Draft Revegetation Management Plan

Rum Jungle Rehabilitation Project Stage 3

RJ3-4-MP-009

NORTHERN TERRITORY GOVERNMENT

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Acronyms	Full form
ATV	All Terrain Vehicle
CCGC	Coomalie Community Government Council
CEMP	Construction Environmental Management Plan
DISER	Department of Industry, Science, Energy and Resources (Cth)
DITT	Department of Industry, Tourism and Trade (NT)
EA Act	*Environmental Assessment Act 1982* (NT)
EBFR	East Branch of the Finisss River
EIS	Environmental Impact Statement
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Cth)
ESCP	Erosion and Sediment Control Plan
FAMP	Feral Animal Management Plan
FMP	Fire Management Plan
FRALT	Finniss River Aboriginal Land Trust
HSE	Health Safety and Environment
LFA	Landscape Function Analysis
NT EPA	Northern Territory Environmental Protection Authority

NT	Northern Territory
NTG	Northern Territory Government
RMP	Revegetation Management Plan
TRARC	Tropical Rapid Appraisal of Riparian Condition
WMP	Weeds Management Plan
WRD	Waste Rock Dump
WRDF	Waste Rock Dump Footprint
WSF	Water Storage Facility

Contents

1. Introduction

The Northern Territory Government, represented by the Department of Industry, Tourism and Trade (DITT), in partnership with the Commonwealth of Australia represented by the Department of Industry, Science, Energy and Resources (DISER) proposes the rehabilitation of the former Rum Jungle Mine and associated satellite sites (Rum Jungle Rehabilitation Project). Revegetation of the sites using endemic species will form a major part of this rehabilitation project.

1.1. Scope

This Revegetation Management Plan (RMP) provides a detailed framework for the implementation of the revegetation of the former Rum Jungle Mine, including satellite sites Mt Burton and Mt Finch, and all borrow areas. The RMP describes the revegetation timeline, including the implementation phase (Stage 3 – construction and stabilisation) and long-term ongoing management (Stage 4). The plan details the categorisation of the site into several revegetation domains that reflect the organisation of the landscape and desired rehabilitation outcomes and also covers sourcing of materials, species selection, seed collection, plant propagation and revegetation techniques. Ongoing management of the revegetation is included, focussing on weed control, feral animal control, erosion control and fire management.

Effective monitoring and evaluation and an integrated adaptive management approach are central to the RMP, this includes setting species diversity and density targets and defining completion criteria in line with rehabilitation objectives.

1.2. Objectives

The overall objectives of the Rum Jungle Rehabilitation Project are to:

- ***Improve the environmental condition onsite and downstream of site within the EBFR***; and
- ***Improve site conditions to restore cultural values.***

The RMP will support the achievement of these objectives. The primary objective of the RMP is to:

Return site landforms to safe, stable, and self-sustaining systems using endemic plant species to stabilise constructed surfaces and restore appropriate functional living systems across the entire site.

To achieve this, all historically and planned disturbed areas will be revegetated using suitable species and appropriate site-specific establishment and management techniques. Meaningful Indigenous involvement and consultation is core to the RMP.

The RMP aims to meet regulatory frameworks and provide specific guidance for implementation and management. Important issues of direct relevance to the revegetation are dealt with in detail throughout the RMP and each section is designed to be used as a practical guide.

1.3. Background

The Rum Jungle mine-site was previously rehabilitated in the mid 1980's and revegetated using introduced pasture grasses and legumes, and large amounts of agricultural fertiliser. Most of these species are no longer prevalent, and the site is now largely dominated by Gamba Grass in all areas of prior disturbance, which is widespread in the surrounding area. The invasion of Gamba Grass has contributed to the failure of the previous revegetation and continues to pose one of the most significant threats to the success of this current rehabilitation project.

Mine site revegetation techniques have evolved significantly in the 35 years since and there are several local examples of successful revegetation projects implemented using local endemic species. Woodcutters Mine, approximately 15km east of Rum Jungle, has been progressively rehabilitated over the last 20 years with good overall revegetation outcomes. Woodcutters came up against many of the same issues that exist at Rum Jungle therefore lessons can be learned. Brock's Creek, Union Reef and Princess Louise are all mine-sites in the Pine Creek/ Hayes Creek area, approximately 100km southeast of Rum Jungle that have been partly rehabilitated over the last 20 years. Although all these sites still have ongoing weed and/or erosion issues, the revegetation is performing well over large areas.

The RMP includes learnings gained from these projects and is written with a focus on current best practise mine-site revegetation. Simply put, the recipe for success is:

- Initial weed control
- Good site preparation – materials, shaping, ripping, and armouring
- Ongoing weed control
- High quality seed and seedlings
- Appropriate and balanced species mix
- Well implemented seeding/planting
- Ongoing weed control
- Ongoing erosion control
- Long-term weed control

1.4. Related Dcouments

Background information can be found in:

- Rum Jungle Rehabilitation Project – Draft Environmental Impact Statement (EIS)
- Rum Jungle Rehabilitation Project – EIS – Supplementary Report

The RMP should be read in conjunction with:

- RJP-3-MP-003 Rum Jungle Construction Environmental Management Plan (CEMP) including:
    - RJ3-3-Fr-004 Revegetation Framework
    - RJ3-4-MP-011 Weed Management Plan (WMP)
    - RJ3-4-MP-013 Cultural Heritage Management Plan (CHMP)
    - RJ3-4-P-019 Erosion and Sediment Control Plan (ESCP)
    - RJ3-4-Pr-007 Vegetation Clearing Procedure
    - RJ3-4-Pr-008 Cycad Salvaging Procedure
    - RJ3-4-MP-027 Fire Management Plan (FMP)
    - RJ3-4-MP-008 Feral Animal Management Plan (FAMP)
    - RJ3-4-Pr-009 Rehabilitation Media Stripping and Stockpiling Procedure

1.5. EPBC Act Approval Conditions

At the time of publishing, no EPBC Act approval conditions have been issued. However, this RMP takes into consideration the protected matters for this project and addresses the environmental commitments listed within Section 4 of the Supplement to EIS.

2. Site Overview

The former Rum Jungle Mine is located 6 km north of Batchelor, in the Northern Territory (NT). The Project footprint is comprised of five sites: the former Rum Jungle Mine as well as its associated satellite pits at Mt Fitch and Mt Burton and two planned borrow pits. The main site is adjacent to Territory Resource's Browns Oxide Project, a care and maintenance mine immediately to the west, and is otherwise surrounded by freehold land and the Finniss River Aboriginal Land Trust (FRALT).

2.1. Climate

The climate of the Top End is classified as 'tropical savanna' and is characterised by a distinctly seasonal dry-wet monsoon cycle. The Wet season generally runs from November to April with average rainfall of 1,564 mm and predominantly westerly to north-westerly winds. The Dry season runs from May-October with minimal rainfall and predominantly easterly to south-easterly winds.

The Top End experiences seasonal extreme weather events such as storms, intense rainfall, and strong winds, especially during the Wet season. Cyclones can also occur in the Wet season, affecting coastal and adjacent inland areas.

2.2. Geography and Water Catchment

The project footprint is located within the foothill environments west of the western Arnhem Land sandstone Plateau in the Finniss River catchment on sandstone and granite hills, plains and rises.

As shown in Figure 1, the main Rum Jungle Mine-site and one of the borrow pits are within the catchment of the Finniss River East Branch. Mt Fitch and Mt Burton are adjacent to the West Branch, and the remaining borrow area is adjacent to Meneling Creek (which flows into the West Branch).

The West Branch (and the main Finniss River) is a large, permanent watercourse. It typically has steep banks (3 to 5 m high) that are terraced, a relatively extensive floodplain, and is characterised by sandy, heavily-vegetated levees. There are billabongs associated with the watercourse and floodplains, and downstream it flows through the Finniss River Coastal Floodplain, a national Site of Conservation Significance.

The East Branch is a semi-permanent stream within a distinct channel that dries to a number of pools in the late dry season. The East Branch riparian corridor typically merges rapidly with surrounding Eucalypt woodland areas; there is little to no surrounding floodplain.

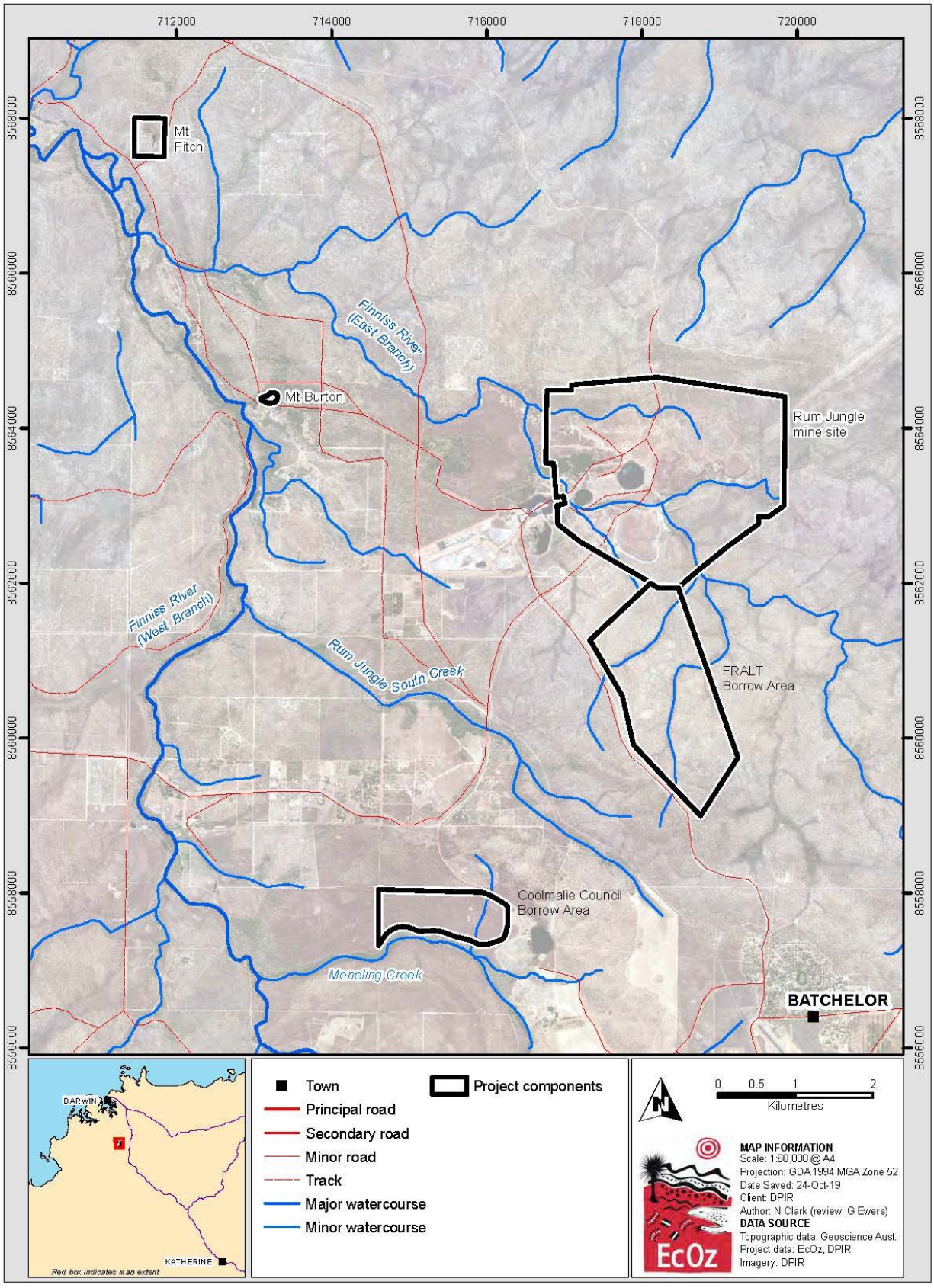

Figure 1 Rum Jungle Rehabilitation Project Footprint

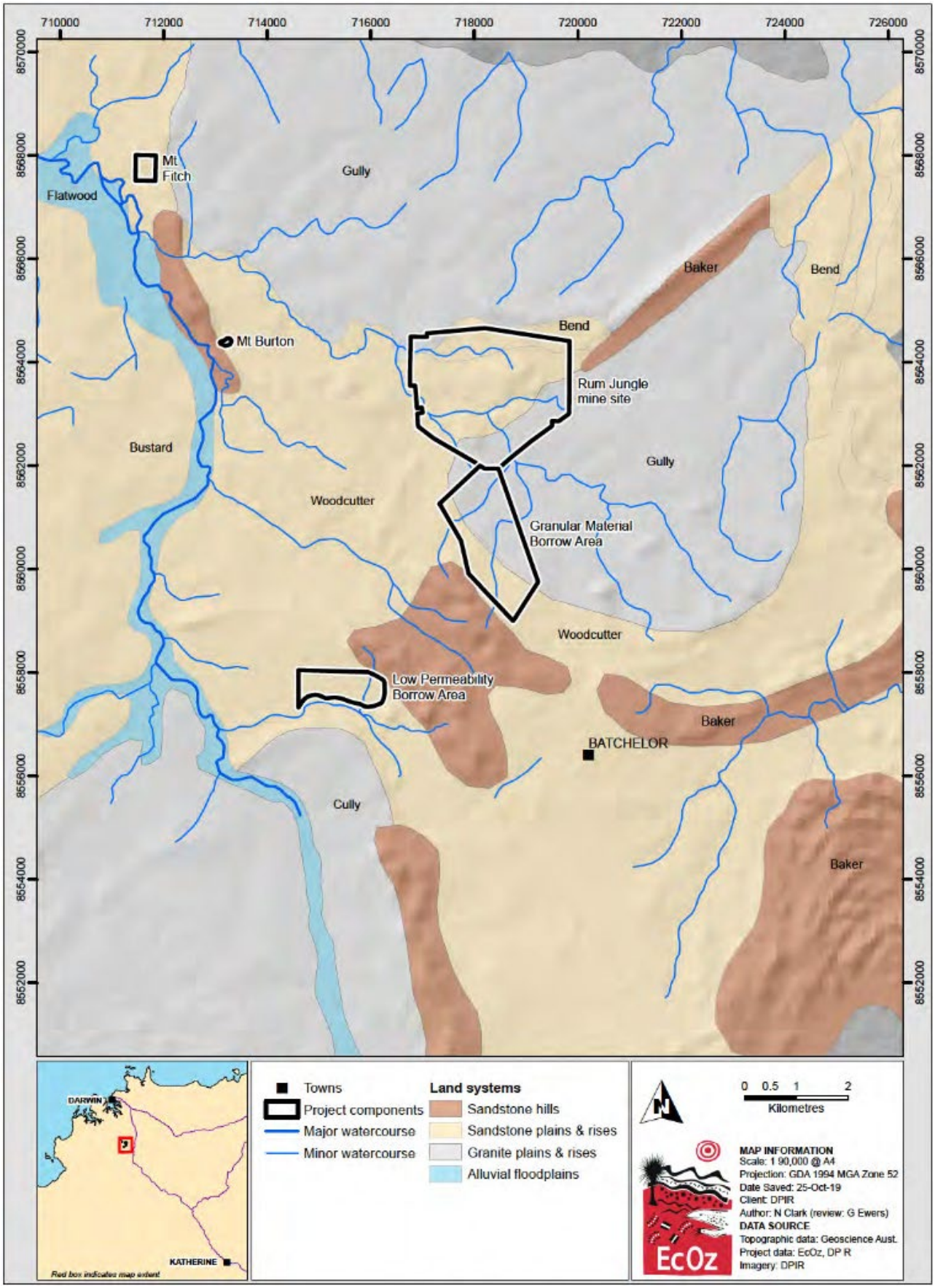

Figure 2 Land system classes within the project footprint

2.3. Flora

The vegetation in the project area is typical Top End savanna, dominated by woodland with discreet areas of water dependent vine thicket and thin riparian corridors, and areas of low lying intermittently seasonally inundated gullies, small floodplains and swampy areas. Vegetation surveys conducted in the project area:

- Riparian Vegetation mapping - Metcalfe (2002)
- Riparian Vegetation mapping - Hydrobiology (2013)
- Vegetation Mapping - Eco Logical (2014)
- Vegetation Mapping of Mt Burton - Metcalfe (2002)
- Vegetation Mapping Mt Fitch - GHD (2009)
- Vegetation Mapping of the Granular material borrow area - EcOz (2019)
- Low permeability material borrow area - EcOz (2019)
- Weed surveys - Wild Man (2011-12) and repeated by
- Weed Surveys - EcOz (2018)
- Broadscale Vegetation Mapping - Christian and Stewart (1968)

Metcalfe (2002) identified and described 10 vegetation communities for the region – see Figure 3. The dominant vegetation comprises mainly *Eucalyptus*-dominated woodland and open woodland communities (59% of survey area). This vegetation community – also known as savanna – is common, widespread and characteristic of the region generally. The remaining vegetation was predominantly riparian habitats, *Lophostemon* communities associated with low-lying drainage areas and Ghost Gum open woodlands and Paperbark communities on surrounding floodplains. Eco Logical (2014) recorded 29 vegetation communities within the mine site (see Figure 4). These can be assigned to five broad vegetation groups:

Woodlands comprised the largest vegetation group, and occur in the north, south and east areas. The most commonly-represented vegetation map units are *Eucalyptus tetrodonta* and *E. miniata* open woodland (map unit 8), and *Eucalyptus tetrodonta*, *E. miniata* and *Erythrophleum chlorostachys* woodland to open forest (map unit 10). These two are very similar in composition, but the former is generally more open and often lower in stature. Map unit 10 (occurring across 75 ha, mostly in the north and northwest of Rum Jungle) comprised the tallest and densest Eucalypt woodlands on the mine site. The soils are likely to be deeper than those of the other Eucalypt woodlands in the area. Typically, species composition and stand structure of woodlands in the Top End are influenced by the soils, especially by their degree of saturation in the Wet season; however, the more recent invasion of Gamba Grass, and changes to the frequency and intensity of fires, are now primary influences in determining species' composition and stand structure.

Grassland communities in the centre and western areas, typically invasions of either previously-rehabilitated or degraded former woodlands by Gamba Grass or other weeds.

Riparian zones and wetlands occur in small areas throughout much of the mine site, and encompass riparian corridors of streams and creeks, and alluvial plains.

Vine forest dominated by *Acacia auriculiformis* occurs as a large patch (~16 ha), and a number of smaller degraded remnant patches, within the vicinity of north of the Intermediate Pit.

Other vegetation occurs as areas of sparse and patchy regrowth – including batter slopes, old disused tracks and other clearings.

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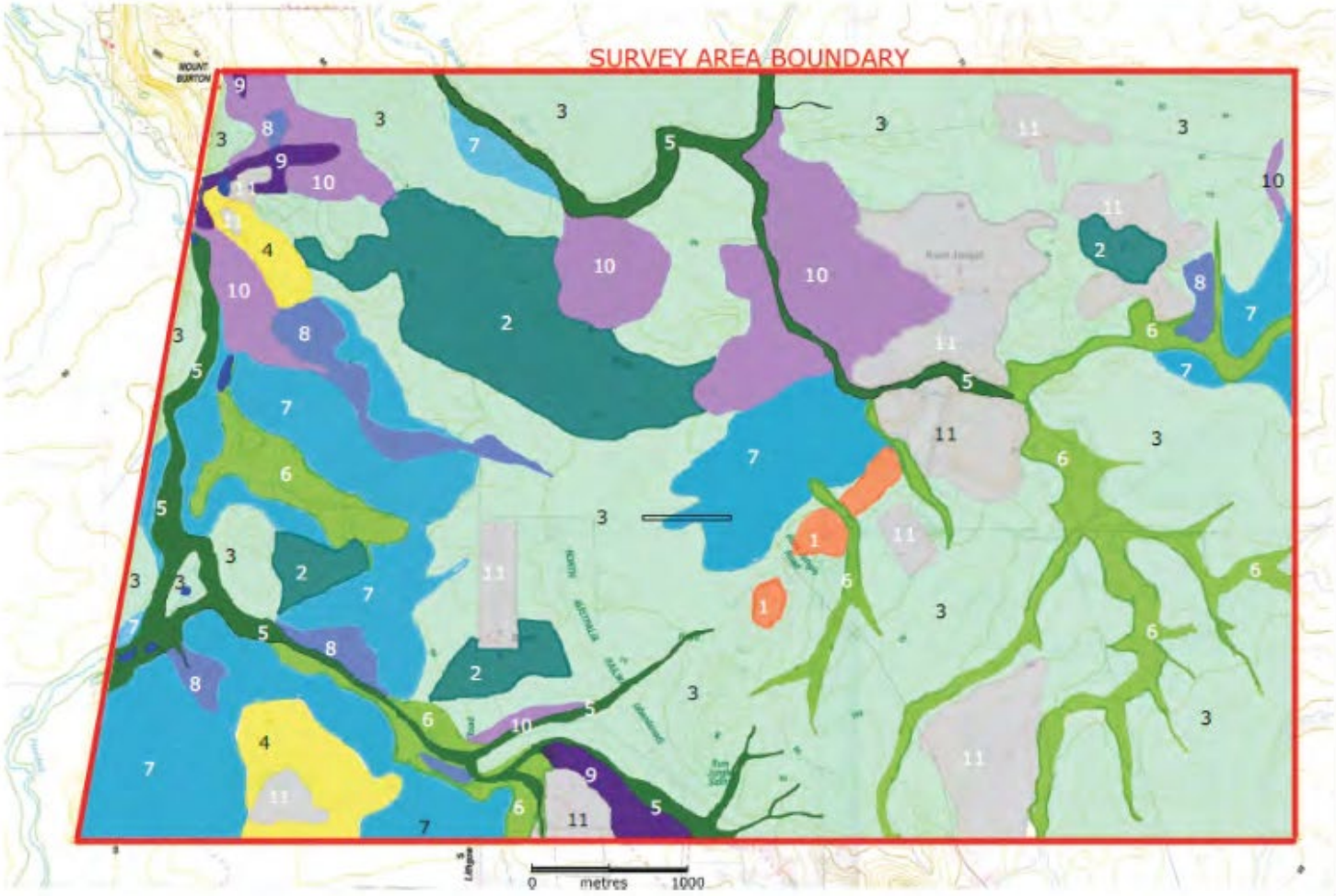

KEY - VEGETATION MAP

BROWNS POLYMETALLIC PROJECT

MAP UNIT	VEGETATION COMMUNITY
	UPLAND EUCALYPT COMMUNITIES
1	*Eucalyptus phoenicea/E. blaxeri* open woodland
2	*Eucalyptus tetrodonta/ E. miniata/ Erythrophleum chlorostachys* woodland
3	*Eucalyptus tetrodonta/ E. miniata* open woodland to woodland
4	Mixed Eucalypt woodland
	DRAINAGE AREAS
5	Riparian corridor
6	*Lophostemon* open woodland communities
7	*Eucalyptus papuana/E. foelschiana/ Melaleuca* spp. open woodland
8	Paperbark woodland to open woodland communities
	MONSOON FOREST COMMUNITIES
9	Monsoon vine-forest
10	*Acacia auriculiformis* woodland communities
	OTHER
11	Previous mining areas, disturbed sites & rehabilitation areas

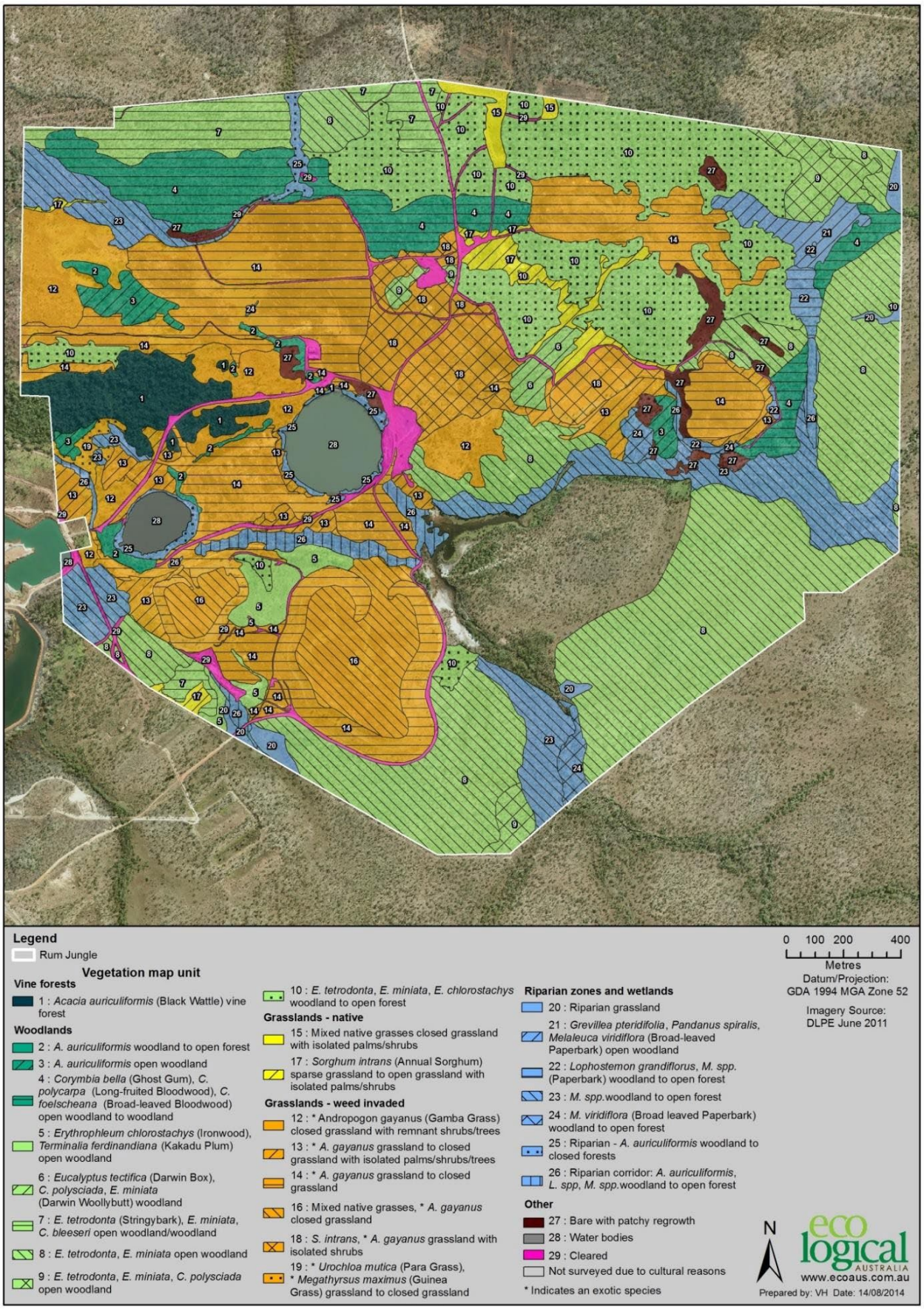

Figure 4 Rum Jungle Mine vegetation units (Eco Logical 2014)

3. Domain Based Strategy

The Rum Jungle Stage 3 Rehabilitation Project area has been divided into several Revegetation Domains that reflect the organisation of the landscape and desired rehabilitation outcomes. Revegetation Domain definitions have been developed by comparing vegetation units and analogue sites from surrounding, relatively undisturbed, areas with vegetation units in disturbed zones to form modified vegetation types suitable for each area of disturbance.

Specific revegetation strategies have been developed and refined for each domain to meet the previously-established objectives for each area. Each domain has its own detailed species list as well as site preparation and implementation methodologies. Revegetation Domains are grouped according to their functionality – Ecological Restoration or Stabilisation – and their vegetation type.

Revegetation Domain areas are shown in Figure 5 with a summary in Table 1.

3.1. Stabilisation Domains

The purpose of Stabilisation Domains is to provide long-term stability to protect the low permeability capping system and help protect underlying material from any intrusion. Revegetation will aim to provide long-term vegetative cover to improve resistance to erosion, using relatively shallow-rooted, local endemic species. Deep rooted species will be excluded as they are more likely to impact the integrity of the underlying compacted barrier layers. Bush tucker species will also be excluded to reduce potential impacts on human health. The stabilisation domain areas are:

WSF Batters – the sloped outer batter surfaces of the WSF. To be revegetated as modified Open Woodland / Low-lying Woodland

WSF Plateau – the flatter top surfaces of the WSF. To be revegetated as modified Open Woodland

Dyson's (backfilled) Pit – the new surface developed after removal of the copper extraction materials and soil. To be revegetated as modified Riparian / Low-lying Woodland

Stabilisation Domains will include:

- 0.5 m low permeability barrier layer
- 2.0 m store and release growth medium layer
- Internal capillary breaks/drainage layers
- Topsoil patches
- Rocky mounds as "habitat nodes" on flats and plateaus
- Rock mulching and armouring of drainage structures to improve erosion protection
- Surface water drainage systems to safely convey plateau area catchment down to natural surface
- Diverse range of low growing local endemic open woodland species (over 40 species)
- Preference for shallow-rooted species to minimise root penetration of low permeability layer
- Preference for low bio-mass grass species to reduce long term fire risks
- No bush tucker plants to avoid any long-term exposure pathway for metals to the environment or people.

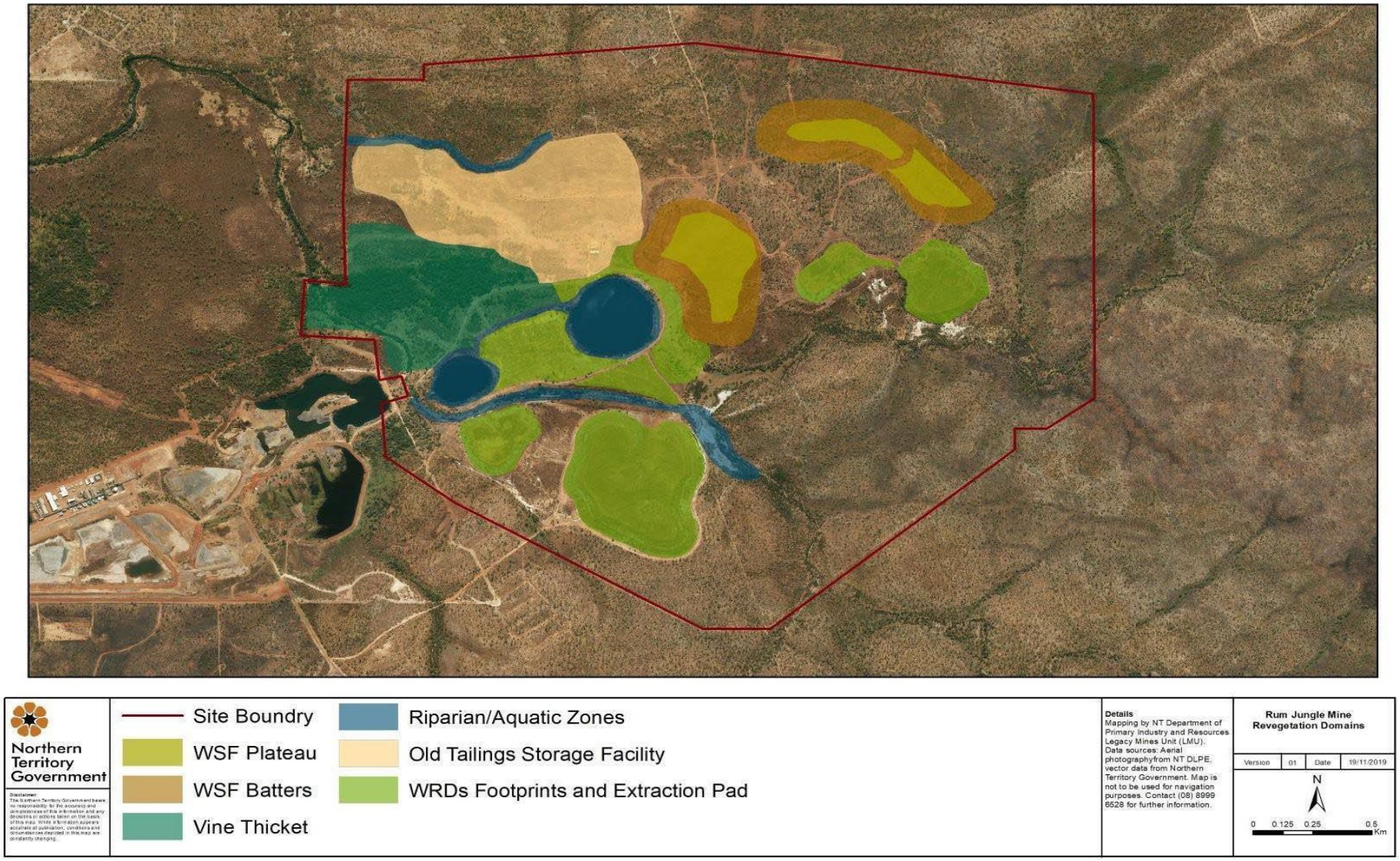

Figure 5 Rum Jungle Revegetation Domains

Table 1 Rehabilitation Domains

Revegetation Domain	Objective	Area (ha)	Gradient (%)	Growth Medium	Habitat Nodes*	Target Vegetation Type	Limitations	Map Units	Revegetation Techniques
WSF Batters	Stabilisation	48	25	Yes	Nil	Open woodland / Low-lying woodland	Mid-storey shrubs and understorey species only No bush tucker	2,3,4,5,6, 7,8,9,10	Primarily direct seeding Some tubestock planting
WSF Plateau	Stabilisation	24	0-5	Yes	RM	Open woodland / Low-lying woodland	Mid-storey shrubs and understorey species only No bush tucker	2,3,4,5,6, 7,8,9,10	Primarily direct seeding Some tubestock planting
Dyson's (backfilled) Pit	Stabilisation	6	0-5	Yes	RM	Riparian / Low-lying open woodland	Mid-storey shrubs and understorey species only No bush tucker	20,21,22, 23,24,25, 26	Primarily direct seeding Some tubestock planting
WRD Footprints inc Cu Extraction Pad	Ecological restoration	61	0-5	Yes	RM, LG, PS	Open woodland / Low-lying open woodland	All species	2,3,4,5,6, 7,8,9,10	Primarily direct seeding Some tubestock planting
Old Tailings Dam	Ecological restoration	32	0-5	No	RM, LG, PS	Open woodland / Low-lying open woodland	All species	2,3,4,5,6, 7,8,9,10	Primarily direct seeding Some tubestock planting
Vine Thicket	Ecological restoration	25	0-5	No	LG	Vine Thicket	All species	1	Tubestock planting following extensive weed control
Riparian (EBFR, EFDC, Main Pit)	Ecological restoration	15	0-10	No	LG, PS, WD	Riparian	All species	20,25,26	Tubestock planting and direct division
Mt Burton **	Ecological restoration	2	0-5	TBC	Nil	Vine Thicket	All species	1	Tubestock planting following extensive weed control
Mt Fitch	Ecological restoration	2	0-5	TBC	Nil	Open woodland / Low-lying open woodland	All species	2,3,4,5,6, 7,8,9,10	Direct seeding Tubestock planting
Roads	Ecological restoration	Varies	0-10	TBC	LG, PS	TBC	All species	TBC	Primarily direct seeding Some tubestock planting
Borrow – FRALT **	Ecological restoration	60	0-10	No	LG	Open woodland / Low-lying open woodland	All species	2,3,4,5,6, 7,8,9,10	Primarily direct seeding Some tubestock planting
Borrow – CCGC **	Ecological restoration	45	0-10	No	Nil	Open woodland / Low-lying open woodland	All species	2,3,4,5,6, 7,8,9,10	Primarily direct seeding Some tubestock planting

WD – Woody Debris LG – Large Log RM – Rocky Mounds PS – Pandanus Strands

** Final rehabilitation goals to be established with landholder. Minimum will be described in this Table.

3.2. Ecological Restoration Domains

The purpose of Ecological Restoration Domains is to rehabilitate historically disturbed areas, stabilising the landforms and improving habitat values by establishing revegetation of high diversity and structural complexity, using local endemic species. Revegetation will aim to reflect the existing relatively undisturbed habitat around the site.

The Ecological Restoration areas are:

WRD Footprints – The stripped and backfilled surfaces close to natural ground level that will remain after waste rock removal at the existing WRDs. To be revegetated as Open Woodland / Low-lying Open Woodland.

Old Tailings Dam – Stable area that doesn't require any major earthworks. To be used as a trial area to prove establishment techniques and revegetation systems. To be revegetated as Open Woodland / Low-lying Open Woodland.

Vine Thicket – Naturally-occurring vine thicket (including areas of vine forest) north of Intermediate Pit that is heavily impacted by historical disturbance, weeds and fire. To be used as a trial area to prove establishment and management techniques for vine thicket systems.

Riparian – Areas along watercourses that are yet to be constructed (EBFR, Main pit riparian zone) or currently exist in a poor condition.

Mt Burton – Satellite site surrounded by high ecological value monsoon wet forest. The revegetation plan for this area is yet to be agreed with the current landowner.

Mt Fitch – Satellite site that requires minor works to improve and return to Open Woodland.

Roads – Linear structures that pass through many Revegetation Domains. The Revegetation Domain for a road will be specified once the road is nominated for revegetation.

Borrow – FRALT – Potential borrow pit south of Rum Jungle. Agreements for final closure of this landform have not yet been reached with the FRALT. Intended to be revegetated as Open Woodland/ Low-lying Open Woodland.

Borrow – CCGC – Potential borrow pit adjacent to Rum Jungle Creek South. Agreements for final closure of this landform have not yet been reached with the CCGC. Intended to be revegetated as Open Woodland/ Low-lying Open Woodland.

The **Old Tailings Dam, Waste Rock Dump Footprint** (WRDF) and **Mt Fitch Domains** will include:

- 2.0m growth medium layer on WRDF
- Topsoil patches
- Rocky mounds, large logs, and woody debris as "habitat nodes"
- Rock mulching and armouring of drainage structures to improve erosion protection
- Establishment of a diverse range of local endemic open woodland and low-lying woodland species (over 80 species)
- Intensive weed control works to eliminate the large weed infestations (especially Gamba Grass and Grader Grass) already on these sites through a combination of burning, aerial spraying and ground spraying

- Establishment of vegetation by direct seeding once weeds have been adequately controlled/eliminated
- Establishment of recalcitrant and special species by seedling plantings and/or species-specific targeted seeding

The **Vine Thicket Domain** will be focussed on the enhancement and protection of existing remnant patches of vegetation that have been compromised by fragmentation, disturbance and weed infestation. These areas will include:

- Intensive and targeted weed control to eliminate the large existing weed infestations, especially Gamba Grass and Calopo. Weed control needs to be thorough and ongoing to reduce the amount of weed seed surviving in the soil
- Protection from fire
- Encouraging recruitment of existing vegetation
- Rocky mounds, large logs and woody debris and Pandanus stands as “habitat nodes”
- Establishment of a diverse range of local endemic vine thicket and riparian species in degraded areas (over 40 species)
- Vegetation will be established primarily by seedling infill plantings once weeds have been eliminated successfully
- Whole-of-site feral animal control (especially pigs and buffalo) will be an essential element to the establishment of vegetation in these areas

The **Riparian Domain** includes existing degraded riparian corridor and yet-to-be constructed watercourses. It focuses on the controlling of waterflow, and the enhancement and protection of existing remnant patches of vegetation that have been compromised by fragmentation, disturbance and weed infestation. These areas will include:

- Intensive ongoing and targeted weed control works to eliminate the large weed infestations already on these sites
- Protection from fire
- Encouraging recruitment of existing vegetation
- Bank stabilisation and erosion control on drainage lines and steep banks, using rock armouring and jute matting
- Rocky mounds, large logs and woody debris and Pandanus stands as “habitat nodes”
- Establishment of a diverse range of local endemic vine thicket and riparian species (over 50 species)
- Vegetation will be established primarily by seedling infill plantings once weeds have been eliminated successfully
- Direct division techniques will be used to establish specific rushes, sedges and grass species.
- Hydroseeding native grasses may be required in certain areas to provide rapid stabilisation.
- Temporary irrigation of seedling plantings may be required in the early wet season to improve establishment especially in seasonally inundated areas
- Whole-of-site feral animal control (especially pigs and buffalo) will be an essential element to the establishment of vegetation in these areas
- Progressive introduction of surface water flows to allow for a period under lower flow conditions for vegetation establishment and landform stabilisation.

3.3. Vegetation Types

Four broad vegetation types have been defined to be used in the revegetation – based on map unit species lists, domain definitions and a practical understanding of the variations in the surrounding landscape:

- Open Woodland – Open mixed Eucalypt woodland with a grassy understorey and a mid-storey of variable density. Growing on low hills and rises.
- Low-lying Open Woodland – Open mixed Eucalypt woodland with a grassy understorey and a mid-storey of variable density. Growing on low rises, flats, and small valleys, with some areas subject to seasonal inundation.
- Vine Thicket – Open or closed monsoon forest with areas of vine thicket and an otherwise fairly sparse understorey. Growing in discrete areas associated with permanent water, either freshwater streams or an underground water source.
- Riparian – Open monsoon forest with a highly variable mid and understorey, generally growing as a thin band along watercourses.

4. Implementation

The revegetation of the Rum Jungle site will be implemented progressively over 10 years. Revegetation works will be integrated into the construction program, as earthworks are completed in each area it will be direct seeded and/or planted out.

- 171 ha of mine rehabilitation and 105 ha of borrow pit areas will be revegetated primarily by direct seeding.
- 40 ha will be revegetated primarily through the planting of seedlings.

The implementation will build on learnings from other similar local projects. Meaningful Indigenous involvement and consultation will be at core of all revegetation works. This includes employment of traditional owners on the revegetation team, and review of this plan by traditional owners. The implementation is focussed on best practise, and aims to raise the bar in terms of mine-site revegetation in the NT. Initial revegetation trials are being initiated to progress the rehabilitation methodology and build momentum and technical knowledge within the project team.

The Old Tailings Dam area and the adjacent existing vine thicket is earmarked as a starting point for trials to prove the establishment of revegetation systems for the site.

4.1. Revegetation Plan Implementation Schedule

Works	Stage 2b	Stage 3- Scope of work										Stage 4
		Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9	Yr 10	
Planning												
Sourcing of materials												
Site Preparation												
Seed Harvesting												
Nursery propagation												
Seeding and planting												
Weed management												
Fire management												
Feral animal control												
Erosion remediation												
Replanting and reseeding												
Weed, Erosion and Fire monitoring												
Structural species baseline survey												
LFA survey												
Vegetation survey												

Table 2 Revegetation Plan Implementation Schedule

4.2. Annual Implementation Schedule

The success of the revegetation will depend on implementing an ongoing comprehensive annual program that remains flexible enough to work with the variable seasons. Wholistic adaptive management principles will be applied to all aspects of the implementation. The annual schedule (Table 3) aims to maintain momentum throughout the year, as breaks in implementation will often lead to missed opportunities that go far beyond what is immediately obvious.

	JAN	FEB	MAR	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
Tree and shrub seed harvesting							■	■	■	■	■	■
Grass seed harvesting	■	■	■	■								■
Rainforest species harvesting	■	■	■	■	■							■
Nursery propagation	■	■	■	■	■	■	■	■	■	■	■	■
Weed control	■	■	■	■	■	■					■	■
Fire management			■	■	■	■						
Monitoring and evaluation survey work					■	■					■	■
Final shaping					■	■	■	■	■	■		
Deep ripping										■	■	
Habitat nodes											■	■
Direct seeding	■											■
Seedling planting	■	■									■	■

Table 3 Annual Implementation Schedule

4.3. Sourcing of Materials

Sourcing of high-quality materials from on, or close to, the Rum Jungle site will be critical to the success of the revegetation. Detailed here are important issues in relation to the sourcing of materials that are likely to impact on the revegetation program. These points will need to be taken into account when developing construction plans and throughout the construction process.

4.3.1. Growth Medium

A suitable growth medium will be sourced from borrow pits close the Rum Jungle site. The growth medium is to be applied to constructed areas (over the capping layer) prior to seeding/planting to help ensure vegetation can establish and persist. As well as sustaining vegetation, it will have to resist erosion and provide long-term stability.

The Rehabilitation Media Stripping and Stockpiling Procedure RJ3-4-Pr-009 details how all opportunistic rehabilitation media salvaging is to take place. The formal cover system for the WSFs and the backfilled WRD footprints will be substantially sourced from the nearby granular material borrow pit – the management plan for this material is yet to be developed.

To best support the revegetation process, it is important that this growth medium:

- Have sufficient moisture holding capacity to support vegetation over the dry season
- Contain sufficient proportion of gravel and rock
- Is entirely free of weed and weed seed
- Is relatively low in nutrients
- Has appropriate structure and composition

Gravel and rock help to stabilise the landform surface and provide a rock mulch to improve vegetation establishment. The niches created by rocks persist for many years and help to maintain nutrient cycling and volunteer seedlings in the longer term. Rocks also provide habitat for a range of fauna. The size of rocks used in the growth medium is only limited by the machinery used and the slope angle of the revegetation area. Too much, too large rock can exacerbate erosion on steeper slopes rather than providing erosion protection. If material is too course on the whole, it may not provide sufficient moisture holding capacity.

The growth medium should be free of weed and weed seed, as weeds introduced with the material will be very difficult to eradicate. Gamba Grass is of particular concern. Sourcing growth medium material from areas heavily infested with Gamba Grass (including heavily infested adjacent areas) will be managed by

Where it is suspected that Gamba Grass seed remains in the soil, topsoil will be deemed contaminated and pre-stripped to a depth of 150-200mm and windrowed. Weed monitoring and control will continue on these windrowed stockpiles for at least two growing season, and only if Gamba Grass and other serious weeds are able to be eradicated can it be incorporated into the growth medium. This topsoil should not be used as topsoil in the revegetation but can form part of the lower layers on the cover system if it passes geotech specification.

Detailed strategies and procedures for weed control on growth medium borrow areas are detailed in the Rehabilitation Media Stripping and Stockpiling Procedure RJ3-4-Pr-009 and Weed Management Plan RJ3-4-MP-011.

Growth medium should have appropriate structure/texture to support a large range of endemic species, ideally a rocky, gravelly loam with varying amounts of sand, silt and clay. The growth medium should also

be of low fertility – i.e., low in nutrients – to give hardier native species a competitive advantage over introduced weeds, especially Gamba Grass.

4.3.2. Topsoil

Topsoil will be stripped from areas that are required to be cleared for landform construction. Topsoil stripping and storage is covered in the Vegetation Clearing Procedure RJ3-4-Pr-007 and Rehabilitation Media Stripping and Stockpiling Procedure RJ3-4-Pr-009. Weed control on areas prior to clearing and on soil stockpiles will be covered in the Weed Management Plan RJ3-4-MP-011.

The revegetation will benefit greatly from the biological values of topsoil, including symbiotic soil microbes and nutrients, if it is well managed. But weeds can easily be introduced in the topsoil seedbank and impact revegetation success. Weed control, especially Gamba Grass, should be carried out for at least two years prior to clearing. The risk of introducing Gamba Grass seed into the revegetation is greater than the benefit of biological values in the topsoil.

Topsoil will be assessed as part of the pre-clearing site inspection and classified into high grade, low grade and unsuitable. This assessment will be largely based on presence of weeds but will also consider topsoil type and depth and any impact from previous disturbance.

High grade weed-free topsoil sourced during the clearing of borrow areas (and other areas that have had minimal disturbance) will be treated like gold as true weed free topsoil is scarce over the whole project site. The topsoil will be stockpiled and used as soon as practicable by spreading in patches at 0.1 to 0.2m depth (as thin as practically achievable by machine) during the growth medium application process. Topsoil will be stored for as little time as possible to maximise the retention of soil microbes and nutrients and reduce the risk of cross contamination.

Low grade weed-free topsoil sourced during the clearing of previously modified areas will be incorporated into the growth medium upper layers.

Unsuitable weedy topsoil will be pre-stripped and windrowed. Weed control will continue on these windrowed stockpiles, and only if Gamba Grass and other serious weeds are able to be eliminated can it be incorporated into the growth medium or used in the rehabilitation of borrow areas.

4.3.3. Rock

Hard, chemically-benign rock will be used to armour drainage lines and key areas prone to erosion, as well as building rocky mounds as “habitat nodes”. It is important that the rock is entirely free of weeds and weed seed. Strategies for weed control on the quarry and stockpiles are detailed in the Weed Management Plan RJ3-4-MP-011 however responsibility may be passed to the supplier and site contractors.

4.3.4. Logs and Woody Debris

Logs and woody debris stockpiled during land clearing that are not required for the rehabilitation of the borrow areas themselves will be placed in the revegetation areas as “habitat nodes” to encourage fauna colonisation. Habitat nodes are not suitable for steeper WSF batters but will be incorporated into flatter WSF plateaus (out of drainage lines) and the backfilled footprints of the old WRDs.

The material will be placed on revegetation areas during the growth medium application process. The Vegetation Clearing Procedure RJ3-4-Pr-007 will describes the sourcing of this material.

It is important that the material is entirely free of weeds and weed seed. Log and woody debris that contain weeds should be stockpiled separately and used in the revegetation of the borrow pits once key weeds have been eliminated.

High quality material should be separated into two separate stockpiles; larger logs for use on flats and plateaus, and smaller material for use on batters (larger logs should not be placed on batters as they can impede accurate contour ripping.

4.4. Site Preparation

Site preparation provides the foundation for the revegetation and good site preparation is imperative for revegetation success. The two primary aims of site preparation are to optimise plant establishment and minimise soil erosion.

The site preparation has been divided into four types, based on the domain areas:

- Stabilisation Domains
- Ecological Restoration Domains – Constructed
- Ecological Restoration Domains – Vine thicket / Riparian infill areas
- Ecological Restoration Domains – Vine thicket / Riparian constructed areas
- Site preparation will vary greatly between these different domain groups.

4.4.1. Stabilisation Domains

Site preparation for stabilisation areas will focus on creating stable landforms to provide long term protection to the low-permeability layer and will include:

- Shaping of final landform
- Spreading of growth medium layer
- Application of soil ameliorants if required, though at this stage no plans to amend soil
- Installation of surface water drainage system
- Dumping and spreading of topsoil patches
- Rock mulching
- Installation of “habitat nodes” (rocky mounds)
- Surveying of contours
- Deep ripping along contours
- Weed control works undertaken as required.

4.4.2. Ecological Restoration Domains – Constructed

Site preparation for these areas will focus on creating a stable landform that is able to support diverse and complex revegetation and provide potential habitat for local fauna. Works will include:

- Shaping of final landform
- Spreading of growth medium layer where required
- Application of soil ameliorants if required, though at this stage no plans to amend soil

- Installation of surface water drainage system
- Dumping and spreading of topsoil patches
- Installation of “habitat nodes” (rocky mounds, woody debris and large logs)
- Surveying of contours
- Deep ripping along contours
- Maintaining fire exclusion infrastructure and processes
- Weed control works undertaken as required.

4.4.3. Ecological Restoration Domains – Vine Thicket / Riparian Infill Areas

Site preparation for these areas will focus on intensive weed control, fire exclusion and protection of existing remnant vegetation. Works will include:

- Ongoing intensive weed control
- Identification and tagging of existing native saplings
- Concentrated and careful weed control around tagged saplings
- Maintaining fire exclusion infrastructure and processes
- Installation of “habitat nodes” (rocky mounds, woody debris, large logs and Pandanus stands).

4.4.4. Ecological Restoration Domains –Riparian Constructed Areas

Site preparation for these areas will focus on creating a stable landform that is able to channel stream flows, support diverse and complex revegetation, and provide potential habitat for local fauna. Works will include:

- Shaping of basic creek bed and overbank landform including structures required by the aquatic ecologists to support fish passage
- Installation of surface water erosion and sediment control system
- Rock armouring of banks and drainage lines as required by the ESCP
- Rock mulching of banks and creek bed as required by the ESCP
- Spreading of growth medium layer where required
- Application of soil ameliorants if required, though at this stage no plans to amend soils
- Dumping and spreading of topsoil patches
- Installation of “habitat nodes” (rocky mounds, woody debris and large logs)
- Surveying of contours
- Installation of jute matting as required
- Weed control works undertaken as required
- Irrigation installed if required to support initial phases of vegetation establishment.

4.5. Domain Specific Species Mixes

A seed mix and seedling mix will be developed specifically for each domain and adapted and refined for different areas within that domain as required. The amount of seed / number of seedlings required differs for each species and for each site.

Stabilisation Domains will be direct seeded and infilled with seedlings of recalcitrant species. The species mix used for these domains will be relatively shallow rooted to minimise root penetration of the low permeability layer. A survey to determine the root depth of some key species will be initially required to confirm the exact species mix for this domain. Bush tucker species have also been excluded from Stabilisation Domains to avoid any long-term exposure pathway for radionuclides or metals to the environment or people.

The Vine Thicket and Riparian Ecological Domains will be predominantly planted with seedlings of a diverse range of trees and shrubs, with some small areas of direct seeding and direct tiller division.

The remaining Ecological Domains will be direct seeded with a diverse range of trees, shrubs, grasses, and herbs, and infilled with seedlings of recalcitrant species.

4.5.1. Seeding Rates

The initial overall seeding rates are based on previous successful projects in the Top End but may need to be refined over time based on site specific revegetation data:

- 4kg/ha Tree and Shrub seed
- 3kg/ha Grass and herb seed

Due to the exclusion of deep-rooted species in the Stabilisation Domain, and the requirement for increased erosion protection, the tree and shrub seed rate will be reduced, and the grass and herb seed rate will be increased. These rates could change based on the outcomes of the initial Root Depth Baseline Survey (section 6.6), depending on the exclusion/inclusion of suitable species.

- 2kg/ha tree and shrub seed
- 10kg/ha grass and herb seed

Within each of these categories, each individual species has a specific seeding rate expressed as kg/ha.

The amount required is based on:

- Target density numbers for each species in the revegetation (expressed as plants/ha for trees/shrubs and % cover for grasses/herbs)
- Number of viable seeds/gram for that species/seedlot (% viability X seeds/g)
- Expected % successful recruitment for each species
- Domain specific limitation/requirements.

In the early stages of the project, decisions on seed amounts will be based on results of local baseline vegetation surveys and knowledge gained from previous projects in the Top End of the Northern Territory. As the project progresses and revegetation survey results become available from previous years, the recruitment success of each species can be better understood, and the g/ha or seedlings/ha can be adjusted to better reflect the desired plants/ha.

It is worth noting that success of individual species in the revegetation can vary greatly between years depending on the quality of site preparation and climatic conditions (primarily amount and timing of rainfall

through the wet season). Each species has a different set of ideal growth conditions and a good year for some species may be a poor year for others. Survey results from multiple years are required in order to get more accurate picture.

4.5.2. Seed Species Mix

A balanced species mix is critical to the success of a revegetation project. The mix is divided into four main categories and as a guideline set of proportions:

- Acacias - 20%
- Eucalypts/Corymbias - 30%
- Grasses/Herbs - 20%
- Other Species - 30%.

The species mix should be seen as a baseline on which to build and that should be refined and improved over time based on learnings from previous years; adding new species, removing species, adjusting seeding rates for individual species and trialling seed treatments for recalcitrant (hard to establish) species as required.

Domain specific requirements will govern this process. Generally, the higher the number of suitable species that can be successfully established, the more robust the revegetation.

Acacias (20% of seed mix)

- Early colonisers
- Important role in early soil improvement and nutrient cycling
- Nitrogen fixing
- Vigorous and can often dominate a rehabilitation site if the seeding rate is too high
- High fuel load and prone to fire after approx. 5-10 years growth.

Acacias should make up no more than 20% of a species mix. Diversity of Acacia species is very important and there should be a focus on species that are less likely to form monocultures, or completely dominate a site.

Eucalyptus / Corymbias (30% of seed mix)

- Long lived, main structural species in most open woodland/savannah land types
- Critical to the long-term stability of rehabilitation areas
- Shy, slow growing seedlings and low recruitment rates
- Seed is prone to getting buried or washed away.

Eucalypts should make up at least 30% of species mix to ensure adequate stems/ha. For the Stabilisation domains, lower proportions of deeper-rooted Eucalyptus and Corymbias will be required.

Other Species (30% of seed mix)

- A large range of species reflecting the diversity of the project area
- Usually further divided into ‘Other Species – Big Seed’ (approx. 65% of other species) and ‘Other Species – Small Seed’ (approx. 35% of other species) to help balance seed mix.

- Each species has its own requirements regarding seeding rate, seed treatment, storage issues etc.
- Many species, such as Terminalia, Cochlospermum, Erythrophleum, Buchania, Petalostigma, Kurrajong, and Calytrix have low recruitment rates and can be hard to establish in rehabilitation areas.
- There are a number of species that are extremely hard to establish by direct seeding and are better suited to alternative establishment techniques, such as nursery propagation

Other Species should make up no less than 30% of species mix, with a focus on natural colonisers, long-lived structural species and species that create the 'character' of the area or have special meaning.

Grasses (20% of seed mix)

- Many grasses are natural colonisers
- Important role in erosion control, early soil improvement and nutrient cycling
- Seeds often have a post ripening dormancy, so must be stored for a dry season before they can be used
- Some species, especially *Heteropogon contortus* are extremely vigorous and can dominate rehabilitation areas if the seeding rate is too high
- Many grass species have a high fuel load and can make rehabilitation prone to burning. Using low biomass grass species reduces this fire risk.

Grasses should make up around 20% of the species mix, with a focus on diversity and low biomass species, to help reduce fire risks.

4.5.3. Seedling Amounts

A nursery species target list has been constructed to prioritise the propagation of plant species for inclusion in the annual revegetation works. The seedling amounts required will be calculated as part of the planning process for each specific area. Quantitative baseline data of species composition will be collected as part of the Stem Density Baseline Survey (section 6.6) and will guide an ideal stems/ha target value for each of the core nursery species. Approximately 2000 seedlings per hectare will be required for vine thicket and riparian domains and 30 seedlings per hectare for direct seeded areas.

4.6. Species Lists

Species lists have been developed specifically for each domain and presented as a **Species Matrix** (Appendix A) that can be adapted to each domain. Also developed is a **Harvest Target Calculator** (Appendix B) with separate adjustable species mixes for each domain group. These tools will assist in planning and budgeting and will also be able to be used by the harvest team.

It is important to view these initial species lists as a base upon which to build and the species list for each domain should be re-evaluated from time to time as new information becomes available. Making changes, such as selecting new species, removing species, or changing establishment techniques for individual species, should be based on local vegetation surveys, and advice from Traditional Owners and other knowledgeable people. All local species can potentially be evaluated, but should only be included where there is a reasonable chance of 1) successful harvesting and/or propagation, 2) successful recruitment, 3) positive contribution to the revegetation.

Note: It can be worth adding difficult species in very small quantities if they are expected to persist and provide a long-term positive contribution. It is also worth investigating techniques that justify the inclusion

of very difficult or recalcitrant species, such as: seed treatments, soil inoculants, creating micro-climates in the rehab, growing small numbers in nursery and planting seedlings in dense patches etc.

The Species Matrix is attached as an Excel spreadsheet in Appendix A. The matrix details how and where each species will be used in the revegetation.

The Harvest Target Calculator is attached as an Excel spreadsheet in Appendix B. The calculator sheets can be adjusted by changing the Revegetation Ha cell and the Kg/Ha cells for each species.

4.7. Ecological Considerations

4.7.1. Volunteer Species

Volunteer species are those that are not purposefully seeded. These species are primarily introduced through topsoil but can also be blown in by the wind, brought in by birds or animals, or inadvertently introduced in the locally-harvested native grass seed. Many volunteer species are important natural colonisers and contribute significantly to rehabilitation. Many of these species are also very difficult to establish in any other way. There will be many ephemeral and elusive volunteer species that have not yet been captured on the species lists. Good topsoil management is critical to the inclusion of these species.

4.7.2. Long-Lived Structural Vegetation

Eucalypts and *Corymbias*, as well as a handful of other species such as *Erythrophleum* and *Alstonia*, are the largest and longest-lived species in the Ecological Restoration Open Woodland Domains. They also dominate the surrounding natural vegetation, which is predominantly Open Woodland. They form the 'structure' of the vegetation in the long term. They are fire resistant, and create important habitat, including tree hollows, for a variety of fauna. For these reasons, it is very important that long lived species establish in sufficient numbers in the rehabilitated areas. Setting specific target numbers, in terms of number of stems per hectare, for this group of species will be an important early step.

Most of the upper storey species in the Vine Thicket and Riparian Domains are long-lived structural species. Targets will be set for number of stems per hectare for these species based on the Stem Density Survey in healthy example of similar vegetation types in the surrounding area.

Almost all of the most common, long-lived structural species will be excluded from Stabilisation Domains due to their tendency to be deep rooted. Long-lived mid-storey species will be assessed in the Root Depth Baseline Survey, to ensure they are suitable for inclusion, and then seeding rates adjusted accordingly.

4.7.3. Habitat Nodes

"Habitat Nodes" – including rocky mounds, woody debris and Pandanus stands – will be positioned throughout ecological restoration domains to provide habitat and encourage fauna utilisation of newly revegetated areas. Placement and spacing of these "Habitat Nodes" will be decided during implementation depending on availability of resources and suitable locations. Not disturbing large trees, hollows and existing rock outcrops will be a priority during ground disturbance work however should these resources be available to revegetation, they will be efficiently utilised. A target number for each type has been included here to assist in project planning at Table 4. Note that rocky mounds material can be bought in from existing quarry suppliers and as such this target is achievable.

Nodes are also only suitable for flatter areas as they may exacerbate erosion on steeper slopes.

Habitat Node type	Function	Target number
Rocky mound	Habitat and potential burrows for mammals and reptiles	100
Woody debris	Habitat and potential burrows for mammals and reptiles Organic material foraging habitat	100
Large logs	Habitat and potential dens / burrows for mammals and reptiles	50
Pandanus stand	Shelter and nesting habitat for birds and mammals	100

Table 4 Habitat Nodes

4.8. Seed Harvesting Strategy

A large amount of native seed is required for the Rum Jungle Rehabilitation project. For projects of this size, a coordinated strategy is required to ensure a quality and diverse seed mix. One of the main limiting factors for large scale revegetation projects is seed availability in the landscape. This is because the required amount of seed for each species will not always be available in any given year, due to the unpredictable nature of climate and other factors. Working to a long-term seed strategy with flexible provenance zones help to maximise productivity and seed availability.

The seed requirements for the Rum Jungle Mine project are detailed below:

Rehabilitated Areas	Ha	Tree and shrub seed (kg)	Grass and herb seed (kg)
Ecological direct seeded areas	93	372	279
Stabilisation areas	78	156	780
Vine Thicket and Riparian Areas	40	5	80
Borrow pit areas	105	420	315
Total	**316**	**953**	**1,454**

Table 5 Seed Requirements

Seed availability and supply is seasonal and requires a long-term planning approach. For large projects, taking a long-term view is recommended using three-year work plans.

Typical harvest times are:

- Tree and shrub season: July – December
- Grass season: December – May
- Rainforest and bush tucker species: December – May

A focused but flexible harvest strategy will enable the seedbank to meet the immediate annual revegetation needs, while also taking advantage of good crops of key species as they occur. It is common for many species to only seed well every 2-3 years, so setting longer term targets is necessary to ensure that all species can be collected in the required quantities.

A proven harvest strategy is to focus on collecting enough seed of all species for the current year's planned revegetation, while also working to a set budget for opportunistically collecting good crops of key species as they occur. As the years progress and the seedbank is built up, urgent annual seed harvesting requirements will be reduced, and the focus can shift to harvesting harder-to-get species.

When it becomes apparent that a species will be unavailable or in short supply, adjustments will be made to the seed mix for that year, and the harvest targets will be updated. An easily managed harvest target spreadsheet (Appendix B Harvest Target Calculator) has been created. The harvest target calculator includes a separate adjustable species mix for each domain group – to assist in planning and budgeting – and is also able to be used in real time by the harvest team.

Building a seedbank for a large-scale revegetation project is a long-term investment and requires long-term planning. The seedbank is best seen as a living thing, which needs to be continually cared for, evaluated, and maintained. A three-year harvest target plan has been developed and will be re-evaluated at the end of each calendar year (after the direct seeding and planting for that year has been completed).

Seed collecting permits will be obtained for all harvesting activities.

4.8.1. Building the Harvest Team

Local native endemic seed will be harvested specifically for the project. A team of local Indigenous land managers are currently being trained to help with the seed collection, which will be co-ordinated by local, experienced seed collectors/suppliers. The harvest team will be made up predominantly of trainees from this group and other local Aboriginal people. Any seed that is unable to be harvested by this team will be sourced from a commercial Northern Territory native seed supplier.

Commercial-scale seed collecting involves considerable technical skill, experience and specialised knowledge. It takes 2-3 years to become proficient in many of the skills involved, much like an apprenticeship. Seed harvesting work is physical and highly seasonal, much like farm or station work, so suits individuals or family groups that prioritise a flexible, seasonally-based lifestyle. The local Indigenous harvest team will be supported through ongoing training, seasonal casual employment, sub-contract arrangements for seed supply and business mentoring. Tools and equipment will be made available to all team members.

Over the period of this project, it is hoped that some of the harvest team can become fully competent, trained seed collectors and continue to contribute to the native seed and land restoration industries into the future.

4.8.2. Provenance

All seed and propagation material will be sourced from the local area to ensure that it is suitable for the site and the genetic integrity of the revegetation is maintained.

All seed and material should be sourced from as close to the mine as practicable. The following should be used as a provenance harvesting guideline to maximise the chances of successful harvest while still maintaining the quality and genetic integrity of the seedbank:

- As much seed as possible should be harvested from the area immediately adjacent to the site, especially the Finniss River Aboriginal Land Trust which surrounds the mine.
- Seed that cannot be sourced from the immediate area should be harvested within the Finniss River, Reynolds River, Adelaide River, Darwin River, Blackmore River and Elizabeth River catchments.
- It is often necessary to harvest some species from further afield in some years due to limited local availability. It is common for species to seed well in one area but not at all in another nearby area. Where this is the case seed should be harvested within a 200km radius of the site.
- To build in climate change resilience – collection of seed from areas closer to Katherine might improve the genetic diversity and resilience to drier condition in the long term.

4.8.3. Harvesting

Most tree and shrub seed in Northern Australia is collected by hand. To ensure seed quality and harvest efficiency, it is important to use high quality professional equipment and have experienced collectors on the team. Local knowledge is imperative, as is the ability to gauge seed quality and ripeness and knowing when and how to collect.

For this project, the following techniques will be used:

- Long pole tree pruners to collect most tree species. A cherry picker will be used in conjunction with a long pole for very tall trees.
- Some tree and shrub species will be shaken onto shade cloth.
- A range of species will be picked by hand or with secateurs into a bucket or bin.
- Some grass species will be harvested with a sickle.
- Most native grass species will be harvested using a mechanical brush harvester towed behind a quad bike or an ATV.

4.8.4. Processing

Initial processing takes place in the field using sieves, bins and weed matting:

- Many species require drying of fruits/nuts/pods to release seed. Other material is then removed from seed by sieving and hand winnowing.
- Most Acacia species and some others are sieved by hand immediately after harvest.
- Many grass species and some other species require drying immediately after harvest to reduce seed moisture content to acceptable levels.

Small processing equipment is generally used for the final cleaning of native plant seeds:

- Sieves that fit inside plastic 70L plastic rubbish bins are initially used remove large sticks/leaves and fine dust.
- Threshing machines are used for some species to remove seed from pods.
- A winnower machine that uses a series of sieves and controlled air to remove lighter seeds, insects, small sticks and rocks and other contaminants is used.
- A final, hand cleaning, quality control stage removes any extra impurities.
- Grass seed is generally bulky and hard to clean through most machinery. This is hand cleaned or put over a shaker table (large mechanical sieve) to remove impurities.

Seed needs to be high quality and processed to industry standard before fumigating and storing.

4.8.5. Fumigation

Seed must be free of insects before storage. Insects can seriously harm seeds and reduce germination and storage life.

All seed will be fumigated with carbon dioxide for 21 days to kill insects at all stages of their life – including eggs and larvae. Carbon dioxide is an alternative insect pest control option to chemical pesticides that is non-toxic and non-flammable, relatively safe, and easy to manage in smaller, gas tight containers.

4.8.6. Storage

Once seed has been fumigated, it will be stored at 20°C in a climate-controlled seed store. The expected storage life of seed differs between species. The storage life needs to be considered when setting harvest targets, especially in regard to long term seed-bank targets.

The approximate storage life when stored in airtight containers at 20^0C and controlled humidity levels between 20-40% Relative Humidity is shown here.

Seed Type	Storage Life
Acacias and other hard-coated seeds	10+ years
Eucalypts and Melaleucas	5-10 years
Grevilleas and Hakeas	2-5 years
Grasses and Herbs	2-5 years
Soft-seeded / fleshy-fruited species	<1 year

Table 6 Approximate seed storage life

The species have been divided into four storage life categories to guide decision making: 10 years, 5 years, 2 years, <1 year. These categories are conservative, to ensure that seed is not stored for too long.

Species with long storage life will be harvested in large quantities where possible, making the most of good seasons, and stored until used. Species with short storage life will only be collected in smaller quantities, enough to cover short term needs.

Native grass seed generally have an inbuilt dormancy of up to 10 months. This means that the seed harvested in one wet season cannot be used until the following wet season. Grass seed should be stored at room temperature for the first 6-8 months.

4.8.7. Seed Viability

Seed viability is best expressed in terms of % (for species with large seeds) or as seeds/gram (for species with smaller seeds and chaff). Seed viability varies widely between species, and also between seasons.

Germination standards have been developed for many of the core direct seeding species on the Rum Jungle species list. This information will be used as a guide of expected viability, to assess quality and to ensure that each seed-lot is up to standard.

Independent seed tests will be carried out as required on seed lots over 1000g to ensure seed quality. This information will also be used to refine seed mixes as part of the adaptive management process.

4.9. Direct Seeding

The Rum Jungle Rehabilitation Project will include 276 hectares of direct seeding, carried out over 10 years. Direct broadcasting will be done by hand or with an agricultural spreader. The method used will be decided on as the project progresses and will most likely be a combination of both techniques.

Direct broadcast of the seed on to the soil surface is the most common technique used in the direct seeding of diverse native tree / shrub and grass seed mixes. Hand seeding with a team of people, walking in formation and broadcasting seed out of a bucket or bin, is suitable for all species. This technique is suited to steep, rough, or hard to access sites, and can be efficient, even for large areas.

Machine broadcasting using an agricultural spreader is very efficient and works for the majority of seeds on the species lists. Spreaders can be helicopter-mounted, drone-mounted or mounted behind machinery.

Hydroseeding involves spraying a slurry of seed, mulch and tackifying agent using a specialised machine. The mix essentially glues the seed to the soil and holds the site together until germination takes place. Hydroseeding is often used as an erosion control technique on steep banks where rapid stabilisation is required. For purpose of revegetation with native seeds, both the mulch and glues do not have to be added so that they do not interfere with native seed germination. A test site at Rum Jungle Lake was used to trial hydroseeding and mulch was specifically left out of the mix. Sterile Japanese Millet was added to the mix to provide a rapid cover crop. This trial proved successful for rapid application of finer native seed and rapid cover crop establishment.

The seed of some species, including most native grass species, have seed morphology that make it difficult to seed through most conventional seeding machines. These species will be seeded separately by hand or hydroseeded.

The optimal time to carry out direct seeding in the Top End is early December to take advantage of the most reliable period of rainfall. Seeding any earlier could mean a 'false start' with high germinant mortalities due to lack of follow-up rain and risk of seed predation by ants and birds. Seeding any later risks being 'rained out', with rain putting a stop to seeding or seed being washed away by heavy downpours. Seeding later can also lead to missing out on a large proportion of the wet season rainfall.

The actual timing of seeding, in any one year, is weather dependent and should occur once site earthworks and contour ripping are completed, and after a few rain events have settled the ground. This helps to reduce the amount of seed getting buried too deeply.

4.9.1. Seed Treatment

Seed treatments are required to help stimulate germination for some species. Mechanical scarification will be carried out on all Acacia's and a few other hard-coated species. Seed should be scarified as close to the seeding date as possible, as once scarified, seed can begin to lose viability.

Smoke treatment will be carried out on the seed of all species before direct seeding. The smoking of the seed will be done by the harvest team in conjunction with other interested Traditional Owners and will provide an opportunity for them to contribute to the seeding and revegetation process.

4.9.2. Seed Mixing

The seed for each area is mixed just prior to seeding. Seed will be sorted into sub-mixes to suit the seeding techniques used. Sub-mixes contain seeds with similar characteristics, specifically size, shape, weight, and type of appendages.

For hand broadcasting, three separate mixes will be used.

- Mix 1 - includes most tree and shrub species, and some small heavy-seeded grass and herb species.
- Mix 2 - includes fluffy and spikey seeds most grass species, and some herb, tree and shrub species.
- Mix 3 - very large seeds, such as Pandanus and Cycad.
- When seeding using a mechanical spreader, two separate mixes will be used.
- Mix 1 - includes small tree and shrub seeds with good "flow" characteristics.
- Mix 2 - includes large tree and shrub seeds with good "flow" characteristics.
- Each separate mix will be bagged up into hectare amounts (1ha or 2ha bags).

4.9.3. Germination

Seed generally begins to germinate once the soil remains wet for a day or more and begin to emerge within one or two weeks.

Follow-up rainfall is required to ensure seedling survival, and high seedling mortalities should be expected in the first few weeks, even under good conditions. After germinating rains, good follow-up rains are generally required within one month. In the case that follow up rains fail, emergency provisions can be made to manually irrigate revegetation areas with the best quality water available on site.

Germination of seeds can continue for the next 12-18 months. It is important to remember that poor rainfall years happen from time to time and are unavoidable, but that some seed can survive in the soil through the dry season and germinate the following season.

4.10. Nursery Propogation

A locally commercial native nursery will form an integral part of the rehabilitation at Rum Jungle. The nursery will be able to provide the bulk of the revegetation species for the Vine Thicket and Riparian domains- and contribute special or hard to establish species to the whole project.

The nursery will provide an employment and training opportunity for project staff. The nursery propagation program will be integrated into the seed harvesting work program because species will need to be specifically targeted for the nursery. Nursery work will continue year-round. Seedlings will be ready for planting by December each year.

4.10.1. Species Selection

A nursery species target list has been constructed to prioritise the propagation of plant species for inclusion in the annual revegetation works. This list is based on existing survey data but will be fine-tuned over time.

The Stem Density Baseline Survey (section 6.6) will inform species composition for Vine Thicket, Riparian Domains and some Open Woodland species, and will help determine an ideal stems/ha target value for each of the core nursery species. Annual nursery targets can then be set based on the revegetation sites for that year.

Propagation of opportunistic nursery species will be trialled once the nursery is well established.

Species to be grown in nursery:

- Rainforest infill plants – planting seedlings will be the main revegetation technique used in the Riparian and Vine Thicket Domains.
- Species with high value seeds that are difficult to collect in large quantities.
- Species that are hard to establish through direct seeding techniques. These species are often underrepresented in revegetation; they are either difficult to germinate, are predated on by insects and birds or hard to collect in large quantities.
- Species that are best propagated by direct division techniques.
- Special species with cultural values – plants requested by Traditional Owners that have special meaning and are more reliably established by seedlings.

4.10.2. Propagation Techniques

Methods for propagation include:

- Treating or scarifying seeds to stimulate germination.
- Soft-fruited rainforest and bush tucker species to be planted the previous wet season from fresh seed
- Cuttings for some woody plant species
- Tiller divisions for plants such as rushes and sedges and riparian grasses

4.11. Planting

The Rum Jungle Rehabilitation Project will include the planting of 90,000 seedlings, carried out over 10 years.

- 40 hectares will be revegetated primarily by seedlings at an average of 2000 per hectare.
- 276 hectares of direct seeding will be infill planted with seedlings at an average of 30 per hectare.

Planting out of seedlings is best done in the first half of wet season into moist soil, when there is a good chance of ongoing rainfall (Dec-Feb). Short- and medium-term weather forecasting will be used so planting can coincide with a significant rain event or monsoon period. Flexibility of planting timing is essential to minimise mortalities.

All planting will be done by hand. Slow-release fertiliser tablets should be placed in the bottom of each hole and covered with a layer of soil to ensure it does not come into contact with the roots of the new plant.

Where possible, seedlings will be mulched with local weed-free hay or weed-free locally sourced woodchip mulch. All plants will be watered in at planting time to ensure good root contact with the soil, removal of air pockets and reduction in transplant shock. Timing planting with a solid rain event can be just as effective as watering in after planting.

4.11.1. Planting Density

Planting densities and spacings will be specific to each area. A Stem Density Baseline Survey will guide the optimal planting density for each area. Plant density will be expressed as plants/ha. Some species are best planted as a clump/stand e.g. riparian grasses or Pandanus. Densities will be:

- Vine thicket infill plantings – Confirm plants/ha to suit each site/ area
- Riparian in fill plantings – Confirm plants/ha to suit each site/ area
- Re-constructed riparian corridor – approximately 2000 plants/ha
- Recalcitrant/ special species into direct seeded revegetation – approximately 30 plants/ha.

4.11.2. Tiller Division

Planting by tiller division is suitable for grass, rush and sedge species growing in riparian areas that naturally reproduce in this way. Material should be sourced from healthy plants as close to the site to be revegetated as possible. The plant material should be protected from wind and sun and kept wet until planting.

Tillers should be planted when there is adequate moisture in the soil. The easiest method for planting is to drive a shovel into the ground with the front facing up slope and wobble it backwards and forwards to create a slot in the ground. The tiller can then be planted directly into this slot, and the slot sealed up by stomping on it on the up-slope side. A large number of plant mortalities using this technique are to be expected, even under ideal conditions.

4.11.3. Cycad Relocation

Cycad relocation is covered in detail in the Cycad Salvaging Procedure RJ3-4-Pr-008. Cycads will be relocated into Open Woodland Ecological domains. They will be planted in patches in favourable areas, preferably where topsoil has been applied.

5. Ongoing Management

Ongoing management of the site will have to continue for the foreseeable future to ensure the integrity of the revegetation is maintained. Intensive and timely management will be required during the immediate post establishment phase, but the effort required will decrease over time if works are well implemented. Ongoing adaptive management is at the core of the Performance Standards process (section 8) and underpins the risk management (section 7). This section outlines current planning for the latter years of Stage 3 with an eye to requirements for Stage 4. Detailed ongoing management requirements for Stage 4 will be established with the Traditional Owners and Northern Land Council and informed by the Contaminated Sites audit process relating to the Land Use and Management Plan.

5.1. Weed Control

Ongoing management of weeds, including annual control programs, response to outbreaks, and weed control as part of broader land management activities on the FRALT, are covered in detail in the Weed Management Plan RJ3-4-MP-011.

The primary weeds of concern in terms of their direct impact on the revegetation are **Gamba Grass** *Andropogon gayanus*, **Grader Grass** *Themeda quadrivalvis and* **Calopo** *Calopogonium mucunoides*.

5.2. Erosion Control and Remedial Works

The Erosion and Sediment Control Plan RJ3-4-MP-014 will deal with erosion control and remedial works in detail. Remedial works as a corrective action should focus primarily on the source of the erosion through re-design and reshaping, or rock armouring. Superficial earthworks will be kept to a minimum and the total area of disturbance within the revegetation will be minimised wherever possible.

The WSF and the reconstructed section of the EBFR will be the most prone to erosion. Erosion control and remedial works must ensure these areas are a priority.

5.3. Feral Animal Control

Ongoing management of feral animals, including culling programs as necessary, is covered in detail in the Feral Animal Management Plan RJ3-4-MP-008. Pigs are of most concern in terms of their direct impact on the revegetation, especially in riparian and Vine Thicket domains.

5.4. Fire Management

Ongoing fire management, including the initial protection of revegetation areas and a framework for an annual burning strategy, is covered in detail in the Fire Management Plan RJ3-4-MP-027.

Burning will be used as a biomass reduction tool as part ongoing Gamba Grass control. Areas of relatively undisturbed open woodland surrounding the revegetation areas will be burnt periodically to create firebreaks and as part of broader management activities on the FRALT.

Developing annual, cross-boundary fire planning with relevant stakeholders will help guide annual fire management activities and prioritise areas of concern. Active firefighting efforts may be required to manage out-of-control fires.

5.5. Infill Planting

Follow-up infill planting of seedlings will be required as the revegetation progresses, to improve species diversity and vegetation structure and establish special species. An extra 10% of the total seedling requirements has been allowed for infill planting.

Infill planting will be implemented as per section 4.10 Nursery Propagation and 4.11 Planting, with particular emphasis on species selection to ensure the new plantings are best suited to the site and work in well with the already established revegetation.

When planting as a corrective action it is important to identify why an area has failed and modify or remediate the area as required before re-planting.

5.6. Re-seeding

Re-seeding of some areas will be required as the revegetation progresses, to improve outcomes on areas that are underperforming or have failed altogether. Re-seeding will be implemented as per section 4.8 Seed Harvest Strategy and 4.9 Seeding. When seeding as a corrective action it is important to identify why an area has failed and modify or remediate the area as required before re-seeding.

Impact on existing revegetation will be minimised during re-seeding but some collateral damage is to be expected. Established plants of long-lived structural and special species will be tagged and protected prior to works commencing. Site preparation and seeding techniques will differ for each site, depending on size and shape of the area, the slope, and the species mix.

6. Monitoring and Evaluation

A comprehensive monitoring and evaluation program has been developed for revegetation areas at the Rum Jungle site. The monitoring and evaluation will be focussed on adaptive management principles, applying learnings from past results to ongoing revegetation work. Revegetation monitoring results will be assessed annually to identify if revegetation is trending towards completion criteria. Monitoring results will also be used to refine revegetation performance criteria.

The key components of the revegetation monitoring program are:

- Annual whole-of-site weed survey and regular inspections to guide weed control works.
- Annual rapid whole-of-site erosion assessments, as well additional assessments following major rainfall or flood events, to guide erosion control and remediation works.
- Establishment of permanent Landscape Function Analysis (LFA) transects in each rehabilitated area within 6 months of seeding/planting to guide future rehabilitation works, provide baseline data and performance indicators for underlying system drivers

- Vegetation survey of each rehabilitated area approximately 18 months (after the following wet season) from the date of seeding/planting to guide future revegetation works and provide baseline data and performance indicators for vegetation composition and structure.
- Biannual Tropical Rapid Appraisal of Riparian Condition (TRARC) surveys.
- Additional targeted analogue surveys to assess species densities of vine thicket species and other special species in the surrounding landscape to provide appropriate planting/seeding targets, and assess root depth of species for inclusion in stabilisation domains. This is not for the purpose monitoring but for planning.

These are discussed further below.

6.1. Adaptive Management

Adaptive management principles will be at the core of the revegetation monitoring and evaluation framework. All data collected will be directly applicable to the practical outcomes of the project and/or be directly related to performance standards. Collecting succinct, highly targeted data will help to facilitate a manageable adaptive management feedback process.

Data interpretation and analysis will also be kept succinct – focussing on common metrics such as plants/ha for mid and upper storey, cover % for ground storey and a simple 1-5 scoring scale for the subjective assessment of vegetation health and invasive species impacts.

During the early stages of rehabilitation, focussed datasets are required to understand the trajectory of the revegetation. Simple measures of plants/ha coupled with basic plant health and erosion data can be a very effective predictor. These data – once overlayed with survey data from key invasive species – forms the basis of an adaptive management framework able to guide remediation and management works.

6.2. Weed Surveys

A detailed annual weed monitoring methodology will be incorporated into the Weed Management Plan (WMP) RJ3-4-MP-011. Whole-of-site weed surveys will be completed annually with additional regular inspections conducted through the growing season. The annual survey will target all key weed species and cover the whole of site, including borrow areas and satellite sites. Weed inspections will focus on areas where weed control has been carried out, as well as sensitive areas such as recently implemented revegetation, vine thickets and riparian domains, and recently burnt areas.

The surveys will be comprehensive in scope but with a rapid delivery model. Datasets and mapping will be kept simple and be able to be used to directly inform the ongoing weed control works.

As the primary weed threat, Gamba Grass will be a particular focus of weed monitoring. Close attention will also be paid to Calopo in Vine Thicket and Riparian domains.

6.3. Erosion Assessments

The Erosion and Sediment Control Plan RJ3-4-MP-014 will deal with erosion monitoring in detail.

Rapid erosion assessments in the revegetation areas will be carried out at the end of each wet season or as required after large rainfall events. These assessments will focus on areas most prone to erosion such as batters, drainage lines and water management and collection structures. Datasets will be very basic and focussed on directly informing ongoing erosion control and remedial works. Results from these assessments can also be used to improve landform design and construction on future rehabilitation areas.

More detailed erosion assessments will also be included in Vegetation Surveys/LFA monitoring where appropriate, with erosion transects set-up perpendicular to LFA transect to measure width and depth of erosion rills/gullies. These datasets will be used to better understand long-term stability trends of constructed batters and banks.

6.4. Landscape Function Analysis

Landscape Function Analysis (LFA) monitoring transects will be established in newly revegetated areas within 6 months of seeding/planting. Analogue transects will be established in surrounding, relatively intact, vegetation at the same time on the first year only. Follow-up monitoring will be carried out on all transects after 2 or 3 years and then every 4-5 years after that.

Transects will be spaced as evenly as possible along each domain. Each transect will be positioned to be representative of the material, slope, vegetation and erosion of that area.

Analogue transects will be chosen to be representative of the surrounding vegetation and soil types. Slope will be taken into account, to match as closely as possible the slope of each domain

The LFA framework, developed by CSIRO, involves the use of simple visual indicators of surface processes to rapidly assess landscape and ecological function. LFA is focussed on the accumulation and/or loss of surface resources and the underlying drivers of natural systems (stability, infiltration, and nutrient cycling) rather than the specifics of a particular system (such as lifeforms, species and seasons). It has been specifically adapted for use in monitoring mine site rehabilitation.

The measures include:

- **Stability index** – surface resistance to erosion. Stability is increased where there is good rock mulch cover, well-designed landforms, and well-executed shaping and ripping.
- **Infiltration index** – potential of surface soils to infiltrate water. Infiltration is improved where there is high quality growth medium and accurate ripping.
- **Nutrient cycling index** – potential of surface system to cycle nutrients back into the soil. Nutrient cycling is improved where there is high quality growth medium and good vegetation establishment.

This initial monitoring provides baseline values for the rehabilitated areas. Analogue transects established in surrounding bushland provide corresponding index values which are used to compare to rehabilitation areas, reflecting the landscape function of a healthy local ecosystem and providing a set of target values for rehabilitation.

Transects are reassessed over time to monitor trends in the key LFA values, highlight areas that require more work, and help to inform future rehabilitation. Index values for rehabilitated areas will initially be low compared to mature surrounding bushland, but if the rehabilitation is well implemented, the establishment of vegetation over time will result in increases in the ecological function of the site, and associated increases in LFA index values.

The LFA framework will be modified for this project to include additional data relating to plant health, structural species, erosion, and invasive species impact.

Additional transect data outline:

- Overall plant vigour score (1-5, with 1 being very unhealthy to 5 being very healthy)
- Feral animal impact 5m each side of transect (species)

- Overall feral animal impact score for each species recorded (1-5, with 1 being low impact to 5 being high impact)
- Weed presence 5m each side of transect (species)
- Overall weed impact score for each species recorded (1-5, with 1 being low impact to 5 being high impact)
- Long-lived structural species 5m each side of transect (number of each species)
- Erosion transects running perpendicular (cross slope 5m each side) to LFA transect (width, depth of each erosion rill/gully).

6.5. Vegetation Surveys

Detailed vegetation surveys of revegetated areas will be carried out approximately eighteen months (two wet seasons) after seeding/planting. Waiting for two wet seasons of growth before surveying allows the newly revegetated area to "settle" and paints a more accurate picture of plant recruitment. This timing allows for "shy seedlings" to emerge and takes into account the expected high mortality rates in the first dry season. Follow-up surveys will be conducted every four to five years after seeding/planting to better understand the trajectory of the revegetation.

The vegetation survey will be detailed but focussed on applicable datasets that are able to be used as part of adaptive management. The learnings from the survey must be able to directly inform ongoing revegetation works and/or be applicable in terms of gauging rehabilitation success. The data will include:

- % cover for grasses and herb species
- Number of plants and heights for each species
- Health/vigour scores for each site/species

The survey will take place along each permanent LFA transect.

6.6. Stem Density and Root Depth Baseline Surveys

A single round of targeted and rapid baseline surveys will be conducted to assess densities of vine thicket species and other special species in the surrounding landscape to determine appropriate, species specific, planting/seeding targets.

The surveys will be carried out in areas of relatively intact vine thicket and woodland and will focus on quantifying stems per hectare for each core structural species in the Vine Thicket and Riparian Domains as well as special species in other domains.

An additional investigation into the root depth of structural species identified as important potential candidates for use in the stabilisation domain will be conducted. This investigation will help to gain a better understanding how the root systems of key species are likely to interact with the capping layer.

6.7. Riparian Surveys

Improved riparian health will be a key performance indicator for the whole project, so it will be important to keep track of short- and long-term trends in riparian vegetation condition following rehabilitation of the mine site.

The revegetation of the site will contribute to riparian health directly, by revegetating riparian corridors, and indirectly, by reducing run-off, sediment and weed seed into riparian areas.

In addition to Vegetation and LFA surveys, targeted riparian surveys will be carried out using Tropical Rapid Assessment of Riparian Condition (TRARC) every two years. TRARC can be used as an assessment tool over time to evaluate the effectiveness of existing rehabilitation programs.

Developed by Tropical Savannas CRC, the TRARC provides a standardised approach to rapidly assess the health of riparian locations adjacent to creeks and rivers in Northern Australia. The entire assessment is a visual measurement of features (indicators) in and around the riparian zone that indicate good or poor condition. The indicators are grouped into four sub-indices.

- Plant Cover - the amount of cover provided by vegetation.
- Regeneration - the amount of native plant regeneration.
- Weeds - the cover of exotic weeds relative to native plants.
- Erosion - the amount of bank erosion.
- Pressure - derived from six indicators which help identify the likely causes of change in condition

6.8. Fire and Fuel Monitoring

Fire management and monitoring will be covered in detail in the Fire Management Plan RJ3-4-MP-027.

Large hot fires burning in the rehabilitation areas during the first 8 years after establishment will have a detrimental effect on the revegetation.

Real-time monitoring of existing fires in the surrounding areas, with particular interest on immediately adjacent areas, will be an integral part of protecting revegetation areas from large uncontrolled fires.

Monitoring activities will include:

- Regular monitoring of NAFI website during the main fire season. May-Nov. This will guide fire management activities.
- Analysis of NAFI fire scar mapping to guide and prioritise burning and firefighting efforts.
- August wildfire risk assessment carried out in June-July each year, using the table below as a guide

	Threshold/Completion	Trigger
August wildfire risk	Low	Medium
Hazard (fuel loads/ tonnes/ ha)	<6 tonnes/ha	>6 tonnes/ha
Hazard (fuel patch size ha)	<50 ha	>50 ha
Hazard (gamba grass)	Absent	Present

7. Threats and Risks

Self-sustaining revegetation will be critical to the success of the rehabilitation of the Rum Jungle mine site. The environmental threats and risks discussed here relate to revegetation underperformance or failure, which could compromise the rehabilitation and result in no net improvement or lead to further detrimental effects.

The risks are mainly around under-performance of the revegetation, failure of constructed landforms and the potential for the site to be overwhelmed by invasive species and/or fire. Key risks are considered at every stage of project planning and implementation.

7.1. Weeds

Invasive weed species are the most significant threat to the success of the revegetation, as the site is already heavily infested with many declared weeds – as well as several environmental weeds – that are capable of outcompeting and overwhelming native vegetation.

The Weed Management Plan RJ3-4-MP-011 deals with weed management and control in detail. Listed here are the primary weeds of concern in terms of their direct impact on the revegetation.

- **Gamba Grass** *Andropogon gayanus* - Class B, WoNS weed
- **Grader Grass** *Themeda quadrivalvis* - Class B
- **Calopo** *Calopogonium mucunoides* - Environmental Weed

The increased fire hazard from Gamba Grass will be addressed with integrated weed and fire management.

7.2. Erosion

Erosion poses a threat to the long-term stability of constructed landforms. Stability of these landforms is critical to the success of the revegetation. Erosion of the growth medium cover on the WSF and WRD footprint could lead to failure of the capping layer. Erosion within the riparian zone could compromise the stability and creek bank structure of the reconstructed portion of the EBFR.

Failure of drainage management structures could also mobilise large amounts of sediment, resulting in the smothering of lower areas, especially natural drainage lines and the riparian domain. The Erosion and Sediment Control Plan RJ3-4MP-014 will deal with these issues in detail.

7.3. Uncontrolled Fire

Large fires burning in the rehabilitation areas during the first 10 years after establishment will have a detrimental effect on the revegetation. In particular, hot Gamba Grass fires pose a critical risk to the revegetation, and the success of the project as a whole. The increased fuel hazard from Gamba Grass will be addressed with integrated weed and fire management.

Fire should be excluded from revegetation areas except where the burn is part of targeted management – such as creation of firebreaks through fuel reduction, or as part of the control measures for serious weed outbreaks.

Extreme fire regimes represent a significant risk to success; very frequent fires (recurring annually in revegetation areas), large fires (burning a large proportion of a revegetated area), or severe fires (burning with high fuel loads and/or under high fire conditions) will have a large impact on the project. On the other extreme, the absence of any fire from the site is likely to result in the accumulation of an unacceptable fuel hazard risk, or a missed opportunity in later years to succeed the revegetated areas towards a fire resilient system required for long term success.

The Fire Management Plan RJ3-4-MP-027 deals with fire management and burning in detail.

7.4. Feral Animals

Feral animals could have a serious impact on the revegetation, particularly in the Riparian and Vine Thicket Domains. Controlling pig numbers will be critical to success in these areas as they can cause widespread damage to sensitive vegetation and compromise creek bank structure. Buffalo and Cattle can also cause

significant damage, but only if a resident population is allowed to build up. The Feral Animal Management Plan RJ3-4-MP-008 deals with feral monitoring and control in detail.

7.5. Risk Assessment & Management Table

The following risk assessment addresses issues related to the success of achieving the management objective of the RMP. Which is to:

> Return site landforms to safe, stable, and self-sustaining systems using endemic plant species to stabilise constructed surfaces and restore appropriate functional living systems across the site.

Risk	Management activity	Residual risk level	Performance indicator/criteria	Monitoring activity
Gamba Grass outcompetes native vegetation	Ongoing and thorough Gamba Grass control, as per the Weed MP	**HIGH** L: Likely C: High	**Performance indicator:** Invasive Flora Impact **Trigger Criteria:** Invasive Flora Impact Score- **4-5** **Threshold** Invasive Flora Impact Score- **2-3**	Annual Weed Surveys (**Section 6.2**)
Calopo outcompetes native vegetation in Riparian and Vine Thicket Domains	Ongoing and thorough Calopo control, as per the Weed MP	**MEDIUM** L: Possible C: Moderate	**Performance indicator:** Invasive Flora Impact **Trigger Criteria:** Invasive Flora Impact Score- **4-5** **Threshold** Invasive Flora Impact Score- **2-3**	Annual Weed Surveys (**Section 6.2**)
Erosion of growth medium on constructed landforms	Ongoing erosion control, as per the ESCP	**MEDIUM** L: Possible C: High	**Performance indicator:** Erosion Assessment LFA Stability Assessment **Trigger Criteria:** Erosion Assessment Score- **TBC** Stability Score- **<50%** **Threshold** Stability Score- **50-75%**	Annual Erosion Assessments **(Section 6.3)** LFA surveys **(Section 6.4)**
Endemic vegetation fails to establish	None, unless triggered	**LOW** L: Unlikely C: Moderate	**Performance indicator:** Vegetation Health Vegetation Structure **Trigger Criteria:** Long lived structural species- stems/ha - **TBC** Cover each strata %- **TBC** Vegetation Health Score-**2** **Threshold** Long lived structural species- stems/ha - **TBC** Cover each strata %- **TBC** Vegetation Health Score- **3**	Vegetation Survey **(Section 6.5)**
Feral animals damage riparian and vine thicket revegetation	Ongoing feral animal control, as per the Feral Animal MP	**MEDIUM** L: Possible C: Moderate	**Performance indicator**: Invasive Fauna Impact **Trigger Criteria:** Invasive Fauna Impact Score- **4-5** **Threshold** Invasive Fauna Impact Score- **2-3**	Riparian Survey (**Section 6.7**)
Overall weed pressure compromises revegetation	Ongoing and thorough weed management, as per the Weed MP	**MEDIUM** L: Possible C: High	**Performance indicator:** Invasive Flora Impacts **Trigger Criteria:** Invasive Flora Impact Score- **4-5** **Threshold**	Annual Weed Surveys (**Section 6.2**)

Risk	Management activity	Residual risk level	Performance indicator/criteria	Monitoring activity
			Invasive Flora Impact Score- **2-3**	
Large uncontrolled fire burns immature revegetation	Ongoing fire management, as per the Fire MP Well-maintained fire breaks around and within revegetation Controlled burns around revegetation (could also be within)	**MEDIUM** L: Unlikely C: High	**Performance indicator:** Fire Impact Fire Risk **Trigger Criteria:** Occurrence of uncontrolled fire in reveg in the first 10 years Wildfire risk medium (unacceptable fuel hazard) **Threshold** Fire Impact low, Wildfire Risk low	Fire and Fuel Monitoring **(Section 6.8**)
Ongoing adverse climatic conditions affect revegetation establishment and growth	Diverse species mix, progressive revegetation works	**MEDIUM** L: Possible C: Moderate	**Performance indicator:** Vegetation Health, Vegetation Structure **Trigger Criteria:** Long lived structural species- stems/ha- **TBC** Cover for each strata **TBC** Vegetation Health Score- **2** **Threshold** Long lived structural species- stems/ha- **TBC** Cover for each strata **TBC** Vegetation Health Score- **3**	Vegetation Survey **(Section 6.5)**
Seed availability does meet project requirements	Long-term approach with seed harvesting efforts, maximising seed collecting works in good season. Purchasing seeds that are unavailable from a commercial seed supplier.	**LOW** L: Unlikely C: Moderate	**Performance indicator:** Vegetation Structure **Trigger Criteria:** Seed species mix ratios inappropriate **Threshold** Seed species mix ratio appropriate	Annual assessment of seed stock.
Seedling availability does not meet project requirements	Outsourcing a percentage of seedlings each year to a commercial nursery as well as growing seedlings in house.	**LOW** L: Unlikely C: Moderate	**Performance indicator:** Vegetation Structure **Trigger Criteria:** Plant species mix ratio inappropriate **Threshold** Plant species mix ratio appropriate	Annual assessment of nursery stock.
Growth medium inadequate quality and/or quantity	Thorough assessment of growth material, quality and quantity. Thorough assessment of amount of growth material needed to meet the needs of the entire site.	**MEDIUM** L: Possible C: High	**Performance indicator:** Erosion Assessment Vegetation Health, Vegetation Structure **Trigger Criteria:** Erosion Assessment Stability Score Long lived structural species- stems/ha-**TBC** Cover each strata-**TBC** Vegetation Health Score- **2** **Threshold** Long lived structural species- stems/ha-**TBC** Cover each strata %-**TBC** Vegetation Health Score-**3**	Vegetation Survey **(Section 6.5)**

Risk	Management activity	Residual risk level	Performance indicator/criteria	Monitoring activity
Collateral damage of revegetation during weed control	Weed control will be as topical and targeted as possible	**LOW** L: Possible C: Minor	**Performance indicator:** Vegetation Health, Vegetation Structure **Trigger Criteria**: Long lived structural species- stems/ha- **TBC** Cover each strata %- **TBC** Vegetation Health Score- **2** **Threshold** Long lived structural species- stems/ha- **TBC** Cover each strata %- **TBC** Vegetation Health Score- **2**	Vegetation Survey **(Section 6.5)** Annual Weed Surveys (**Section 6.2**)
Revegetation has inappropriate composition or structure	Appropriate diverse seed mix and good site preparation.	**LOW** L: Unlikely C: Moderate	**Performance indicator:** Vegetation Structure **Trigger Criteria:** Long lived structural species- stems/ha- **TBC** Cover each strata- %- **TBC** Vegetation Health Score- **2** **Threshold** Long lived structural species - stems/ha- **TBC** Cover each strata- %- **TBC** Vegetation Health Score- **2**	Vegetation Survey **(Section 6.5)**

8. Perfomance Standards

8.1. Performance Indicators

The objective of the revegetation is to:

Return site landforms to safe, stable, and self-sustaining systems using endemic plant species to stabilise constructed surfaces and restore appropriate functional living systems across the site.

To evaluate the trajectory of the health and function of the rehabilitated landforms and gauge progress in achieving the above objective, the following performance indicators will be assessed:

- Vegetation Structure
- Vegetation Health
- Natural Recruitment
- Stability
- Nutrient Cycling
- Invasive Flora Impact
- Invasive Fauna Impact
- Fire Impact

These performance indicators are designed to be Specific, Measurable, Achievable, Realistic and Timely. They help to form the foundation of the adaptive management and risk mitigation process.

Assets and threats have both been included here, because the indicators have been considered in terms of their contribution to overall project success.

8.2. Performance Criteria

Specific performance criteria have been proposed for each performance indicator. The type of assessment and the assessment timing/frequency have also been included for each indicator.

The criteria definitions and the specific completion, threshold, and trigger values will continue to be developed and refined with the project team, based on baseline and analogue data, and what represents positive outcomes. Completion, threshold, and trigger scores listed below are proposed. Scores have been left blank where appropriate values are yet to be determined.

8.2.1. Vegetation Structure

Species demography data; strata data for ground, mid, upper storey layers and plant density for long lived structural species. Completion, threshold, and trigger values to be confirmed based on existing and future surveys once project has commenced

- **Assessment-** Vegetation Survey
- **Timing/Frequency-**18 months after seeding (the end of the 2nd wet season), then again 4-5 years after seeding.
- **Score-** Plants per ha and height of long-lived structural species. Strata % cover (Ground storey mid storey and upper storey). Different completion, threshold, and trigger scores will be developed for each domain.
- **Required for completion- TBC** Stems/ha of long-lived structural species. **TBC**% cover for each strata
- **Threshold- TBC** Stems/ha of long-lived structural species. **TBC**% cover for each strata
- **Trigger value- TBC** Stems/ha of long-lived structural species **TBC%** cover for each strata

8.2.2. Vegetation Health

Subjective score of Plant health/ Vigour.

- **Assessment-** Vegetation Survey
- **Timing/Frequency-** 18 months after seeding- (the end of the 2nd wet season), then every 4-5 years after that.
- **Score-** 1-5
- **Required for completion-** 4-5
- **Threshold-** 2-3
- **Trigger value-** 1

8.2.3. Natural Recruitment

Species reproduction: presence of seeds, young seedlings.

- **Assessment**- Vegetation survey
- **Timing/Frequency-**18 months after seeding- (the end of the 2nd wet season), then every 4-5 years after that
- **Score**- Prescence/ absence of seeds for each species
- Presence/ absence of seedlings for each species
- **Required for completion-** >50% of mature species naturally recruiting
- **Threshold-** 20-50% of mature species naturally recruiting
- **Trigger value-** >20% of mature species naturally recruiting

8.2.4. Stability

Stability is the primary factor for successful rehabilitation. A stable environment provides a foundation for revegetation and positive long-term nutrient cycling. Target stability is to be measured using long-term LFA monitoring. Trigger values for remedial works will use frequent, timely, rapid, and targeted erosion assessments.

- **Assessment-** LFA and rapid erosion assessments
- **Timing/Frequency**- Erosion surveys annually April – May **(**at the end of the wet season), Targeted erosion assessments carried out after major rainfall events, LFA 6 months after seeding then year 2 or 3 and then every 4-5 years after that.
- **Score-** LFA stability Index value**,** Annual and targeted erosion survey results

The completion, threshold and trigger scores need to be developed over time specifically for this project, based on LFA analogue site data and informed by LFA survey results, considering what is realistic and what scores represent a positive outcome. Different completion, threshold, and trigger scores will be developed for each domain.

- **Required for completion**-.LFA stability score - >75% of analogue
- **Threshold-** LFA stability score 50-75% of analogue
- **Trigger value-** LFA stability score <50% of analogue, Annual rapid erosion survey result action

8.2.5. Nutrient Cycling

Nutrient Cycling is a measure of vegetation function, focussed on the positive impact that plants have on the soil.

- **Assessment**- LFA.
- **Timing/Frequency-** 6 months after seeding then year 2 or 3 then every 4-5 years after that.
- **Score-** LFA Nutrient Cycling Index value

The completion, threshold and trigger scores need to be developed over time specifically for this project, based on LFA analogue site data and informed by LFA survey results, considering what is realistic and what scores represent a positive outcome. Different completion, threshold, and trigger scores will be developed

for each domain. Nutrient cycling Trigger and Completion scores are only relevant for mature revegetation (>8 years)

- **Required for completion**- LFA Nutrient Cycling score - >50% of analogue
- **Threshold**- LFA Nutrient Cycling score - 30-50% of analogue
- **Trigger value**- LFA Nutrient Cycling score - <30% of analogue

8.2.6. Invasive Flora Impact

Impact of key invasive weeds.

- **Assessment-** Annual weed surveys, targeted assessments, vegetation and LFA surveys.
- **Score-** Overall weed impact score for each species recorded (1-5, with 1 being low impact to 5 being high impact)
- **Required for completion-** impact score 1
- **Threshold-** impact score 2-3
- **Trigger value-** impact score 4-5

8.2.7. Invasive Fauna Impact

Impact of key invasive feral animals, especially for Riparian and Vine Thicket Domains

- **Assessment-** Annual feral surveys.
- **Score-** Overall feral animal impact score for each species recorded (1-5, with 1 being low impact to 5 being high impact)
- **Required for completion-** impact score 1
- **Threshold-** impact score 2-3
- **Trigger value-** impact score 4-5

8.2.8. Fire Impact

Fire impact as well as wildfire risk are both important measures. The wildfire risk assessment tool will continue to be refined as the project progresses.

- **Assessment-** Fire management regime and wildfire risk assessment
- **Score-** Occurrence of fire in revegetation areas and,

August wildfire risk for site

- **Required for completion-** fire impact low, wildfire risk low
- **Threshold-** fire impact low, wildfire risk low
- **Trigger value-** Occurrence of uncontrolled fire in revegetated areas in the first 10 years and/or wildfire risk medium

8.3. Threshold Criteria

Threshold criteria are performance indicator values relating to a site/area that show it is on an acceptable trajectory.

Routine rehabilitation maintenance works will be required in areas above threshold criteria (weed control, infill seedling plantings, repair of minor erosion).

Performance Indicator	Minimum Score
Vegetation Health	TBC Stems/ha of long-lived structural species. TBC % cover for each strata
Vegetation Health	Vegetation Health Score- 2-3
Natural Recruitment	20-50% of mature species naturally recruiting
Stability	LFA Stability score- 50-75% Erosion Assessment Score TBC
Nutrient Cycling	LFA Nutrient Cycling score- 30-50%
Invasive Flora	Invasive Flora Impact Score-2-3
Invasive Fauna	Invasive Fauna Impact Score- 2-3
Fire Impact	Fire Impact low, Wildfire Risk low

8.4. Trigger Criteria

Trigger criteria are performance indicator values relating to a site/area that show it needs major intervention or extensive remedial work. The aim of a Trigger Action Response Plan (TARP) is to provide guidance and clarity when a situation deviates from the original plan or there is a change in conditions that could effectively lead to the failure of the overall management objective.

Works could include: reseeding, replanting, weed control, feral animal control, erosion repair, re-applying growth medium, re-ripping contours and armouring of drainage structures.

Trigger Action Response Plan

Performance Indicator	Score	Corrective Actions
Vegetation Structure	TBC Stems/ha of long-lived structural species. TBC % cover for each strata	Reseeding, replanting
Vegetation Health	Vegetation Health Score- 1	Soil ameliorants applied to site. Determine root cause of poor health and address root cause. Reseeding, replanting
Natural Recruitment	>20% of mature species naturally recruiting	Determine root cause of poor health and address root cause. Reseeding, replanting
Stability	LFA Stability score- <50%	Determine root cause of poor performance and address root cause Replanting, reseeding.
Nutrient Cycling	LFA Nutrient Cycling score- <30%	Determine root cause of poor performance and address root cause Reseeding, replanting
Invasive Flora	Invasive Flora Score- 4-5	Weed control works, replanting, reseeding
Invasive Fauna	Invasive Fauna Score- 4-5	Feral control works, replanting, reseeding
Fire Impact or Risk	Fire impact- Occurrence of uncontrolled fire in reveg in the first 10 years Fire Risk- Medium (unacceptable fuel hazard)	Hazard reduction (weed management, prescribed burning, fire break maintenance) Reseeding, replanting

8.5. Draft Completion Criteria

Completion criteria are performance indicator values relating to a site/area that show it is on a successful trajectory that is likely to continue long-term. Routine rehabilitation maintenance works will still be required in areas that have achieved completion criteria (weed control, repair of minor erosion).

Performance Indicator	Required Score
Vegetation Structure	TBC Stems/ha of long-lived structural species. TBC % cover for each strata
Vegetation Health	Vegetation Health Score- 4-5
Natural Recruitment	50% of species naturally recruiting
Stability	LFA Stability score >75%
Nutrient Cycling	LFA Nutrient Cycling score >60%
Invasive Flora Impact	Invasive Flora Score- 1
Invasive Fauna Impact	Invasive Fauna Score- 1
Fire Impact	Fire impact- TBC

9. Review and Reporting

9.1. Responsibilities

Unless otherwise specified, the provisions within this plan are the responsibility of the Northern Territory Government Rum Jungle Rehabilitation Project Health, Safety and Environment (HSE) Manager. Responsibility may be delegated to contractors undertaking the works, however NTG will maintain overarching responsibility for communication with and between contractors, and compliance. The (HSE) Manager will be responsible for understanding and carrying out the following sections of the RMP:

- Implementation (Section 4)
- Ongoing Management (Section 5)
- Monitoring and Evaluation (Section 6)
- Managing Threats and Risks (Section 7)
- Performance Standards (Section 8)

9.2. Data Management, Reporting and Review

All relevant data and information related to the responsibilities above will be filed in a central database and managed by the (HSE)Manager. Review will be triggered by:

- Annual review
- Project risk assessment
- Adaptive management
- Changes in legislation
- Changes in enironmental requirements

10. REFERENCES

Dixon,I., Douglas,M., Dowe,J. and Burrows,D. (2006). Tropical Rapid Appraisal of Riparian Condition Version 1 (for use in tropical savannas). River Management Technical Guidelines No. 7, Land and Water Australia, Canberra.

Eco Logical (2014). Flora and fauna surveys of the former Rum Jungle mine site. Prepared for Northern Territory department of Mines and Energy.

Ec Oz Environmental Consultants (2019) Review of terrestrial ecological surveys relevant to the Rum Jungle EIS.

Metcalfe, K. (2002). Flora assessment study for environmental impact statement- browns polymetallic project, Batchelor, N.T. Report prepared for Compass Resources NL and NSP Environmental Consultants Pty Ltd.

Tongway, DJ. And Hindley, NL. (2005). Landscape Function Analysis: Procedures for monitoring and assessing landscapes with special reference to Minesites and Rangelands, CSIRO sustainable ecosystems, Canberra.

11. Appendices

Appendix A – Species Matrix

Species Name	Common Name	Life form	STRATA			VEGETATION TYPE				OBJECTIVE		ESTABLISHMENT TECHNIQUE					
			Upper storey	Mid storey	Lower storey	Open Woodland	Low-lying Woodland	Vine Thicket	Riparian	Ecological Restoration	Stabilisation	Direct Seeding - Core Species	Direct Seeding - Opportunistic Species	Nursery Propagation - Core Species	Nursery Species - Opportunistic Species	Direct Division Planting	Volunteer Species
Abrus precatorius	Jungle Beads	Vine		●				●		●		●		●			●
Acacia alleniana		Shrub		●		●	●				●	●					
Acacia auriculiformis	Black Wattle	Tree	●			●	●	●	●	●		●					●
Acacia difficilis		Shrub		●		●	●				●	●					
Acacia dimidiata		Shrub		●		●					●	●					
Acacia holosericea	Soapbush	Shrub		●		●	●					●					●
Acacia lamprocarpa		Shrub		●		●					●	●					
Acacia oncinocarpa		Shrub		●		●					●	●					
Alloteropsis semialata	Cockatoo Grass	Grass			●	●	●				●	●					
Alphitonia excelsa	Red Ash	Tree	●			●	●	●	●	●		●					
Alstonia actinophylla	Milkwood	Tree	●			●	●	●					●	●			
Ampelocissus frutescens	Wild Grape	Shrub			●	●				●	·						●
Antidesma ghesaembilla	Blackcurrant	Shrub		●			●	●	●	●				●			●
Aristida holathera	Kerosene Grass	Grass			●	●	●			●	●	●					

Species Name	Common Name	Life form	STRATA			VEGETATION TYPE				OBJECTIVE		ESTABLISHMENT TECHNIQUE					
			Upper storey	Mid storey	Lower storey	Open Woodland	Low-lying Woodland	Vine Thicket	Riparian	Ecological Restoration	Stabilisation	Direct Seeding - Core Species	Direct Seeding - Opportunistic Species	Nursery Propagation - Core Species	Nursery Species - Opportunistic Species	Direct Division Planting	Volunteer Species
Aristida jacobsiana		Grass			●		●			●	●	●					
Asparagus racemosa		Shrub			●		●			●					●		
Bacopa floribunda		Herb			●		●		●	●			●				○
Blumea saxatilis	Blumea	Herb			●		●		●	●			●				○
Boerhavia sp.		Herb			●	●	●			●	●		●				●
Bothriochloa bladhii	Forest Bluegrass	Grass			●		●		●	●	●	●					
Brachychiton diversifolius	Kurrajong	Tree	●			●	●	●		●		●		●			
Brachychiton megaphyllus	Kurrajong	Shrub		●		●				●		●		●			
Breynia cernua		Shrub		●		●	●	●	●	●				○	●		○
Bridelia tomentosa		Shrub		●			●			●					●		○
Buchanania obovata	Green Plum	Tree	●			●	●			●		●		●			
Buchnera linearis		Herb			●		●		●	●			●				
Bulbostylis barbata		Rush/Sedge			●		●		●	●			●			○	○
Calytrix exstipulata	Turkey Bush	Shrub		●		●	●			●	○	●		●			
Canarium australianum	Canarium	Tree	●			●	●	●	●	●				●			●
Canscora diffusa		Herb			●				●	●			○		○		○
Capillipedium parviflorum		Grass			●		●			●			●				
Capparis sepiaria		Shrub		●			●	●		●				○			○
Celtis philippensis	Celtis	Tree	●					●		●				○			○

Species Name	Common Name	Life form	STRATA			VEGETATION TYPE				OBJECTIVE		ESTABLISHMENT TECHNIQUE					
			Upper storey	Mid storey	Lower storey	Open Woodland	Low-lying Woodland	Vine Thicket	Riparian	Ecological Restoration	Stabilisation	Direct Seeding - Core Species	Direct Seeding - Opportunistic Species	Nursery Propagation - Core Species	Nursery Species - Opportunistic Species	Direct Division Planting	Volunteer Species
Chrysopogon latifolius	Ribbon Grass	Grass			●	●	●			●	●	●					
Clerodendrum floribundum	Lolly Bush	Shrub		●			●			●					●		
Cochlospermum fraseri		Shrub		●		●	●			●		●		●			
Corchorus aestuans		Herb		○	●				●	●			●		●		○
Cordia dichotoma		Shrub		●				●		●					●		○
Corymbia bella	Ghost Gum	Tree	●			●	●	●		●		●		●			
Corymbia bleeseri	Shiny-leaved Bloodwood	Tree	●			●				●		●					
Corymbia confertiflora	Broad-leaved Carbeen	Tree	●			●				●		●					
Corymbia disjuncta		Tree	●			●	●		●	●		●					
Corymbia foelscheana	Broad-leaved Bloodwood	Tree	●			●	●			●		●					
Corymbia grandiflora	Large-leaved Cabbage Gum	Tree	●			●	●			●		●					
Corymbia latifolia	Round-leaved Bloodwood	Tree	●			●	●			●		●					
Corymbia polycarpa	Long-fruited Bloodwood	Tree	●			●	●		●	●		●					
Corymbia polysciada	Apple Gum	Tree	●			●	●			●		●					
Corymbia porrecta	Grey Bloodwood	Tree	●			●				●		●					
Crotalaria sp.		Herb			●	●				●	●		●				○
Croton arnhemicus		Shrub		●		●				●			●		●		
Cupaniopsis anacardioides		Tree		●			●	●	●	●				●			○
Cycas armstrongii	Cycad	Palm		●	○	●	●			●				●		●	

Species Name	Common Name	Life form	STRATA			VEGETATION TYPE				OBJECTIVE		ESTABLISHMENT TECHNIQUE					
			Upper storey	Mid storey	Lower storey	Open Woodland	Low-lying Woodland	Vine Thicket	Riparian	Ecological Restoration	Stabilisation	Direct Seeding - Core Species	Direct Seeding - Opportunistic Species	Nursery Propagation - Core Species	Nursery Species - Opportunistic Species	Direct Division Planting	Volunteer Species
Cyperus difformis	Sedge	Rush/Sedge			●		●		●	●			●			○	○
Desmodium heterocarpon		Shrub			●				●	●			●		●		
Dichanthium fecundum	Curly Bluegrass	Grass			●	□	●			●	●		●				
Dioscorea bulbifera	Cheeky Yam	Vine		●		●	●			●					●		○
Dodonaea hispidula		Shrub		●		●				●	●		●				
Drypetes deplanchei		Shrub		●			●	●	●	●					●		○
Dunbaria singuliflora		Vine			●	●				●	●				●		○
Ectrosia leporina	Haresfoot Grass	Grass			●	●	●			●	●	●					
Eleocharis sp.		Rush/Sedge			●				●	●						●	○
Embelia curvinervia		Vine		●				●		●					●		○
Eragrostis sp.	Lovegrass	Grass			●	●	●		●	●	●	●					
Eriachne avenacea		Grass			●	●				●	●	●					
Eriachne burkittii		Grass			●		●		●	●	●	●					
Eriachne ciliata	Slender Wanderrie Grass	Grass			●	●				●	●	●					
Eriachne schultziana		Grass			●		●			●	●	●					
Eriachne triseta		Grass			●	●				●	●	●					
Erythrophleum chlorostachys	Ironwood	Tree	●			●	●	●		●		●		●			
Eucalyptus bigalerita	Salmon Gum	Tree	●				●			●		●					
Eucalyptus miniata	Woolybutt	Tree	●			●	●			●		●					

Species Name	Common Name	Life form	STRATA			VEGETATION TYPE				OBJECTIVE		ESTABLISHMENT TECHNIQUE					
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Eucalyptus tectifica	Darwin Box	Tree	●			●	●			●		●					
Eucalyptus tetrodonta	Stringybark	Tree	●			●				●		●					
Euphorbia schultzii		Herb			●		●			●	●		●		●		
Exocarpos latifolius	Native Cherry	Shrub		●		●	●	●	●	●					●		●
Ficus aculeata	Sandpaper Fig	Tree	●			●	●	●		●					●		●
Ficus brachypoda	Fig	Tree	●				●			●				●			●
Ficus platypoda	Rock Fig	Tree	●						●	●				●			●
Ficus racemosa	Cluster Fig	Tree	●					●	●	●				●			●
Ficus virens	Banyan	Tree	●			●	●	●	●	●				●			●
Fimbristylis sp.		Rush/Sedge			●		●			●			●			○	○
Flagellaria indica		Vine		●			●	●	●	●					○	○	○
Flueggea virosa	White Currant	Shrub		●		●			●	●				●			●
Fuirena ciliaris		Rush/Sedge			●		●		●	●			●			●	○
Ganophyllum falcatum	Scaly Ash	Tree	●					●		●				●			
Gardenia megasperma		Tree		●		●				●		●		●			
Grevillea decurrens		Shrub		●		●				●		●		●			
Grevillea dryandri		Shrub			●	●	●			●		●		●			
Grevillea heliosperma		Tree		●		●				●		●		●			
Grevillea pteridifolia		Tree		●		●	●			●		●		●			

Species Name	Common Name	Life form	STRATA			VEGETATION TYPE				OBJECTIVE		ESTABLISHMENT TECHNIQUE					
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Grewia breviflora	Grewia	Shrub		●				●		●				●			○
Gymnanthera oblonga		Vine		●			●	●	●	●					●		○
Hakea arborescens	Hakea	Shrub		●		●	●			●		●					
Heliotropium ventricosum		Herb			●	●				●	●		●				
Heteropogon contortus	Black Speargrass	Grass			●	●	●			●	●	●					
Heteropogon triticeus	Giant Spear grass	Grass			●	●	●			●	●	●					
Hibiscus meraukensis		Shrub			●	●	●		●	●	●	●					
Hydriastele wendlandiana		Palm	●					●		●			○	○	○		○
Indigofera hirsuta		Herb			●	●				●	●		●				
Ipomoea eriocarpa		Vine			●		●			●	●		●				
Ischaemum australe		Grass			●				●	●	●				●	●	
Jasminum molle		Shrub			●	●				●	●		●		●		●
Litsea glutinosa		Tree		●				●	●	●				●	○		○
Livistona humilis	Sand Palm	Palm		●		●	●		●	●		●		●			
Lophostemon grandiflorus	Swamp Box	Tree	●				●		●	●		●		●			
Lophostemon lactifluus	Swamp Mahogany	Tree	●				●		●	●		●		●			
Ludwigia octovalvis	Willow Primrose	Herb			●				●	●			●				●
Ludwigia perennis		Herb			●		●		●	●			●				○
Mallotus nesophilus		Tree		●				●		●				○	○		○

Species Name	Common Name	Life form	STRATA			VEGETATION TYPE				OBJECTIVE		ESTABLISHMENT TECHNIQUE					
			Upper storey	Mid storey	Lower storey	Open Woodland	Low-lying Woodland	Vine Thicket	Riparian	Ecological Restoration	Stabilisation	Direct Seeding - Core Species	Direct Seeding - Opportunistic Species	Nursery Propagation - Core Species	Nursery Species - Opportunistic Species	Direct Division Planting	Volunteer Species
Mallotus philippensis		Tree	●				●	●		●				○	○		○
Melaleuca cajuputi	Paperbark	Tree	●				●		●	●		●		●			
Melaleuca dealbata	Paperbark	Tree	●				●		●	●		●		●			
Melaleuca leucadendra	Weeping Paperbark	Tree	●				●		●	●		●		●			
Melaleuca nervosa	Paperbark	Tree	●				●		●	●		●		●			
Melaleuca viridiflora	Broad-leaved Paperbark	Tree	●				●		●	●		●		●			
Melochia corchorifolia		Herb			●				●	●			○		○		○
Miliusa traceyi		Tree		●				●		●				●			○
Mnesithea rottboellioides	Northern Canegrass	Grass			●		●		●	●	●			●	○	●	
Mollugo pentaphylla		Herb			●				●	●			●				
Myristica insipida	Native Nutmeg	Tree	●					●		●				●	●		
Opilia amentacea		Shrub		●		●				●					○		○
Owenia vernicosa	Emu Apple	Tree	●			●	●			●		●		●			
Pachygone ovata		Vine		●				●		●				○	○		○
Pachynema sp.		Shrub			●	●				●			○				
Pandanus spiralis	Pandanus	Palm		●		●	●	●	●	●		●		●			
Panicum mindanaense		Grass			●		●			●	●	○	●				
Panicum trachyrhachis		Grass			●				●	●			●				
Paspalum scrobiculatum		Grass			●		●		●	●	●		○				

Species Name	Common Name	Life form	STRATA			VEGETATION TYPE				OBJECTIVE		ESTABLISHMENT TECHNIQUE					
			Upper storey	Mid storey	Lower storey	Open Woodland	Low-lying Woodland	Vine Thicket	Riparian	Ecological Restoration	Stabilisation	Direct Seeding - Core Species	Direct Seeding - Opportunistic Species	Nursery Propagation - Core Species	Nursery Species - Opportunistic Species	Direct Division Planting	Volunteer Species
Persoonia falcata		Shrub		●		●	●			●					●		●
Petalostigma pubescens	Quinine	Shrub		●		●	●			●		●		●			
Petalostigma quadriloculare		Shrub			●	●				●		●		●			
Phyllanthus reticulatus		Shrub		●				●		●				○	●		○
Planchonia careya	Cocky Apple	Tree		●		●	●			●				●			
Polyalthia australis		Tree		●				●		●				○	●		○
Pouteria sericea		Shrub		●				●	●	●				○	●		○
Sacciolepis indica		Grass			●				●	●			●				○
Schizachyrium fragile	Firegrass	Grass			●	●				●	●	●					
Scleria ligulata		Sedge			●				●	●			●			●	○
Sorghum intrans	Annual Speargrass	Grass			●	●	●										●
Sporobolus australasicus	Fairy Grass	Grass			●		●			●	●		●				○
Stemodia lythrifolia		Herb			●	●	●			●	●		●		●		
Strychnos lucida	Strychnine Tree	Tree		●			●	●	●	●				●			○
Syzygium angophoroides		Tree	●	○				●	●	●				●			○
Syzygium armstrongii	White Bush Apple	Tree	●						●	●				●			○
Syzygium suborbiculare	Red Bush Apple	Tree	●			●	●	●	●	●				●			○
Terminalia carpentariae		Tree	●			●	●			●		●		●			
Terminalia ferdinandiana	Billygoat Plum	Tree	●			●	●	●		●		●		●			

Species Name	Common Name	Life form	STRATA			VEGETATION TYPE				OBJECTIVE		ESTABLISHMENT TECHNIQUE					
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Terminalia grandiflora	Nutwood	Tree	●			●	●			●		●		●			
Terminalia microcarpa		Tree	●				●	●	●	●				●			○
Terminalia pterocarya		Shrub		●		●				●		●					
Themeda triandra	Kangaroo Grass	Grass			●	●	●			●	●	●					
Timonius timon		Tree	●				●	●	●	●				●			○
Tinospora smilacina	Snake Vine	Vine		●			●	●		●					●		●
Trema tomentosa		Shrub		●			●	●		●				○	○		○
Tylophora flexuosa		Shrub		●				●		●					○		○
Urochloa pubigera	Summer Grass	Grass			●	●	●		●	●	●		●				○
Vigna vexillata		Vine			●	●	●			●	●		●				
Vitex acuminata		Tree		●		●	●	●	●	●				○	○		○
Waltheria indica		Herb			●	●	●			●	●		●				●
Whiteochloa sp.		Grass			●		●			●	●		●				
Wrightia pubescens		Shrub		●			●	●	●	●			○	●			
Wrightia saligna		Shrub		●		●				●	○		○				
Xanthostemon paradoxus		Tree	●			●	●			●			●	●			

Definite - ●

To be confirmed - ○

Appendix B – Harvest Target Calculator

Ecological Direct Seeded Zones

	Kg/Ha Planned	Kg/Ha Actual
TREE AND SHRUB	**4**	**4.000**
GRASS & HERBY	**3**	**3.000**

Species	Kg/Ha	Total Kg
ACACIAS		
Acacia alleniana	0.078	8.190
Acacia auriculiformis	0.050	5.250
Acacia difficilis	0.077	8.033
Acacia dimidiata	0.077	8.033
Acacia hemignosta	0.077	8.033
Acacia holosericea	0.020	2.100
Acacia lamprocarpa	0.077	8.033
Acacia latescens	0.077	8.033
Acacia platycarpa	0.077	8.033
Acacia plectocarpa	0.020	2.100
Acacia oncinocarpa	0.077	8.033
Acacia mimula	0.077	8.033
Acacia umbellata	0.020	2.100
Total Kg Acacias	**0.800**	**84.000**
Total % of Acacias in mix	**20.00%**	
EUCALYPTS/CORYMBIAS		
Corymbia bella	0.100	10.500
Corymbia dichromophloia	0.100	10.500
Corymbia disjuncta	0.100	10.500
Corymbia dunlopiana	0.030	3.150
Corymbia foelscheana	0.100	10.500
Corymbia latifolia	0.100	10.500
Corymbia polycarpa	0.100	10.500
Corumbia polysciada	0.100	10.500
Corymbia porrecta	0.100	10.500
Eucalyptus bigaleritia	0.100	10.500
Eucalyptus phoenicea	0.100	10.500
Eucalyptus miniata	0.120	12.600
Eucalyptus tectifica	0.100	10.500
Eucalyptus tetradonta	0.120	12.600
Eucalyptus tintinans	0.100	10.500
Total Kg Euc/Cor	**1.470**	**154.350**
Total % Euc/Cor in mix	**36.75%**	
OTHER SPECIES SMALL SEED		
Alphitonia excelsa	0.050	5.250

Brachychiton diversifolius	0.050		5.250
Brachychiton megaphyllus	0.050		5.250
Calytrix exstipulata	0.020		2.100
Callitris intratropica	0.050		5.250
Cochlospermum fraseri	0.020		2.100
Erythrina vespertillio	0.020		2.100
Erythrophleum chlorostachys	0.050		5.250
Grevillea decurrens	0.030		3.150
Grevillea pteridifolia	0.030		3.150
Hakea arborescens	0.010		1.050
Leptospermum maddidum	0.010		1.050
Lophostemon lactifluus	0.040		4.200
Petalostigma pubescens	0.050		5.250
Melaleuca viridiflora	0.020		2.100
Melaleuca cajuputi	0.010		1.050
Melaleuca dealbata	0.010		1.050
Melaleuca leucadendra	0.010		1.050
Total Kg Other Species	**0.53**		**55.650**
Total % of Other Species in mix	**13.3%**		
OTHER SPECIES BIG SEED			
Livistona humilis	0.200		21.000
Owenia vernicosa	0.200		21.000
Terminalia pterocarya	0.200		21.000
Terminalia carpentariae	0.200		21.000
Terminalia ferdinandiana	0.200		21.000
Terminalia platyphylla	0.200		21.000
Cycas armstrongii	0.700		73.500
Pandanus spiralis	7.000		735.000
Total Kg Other Species	**1.200**		**934.500**
Total % of Other Species in mix	**30.00%**		
TOTAL TREE & SHRUB	**4.000**		**1228.500**

GRASS SEED			
Alloteropsis semialata	0.25		26.250
Aristida holathera	0.25		26.250
Aristida hygrometrica	0.25		26.250
Aristida pruinosa	0.25		26.250
Brachyachne convergens	0.25		26.250
Eriachne glauca	0.25		26.250
Eriachne obtusa	0.25		26.250
Heteropogon contortus	0.25		26.250
Heteropogon triticeus	0.2		21.000
Themeda triandra	0.25		26.250
Triodia bitextura	0.25		26.250
Total	**2.7**		**283.500**
HERBY SPECIES			

Boerhavia sp.	0.010		1.050
Euphorbia sp.	0.010		1.050
Galactica sp.	0.010		1.050
Gomphrena canescens	0.200		21.000
Ludwigia sp	0.010		1.050
Pachynema sp.	0.010		1.050
Ptilotis sp.	0.010		1.050
Waltheria sp.	0.010		1.050
Herby sp.	0.030		3.150
Total Kg Herby Species	**0.300**		**31.500**
TOTAL GRASS & HERBY	**3.000**		**315.000**
Total Tree & Shrub & Grass & Herb Seed Mix	**7.000**		**1543.500**