# Revegetation Plan – Millmerran Power Project

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# 1 INTRODUCTION

## 1.1 Background

The Millmerran Power Project is a joint venture operating the Millmerran Power Station, that is primarily overseen by Intergen Australia and Commodore Coal Mine (operated by Downer Group). The mine is an open pit mining operation based within Mining Lease (ML) 50151 and operates with Environmental Authority (EA) EPML00841513. The project is located near Millmerran, Queensland approximately 215 km west of Brisbane.

The Queensland Government recently implemented a Mined Land Rehabilitation Policy that requires all mining activity EA holders to develop and submit a progressive rehabilitation and closure plan (PRC Plan).

The project was issued with a notice to amend the PRC Plan for the Millmerran Power Project submitted on 1 June 2021. The amendment is currently being completed.

The main purposes of the PRC Plan are to:

- Ensure the holder of an EA plans a schedule of activities for the land to maximise its progressive rehabilitation and attain stable conditions; and
- Specify the conditions of the rehabilitated land before EA and ML obligations may be surrendered.

A PRC Plan consists of two parts:

1. Rehabilitation planning; and
2. PRC Plan schedule.

As part of the rehabilitation planning component, a revegetation plan is required. The revegetation plan must propose activities that will establish self-sustaining vegetation communities appropriate for the intended post-mining land uses (PMLU). Therefore, revegetation should not only establish a ground cover, but in some domains, also establish associated fauna habitat and other ecological services.

## 1.2 Regulatory Obligations

Organisations carrying out mining activities in Queensland are legally obligated to rehabilitate the land disturbed by their activities (Department of Environment and Science, 2019). The *Environmental Protection Act 1994* requires all areas disturbed within the relevant mining tenure to be rehabilitated to a PMLU. The land disturbed must also be rehabilitated to a safe, stable and non-polluting landform, with self-sustaining vegetation cover or managed as a non-use management area (NUMA).

Land is in a stable condition when:

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

Furthermore, the Environmental Protection Act requires that each PMLU:

a) Is viable, having regard to the use of land in the surrounding region, and
b) Satisfies at least one of the following –

i. The use is consistent with how the land was used before mining activity was carried out on the land.
ii. The use is consistent with a development approval relating to the land.
iii. The use is consistent with a use of the land, other than a use that is mining, permitted under the State or Commonwealth Act, including, for example, a planning instrument under the Planning Act.
iv. The use will deliver, or is aimed at delivering, a beneficial environmental outcome.

The disturbance areas are deemed to be successfully rehabilitated when completion criteria for each rehabilitation goal have been met.

### 1.3 Scope

Landloch was engaged by the Millmerran Operating Company to assist in the development of a revegetation management plan for inclusion in the PRC Plan.

The aim of the revegetation plan is to provide sufficient technical specifications to achieve a safe, stable and non-polluting landform, with a suitable self-sustaining vegetation cover in accordance with the rehabilitation requirements set out in the EA and in consideration of the approved PMLU.

Specifically, the revegetation plan objectives include:

- Developing soil properties that support and will continue to support the desired final land uses.
- Establishing self-sustaining pasture and wildlife corridors.
- Establishing land with comparable management requirements to similarly used non-mining land.

The revegetation plan must also conform with the requirements outlined in the *Guideline – Progressive rehabilitation and closure plans* (Department of Environment and Science, 2019).

## 2 MILLMERRAN POWER PROJECT

### 2.1 General Description

The mine is located within the Condamine River catchment in the Darling Downs region. The surrounding land consists of flat ground or gently undulating landforms with low relief, and is predominantly used for grazing.

### 2.2 Vegetation Communities

Pre-mining vegetation communities on the mine site were consistent with those found on the land resource areas (LRA')s identified in Harris et al 1999. These included:

- LRA 2d: Poplar box and Qld blue gum woodland with belah and wilga; and
- LRA 6c: Brigalow, belah, wilga forest with black tea tree.

A record of the vegetation communities within the mining lease was assessed and described in the initial *Impact Assessment Study* (SKM, 1998). The vegetation on site was classified into the following communities:

- *Acacia harpophylla* tall open forest;
- *Melaleuca* low open forest;
- *Allocasuarina cristata* tall open woodland
- Poplar box woodland;
- Open eucalypt woodland; and
- Agricultural land.

A map of the vegetation communities on the mining lease is presented in Appendix A.

## 2.3 Protected Wildlife Habitat

The Impact Assessment Study (SKM, 1998) indicated that no rare or threatened fauna species or wildlife habitats were identified from existing mapping or during field assessments.

## 2.4 Post-mining Land Uses

Schedule F - Table 1 of the EA prescribes post mine land use and land classifications for various types of disturbance at the mine. The mine's plan for post-mining land use are in accordance with the EA. These include:

- Grazing with wildlife corridors;
- Creek and floodplain areas; and
- Water storages.

The Post-Mine Land Capability Classifications detailed in Table 1 refer to the specific agricultural uses for the designated area (DSITI & DNRM, 2015). With reference to areas that have been progressively rehabilitated at the mine to date, the classes are identified and defined as:

- Class IV: "land primarily suited to pastoral use but which may be safely used for occasional cultivation with careful management".
- Class V: "land which in all other characteristics would be arable but has limitations which, unless removed, make cultivation impractical and/or economic".
- Class VI: "land which is not suitable for cultivation but is well suited to pastoral use and on which pasture improvement involving the use of machinery is practicable".
- Class VII: "land which is not suitable for cultivation but on which pastoral use is possible only with careful management. Pasture improvement involving the use of machinery is not practicable".
- Class VIII: "land that has such severe limitations that it is unsuitable for either cultivation or grazing".

The final land use and approval schedule domains are detailed in Table 1 and Figure A1 (Appendix A – Maps).

Table 1: Final land use and approval schedule for the mine (from EA Schedule F).

| Disturbance | | Land Description | | Land Classification | |
|---|---|---|---|---|---|
| **Type** | **Area (ha)** | **Pre-mining** | **Post-mining** | **Pre-mining** | **Post-mining** |
| Residual Void | 40 | Predominantly grazing with some cultivation | Possible water storage | II-IV | VIII |
| Re-Contoured spoil area | 1179 | Predominantly grazing with some cultivation, as well as Back Creek system and local roads | Grazing with wildlife corridors | II-IV<br><br>VIII (creeks and roads) | IV (in pit)<br><br>IV-VII (out of pit) |
| Sediment dams | 11 | Predominantly grazing with some cultivation | Water storage | II-IV | VIII |
| Creek diversion | 171 | Predominantly grazing with some cultivation and local roads | Creek and floodplain | II-IV | IV-VIII |
| Infrastructure | 19 | Predominantly grazing with some cultivation | Infrastructure | II-IV | VIII |
| Regulated Structures | All areas described during operations | Predominantly grazing with some cultivation, as well as Back Creek system and local roads | Grazing with wildlife corridors or possible water storage | II-IV | VIII |

## 2.5 Non-use Management Areas

Non-Use Management Areas (NUMAs) are not proposed for the project. A final void of 40 ha is approved (refer to Maps in current EA), however it has been determined that the final void can be non-water bearing and be incorporated into an undulating final landform.

No condition conversion application is proposed.

## 2.6 Rehabilitation Requirements

The rehabilitation goals, objectives, indicators and completion criteria approved as part of the EA are provided in Table 2.

Table 2: Summary of completion criteria for rehabilitation at the mine. EA Schedule F (Land).

| Rehabilitation Goal | Rehabilitation Objective | Rehabilitation Indicator | Completion Criteria |
|---|---|---|---|
| Safe site | Site is safe for wildlife and humans in the foreseeable future. | Adequacy and performance of barriers. | Safety barriers are installed in accordance with *Technical Guidelines for Environmental Management of Exploration and Mining in Queensland, 1995* and certified by an RPEQ. |
| | | Site is trafficable to humans and wildlife. | Certification in rehabilitation report that slopes are safe and risk of future failure is determined to be acceptable. |
| | | No significant cracking or gullying (>1m depth) occurring in the spoil dumps from subsidence or erosion. | Certification in final/progressive rehabilitation report that no surface cracks or erosion rills/gullies greater than 1m depth in any area to be relinquished. Confirmed by survey/remote sensing. |
| | The batter slopes are suitable for wildlife, livestock, human and farm machinery traffic. | Geotechnical stability | Geotechnical testing and analysis have confirmed that capping material and rehabilitated batters are constructed as designed. Confirmed by an RPEQ-certified Geotechnical Engineer. |
| | Dam walls are fit for purpose and do not show signs of probable failure. | Erosion | Dam walls are fit-for purpose and have been inspected and deemed stable by a suitably qualified person (RPEQ). |
| | Infrastructure has been retained in a safe and operable state or is decommissioned and removed. | Certification that residual infrastructure is safe and fit for purpose. | Final inspection by suitably qualified person (e.g. RPEQ structural/mechanical/electrical engineer) that residual infrastructure is fit for purpose and suitable for adoption by the post-mine landholder. |
| Stable site | Landform design achieves appropriate erosion rates. | Slope Angle | Slopes do not exceed those provided in *Schedule F – Table 2 of the EA* document. Confirmed by survey/remote sensing. |
| | | Presence of erosion | Erosion (sheet, rill and gully) similar to vegetation reference sites. Site is stable when comparing photographs from successive monitoring events. |
| | | | No slumping or slips occur. |
| | Vegetation cover to minimise erosion | Ground cover density | Groundcover density achieves and maintains at least 70 % surface cover. |
| | | Litter | Litter density comparable to vegetation reference sites. |

| Rehabilitation Goal | Rehabilitation Objective | Rehabilitation Indicator | Completion Criteria |
|---|---|---|---|
| | Topsoil is fastened to the underlying spoil to minimise the chances of mass movements and slumping. | Methodology of Rehabilitation | Topsoil has been keyed into the spoil below or vegetation in sufficient densities to hold the topsoil to the underlying spoil material, as confirmed by rehabilitation monitoring and certified in final rehabilitation report. |
| | Ensure long-term stability of void structures in terms of safety and consequences of further erosion. | Final void wall stability | Highwall and low walls of any residual void are made stable and certified as such by a geotechnical engineer. |
| | | | The zone of highwall / low wall instability, within the period identified by the regulator, must be calculated by a suitably qualified Geotechnical Engineer. |
| | | | Safety bunds are installed to prevent access to the residual void in accordance with the *Technical Guidelines for Environmental Management of Exploration and Mining in Queensland,* 1995 or any subsequent guideline. |
| The post-mining land use is sustainable and suitable to the site. | Soil properties to support desired land use and self-sustaining vegetation. | Chemical properties of soil | Cation exchange capacity and major macronutrient (N, P, K, and organic C) concentrations in root zone (0-0.3 m) are at least 80 % of those measured at comparable reference sites and indicate the soil is capable of sustaining required groundcover levels. |
| | | | pH(1:5) range of soil is between 5.5 – 9.0 to at least 0.3 m. |
| | | | Root zone (0-0.3 m) salinity is less than 0.7 dS/m (in a 1:5 soil water mixture) and 600 mg/kg of chloride. |
| | | | No persistent bare areas >100 $m^2$ – confirmed by remote sensing. |
| | | Topsoil quality for riparian vegetation | Soil Organic Carbon > 1.5 % in topsoil layers. |
| | | Physical properties of soil | Topsoil is >200 mm thick across all vegetated areas or chemical analyses indicate spoil is suitable to support long-term vegetation cover and meet the required land suitability classification. |
| | | | The thickness of material able to support vegetation cover on waste dump tops and batters is >0.8 m (allowing for 1m thickness of capping material and limited compaction / settling / erosion since installation). |
| | | Landscape Function Analysis (LFA) | LFA values for stability, infiltration and nutrient cycling to be at least 95 % of the analogue sites. |
| | Established land use with comparable management | Presence of weeds | Evidence of weed management being successful by weed diversity not exceeding 110 % of baseline survey results and abundance being comparable to analogue sites |

| Rehabilitation Goal | Rehabilitation Objective | Rehabilitation Indicator | Completion Criteria |
|---|---|---|---|
| | requirements to non-mined land. | | No class 1 or 2 declared plants present in rehabilitation. |
| | | Requirements are consistent with the proposed use of low intensity grazing. | Vegetation dominated by pasture grass and legume species suitable for grazing. |
| | | | Maintenance and monitoring be continued until all completion criteria have been met. |
| | | | Vegetative cover >70 %, over at least 90% of the area. |
| | | | Pasture productivity measurements (biomass, quality and stocking rates) to be consistent with grazing data in the region and comparable with analogue areas. |
| | | Rehabilitated areas achieve the intended land capability class. | Monitoring demonstrates indicators consistent with criteria for relevant Land capability class (see Appendix A). |
| | Vegetation diversity in rehabilitation is similar to surrounding areas. | Vegetation | Species diversity in rehabilitated native vegetation communities is at least 80 % of that of relevant analogue sites. |
| | Rehabilitation to encourage the presence of native fauna. | Establishment of wildlife corridors | Wildlife corridors will consist of a minimum of three (3) native tree species. |
| | The residual void is suitable for the post-mining land use. | Geological and mineralogical waste material placement. | No bulk waste, contaminated or highly saline material is threatened to be exposed by long term (i.e. 50 years) erosion. |
| | | Residual voids remain for future water storage. | Agreement from local landholders and local and state government for allowing voids to remain largely intact for potential water storage with the intention for use as livestock drinking water. The remaining water will comply with the water conditions set out in the Australian and New Zealand guidelines for Fresh and Marine Water Quality guidelines (ANZECC, 2000). Specifically, Section 4.3 – Livestock drinking water quality (Appendix C) |
| | Retained infrastructure and water-holding structures compatible with post-mining land-use. | Infrastructure and/or dams retained after closure. | Agreement from local landholders and local and state government for allowing retention of some infrastructure and/or dams for use after closure. |

# 3 REVEGETATION STRATEGY

## 3.1 Revegetation Strategy Overview

The revegetation strategy for the project is based on a re-construction approach to establishing vegetation. This approach is most suitable for disturbed areas with modified or disturbed soil, depleted or absent soil seed bank, and having a high potential for domination of weed species that prevent natural regeneration of the pre-disturbance ecological community. This approach is employed when the removal of external disturbance and processes alone is insufficient to allow natural establishment of vegetation communities.

The strategy is aimed at establishing a safe, stable and non-polluting landform, with a self-sustaining vegetation cover consistent with the proposed PMLU. The revegetation strategy does not aim to recreate the conditions of the target regional ecosystems in their remnant or undisturbed state.

Initial revegetation activities for the PMLU will focus on the establishment of groundcover to facilitate stability and topsoil retention. Pasture seed mixtures will contain a variety of perennial pasture grass and legume species introduced by direct seeding to establish a self-sustaining pasture suitable for grazing. Native tree seedlings will be strategically planted to form wildlife corridors throughout the rehabilitation process.

## 3.2 Domains and Revegetation Schedule

Rehabilitation activities will progressively follow the advancing pit. These rehabilitation domains are recognised:

- Residual void;
- In-pit re-contoured spoil area;
- Out-of-pit re-contoured spoil area;
- Sediment dams;
- Creek diversion; and
- Infrastructure.

Key rehabilitation and revegetation activities for each rehabilitation domain are summarised in Table 3. The location of each rehabilitation domain is presented in Appendix A.

Table 3: Summary of rehabilitation domains.

| Domain | Rehabilitation Type | Rehabilitation Activities |
|---|---|---|
| Residual void | N/A | A residual void will remain at the completion of mining as allowed in the EA.<br>The final void will be left in a safe condition (to be assessed by a geotechnical engineer) and meet the relevant completion criteria in table 4. |
| In-pit re-contoured spoil area | Grazing and wildlife corridors | The final rehabilitated landform will consist of gently undulating slopes. The surface will be top-dressed with a primary growth media (e.g. topsoil) with adequate soil depth and condition in places to permit some cultivation.<br>Revegetation will include species suitable endemic to the local area suitable for grazing. |
| Out-of-pit re-contoured spoil area | Grazing and wildlife corridors | Where practical, the out of pit spoil dumps will be contoured to form an extension of the backfilled mining pit. The top of the dump will be contoured to drain away from the backfilled pit.<br>The surface will be top-dressed with a primary growth media (e.g. topsoil) with adequate soil depth (300mm – minimum).<br>Revegetation will include species suitable endemic to the local area suitable for grazing. |
| Sediment dams | Grazing or water storage | Sediment dams considered of value to post-mining agriculture will remain after relinquishment for the purposes of water storage.<br>Any sediment dams that are not required for post-mining agriculture will be decommissioned and rehabilitated. Rehabilitation will consist dewatering (via draining or evaporation); then earthworks to remove the dam walls and backfill the void.<br>The surface will be top-dressed with a primary growth media (e.g. topsoil) with adequate soil depth and condition in places to permit some cultivation.<br>Revegetation will include species suitable endemic to the local area suitable for grazing. |
| Creek diversion | Grazing and creek | The final rehabilitated batter slopes will be topsoiled and revegetated with species suitable for the local area and for the final land use of grazing as per the *Detailed Design Report: Back Creek Diversion* (Alluvium, Dec 2007). |

| Domain | Rehabilitation Type | Rehabilitation Activities |
|---|---|---|
| | | The base and areas within the creek diversion (except the low flow channel) will be ripped and seeded to encourage pasture grass growth. |
| Infrastructure | N/A | All buildings and equipment will be dismantled and removed upon the cessation of mining operations or left for the landowner (under agreement).<br>Disturbed areas will be left in a safe condition. |

## 3.3 Revegetation Specifications

The following specifications are provided to guide the successful delivery of the four key revegetation goals for rehabilitation of the project.

Rehabilitation will be undertaken progressively as the mining operations expand. The sequence of works is generally to:

1. Shape and remediate waste material as required.
2. Rip waste material to a minimum of 0.3 m to ensure suitable soil preparation and allow adequate water and root penetration.
3. Spread topsoil to a minimum depth of 0.25 m.
4. Apply ameliorants (gypsum, lime, fertiliser, etc) as required.
5. Scarify the topsoil to incorporate soil ameliorants but not to a depth that will bring waste material to the surface.
6. Apply seed and till on the contour with a tyned implement with tyne spacing no greater than 0.5 m.

### *3.3.1 Topsoil quality and amendment*

Rehabilitation objectives and requirements in the completion criteria state that soil properties to support desired land use and self-sustaining vegetation should have:

- Cation exchange capacity and major macronutrient (N, P, K, and organic C) concentrations in root zone (0-0.3 m) are at least 80 % of those measured at comparable reference sites and indicate the soil is capable of sustaining required groundcover levels.
- $pH_{(1:5)}$ range of soil is between 5.5 – 9.0 to at least 0.3 m.
- Root zone (0-0.3m) salinity is less than 0.7 dS/m (in a 1:5 soil water mixture) and
  600 mg/kg of chloride.

A detailed material characterisation report (Landloch, 2021) was undertaken to summarise the results of previous soil studies and management recommendation for rehabilitation on the project. Recommendations in the material characterisation report, along with the *Topsoil Management Plan for Commodore Mine* (Downer Mining, 2020), guide the recovery, storage and replacement of topsoil in rehabilitation on the project.

Prior to the commencement of topsoiling works, adequate sampling will be undertaken to check soil chemistry is within the specified range. Additional ameliorants may be required to adjust soil values. Recommended topsoil amelioration rates based on material characterisation are provided in Table 4.

Table 4: Topsoil management recommendations.

| Material | Limitations | Amendments |
|---|---|---|
| Non-sodic topsoil | • Sometimes moderately alkaline.<br>• Low nitrogen, available phosphorus, calcium and sulphur. | • MAP fertiliser: 300 kg/ha<br>• Coated Urea: 100 kg/ha<br>• Gypsum: 100 kg/ha |
| Sodic topsoil | • Moderately to strongly alkaline.<br>• Marginally to strongly sodic. | • Gypsum: 1-2 t/ha per 0.1 m soil depth<br>• MAP fertiliser: 300 kg/ha |

| Material | Limitations | Amendments |
|---|---|---|
| | • Low nitrogen, available phosphorus, calcium and sulphur. | • Coated Urea: 100 kg/ha |

### *3.3.2 Topsoil management*

Topsoil is to be placed on wastes and spread in even layers at an appropriate thickness of 0.25 m, or greater. The Sodic Topsoil requires amelioration of sodicity and needs thorough incorporation of gypsum at a rate of 1–2t/$m^3$ prior to seed and fertiliser applications. Application of gypsum should be followed by shallow ripping/scarifying to incorporate gypsum amendments into the upper 0.25 m of materials.

The Non-sodic Topsoil does not require incorporation of gypsum to amend sodicity. A low rate of gypsum is specified; but this is to amend the low calcium levels in soil and can be applied with fertiliser

### *3.3.3 Species and planting types*

Applicable rehabilitation objectives and requirements outlined in Table 2 require the establishment of self-sustaining pasture and wildlife corridors with comparable management requirements to similarly used non-mining land. This is achieved by:

Pasture

- Establishing greater than 70 % vegetation cover that is dominated by pasture grasses and legume species suitable for grazing.
- Maintaining pasture productivity measurements (biomass, quality and stocking rates) consistent with regional grazing data and comparable to analogue areas.
- Meeting relevant land capability classes.

Wildlife Corridors

- Reaching a species diversity of at least 80 % of the analogue areas.
- Establishing wildlife corridors with a minimum of three native tree species.

#### *3.3.3.1 Cover crops*

A fast-germinating cover crop will be established during or immediately after topsoil reinstatement. Cover crop application will be undertaken on all rehabilitation areas with exposed topsoil. The use of a suitable cover crop is beneficial for:

- Reducing soil loss by rainfall and wind erosion.
- Reducing surface crusting and improved topsoil structure; improving infiltration.
- Increased organic matter and improved soil biology.
- The slow-release form of nutrients associated with organic breakdown at life cycle end.

Cover crop species selection will be based on the time of year and may vary depending on the time of rehabilitation. Suitable cover crops include:

- Japanese millet – summer seedings (October – March); and
- Annual ryegrass – winter seedlings (April – September).

#### *3.3.3.2 Pasture species*

Pasture grass and legume species desirable for rehabilitation on the project are provided in Table 5. Most of the grass and legume species recommended for the rehabilitation are exotic and are intended to establish a high value agricultural pasture.

It is not a requirement for all species listed in Table 5 to be seeded as part of the rehabilitation, although desirable, as this is not practical due to seed availability being a potential limiting factor. As a guide, a minimum of three 3P (perennial, productive, and palatable) pasture species and two legume species with different seasonal growing periods should be included during revegetation. Some species may be substituted with similar varieties under consultation if required.

Sowing of seed can be done via broadcasting, drill seeding, or applying hydraulicity (e.g. hydroseed or hydro-mulch).

Table 5: Recommended pasture grass, legume and cover crop species for rehabilitation.

| Type | Common Name | Scientific Name |
|---|---|---|
| Exotic Grass | Reclaimer Rhodes | *Chloris gayana* |
| | Bambatsi Panic | *Panicum coloratum var. makarikariense* |
| | Gatton Panic | *Panicum maximum* |
| | Bisset Creeping Blue | *Bothriochloa insculpta* |
| | Purple Pigeon Grass | *Setaria incrassate cv. Inverell* |
| | QLD Bluegrass | *Dichanthium sericeum* |
| | Wiregrass | *Aristida spp.* |
| | Windmill Grass | *Chloris truncate* |
| Legume | Barrel Medic | *Medicago truncatula* |
| | Snail Medic | *Medicago scutellata* |
| | Burgandy Bean | *Macroptilium bracteatum* |
| | Woolly Pod vetch | *Vicia villosa* |
| | Lucerne | *Medicago sativa* |
| | Desmanthus (Inoculated) | *Desmanthus spp.* |
| Cover Crop | Japanese Millet | *Echinochloa esculenta* |
| | Annual Ryegrass | *Festuca perennis* |

#### *3.3.3.3 Wildlife corridor species*

Tree species will be incorporated to provide wildlife corridors, shelter for stock and visual enhancement to the site. Species recommended for the revegetation project are presented in Table 6. Species have been selected based on their compatibility with:

- The intended PMLU (grazing);

- Pre-mining vegetation communities; and
- Rehabilitation works previously on site.

Most species were established during early rehabilitation works and identified during rehabilitation monitoring assessments (Landloch, 2021). Additional native species have been included where they are readily available from seed collected on site or from plant and seed retailers. A selection (minimum of three) of the species listed in Table 6, based on availability of seed or tube stock prior to rehabilitation works is recommended for use in revegetation.

Table 6: Recommended native tree species for wildlife corridors.

| Common Name | Scientific Name |
|---|---|
| Belah | *Casuarina cristata* |
| Narrow leaf ironbark | *Eucalyptus crebra* |
| Broad-leaved ironbark | *Eucalyptus fibrosa* |
| Gum topped box | *Eucalyptus moluccana* |
| Grey Box | *Eucalyptus microcarpa* |
| Blackbutt | *Eucalyptus pilularis* |
| Poplar box | *Eucalyptus populnea* |

#### *3.3.3.4 Seed procurement and collection*

Exotic and native pasture and legume species may need to be purchased from local suppliers up to six months in advance, in quantities sufficient to undertake direct seeding operations. If required, and where possible, native seed will be collected from populations on or near the project area to maintain regional tolerances.

#### *3.3.3.5 Planting stock*

Planting stock may need to be ordered at least twelve months ahead of the planting date to allow sufficient time to propagate plants and sun harden in preparation for planting.

Throughout the term of the propagation phase, the chosen nursery will be requested to provide regular updates on their progress in order for planting operations to proceed as planned. Plants will only be accepted where adherence to the following quality characteristics is achieved:

- Healthy and displaying signs of active growth;
- Characteristics of the species at the current growth stage;
- Sturdy stems and being free-standing;
- Fresh actively growing roots and a well developed root system that is coherent when removed from the pot, but not tightly pot bound;
- No signs of nutrient deficiencies; and
- Sun hardened.

All plants will need to be water saturated prior to dispatch from the nursery. An appropriate temporary storage will be set up on site in advance of receiving the plants. Watering will be conducted for the duration of time the plants are held in temporary storage.

### 3.3.4 Establishment methods

#### 3.3.4.1 Direct seeding

Direct seeding will be preferred to achieve a dense or continuous cover of pasture species. Seeding may be undertaken using conventional broadacre seeding equipment (e.g. combine seeder, spread with harrows or spinner).

Grass seed application rates for pasture establishment will follow supplier recommendations for each species but typically range from 1 kg/ha for uncoated seed to 3 kg/ha for coated seed.

Seeding works will generally be conducted through spring or early summer when temperatures are favourable for germination. Where practicable, seed will be sown immediately before the expected onset of reliable rainfall.

#### 3.3.4.2 Planting

Wildlife corridors, consisting of native trees, will be established to provide connectivity and allow native fauna to move freely across rehabilitated areas. Native tube stock will be planted in clumped and lineal distributions to establish wildlife corridors. General planting specifications include:

- All plants will need to be water saturated within 24 hours of planting.
- Plants will be placed in a vertical hole that is deeper than its root ball;
- Depending on growth form of tube stock, planted to a depth so that the top of the plug is between 0.05 m and 0.1 m (5–10 cm) below the soil surface (no visible potting media at soil surface);
- Plants will be planted with a slow-release fertiliser and a soil conditioner, with use of water crystals, where practicable;
- Firmly backfilled so that the plant may not be pulled out of the ground by pulling the top leaves; and
- Not damaged the tube stock during planting.

Timing of planting will typically be targeted for early spring or late summer when temperatures are milder. Planting will generally be carried out once the surrounding pasture areas have been established. Pre-plant spot spraying may be required to reduced grass competition within the immediate vicinity of the planted tree.

#### 3.3.4.3 Planting stock and seed quantities

Recommended sowing rates for the identified pasture species are provided in Table 7. Planting rates for native trees that will make up the wildlife corridors have not been provided due to the variability of placement across the final landform. Generally, tree plantings will:

- Establish trees at a planting density equivalent to a 600-1400 stems / ha (forest) within the designated wildlife corridor area; or
- Provide sufficient cover, post establishment, to provide connectivity between rehabilitation blocks.

It should be noted that not all species listed in Table 7 are required to be used in revegetation. Rather, a combination of species will be chosen from the list based on availability and species requirements at the rehabilitation stage. Therefore, quantities that are based on sowing rates per species basis, may not be representative of the final total seed application. A contingency amount of 20 % will typically be utilised to account for mortality.

#### 3.3.4.4 Watering

Planted stock will be watered until establishment if soil moisture is less than optimal or persistent natural rainfall is absent. The watering rate should be at greater than the daily evaporation rate. Pre-saturation of plants prior to planting is critical for early-stage survival. Where practical, hydrated water crystals will be incorporated into planting holes at the time of planting to maximise water retention in the root zone.

Seeded pastures will be established under dry land conditions, and be reliant on natural rainfall events.

### 3.3.5 Maintenance and protection

Applicable rehabilitation objectives and requirements outlined in Table 2 note the establishment of self-sustaining pasture and wildlife corridors with comparable management requirements to similarly used non-mining land, and include:

- Evidence of weed management being successful by weed diversity not exceeding 110 % of baseline survey results and abundance being comparable to analogue sites.
- No class 1 or 2 declared plants are to be present in rehabilitation.

#### 3.3.5.1 Weed control

Weed control will be managed cautiously to promote healthy pasture growth and prevent the dominance of weed species.

Weed management operations will typical use controlled and targeted herbicide applications to prevent damaging desirable vegetation. Broadscale herbicide applications will only be used as a last resort to avoid the likelihood of exposing large areas of soil and increasing erosion risks.

Table 8: Declared weed species known to occur in the project area and recommended controls.

| Species | Biosecurity Act Status | Control Measures |
|---|---|---|
| Prickly or Velvety Tree Pear *(Opuntia spp.)* | Prohibited | Chemical control<br>• Foliar spray covering all stems for smaller specimens.<br>• Basal bark/ cut stump application, with spray wetting all areas on and below the cut to ground level. |
| | | Physical control<br>• Fire is an effective control method for dense infestations.<br>• Using machinery is unsatisfactory due to the risk of reestablishment from missed or cut pad sections. |
| | | Biological controls<br>• a stem-boring moth *Cactoblastis cactorum.*<br>• cochineal scale insects *Dactylopius ceylonicus, Dactylopius opuntiae, Dactylopius confuses, Dactylopius austrinus.*<br>• a cell-sucking bug *Chelinidea tabulate.*<br>• a stem-boring moth *Tucumania tapiacola.*<br>• a stem-boring beetle *Archlagocheirus funestus.*<br>• prickly pear red spider mite *Tetranychus opuntiae.* |
| Harrisia Cactus *(Harrisia spp.)* | Prohibited | Chemical control<br>• Foliar spray covering all stems. |
| | | Physical control<br>• Dig out plants completely and burn. Ensure all tubers are removed and destroyed.<br>• Plough only if followed by annual cropping. |
| | | Biological controls<br>• A stem-boring longicorn beetle *(Alcidion cereicola)*.<br>• A mealybug *(Hypogeococcus festerianus)*. |
| African Boxthorn *(Lycium ferocissimum)* | Restricted | Chemical control<br>• Foliar spray to the point of run-off.<br>• Basal bark/ cut stump application, with spray wetting all areas on and below the cut to ground level.<br>• Root application by applying residual herbicide (pelleted) prior to rainfall. |
| | | Physical control<br>• Hand-pull young plants. |

| | | |
|---|---|---|
| | | • Clear large stands by dozing, stick raking or blade plough. Control regrowth from seed or roots using cultivation. |
| Mother-of-millions *(Bryophyllum delagoense)* | Restricted | Chemical control<br>• Thorough spraying is effective if sufficient wetting agent is used to penetrate the waxy outer covering of the plants. |
| | | Physical control<br>• Manual (hand) removal is the most effective control for scattered and small infestations. |

#### *3.3.5.2 Planting success*

Monitoring of newly planted seedlings will commence immediately after planting and continue until plants have established. Plant health and mortality will be recorded, and any damaged or distressed plants will be attended to. If the mortality rate exceeds 30 % of total plants, supplementary planting will be undertaken.

#### *3.3.5.3 Erosion and sediment control*

Erosion presents a key risk to the overall rehabilitation outcome. All aspects of the revegetation program will be managed under the site erosion and sediment control plan (Downer Mining , 2020) with minimising erosion risk as a key priority.

#### *3.3.5.4 Pest fauna and livestock control*

Over grazing activity from native animals (e.g. kangaroos and wallabies), livestock (cattle, sheep, etc), and feral pests (e.g. pigs, goats, and mice) have the potential to impact rehabilitation success.

Grazing activity that impacts rehabilitation will be recorded during annual rehabilitation monitoring assessments. Where damage exceeds acceptable levels, grazing reduction treatments are to be engaged.

Feral pest controls (e.g. trapping and shooting) will be instigated if they are found to be damaging revegetated areas.

Damage from cattle and other livestock represents a low risk due to the large exclusion zones around the mining lease provided stock-proof boundary fences are maintained. Grazing of rehabilitated areas will only commence once the areas have been sufficiently revegetated, achieve the desired completion criteria and have been excluded from the mining tenement.

## 3.4 Monitoring Program

Successful revegetation outcomes rely on an integrated and adaptive approach to risk identification and control. Monitoring is an integral part of the overall management strategy, enabling early detection of risks to rehabilitation and an indicator to commence effective risk management actions.

The monitoring program is split into two phases, an establishment phase, and a maintenance phase (Table 9). Wildlife corridor areas will have longer phases as the growth rate of tree species is slower than pasture species.

Table 9: Revegetation phases and timeframes.

| Revegetation Phase | Definition | Anticipated Timeframe (years) | |
|---|---|---|---|
| | | Pasture | Wildlife Corridor |
| Establishment | The period required for rehabilitation to become self-reliant in normal seasonal conditions. | 2 – 3 | 5 |
| Maintenance | The period of growth post establishment until the time that the rehabilitation becomes | 5 – 7 | 7 – 15 |

| Revegetation Phase | Definition | Anticipated Timeframe (years) | |
|---|---|---|---|
| | | Pasture | Wildlife Corridor |
| | dominant and self-sustaining on site. | | |

Rehabilitation monitoring sites will be established following the completion of each rehabilitation area. Newly revegetated areas will be monitored yearly until the maintenance phase is achieved. At this point monitoring will revert to biennial assessments.

### *3.4.1 Analogue reference sites*

Vegetation reference sites were established at the project in 2010 to provide a comparable benchmark for rehabilitated sites (Landloch, 2020). These vegetation reference sites were chosen based on their representative features of the respective land disturbances such as topography, soil characteristics and vegetation type and structure.

Summary details are included in Table 10, with details of the analogue sites provided below. The location of transects is indicated in Figure A3 (Appendix A – Maps and Figures).

Table 10: Rehabilitation monitoring analogue site locations.

| Transect | Easting | Northing | Period | Status |
|---|---|---|---|---|
| AN3 | 329938 | 6905737 | 2012 to present | Active |
| AN4 | 330876 | 6908794 | 2015 to present | Active |
| AN5 | 330367 | 6907025 | 2018 to present | Active |
| AN6 | 327714 | 6905839 | 2018 to present | Active |

AN3

Transect AN3 was established as a replacement for discontinued transect AN1. The site for AN3 was chosen in an area of high grass density and low levels of weed presence, in a location unlikely to be required for mining. A wide range of pasture grasses are present on the transect including Queensland bluegrass, Rhodes grass, setaria species and urochloa species. This transect has a history of grazing but has remained ungrazed since 2015.

AN4

This transect is the only analogue located on a hill slope. AN4 was established as part of the 2015 monitoring program to provide a third analogue transect representative of the condition of ungrazed rehabilitated transects that are located on steeper gradients. The transect is heavily grassed with a variety of weed species present in small numbers. Pasture grass species present include Queensland bluegrass, setaria species, Rhodes grass, buffel grass, windmill grass and barbed wire grass.

AN5

AN5 was established in 2018 as a replacement for the recently abandoned AN2 and is situated on a flat area of natural ground, slightly upslope from the creek.

The transect has remained relatively unchanged since establishment and is dominated by Rhodes grass and Queensland bluegrass with low weed cover.

AN6

AN6 was also established in 2018 as another replacement of the recently deleted AN2 and is situated on a flat area of pasture, on the outer boundary of the project area.

The transect has remained relatively unchanged since establishment and it has a range of pasture grasses including Rhodes grass, Queensland bluegrass, setaria species, barbed wire grass and windmill grass, with moderate to low weed cover.

### *3.4.2 Field survey*

Monitoring assessments aim to capture data relating to the rehabilitation requirements specified in the completion criteria (Table 2). To monitor the progress of the site with respect to these criteria, monitoring will commence during the establishment of each revegetation area. Sites will be placed randomly within rehabilitation polygons, at a density of approximately one site per 20 ha. The rehabilitation monitoring methodology for the project is provided in Appendix B.

### *3.4.3 Rehabilitation trials*

#### *3.4.3.1 Growth media*

Prior to mining operations commencing, a rehabilitation trial was conducted on overburden and soils associated with the bulk sample pit constructed in the 1970's (Roberts, 1986). The stockpiled overburden spoil was approximately 200 m long, 70 m wide and 20 m high, with slopes up to 30 %. In 1979, 300-400 mm of topsoil was stripped from an adjacent area and placed on the overburden stockpile. Topsoil was placed on the overburden material in two separate sections, one with a thickness of 200-300 mm and the other with a thickness of 300-500 mm.

Both sections were seeded with a variety of exotic pasture grasses (buffel, green panic and Rhodes grass) and legumes (siratro and lucerne). The sections

were then further divided into four parts and each part fertilised with different fertilisers.

Roberts (1986) concluded persistent pastures can be established on overburden at Millmerran and achieve 60 % cover after three seasons. Key findings were:

Soil depth

- A surface covering of 200-300 mm of suitable soil is adequate for good pasture establishment and persistence on overburden even on slopes up to 33 %;
- There is no significant difference in growth between to 200-300 mm and
  300-500 mm topsoil depths.

Fertiliser

- Buffel or green panic suppressed Rhodes grass and there was a significant response to superphosphate fertiliser for two years as well as nitrogen in the first year; and
- Initial applications with phosphatic and nitrogenous fertilisers produced a small positive response in pasture cover and yield. Although the fertilisers disappeared with time, the pasture continued to persist and flourish.

Monitoring results in 1998 report the grasses persisted and the banks of the rehabilitated overburden and provided a stable surface (SKM, 1998).

Recent fieldworks by Landloch report observed the grasses persist and landform remains stable when grazed by livestock (Landloch, 2021).

#### *3.4.3.2 Pasture management*

A trial was conducted to assess the use of fire and slashing to manage vegetation in rehabilitated areas on the mine (Landloch, 2016).

The trial was set up to:

1. Monitor the impacts of fire and slashing upon rehabilitated areas; and
2. Assess the potential for integration of fire and slashing into vegetation management practices on rehabilitated areas to ensure closure criteria (sustainable grazing) are demonstrated and achieved.

If a controlled burn was to be applied to the rehabilitation at Commodore Coal Mine the trial concluded (Landloch, 2018):

- The rehabilitation would be expected to recover within four years. (It should be noted that undesirable growing conditions occurred during the trial and this timeframe may differ under average rainfall.);
- The period immediately after the burn will have reduced stability and increased erosion potential until vegetation recovers;
- Nutrient stores will be reduced after the initial flush of nitrogen from the burn as vegetation growth increases.
- Legume numbers will increase, and will gradually improve nitrogen levels;
- Weed numbers will decrease, thereby improving pasture quality; and
- A wider variety of pasture grasses will establish. This will allow the presence of a larger number of more palatable species and reduce the impacts from seasonal variations of different species.

If the rehabilitation at Commodore Coal Mine was to be slashed the following would be expected:

- The rehabilitation would recover within three years (it should be noted that undesirable growing conditions occurred during the trial and this timeframe may differ under average rainfall). However, if nitrogen levels are low, the additional litter may increase the potential for pasture run down;
- The potential for erosion after the treatment will not change and in some cases may decrease;
- The added mulch from slashing – when decomposed - will increase the potential for nutrient cycling and improve nutrient stores;
- Diversity of pasture grass species will decrease; and
- The slashing process will assist in spreading established weed species.

The trial indicated that both treatments tested will improve the quality of rehabilitation at Commodore Coal Mine if used correctly. Due to the varying nature of the rehabilitated sites across the mine site, a combination of both would be recommended to achieve the best results (Landloch, 2018).

## 3.5 Rehabilitation Milestones

Rehabilitation milestones refer to each significant event or step necessary to rehabilitate land to a stable condition (Department of Environment and Science, 2019). The rehabilitation milestones for the project are displayed in Table 13 and were prepared with reference to the list supplied in Appendix 3 of the *Guideline – Progressive rehabilitation and closure plans* (Department of Environment and Science, 2019).

Table 13: Reference milestones for rehabilitation.

| Reference milestones | Description |
|---|---|
| Infrastructure decommissioning and removal | Disconnect and terminate services such as water, electricity and gas where not required post-mining. |
| | Remove all transportable infrastructure. |
| | Demolish any permanent infrastructure not required post-mining. |
| | Remove bitumen, blue metal, aggregate, etc. not required for roads post mining |
| | Remove fencing not required post-mining. |
| | Decommission boreholes and environmental monitoring infrastructure. |
| | Clear all waste (associated with infrastructure decommissioning). |
| | Note: ROM infrastructure is not included in the ML EA. |
| Remediation of contaminated land | Carry out preliminary and intrusive contaminated land investigations. |
| | Removal and appropriate disposal or onsite treatment of contaminated water/soils (e.g. affected by hydrocarbons) post-mining. |

| Reference milestones | Description |
|---|---|
| | Conduct validation testing to confirm that contaminated water/soils have been removed/remediated. |
| Landform development and reshaping/reprofiling | Finalise engineering and landform design plans in accordance with EA conditions. |
| | Bulk earthworks to achieve required landform and slopes. |
| | General reshaping and pushing/trimming to achieve final landform. |
| | Remove roads and access routes not required for agricultural PMLUs. |
| | Fill/smooth sediment traps, voids, and flatten bunding etc. not required for agricultural PMLUs. |
| | Erosion and sediment control systems installed for final landform design. |
| Surface preparation | Remediate any erosion or subsidence, that is identified annually, as requiring intervention by a suitably qualified person. |
| | Prepare overburden/spoil for topsoiling. Rip over-compacted overburden >200mm deep where required. |
| | Spread growth media (topsoil) as per the EA. |
| | Apply ameliorants to improve or stabilise soils (e.g. gypsum, fertiliser) where required, that is identified annually, as requiring intervention by a suitably qualified person. Refer to the material characterisation report (Landloch, 2021). A soil test is required. |
| | Trim, rake, roll and/or deep rip where required. |
| Revegetation | Direct seeding. |
| | Planting tube stock where appropriate and practical. |
| | Apply fertiliser where appropriate. Nitrogen fertilisers are not to be used near water bodies. |
| | Install stock fencing to protect planting, the creeks, and to prevent overgrazing in paddocks. |
| Achievement of surface requirements | Monitoring to determine whether vegetation is self-sustaining. |
| | Monitoring to determine whether species richness, diversity and density meet required criteria. |
| | Monitoring annually by suitably qualified person. |
| | Ensure water run-off is managed and drainage follows appropriate drainage paths. |
| Achievement of post-mining land use to stable condition | Be able to show that the land is safe, structurally stable, does not cause environmental harm and is able to sustain the PMLU. |
| | Rehabilitation certified and signed off against Commodore Coal Mine Completion Criteria from suitably qualified person. |
| | Rehabilitation certified by DES. |
| Achievement of sufficient improvement | Cause no environmental harm outside of the relevant tenure. |
| | Rain fall run off diverted to natural catchment or agricultural dams. |
| | Relinquish mining lease area and return land to agricultural uses. |

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# APPENDIX A – MAPS AND FIGURES

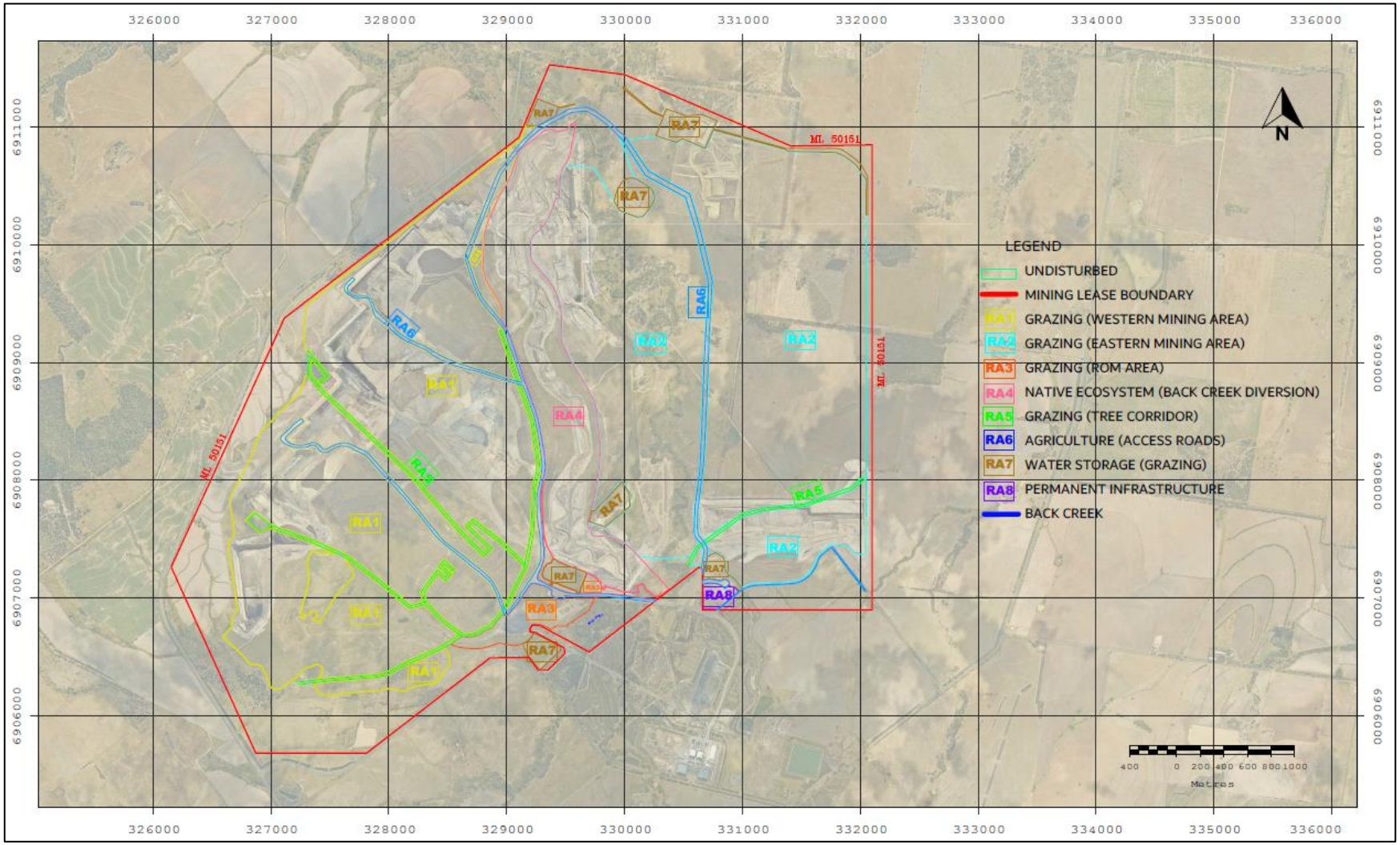


Figure A1: Rehabilitation final land use and domains.

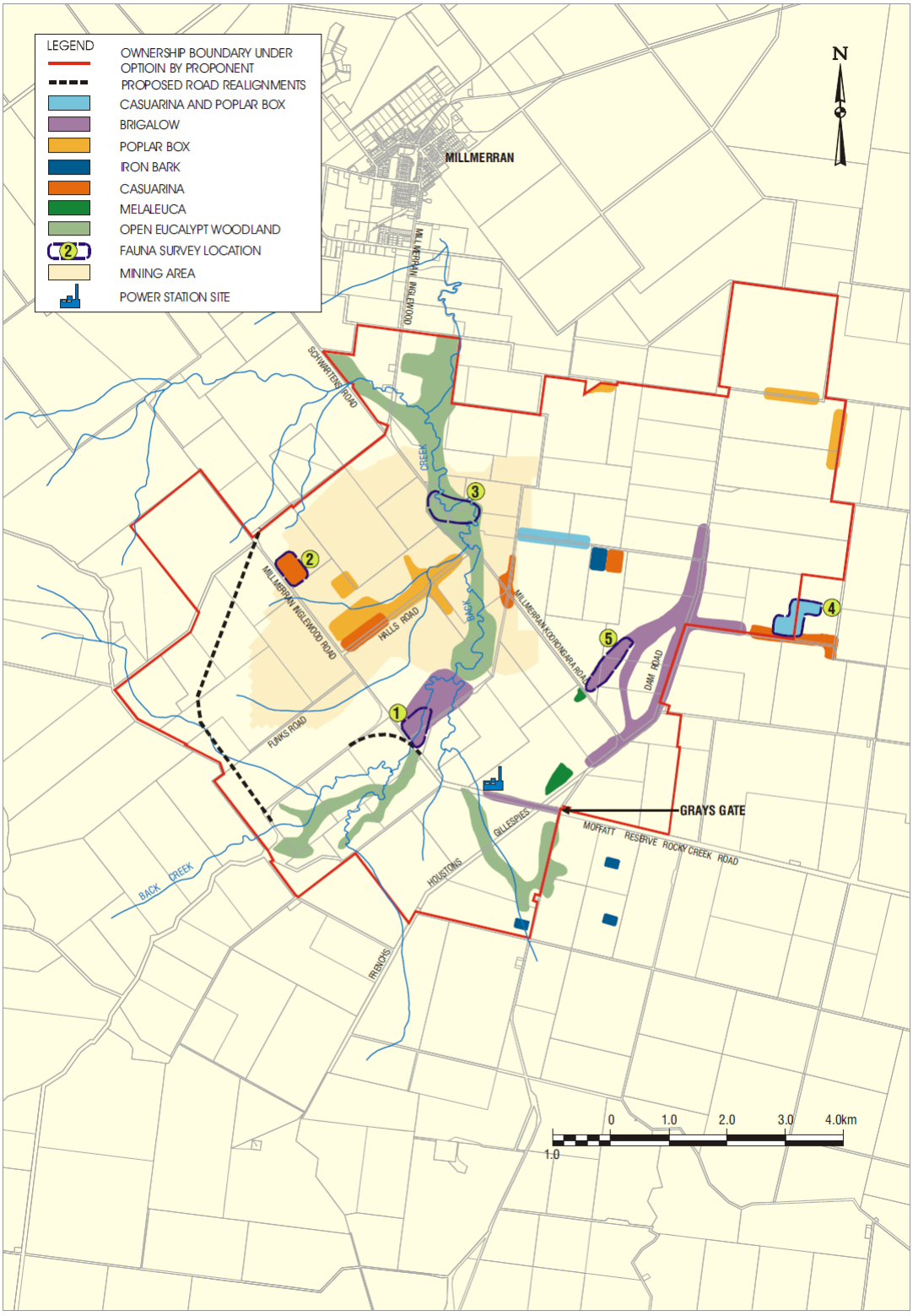


Figure A2: Vegetation Communities (SKM, 1998)


Figure A3: Rehabilitation monitoring reference site locations.

# APPENDIX B – MONITORING METHODOLOGY

## Transect layout

Each monitoring plot consisted of a 50 m long by 10 m wide transect, orientated down slope with the direction of water flow as per Figure 1. LFA scores are assessed along the centre line of the 50 m transect and vegetation diversity measurements are conducted within the entire 50 m by 10 m transect boundary. Biomass and grazing conditions are assessed in 1 $m^2$ quadrats throughout the transect.

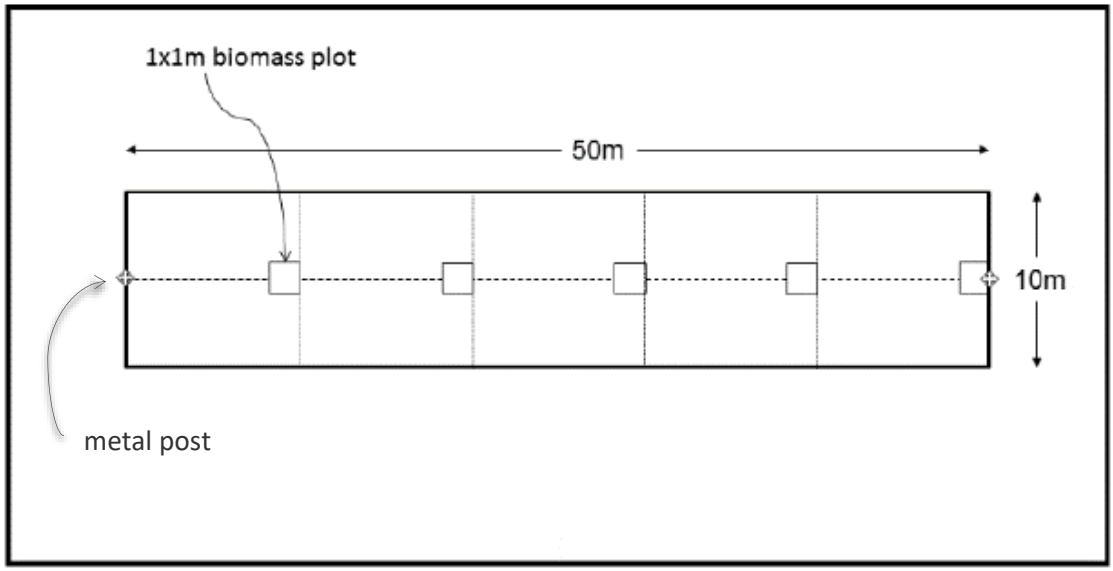


Figure B1: Layout of monitoring transect.

## Transect monitoring methodology

The start of each transect is positioned at the location shown in Figure 1, with the start (0 m) and end (50 m) of the transect marked with a metal post. Transects are established either directly downslope or with the flow of water.

Once established, a GPS photo is taken at the start of the transect, from behind the metal post looking down the transect.

The following general site information is recorded at each transect:

- Date and time;
- Slope;
- Orientation;
- Position in landscape;
- Landuse;
- Soil surface condition (loose, soft, firm, hard setting, cracking, crusting, flaking, trampled, etc.) and surface fragment size (<2 mm to >2,000 mm);
- General notes on vegetation condition, composition and site characteristics; and
- Signs of fauna presence or disturbance.

Detailed monitoring methodology is discussed in the following sections for Landscape Function Analysis (LFA), erosion, soils, vegetation and grazing assessments.

**LFA monitoring**

Ecosystem Function Analysis (EFA) is a valuable tool that uses observed indicators to assess the functional status of rehabilitated landscapes, thereby assessing the various stages of ecosystem recovery. "Function" refers to the biophysical efficiency of the site, rather than an inventory of its biological components (Tongway & Hindley, 2004). EFA is now one of the standard approaches available to industry for objective assessment of mine site rehabilitation.

This system is ideally suited for rehabilitation monitoring at Commodore Coal Mine, especially to assess erosion stability and the sustainability of the vegetation.

EFA is comprised of three inter-related modules, with two of these modules (LFA and Vegetation Dynamics) identified in 2005 as useful for assessing the progress of rehabilitation at Commodore Coal Mine by Landloch.

The LFA component of EFA employs a spatial and systems approach to enable the incorporation of all components of a rehabilitated site into the monitoring process. A "development trajectory" towards a self-sustaining landscape can then be assessed. Furthermore, the LFA method produces indices based on easily-derived field indicators that enable the functional status of the landscape to be monitored. These indices reflect the measured variables of stability, water infiltration, and nutrient cycling.

LFA is comprised of four main components:

1) ***A conceptual framework*** – to describe how landscapes function in a generic sense.
2) ***A field data acquisition methodology*** – provides data for the conceptual framework in the form of indices of system processes. These indices are:
    - Landscape organisation, reflecting overall resource 'economy'; and
    - Soil surface condition, comprising of 11 indicators that contribute to functional status indices of:

        i) Stability (resistance to erosion);

        ii) Infiltration (capacity to infiltrate rain and run-on water); and

        iii) Nutrient cycling (organic matter decomposition and cycling).
3) ***A data reduction and tabulation methodology*** – to provide single figures, for comparison purposes, for stability, infiltration, and nutrient cycling from landscape organisation data and soil surface assessments (Figure 2).
4) ***An interpretational framework*** – to facilitate 'future trajectory' predictions and identify critical thresholds that enable management, regulatory or policy decisions to be made.

The sustainability of pasture grasses, shrubs and trees on-site is monitored using Ecosystem Function Analysis (EFA) measurements of soil surface sustainability (through the LFA indices) and vegetation diversity assessments. The initial soil

sampling, conducted prior to the mine's establishment, will provide profile data (if needed) for the analogue sites.

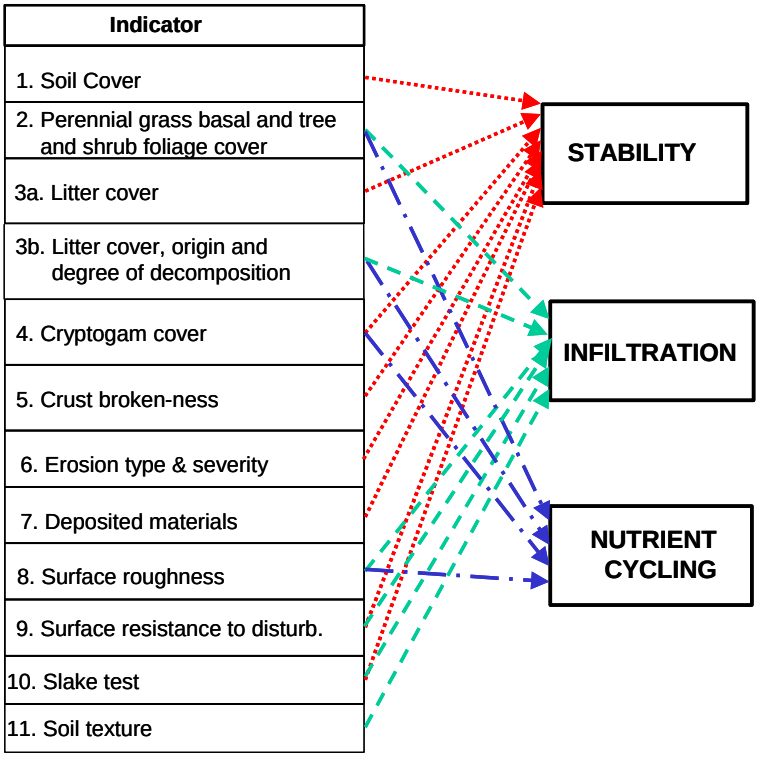


Figure B2: The allocation of the indicators to the three indices of Stability, Infiltration and Nutrient Cycling in LFA.

## Erosion assessment

LFA is used to assess the erosional stability of soil surfaces on rehabilitated areas. Indices produced by the method for rehabilitated areas are compared to those from LFA assessments from nearby undisturbed (analogue) areas.

The LFA Stability and Infiltration Indices provide a means for direct comparison between control (analogue) sites and rehabilitated areas. These indices include indicators measuring ground cover (rock, vegetation and litter), surface stability (evidence of erosion, rill frequency, size, depth and surface hardness) and soil texture that can be directly compared between control and rehabilitated sites.

Surface cover is also measured directly, as it is one of the major factors affecting erosion rates and sediment generation.

### Soil assessment and analysis

*Soil profile descriptions*

Test pit soil descriptions include the collection and recording of the following details:

- Topsoil depths, designation, and boundary type;
- Field texture;

- Colour and mottles; and
- Coarse fragments and segregations.

*Sampling protocol*

Soil samples will be collected in accordance with nationally recognised protocols (Ryan & Wilson, 2008). Generalised sampling depths are 0–100 mm, 100–300 mm, and a subsoil/spoil composite sample from 300–1,000 mm. Allowances will be made for horizon boundaries with samples collected from within major soil horizons (i.e. sampling did not cross A and B horizons).

All samples should be identified using the project name, unique profile number and depth range from where the sample was taken. Samples for chemical analysis are placed into bags with approximately 250–500 grams of soil, which is required to adequately analyse samples.

*Laboratory analysis*

Laboratory analysis will be undertaken by a National Association of Testing Authorities (NATA) and Australian Soil and Plant Analysis Council (ASPAC) accredited laboratory. The typical analytical suite for topsoil is itemised in Table 11.

Table B1: Laboratory Analytical Suites

| Soil Analyses | Topsoil | Subsoil |
|---|---|---|
| Total nitrogen and phosphorous; available phosphorous, potassium, and sulphur; and organic carbon | ✓ | |
| Trace metals (Cu, Zn, Mn and Fe); and Boron | ✓ | |
| pH, electrical conductivity and chloride | ✓ | ✓ |
| Exchangeable cations (with calculations of effective cation exchange capacity and exchangeable sodium percentage) | ✓ | ✓ |
| Particle size analysis (PSA) | | ✓ |

**Assessment of vegetation diversity**

During each monitoring event, species diversity and the presence of weeds are visually assessed. Observations of each different grass, weed, legume and shrub species present within 10 m of both sides of the transect are recorded.

## Grazing assessment

**Standing dry matter**

Pasture volume is determined through Standing Dry Matter estimates, calculated from the biomass samples collected from each transect at randomly selected areas located within the transect boundaries.

Biomass samples will be collected and treated in the following manner:

1. At three locations within each transect, Productivity Quadrats (1m$^2$) were placed on the ground.
2. Using hand shears, all standing pasture within the quadrat was cut 2 cm above ground level and placed into a large, labelled paper bag.
3. A set of scales was tared using an identical, empty paper bag.
4. The freshly cut samples were weighed after the scales had been tared. The weight (in grams) was recorded.
5. If the sample was too large and bulky to send to Landloch's Toowoomba Laboratory, a sub-sample was taken. The sub-sample was weighed on tared scales and recorded.
6. Samples were returned to Toowoomba for further treatment.

**Pasture quality**

Feed quality is determined through sampling and laboratory analyses of forage material. Sampling will be undertaken generally in accordance with the guidelines provided by the NSW Department of Primary Industry (DPI) for pasture sampling (*'Collection technique guidelines Form Collect 1-Version No.2-01/11/07', 2007*).

Random sampling is conducted by taking between 15 and 20 'grab' samples at grazing height across the wider area surrounding the monitoring transect. All 'grabs' are gathered into a bucket and mixed well. Samples will then be sorted to separate the leafy material from the stalky material of the grass plants as far as possible. The leafy material is immediately stored in plastic zip-lock bags, placed in a cooled iced box (and subsequently in a refrigerator at the end of the working day). At completion of the field survey program, all samples will be wrapped in newspaper (to minimise thawing and sample degradation) and sent by overnight courier to the Wagga Wagga Agricultural Institute for feed quality testing. The Wagga Wagga Agricultural Institute is operated by the NSW DPI and is fully accredited by NATA. Samples are tested for the parameters defined in Table 12.

Table B2: Pasture quality test analytes.

| Parameter | Unit | Definition |
|---|---|---|
| **Dry matter content (DM)** | **%** | **'Dry Matter' is everything remaining after all the water in the sample has been removed. DM contains the energy, proteins, vitamins and minerals required by animals for maintenance and production.** |
| **Dry matter digestibility (DMD)** | **% of DM** | **DMD is the proportion of the DM in a feed that can be digested by an animal.** |
| **Organic matter content (OM)** | **% of DM** | **OM is everything present in a feed except ash.** |
| **Dry organic matter digestibility (DOMD)** | **% of DM** | **DOMD is the proportion of the organic matter in the dry matter that can be digested by an animal.** |
| **Crude protein content (CP)** | **% of DM** | **CP is the proportion of protein and non-protein nitrogen in the feed.** |
| **Fibre content** | **% of DM** | **Fibre is the structural part of plants and feeds, consisting mainly of compounds called hemicellulose, cellulose and lignin.** |
| **Metabolisable** | **% of DM** | **ME is the amount of energy in a feed that is** |

| Parameter | Unit | Definition |
|---|---|---|
| **energy (ME)** | | **available to an animal to utilise for maintenance, production and reproduction.** |

### Carrying capacity

Cattle carrying capacity is calculated using the stocking rate calculator provided by Meat and Livestock Australia (MLA). Assumed parameters for the assessment are:

- Pasture available at start of grazing – calculated from standing dry matter estimates;
- Pasture left at end of grazing – 1,000 kg DM/ha (MLA recommended minimum amount for healthy pasture recovery);
- Pasture growth rate – 13 kg DM/ha per day based on the average daily growth rate over a year for the Goondiwindi region;
- Number of days grazing – 365; and
- Stock class – Dry cow.