. Hard and soft $CaCO_3$ may be present below 40 to 50 cm down the profile and below 50 to 60 cm colour lightens to yellowish brown (10YR5/6). The material then becomes light to heavy clay parent colluvium some 20 to 30 cm after the colour lightening. The parent colluvium contains some ironstone and hard limestone material.

Salinity (EC and chloride) is relatively low in the soil surface and increases down the profile, sometimes remaining relatively low down the profile but can reach high levels which may restrict crop rooting depth below 60 cm. The pH of the profiles analysed tend to be acidic or neutral in the surface and become increasingly alkaline with depth. Exchangeable sodium percentage is low to slightly elevated in the surface and sodic in the upper B horizon and becoming highly sodic below 50 to 80 cm. Calcium to magnesium ratios are favourable for the maintenance of soil structure in the immediate surface and decline quite rapidly under the surface.

The dispersion indices in the surface layers vary between 0.59 and 0.66 and this indicates poor surface structural aspects. In addition, silt contents are 15 to 17% and quite severe crusting would be anticipated (as observed in the field). Dispersion generally rises rapidly down the profile and in some areas is extreme in the B horizon clays and colluvial material below.

The soil has low levels of organic carbon in the surface, indicative of nm-down of organic content and structure. Cation exchange capacity is only moderate in the surface indicating a limited ability to hold applied nutrients. The levels of extractable phosphorus and total phosphorus are moderate. Nitrate nitrogen levels are moderate to high in the surface while the levels of total nitrogen present are low and indicate low reserves and nutrient run-down. Sulphate levels are relatively low in the surface (higher at depth) while levels of other major nutrients would be considered adequate with the exception of magnesium which may be low in the immediate surface in some cases. Levels of micronutrients also appear adequate with the exception of zinc which appears to be deficient.

In the profiles analysed, PAWC is approximately 130 mm for a 90 cm rooting depth. However, it is considered that this does not account for poor surface structural characteristics, low moisture infiltration and impermeable subsoil clays. For a 60 cm rooting depth which is considered more likely when these soils are cropped in conjunction with the clay soils the PAWC would be in the order of 100 cm.

Alluvial Clays in Drainage Ways

This soil type occurs in three positions in drainage ways that drain the area. The majority of the area has been semi cleared, and remnant vegetation is poplar box, wilga, myall and belah. Minor areas are cropped. Slopes are generally less than 1 %. No stones are present in these soils.

The soil surface tends to be a light to medium clay (lighter from alluvial deposition), becoming heavy soon under the surface. The surface has a weak medium self-mulch. Colour is dark brown to very dark grey (7.5 YR3.2 to 10YR3/1) to around 50 cm, below which some colour lightening occurs and soft $CaCO_3$ is present. Below 80 to 120 cm further lightening occurs to brown to yellowish brown (7.5YR4/4 to 10YR5/6) and some gypsum may be present at this depth in some profiles. Below 100 to 150 cm parent alluvial clays are present.

Salinity (EC and chloride) is relatively low in the soil surface and increases down the profile, sometimes rising to only moderate levels but sometimes reaching high levels which could be considered to restrict crop rooting depth below 50 to 60 cm. The soil has an alkaline reaction trend. The pH of the profiles analysed tend to be alkaline in the surface and more alkaline at depth.

Exchangeable sodium percentage is very slightly elevated in the surface becoming sodic below 20 to 30 cm and highly sodic by 60 to 80 cm. Calcium to magnesium ratios are favourable for the maintenance of soil structure in the immediate surface and decline down the profile.

The dispersion indices in the surface layers vary between 0.49 and 0.62 and this indicates that in some profiles surface structural problems are evident. Dispersion increases at depth, with some of the material below 60 to 120 cm having high to extreme dispersion. The clay content of the soil is high and the clay activity ratio indicates the presence of clays with moderate activity. The soil has low to high levels of organic carbon in the surface, (low in the cropped site where some erosion appears to have taken place). Cation exchange capacity is moderate in the surface and high immediately below, indicating a good ability to hold nutrients.

The levels of extractable phosphorus are moderate to high and the levels of total phosphorus are moderate. Nitrate nitrogen levels are low to moderate in the surface, while the levels of total nitrogen present are low to high (low where erosion has taken place in the cropped site). Sulphate levels are relatively low in the surface (higher at depth) while levels of other major nutrients would be considered adequate. Levels of micronutrients are adequate, except zinc, which appears to be deficient in some sites.

In the profiles analysed, PAWC varies depending on the presence or absence of salinity at depth. PAWC is approximately 120 to 140 mm.

APPENDIX B

Current Mine

Limitations for Dryland Cropping

Land Suitability Classes for Dryland Cropping – Pre-Mining

Soil Group	Limitations	Suitability
Soils in upslope and mid slope associated with basalt		
Shallow basaltic soils (clay loam and non-cracking clay, outcrop soils)	m5, n2, r2-5, e2-5	5
Shallow and mid depth cracking clays on basalt	m3-4, n2, p2, k2, r1-2, e3	3-4
Red and black clays (basaltic influenced soils on colluvium or in situ sediments)	n2, p2, k2, r1-2, e3-4	3-4
Soils in upslope and mid slope formed on sediments		
Reddish non-cracking and lesser cracking clays on sediments	m2, n2-3, p2-3, k2, e3-4	3-4
Dark cracking clays on sediments (upper slopes)	m1-2, n2, p2, k2, sa1-2, e3-4	3-4
Soils in mid and lower slope		
Dark cracking clays on in situ sediments or colluvium (lower slopes)	m1-2, n2, p2, k2, w2, e3	3
Tight shallow surfaced duplex soils on deep colluvial material	m3, n3, p3-4, k3, w3, e3, f1-5	3, some 5
Alluvial clays in drainage ways	m2, n2, p2, k2, sa1-2, w2, e2, f4-5	5, some 4

Limitations for Dryland Cropping

This classification evaluates the broad acre potential for growing a range of dry land crops normally grown in the area. Ten limitations were identified that significantly affect rainfed cropping in the Project area as outlined below:

- water availability (m);
- nutrient deficiency (n);
- soil physical factors (p);
- soil workability (k);
- salinity (s);
- rockiness (r);

- microrelief (g-gilgai);
- wetness (w);
- water erosion (e); and
- flooding (f).

The major limitations to cropping use are water availability, slope and the potential for erosion.

Water Availability (m)

Plant available water capacity (PAWC) cut off levels were obtained from the DME (1995) Guideline and Vandersee and Mullins' (1977). The PAWC cut off levels assigned are as follows:

- M1-> 150 mm;
- m2 -125-150 mm;
- m3 -90-125 mm;
- m4 --70-90 mm; and
- m5 -< 70 mm.

Vandersee and Mullins (1977) analyses crop failures at certain levels of PAWC and recommends a PAWC level of 75mm as the cut off for land suitable for cropping (i.e. the cut off between Class 3 and 4). The economics of cropping have declined over the past twenty years, with much of the more marginal land which was developed in the 1970's having reverted to pasture. It is considered by the author of this assessment that the cut off level of 75 mm is not appropriate and a level of 90 mm may be more suitable for sustainable agricultural practices.

The 'Shallow basaltic soils' are considered to generally have an extreme limitation (m5) apart from isolated deeper pockets, while the 'Shallow and mid depth cracking clays on basalt' generally have a moderate (m3) moisture limitation, with some shallower areas within the general soil type having a severe (m4) limitation. As such, the soil type is considered to be a marginal soil type for long term cropping. The other basaltic soil 'Red and black clays (basaltic influenced soils on colluvium or in situ sediments' generally has good moisture availability and has a negligible (ml) limitation.

Nutrient Deficiency (n)

The DME (1995) guideline have largely been used in the assessment (apart from pH characteristics of the subsoil). In addition, some soils appear to suffer from nutrient rundown over time with lower than desirable levels of organic carbon and total nitrogen and these soils are given a minor to moderate (n2-3) limitation (depending on the severity of the decline) while soils which may have marginal sulphate or zinc are given a minor (n2) limitation.

Soil Physical Factors (p)

The DME (1995) guideline have been largely used in the assessment. The cracking clay soils are generally given a minor (p2) limitation while the 'Reddish non- cracking and lesser cracking clays on sediments' have some crusting tendencies under cultivation and are given a minor to moderate (p2- 3) limitation.

The 'Shallow basaltic soils (clay loam and non-cracking clay outcrop soils)' generally have a friable surface and are given a negligible limitation. 'Tight shallow surfaced duplex soils on deep colluvial material' have relatively severe surface structural problems for continued cropping and are assigned a moderate to severe (p3-4) limitation.

Soil Workability (k)

The DME (1995) guideline have been largely used in the assessment. The 'Shallow basaltic soils (clay loam and non-cracking clay outcrop soils)' are considered to have a negligible limitation (kl). All clay soils are cracking to a degree and are given a minor (k2) limitation. The hard-set duplex 'Tight shallow surfaced duplex soils on deep colluvial material' would have a narrower moisture range for working and have a moderate limitation (k3).

Salinity (s)

The DME (1995) guideline are largely used, however, they do not take into account the potential for dryland salting to occur with increased leaching through fallowing for cropping. The 'Dark cracking clays on sediments (upper slopes)' and the 'Alluvial clays in drainage ways' all have some incidence of increased salinity in the root zone in some profiles and have a negligible to minor (sal-2) limitation.

Rockiness (r)

Rockiness refers to rock outcrop and coarse fragments within the plough zone that impede cultivation and damage machinery, and the only soils which this occurs on are the soils associated with basalt. For the 'Shallow basaltic soils (clay loam and non-cracking clay outcrop soils)' rock content is variable and the limitation to cultivation ranges from minor to extreme (r2-5.). The other two soils associated with basalt have a negligible to minor (rl-2) limitation depending on how close they are to basalt outcrop material.

Microrelief (g)

This limitation covers the effect microrelief has on uneven cultivation and impeding trafficability of machinery. Only slight linear gilgai are present and all soils have a negligible limitation.

Wetness (w)

This limitation covers the adverse effects of excess water on crop production through reduction in plant growth and yield and restrictions on the use of machinery following rain. The heavier clay soils and soils in low lying areas 'Dark cracking clays on in situ sediments or colluvium (lower slopes)', and' Alluvial clays in drainage ways' are all assigned a minor (w2) limitation. The rigid duplex soil 'Tight shallow surfaced duplex soils on deep colluvial material' reach high sodicity levels within 60 cm of the surface and are considered to have impeded drainage. They are assigned a moderate (w3) limitation. All other soils have a negligible limitation.

Water Erosion (e)

This limitation covers accelerated soil loss which results in declining productivity, increasing difficulty to cultivate and eventually an inability to produce a crop in most years. DME guidelines are generally used but have been modified on advice from the DNRM. On the

Darling Downs, the clay soils formed on sediments are considered to be croppable up to 5% slope, while the basaltic soils are considered to be croppable up to 8% slope.

No soils have a negligible erosion limitation. The' Alluvial clays in drainage ways' have a minor limitation (e2) based on slope only. The 'Shallow basaltic soils' have a minor to extreme (e2-5) limitation because of the large variation in slope.

A moderate limitation (e3) is assigned to the soils with lower slope, being the 'Shallow and mid depth cracking clays on basalt', 'Dark cracking clays on in situ sediments or colluvium' and 'Tight shallow surfaced duplex soils on deep colluvial material'.

The other soils which are slightly steeper in some areas 'Red and black clays', Reddish non- cracking and lesser cracking clays on sediments', and 'Dark cracking clays on sediments' generally have a moderate limitation but in steeper areas where slopes rise above those discussed above, have a severe limitation (e3-.4).

Flooding (f)

This limitation accounts for periodic inundation with damage caused by fast flowing water or submersion. This limitation is negligible as it relies heavily on local knowledge and severe to extreme (f4-5) limitation has been imposed on the' Alluvial clays in drainage ways' depending on their proximity to drainage ways. A negligible to extreme (f4-5) limitation is assigned to the 'Tight shallow surfaced duplex soils on deep colluvial material' depending on their proximity to drainage lines.

APPENDIX C

Current Mine

Limitations for Grazing

Land Suitability Classes for Grazing – Pre-Mining

Soil Group	Limitations	Suitability
Soils in upslope and mid slope associated with basalt		
Shallow basaltic soils (clay loam and non-cracking clay, outcrop soils)	m4-5, r1-5, e2-3	4-5
Shallow and mid depth cracking clays on basalt	m2-3, n2, p2, e1-2	2-3
Red and black clays (basaltic influenced soils on colluvium or in situ sediments)	n2, p2, e1-3	2-3
Soils in upslope and mid slope formed on sediments		
Reddish non-cracking and lesser cracking clays on sediments	n2, p2, e1-3	2-3
Dark cracking clays on sediments (upper slopes)	n2, p2, e1-3	2-3
Soils in mid and lower slope positions		
Dark cracking clays on in situ sediments or colluvium (lower slopes)	n2, p2	2
Tight shallow surfaced duplex soils on deep colluvial material	m2, n3, p2-3, w2, e2-4, f1-2	3-4
Alluvial clays in drainage ways	n2, p2, w2, e1-4, f1-2	2, some 4

Limitations for Beef Cattle Grazing

This classification evaluates the beef cattle grazing potential on improved pastures. Eight limitations to grazing improved pasture were considered in relation to the lands of the mining leases. These limitations are the same as those for rainfed cropping except for the removal of soil workability (k) and microrelief (g-gilgai) (Shields and Williams, 1991).

Water Availability (m)

Pasture production occurs in a shallower root zone than cropping systems and 60 cm of rooting depth in clay soils is considered to be adequate for pastures to achieve maximum production (Shields and Williams, 1991).

The better and deeper clay cropping soils have the highest PAWC' s and have a negligible limitation. These are the 'Red and black clays (basaltic influenced soils on colluvium or in situ sediments)', 'Reddish non-cracking and lesser cracking clays on sediments', 'Dark cracking clays on sediments (upper slopes)', 'Dark cracking clays on in situ sediments or colluvium (lower slopes)' and the 'Alluvial clays in drainage ways'.

A minor limitation (m2) is assigned to the 'Deep heavy clays on clay colluvium' and the 'Tight shallow surfaced duplex soils on deep colluvial material'. The 'Cracking clays with linear gilgai supporting poplar box and scrub understorey species' also generally have a minor (m2) limitation, but this may be moderate (m3) where the rooting depth is restricted by salinity.

The 'Shallow and mid depth cracking clays on basalt also have a minor to moderate (m2-3) limitation depending on the depth to parent material.

The shallow basaltic soils (clay loam and non-cracking clay outcrop soils)' have a severe to extreme (m4-5) limitation, depending on the depth to parent basalt.

Nutrient Deficiency (n)

The DME (1995) guideline have been modified in the assessment. Some soils appear to suffer from nutrient run-down over time with lower than desirable levels of organic carbon and total nitrogen and these soils are given a minor to moderate (n2-3) limitation depending on the severity of the decline, while soils which may have marginal sulphate or zinc are given a minor (n2) limitation. Soil Physical Factors

Physical factors limit pasture establishment and spread. They are typically related to size of surface aggregates, hard setting or cracking. Small seeded species such as buffel and Rhodes grass are difficult to establish on cracking clays as the seeds are lost down large airspaces or rapidly dry out after germination in the porous soil. Spread of most species is restricted on hard setting surface soils such as sandy loam to clay loam textures. Larger seeded species such as sorghum and bambatsi are more suited to the clay surface textures (Lambert and Graham, 1996).

The DME (1995) guideline have been largely used in the assessment. The 'Shallow basaltic soils (clay loam and non-cracking clay outcrop soils)' are given a negligible limitation. All other soils are given a minor limitation (p2) with the exception of the 'Tight shallow surfaced duplex soils on deep colluvial material' where structural problems appear to be quite severe (p2-3).

Salinity (sa)

The DME (1995) guideline are largely used, however, effective rootzones for pastures are generally considered to be shallower than for crops and so milder limitations exist. The assessment is made on a 60 cm rootzone, resulting in all soils having a negligible limitation.

Rockiness (r)

Rockiness refers to rock outcrop and coarse fragments that may impede cultivation. Cultivation is occasionally required for pasture improvement and the same limitations apply as for cropping. The 'Shallow basaltic soils (clay loam and non-cracking clay outcrop soils)' have variable rock content and the limitation ranges from negligible to extreme (rl-5) where areas of rock outcrop may occur. All other soils are considered to have a negligible limitation.

Wetness (w)

This limitation covers the adverse effects of excess water on pasture production through reduced persistence of a range of introduced species and restrictions on use of machinery following rain. The 'Alluvial clays in drainage ways' are given a minor limitation (w2) as are the rigid soils with strongly sodic subsoils ('Tight shallow surfaced duplex soils on deep colluvial material').

Water Erosion (e)

This limitation covers accelerated soil loss which results in declining productivity. Grazing generally increases the potential for soil loss during rainfall, compared to land with little disturbance. Clearing and increased grazing pressure can reduce cover. Occasional cultivation for preparation for seeding or renovation results in temporary exposure. Erosion will result in declining productivity.

Limitations are similar to the cropping limitations but are less severe and DME guidelines are generally used. The clay soils with low slope ('Dark cracking clays on in situ sediments or colluvium') are considered to have a negligible limitation.

The 'Shallow and mid depth cracking clays on basalt' have a negligible to minor (el-2) limitation depending on slope, while the 'Red and black clays (basaltic influenced soils on colluvium or in situ sediments)', 'Reddish non- cracking and lesser cracking clays on sediments' and 'Dark cracking clays on sediments (upper slopes)' have a negligible to moderate (el-3) limitation.

The 'Shallow basaltic soils (clay loam and non-cracking clay, outcrop soils)' have a minor to moderate (e2-3) limitation.

The 'Tight shallow surfaced duplex soils on deep colluvial material' generally have a minor limitation (e2) but within drainage lines that traverse the soil is given a severe limitation (e4). The 'Alluvial clays in drainage ways' have either a negligible or severe limitation (el-4) depending on their proximity to drainage lines and the risk or erosion with soil disturbance.

This limitation covers the adverse effects of excess water on pasture production through reduced persistence of a range of introduced species and restrictions on use of machinery following rain. The 'Alluvial clays in drainage ways' are given a minor limitation (w2) as are the rigid soils with strongly sodic subsoils ('Tight shallow surfaced duplex soils on deep colluvial material').

Flooding (f)

This limitation accounts for periodic inundation with damage caused by fast flowing water or submersion. The limitation is largely ignored as it relies heavily on local knowledge and only a minor limitation has been imposed in and close to drainage channels where they are present on the 'Tight shallow surfaced duplex soils on deep colluvial material' and 'Alluvial clays in drainage ways'.

APPENDIX D

Grazing Trial Program

The grazing trial included slope areas and involved a comparison process with an analogue site. The grazing trial program was managed by the New Hope Group subsidiary APC and included a formal study and report by a professional third party agricultural consultancy and local university. The grazing trial expanded to include the progressively rehabilitated areas designated for grazing as the mine progressed.

NAC believes the grazing trial is a critical assessment tool for demonstrating long term success of its grazing based rehabilitation for future mine closure and mining lease surrender requirements. From an operational perspective, NAC will use the grazing trial:

- To assess the success of the current rehabilitated area in relation to the performance of cattle growth (beef production);
- To evaluate current rehabilitation practices from a final land use perspective; and
- As required, to develop new rehabilitation strategies to improve rehabilitation and long- term grazing performance.

Longer term, the APC will also use this information to develop appropriate land management plans for NAC's former mined land at the site. The grazing trial has provided clarity and confidence in NACs rehabilitation processes and demonstrates with full scientific rigor that proposed post landforms will be able to support grazing (beef production) in a long term sustainable manner.

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