Appendix 27.

Top End Seeds (2020) *Rum Jungle Stage 3 Draft Revegetation Strategy Framework*. Report to the Department of Primary Industry and Resources, Northern Territory.

NORTHERN TERRITORY GOVERNMENT

Department of **Primary Industry and Resources**

RUM JUNGLE STAGE 3

DRAFT REVEGETATION STRATEGY FRAMEWORK

June 2020

Report prepared for

Northern Territory Department of Primary Industries and Resources

by

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INTRODUCTION

Successful rehabilitation of the Rum Jungle Mine site depends on the creation of stable landforms which, in turn, depend significantly on adequate and appropriate self-sustaining vegetation. Ecological rehabilitation of the site has been requested by the Traditional Owners. This strategy document presents further detail on the Ecological Rehabilitation Strategy for the project and is based on the preliminary framework outlined within the project draft Environmental Impact Statement (DPIR, 2020). This strategy draws on the experiences of other mines in northern Australia and overseas, as well as the results from the revegetation trial undertaken at Rum Jungle. The Ecological Rehabilitation Strategy includes a Domain Based Methodology and provides a framework for more detailed and technical implementation plans.

Top End Seeds was engaged to develop this Draft Strategy for the purpose of submission in the Supplementary EIS Report. Department Primary Industries and Resources engaged Top End Seeds to assist in project development as the company has substantial local knowledge and over 20 years of experience in mine rehabilitation. Specifically, the company has been involved in works at the Woodcutters site for over 10 years and learnings have been shared by Newmont to allow improvement of the Rum Jungle strategy.

Ecological rehabilitation, as presented here, focusses on establishing the finer physical elements required for ecological function of a site.

OBJECTIVES

Key rehabilitation aims for the Rum Jungle Mine site are creating a safe and stable environment and reducing offsite impacts. In addition, Traditional Owners desire that the site supports flora and fauna species endemic to the area. To support these aims, active ecological restoration of all historically and planned disturbed areas will be undertaken.

The primary objective is:

> *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 all site surfaces.*

Vegetation communities from the surrounding area, represented by analogue sites situated in relatively intact vegetation, will inform the design of a number of modified revegetation systems suitable for each area of disturbance.

The rehabilitation program will also incorporate structural elements to enhance fauna recolonisation. This is to include elements specific to the threatened species (and culturally-significant fauna) known to have previously or currently exist on and around site.

Rehabilitation at Rum Jungle will involve the formation of a range of environments (*e.g.* re-aligned river channel, WSF, borrow pits, roads *etc*). Given the history of disturbance and the nature of the substrate, many of these environments will pose significant challenges for rehabilitation. This Ecological revegetation strategy has been developed to meet these challenges and rehabilitation techniques will continue to be adapted and refined to suit the specific issues across the site.

DOMAIN BASED STRATEGY

The Rum Jungle Stage 3 Rehabilitation Project area has been divided into several domains that reflect the organisation of the landscape into zones with similar rehabilitation strategies aimed at delivering specific results. These areas are shown here in Figure 1 and a high level strategy summary has been developed and is available in Table 1.

Generally, the domains can be grouped according to their functionality – Ecological Restoration or Stabilisation as shown in Table 1.

- Stabilisation – to provide a long-term vegetative cover to improve resistance to erosion, using relatively shallow rooted local endemic species in order to maintain the integrity of the underlying compacted barrier layers.
- Ecological Restoration – to provide diversity and structural complexity based on surrounding intact vegetation.

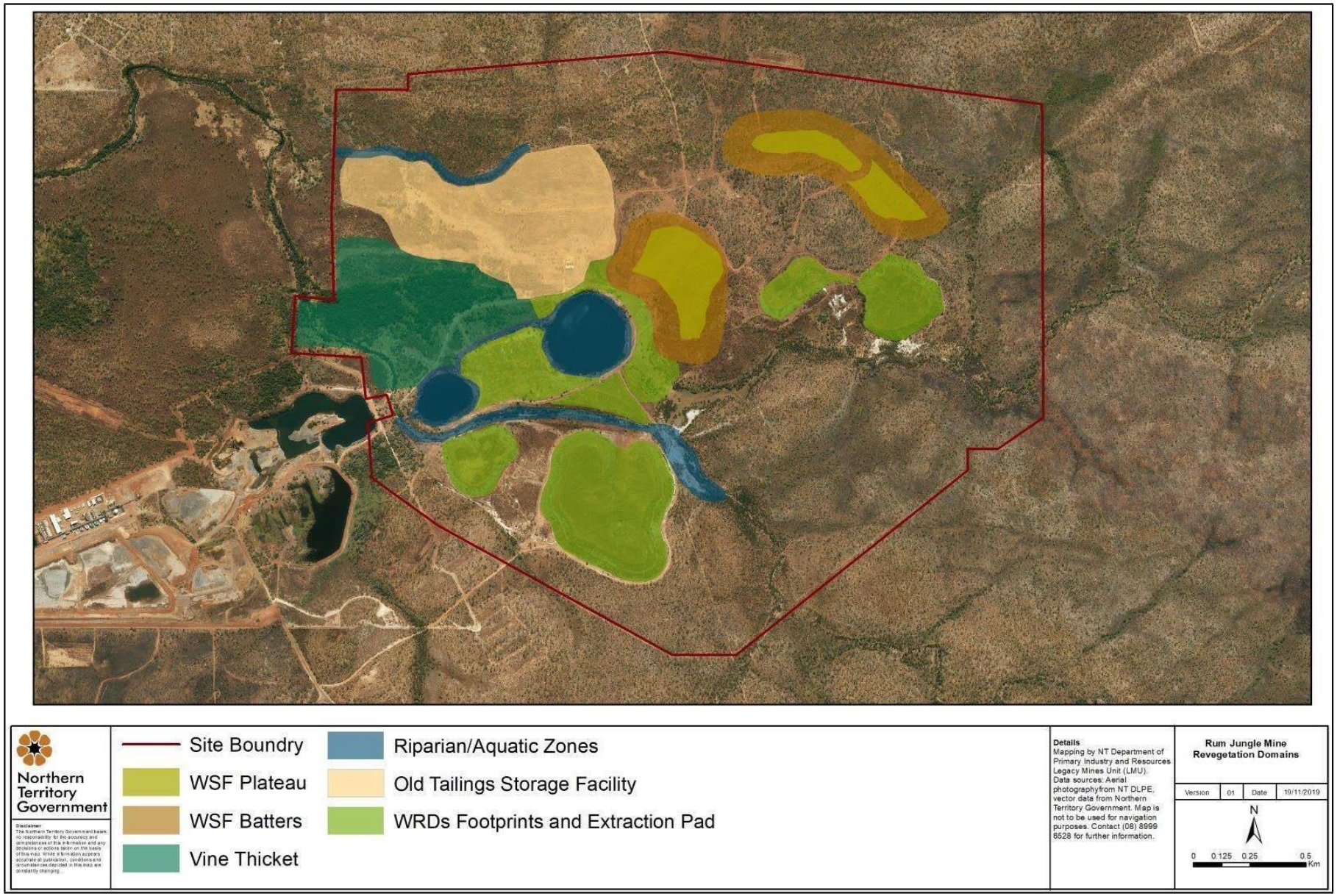

Figure 1 Rum Jungle Vegetation Domains

Table 1 Domain Based Strategy

Domain	Objective	Area (ha)	Gradient (%)	Fauna Elements*	Target Vegetation Type	Limitations	Map Units	Revegetation Techniques
WSF Batters	Stabilisation	48	25	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	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	RM	Riparian/Low Lying Open Woodland	Mid-storey shrubs and understorey species only No bush tucker	20,21,22 ,23,24,2 5,26	Primarily direct seeding Some tubestock planting
WRD Footprints inc Cu Extraction Pad	Ecological restoration	61	0-5	RM, HG, 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	RM, HG, 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	HG	Vine Forest	All species	1	Tubestock planting following extensive weed control

Riparian (EBFR, EFDC, Main Pit)	Ecological restoration	15	0-10	HG, PS, LWD	Riparian	All species	20,25,26	Tubestock planting and direct division
Mt Burton **	Ecological restoration	2	0-5	Nil	Vine Forest	All species	1	Tubestock planting following extensive weed control
Mt Fitch	Ecological restoration	2	0-5	Nil	Open Woodland/ Low Lying Open Woodland	All species	2,3,4,5,6 ,7,8,9,10	Direct seeding Tubestock planting
Roads	Retain or Ecological restoration	Varies	0-10	HG, PS	TBC	All species	TBC	Primarily direct seeding Some tubestock planting
Borrow – FRALT**	Ecological restoration	60	0-10	HG	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	Nil	Open Woodland/Low	All species	2,3,4,5,6 ,7,8,9,10	Primarily direct seeding Some tubestock planting

*LWD Large Woody Debris
HG Hollow Logs on Ground
PS Pandanus Stands
RM Rocky Mounds

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

DOMAIN DESCRIPTIONS

STABILISATION DOMAINS

- **WSF Batters** – includes the sloped outer batter surfaces of the WSF. The vegetation must be shallow rooted to maintain cover system integrity and not include bush tucker plants to avoid any long-term exposure pathway for metals to the environment or people. The purpose of the vegetation is to establish quickly and provide a long-term vegetative cover for the WSF to improve resistance to erosion.
- **WSF Plateau** – refers to the flatter top surfaces of the WSF. The vegetation must be shallow rooted to maintain cover system integrity and not include bush tucker plants to avoid any long-term exposure pathway for metals to the environment or people. The purpose of the vegetation is to establish quickly and provide a long-term vegetative cover for the WSF to improve resistance to erosion.
- **Dyson's (backfilled) Pit** – refers to the new surface developed after removal of the copper extraction materials and soil. The vegetation must be shallow rooted to maintain cover system integrity and not include bush tucker plants to avoid any long-term exposure pathway for metals to the environment or people. The purpose of the vegetation is to establish quickly and provide a long-term vegetative cover to improve resistance to erosion.

ECOLOGICAL RESTORATION DOMAINS

- **WRD Footprints** – includes the stripped and backfilled surfaces close to natural ground level that will remain after completion of the waste rock removal at the current Main, Intermediate and Dyson's WRDs. These areas will be relatively flat. Rehabilitation will aim provide diversity and structural complexity based on surrounding intact vegetation.
- **Old Tailings Dam** – the area was previously rehabilitated; however, the current condition is poor due to the invasion of weeds and repeated bushfires. This area requires physical improvement to reduce fire impacts. Rehabilitation will aim provide diversity and structural complexity based on surrounding intact vegetation. Vegetation types in this area are unrestricted and it will also provide trial areas to establish Open Woodland revegetation systems.
- **Vine Thicket** – an area north of Intermediate Pit that is naturally occurring but heavily impacted at its edges by weeds and fire. Rehabilitation will aim provide diversity and structural complexity based on surrounding intact vegetation. It will provide a trial area to establish revegetation and fauna restoration systems.
- **Riparian** – refers to all areas along watercourses that are yet to be constructed (EBFR, Main Pit riparian zone) or currently exist in a poor condition. Rehabilitation will aim provide diversity and structural complexity based on surrounding intact vegetation.
- **Mt Burton** – a 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. As a minimum, it will be returned to open woodland.
- **Mt Fitch** – a satellite site that is flat and requires minor works to improve and return to open woodland.
- **Roads** – these linear structures are likely to pass through many vegetation units and some roads may be required by future landowners to remain. The revegetation for a road will be specified once the road is nominated for revegetation.
- **Borrow – FRALT** – refers to the potential borrow pit south of Rum Jungle. Agreements for final closure of this landform have not yet been reached with the FRALT.
- **Borrow – CCGC** – refers to the potential borrow pit adjacent to Rum Jungle Creek South. Agreements for final closure of this landform have not yet been reached with the CCGC.

BASELINE SURVEYS AND MAPPING

Several sources were accessed in development of the Ecological Rehabilitation Strategy. The primary data source relevant for the site is the detailed vegetation mapping that has been carried out by several parties over time. This work enables a thorough understanding of potentially analogous sites and provides a starting point to develop a modified revegetation strategy that meets the project objectives whilst being cognisant of the strongly-altered environmental conditions onsite.

Additionally, data was collected from recent revegetation programs at McArthur River Mine, Woodcutters Mine, Ranger Mine and overseas examples. A literature review and review of data from onsite field trials also assisted to

form the strategy and methodologies described in this chapter. This Additional information is located within the draft EIS (DPIR, 2020).

BASELINE VEGETATION MAPPING

Baseline mapping by Eco Logical in 2014 provides a detailed vegetation unit map and assessment of impacts to those vegetation units. Additionally, detailed species lists are provided for each unit.
In order to develop the Revegetation Strategy, the domain area objective was compared to surrounding residual vegetation units and appropriate target vegetation types were developed for each domain. Several vegetation units may bound a single domain and, in this case, species were selected from across all of the appropriate units. This is likely to provide an improved chance of revegetation success. All species selected are endemic to the area.

In the case of the modified vegetation types, shallow rooted framework and coloniser species have been selected in the species list. This is to meet the objective of rapid vegetation establishment on the appropriate landforms.

RIPARIAN VEGETATION SURVEYS

Metcalfe (2002) carried out an overarching riparian vegetation survey along the East and West Branches, as have Hydrobiology (2013), in addition to the work listed above by Eco Logical (2014). Hydrobiology (2013) and Metcalfe (2002) agree that the main branch of the Finniss River differs in density and diversity of riparian species from the East Branch. This can be attributed to both the degradation due to historic mining practices and the ephemeral nature of the East Branch. Data collected from these surveys has informed the development of the species list for each domain.

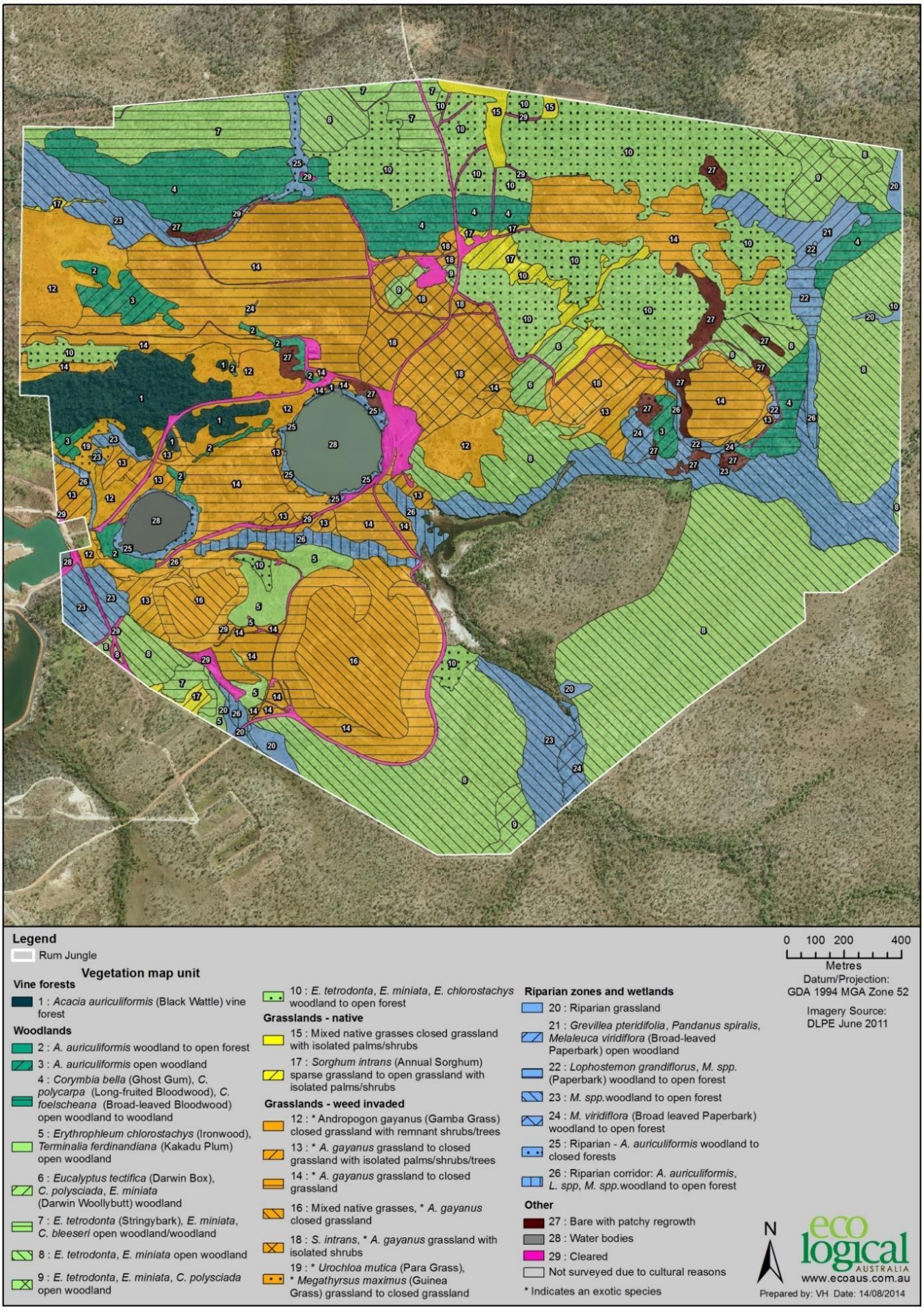

Figure 2 Rum Jungle Vegetation Domains

FAUNA

The rehabilitation program aims to encourage progressive fauna utilisation of newly revegetated areas.

The most significant threatening processes on the Rum Jungle site for the restoration of fauna are:

- Heavily-disturbed land with poor revegetation outcomes to date which provides few resources for fauna
- Gamba Grass and its role as an ecosystem fire modifier; and
- Feral animal impacts particularly pigs, cattle, cats and cane toads
- Water Quality as described by Hydrobiology within the draft EIS (DPIR, 2020)

As such, weed and feral animal management plans will play a strong role in the fauna restoration process.
In order to provide sufficient resources to support fauna restoration, a critical element of the rehabilitation strategy for Rum Jungle is the inclusion of additional structural elements into the work program alongside revegetation practices.

FAUNA ELEMENTS

Review of The Australian Government's National Recovery Plans for the Threatened Species (DoE, 2019) and, The Action Plan for Australian Mammals 2012 (Woinarski et al., 2014) reveals several physical elements that could be incorporated into the rehabilitation strategy to increase the diversity of niches and provide shelter within the habitat. Apart from the mitigation of impacts by fire, weeds and ferals, these elements can be summarised as:

- Rocky Mounds – Quolls and other species utilise rocky mounds as dens. Rocky mounds also provide perching positions for birds.
- Hollows on Ground – Mammals and others utilise hollows for shelter or nesting.
- Pandanus Stands – Black-footed Tree-rats may use as dens.
- Large Woody Debris – utilised by aquatic species as reported at McArthur River Mine. Improves habitat complexity in terrestrial rehab areas.

Resources for these elements are to be recycled within the work program. These elements will be placed within newly rehabilitated areas as far as available resources will allow. Monitoring fauna utilisation is not planned as a formal monitoring parameter for rehabilitation metrics though it may provide an opportunity for research by external organisations.

RESOURCE USE AND SALVAGING

Resource reuse and salvaging is critical to successful rehabilitation processes.

- The Darwin Cycad is a culturally- significant plant and a relocation plan has been developed (see Chapter 14 – Terrestrial Flora and Fauna) to ensure that individuals are salvaged and replanted into non-impacted areas and into new revegetation spaces. Cycad replanting will occur throughout all stages of the earthworks program.
- Additional resource reuse and recycling measures include salvaging of any timber or vegetation that cannot be preserved during the earthworks program and clean rocky oversize that cannot be used in rock armouring. Suitable material will be stockpiled as it becomes available and placed once final landform shaping is completed.

DOMAIN BASED METHODOLOGY

This section presents the general methodology that will be used for revegetation practices for each domain. Generally, the domains can be grouped according to their functionality – Ecological Restoration or Stabilisation as shown in Table 1. Restoration domains have very few modifications required to the surrounding analogous species lists, however Stabilisation domains have modifications due to the domain containing the WSF or Dyson's Pit backfilled.

ECOLOGICAL RESTORATION DOMAINS

OPEN WOODLAND/LOW LYING OPEN WOODLAND

These areas include the Old Tailings Dam and the Waste Rock Dump Footprints.

- Diverse range of species to be established (over 80 species)
- Seed collection activities to be initiated as soon as possible to ensure this diverse species mix is achievable.
- Intensive weed control works are a priority for these areas to eliminate the large weed infestations (especially Gamba Grass and Grader Grass) already on these sites. Weed control needs to be thorough and continued over a number of years to reduce the amount of weed seed surviving in the soil. A combination of burning, aerial spraying and ground spraying is recommended.
- Vegetation will be established primarily by direct seeding once weeds have been adequately controlled/ eliminated.
- Site to be deep ripped along contours to a depth of at least 500mm to reduce erosion and improve vegetation recruitment. Although these sites are relatively flat, they should be surveyed prior to ripping to ensure riplines follow contours exactly.
- Recalcitrant and special species will be established by tubestock plantings and/or species specific targeted seeding.
- Include fauna elements where possible.
- Ongoing weed control of Gamba Grass or other weed species well before the onset of seeding and while the plants are small enough to easily control.

VINE FOREST

Includes remnant patches of vine forest and vine thicket and the immediate surrounding area.

- Diverse range of species to be established (over 40 species)
- Intensive weed control works are a priority for these areas to eliminate the large weed infestations already on these sites. Weed control needs to be thorough and continued over a number of years to reduce the amount of weed seed surviving in the soil.
- Vegetation will be established primarily by tubestock infill plantings once weeds have been eliminated successfully.
- Ongoing weed control will be critical to success in these areas.
- Whole of site feral animal control (especially pigs and buffalo) will be an essential element to the establishment of vegetation.
- Include fauna elements where possible.

RIPARIAN

Includes existing degraded riparian corridor and yet to be constructed watercourses.

- Diverse range of species to be established (over 50 species)
- Intensive weed control works are a priority for these areas to eliminate the large weed infestations in the degraded areas. Weed control needs to be thorough and continued over a number of years to reduce the amount of weed seed surviving in the soil.
- Vegetation will be established primarily by tubestock infill plantings once weeds have been eliminated successfully.
- Temporary irrigation of tubestock plantings may be required in the early wet season to improve establishment especially in seasonally inundated areas.
- Direct seeding and direct division will be used for some specific species, especially grasses and

sedges/rushes.
- Ongoing weed control will be critical to success in these areas.
- Whole of site feral animal control (especially pigs and buffalo) will be an essential element to the establishment of vegetation.
- Include fauna elements where possible.

STABILISATION DOMAINS

Includes Wastes Storage Facilities and Dyson's Backfilled Pit

- Diverse range of low growing species to be established (over 40 species)
- Seed collection activities to be initiated as soon as possible to ensure this diverse species mix is achievable.
- Targeted weed control works will be necessary to avoid weed infestations (especially Gamba Grass). Weed control needs to be thorough and continued over a number of years.
- Cover material should include topsoil where possible. Where top soil availability is limited it should be applied patchily across as many areas as possible.
- Material used for the final landform cover needs to be weed free. If weeds are present in the borrow pit areas then weed control works will be necessary. Weed control needs to be thorough and continued over a number of years to reduce the amount of weed seed surviving in the soil.
- Vegetation will be established primarily by direct seeding once weeds have been adequately controlled/ eliminated.
- Site to be deep ripped along contours to a depth of at least 500mm to reduce erosion and improve vegetation recruitment. Sites should be surveyed prior to ripping to ensure riplines follow contours exactly. This is critical to success on batter slopes.
- Recalcitrant and special species will be established by tubestock plantings and/or species specific targeted seeding.
- Include fauna elements where possible.
- Re-seed bare patches 2-3 years after first seeding.
- Ongoing weed control of Gamba Grass or other weed species well before the onset of seeding and while the plants are small enough to easily control.

INITIAL REVEGETATION AREAS - OLD TAILINGS DAM

The Old Tailings Dam area is earmarked as a starting point for the establishment of revegetation systems for site. The area requires no further bulk earthworks; however, a final check of phytotoxic elements (predominantly copper and soil pH) will aid in development of a Soil Amelioration Plan if it is deemed required. There may be residual patches of copper or low pH soils in the area resulting from historic practices that may need to be addressed prior to the establishment of revegetation practices.
Initial revegetation trials will focus on revegetating small areas, of up to 2ha in size annually, in order to progress the rehabilitation methodology, and build momentum technical knowledge within the project team.

- Targeted intensive weed control works areas to eliminate the large weed infestations (especially Gamba Grass and Grader Grass) already on this site. Weed control needs to be thorough and continued over a number of years to reduce the amount of weed seed surviving in the soil.
- It is likely that the trial areas will continue to be re-infested with weeds from the surrounding areas, so ongoing weed control will be critical to success.

ANNUAL TIMELINE

	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												
Fauna Elements												
Direct Seeding												
Tubestock Planting												

SPECIES LISTS

Species lists have been developed specifically for each domain and presented as a simple spreadsheet able to be adapted to each area. The species lists has been are derived from vegetation map unit data collected as part of baseline mapping by Eco Logical in 2014 and a site visit by Top End Seeds in 2020.

It is important to view these initial species lists as a base on 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 by 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, and 3) positive contribution to the revegetation.

Note: It can be worth adding difficult to harvest species in very small amounts 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 tubestock in dense patches etc.

VEGETATION TYPES

Four broad vegetation types have been defined to be used in the revegetation; based on map unit species lists and a practical understanding of the variations in the surrounding landscape.

1. Open Woodland – Open mixed Eucalypt woodland with a grassy understorey and a mid-storey of variable density, from sparse to thick. Growing on low hills and rises.

2. Low Lying Open Woodland- Open mixed Eucalypt woodland with a grassy understorey and a mid-storey of variable density, from sparse to thick. Growing on low rises, flats and small valleys, with some areas subject to seasonal inundation.

3. Vine Forest- An 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.

4. Riparian- Open monsoon forest with a highly variable mid and understorey, generally growing as a thin band along water courses.

Species Name ● Definite ○ To be confirmed	**Common Name**	**Life form**	STRATA			VEGETATION TYPE				OBJECTIVE		ESTABLISHMENT TECHNIQUE					
			Upper storey	**Mid storey**	**Lower storey**	**Open Woodland**	**Low Lying Woodland**	**Vine Forest**	**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			●	●	●			●	●	●					
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		●		●	●	●	●	●				○	●		○

Species Name ● Definite ○ To be confirmed	**Common Name**	**Life form**	STRATA			VEGETATION TYPE				OBJECTIVE		ESTABLISHMENT TECHNIQUE						
			Upper storey	**Mid storey**	**Lower storey**	**Open Woodland**	**Low Lying Woodland**	**Vine Forest**	**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**
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	●					●		●				○			○
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	●			●	●			●		●					

Species Name ● Definite ○ To be confirmed	**Common Name**	**Life form**	STRATA			VEGETATION TYPE				OBJECTIVE		ESTABLISHMENT TECHNIQUE					
			Upper storey	**Mid storey**	**Lower storey**	**Open Woodland**	**Low Lying Woodland**	**Vine Forest**	**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**
Corymbia porrecta	Grey Bloodwood	Tree	●			●				●		●					
Crotalaria sp.		Herb			●	●				●	●		●				○
Croton arnhemicus		Shrub		●		●				●			●		●		
Cupaniopsis anacardioides		Tree		●			●	●	●	●				●			○
Cycas armstrongii	Cycad	Palm		●	○	●	●			●				●		●	
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	●				●			●		●					

Species Name ● Definite ○ To be confirmed	**Common Name**	**Life form**	STRATA			VEGETATION TYPE				OBJECTIVE		ESTABLISHMENT TECHNIQUE					
			Upper storey	**Mid storey**	**Lower storey**	**Open Woodland**	**Low Lying Woodland**	**Vine Forest**	**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**
Eucalyptus miniata	Woolybutt	Tree	●			●	●			●		●					
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		●		●	●			●		●		●			
Grewia breviflora	Grewia	Shrub		●				●		●				●			○
Gymnanthera oblonga		Vine		●			●	●	●	●					●		○
Hakea arborescens	Hakea	Shrub		●		●	●			●		●					
Heliotropium ventricosum		Herb			●	●				●	●		●				
Heteropogon contortus	Black Speargrass	Grass			●	●	●			●	●	●					

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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		●				●		●				○	○		○
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	●					●		●				●	●		

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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			●		●		●	●	●		○				
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	●						●	●				●			○

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Syzygium suborbiculare	Red Bush Apple	Tree	●			●	●	●	●	●				●			○
Terminalia carpentariae		Tree	●			●	●			●		●		●			
Terminalia ferdinandiana	Billygoat Plum	Tree	●			●	●	●		●		●		●			
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 - ○

SEED HARVESTING STRATEGY

BUILDING THE SEED-BANK

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

HARVEST STRATEGY

Developing a focused but flexible harvest strategy will enable the seed-bank 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 are able to be collected in the required quantities.

A proven harvest strategy is to focus on collecting enough seed of all species for that years planned revegetation, while also working to a set budget for opportunistically collecting good crops of key species as they occur. As the year's progress and the seed-bank is built up, the 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 updated. An easily managed harvest target spreadsheet has been created to make this process quick and easy.

SEED AVAILABILITY

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.

The long term adaptive management approach detailed above and the flexible provenance zones detailed below both help to mitigate this risk allow an agile response to seasonal opportunities and threats

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 success while still maintaining the quality and genetic integrity of the seedbank:

- As much as possible should be harvested from the area immediately adjacent to the site, especially the FRALT 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

VOLUNTEER SPECIES

Volunteer species are those that are not purposefully seeded. These species are primarily introduced through top soil 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 more 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.

LONG LIVED STRUCTURAL VEGETATION

Eucalypt and Corymbia's, 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'. For this reason, it is very important that they establish in sufficient numbers in the rehabilitated areas. They will form the 'structure' of the vegetation in the long term. They are fire resistant, and also form important habitat, including tree hollows, for a variety of fauna. So it is important that they establish in sufficient numbers. 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 Forest and Riparian Domains are long lived structural species. Targets will also be set for number of stems per hectare for these species based on species demography 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. Long lived mid storey species will be assessed to ensure they are suitable for inclusion and then seeded or planted at higher densities to help account for this.

SEED VOLUMES AND SPECIES MIXES

A seed mix will be developed specifically for each domain, and adapted and refined for different areas within that domain as required.

The amount of seed required differs for each species and for each site. It is best expressed as grams required per hectare (g/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

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 can be adjusted to better reflect the desired plants/Ha.

*Setting specific goals in terms of the desired plants/Ha for trees and shrubs and desired cover % for grasses and herbs in the revegetation is the most effective way of using data from baseline vegetation surveys to inform revegetation targets.

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 a number of years are required in order to get more accurate picture.

A balanced species mix is critical to the success of a revegetation project. Top End Seeds has, over the last 20 years, developed a proven approach to species ratios in large scale mine revegetation projects. The mix is divided into 4 main categories:

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

The species mix should be seen as a base on which to build, and that it should be refined and improved over time based on learning's 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. Generally speaking, 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.

Acacia's 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.

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; seeding rate, seed treatment, storage issues etc.
- Many species, such as *Terminalia, Cochlospermum*, Erythrophleum, Buchania, Petalotigma, Kurrajong, and Calytrix have low recruitment rates and are hard to establish in rehabilitation areas.
- There are a number of species that are extremely hard to establish by direct seeding and require special treatment and/or trialling of alternative establishment techniques.

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.

TIMING

Harvest times

Seed availability and supply is seasonal and requires a long-term planning approach. For large projects we recommend taking a long term view and working towards 3 year work plans.

Typical harvest times are:

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

STORAGE LIFE

The expected storage life of seed differs between species. The storage life needs to be taken into account when setting harvest targets, especially in regards to long term seed-bank targets. Approximate storage life when stored in airtight containers at 20^0C:

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

The species have been divided into 4 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 and stored until used, whereas 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 can't be used until the following wet season.

SEED VIABILITY

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

There a many factors that can affect viability, including:

- Amount and timing of rain during flowering and seeding
- Ripeness at time of harvest
- Insect predation
- Mould
- General health of that species in the local area
- Age of plants
- Fire History

Germination standards have been developed by Top End Seeds for many of the core direct seeding species on the Rum Jungle species list. This information will be used as a guide in terms of expected viability.

Independent seed tests will be carried out as required on seed lots over 1000g to ensure seed quality. This information will be also be used to refine seed mixes and help to improve planning for future projects.

NURSERY PROPAGATION OVERVIEW

A locally situated nursery will form an integral part of the Ecological Rehabilitation at Rum Jungle. It will provide the bulk of the revegetation species for the Vine Forest and Riparian Domains and also contribute special or hard to establish species for the whole project. There may be plants requested by Traditional Owners that have special meaning and will need to be established.

The nursery will provide a good employment and training opportunity for local indigenous people and also an opportunity to collaborate with training organisations such as Batchelor College or CDU. Horticultural and Land management qualifications and skills are highly valued and directly applicable to many other forms of employment.

The size and/or capacity of the nursery will need to be determined based on tubestock requirements for the project, which are yet to be confirmed.

A nursery will produce tubestock of species that are hard to establish through direct seeding. These species are often underrepresented in revegetation works due to their recalcitrant nature; they are either difficult to germinate, are predated on by insects and birds or hard to collect the seeds in large quantities.

An initial 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 should be fine-tuned over time. It would be necessary to obtain quantitative baseline data to help determine an ideal stems/ha target value for each of these core nursery species. This will help to determine how many plants to grow each year based on the target revegetation sites for that year.

Production of the core nursery species will be the main priority. There are proven propagation techniques for growing most of these species. Additionally, propagating opportunistic nursery species will be trialled once the nursery is well established. It is required that the nursery will run year round and tubestock will be ready for planting by December each year.

The main propagating and growing season is August through to December but many soft fruited rainforest and bush tucker species need to be grown from fresh seed in one wet season to be ready for planting the following wet season.

The nursery propagation program will need to be integrated into the seed harvesting work program. Species will need to be specifically targeted for the nursery. Many species are hard to collect even in small amounts and they will not generally be used for direct seeding.

NURSERY SPECIES SELECTION

For the purposes of nursery propagation, species to be selected should be:

- High value seeds that are difficult to collect in large quantities
- Recalcitrant species
- Rainforest in fill plants
- Riparian species including sedges and rushes
- Special species with cultural values
- Species that are unable to propagate from seeds

PROPAGATING TECHNIQUES

Methods for propagation include:

- Soft fruited rainforest and bush tucker species need to be planted from fresh seed.
- Cuttings for some woody plant species
- Direct divisions for plants such as rushes and sedges and riparian grasses
- Soaking seeds in various solutions or scarifying seeds in order to stimulate growth.

SITE PREPARATION

CONSTRUCTED AREAS

Once final landform shaping and weed control is complete site preparation will be carried out in the following order:

- Topsoil application
- Survey and mark of contours
- Deep ripping along contours with bulldozer, generally in October-November

DEGRADED RIPARIAN AND VINE FOREST

Site is ready for planting once weed control is considered adequate. If irrigation is required then it should be set up in September-October.

SEEDING & PLANTING

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, base rates to be refined are:

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

DIRECT SEEDING TIMING

The optimal time to carry out direct seeding in the Top End usually 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. 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 to help settle the ground. This helps to reduce the amount of seed getting buried too deeply.

PLANTING TUBESTOCK

Planting out of tubestock is best done in the early part of the wet season into moist soil.

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.

Seedlings are planted into holes and watered in.

Where possible seedlings will be mulched with local weed free hay.

TRAINING OVERVIEW

Training of local indigenous people is fundamental to all facets of the Ecological Rehabilitation Strategy. This includes accredited training in Horticulture and Land Management and also on the job training.

Key areas for training include:

- Certificate/Diploma in Horticulture and/or Conservation and Land Management
- Seed harvesting/processing training
- Direct seeding
- Revegetation project implementation

- Weed control
- Fire management
- Feral animal control
- Site monitoring and evaluation
- Nursery management and operations

SEED COLLECTION TRAINING

Although seed collection forms a small part of conservation and land management training, it is a specialised industry with no formal or accredited training pathways. An on the job seed collection training program has been developed by Top End Seeds for this project.

Ongoing on the job training will be conducted with each trainee at their own pace. The following proficiencies form the core of the training and are assessed by the trainer/supervisor/team leader.

SEED COLLECTION TRAINING

- Overall workplace safety and safe work procedures
- Communication with other team members, including team supervisor
- Healthy eating and hydration
- Plant identification and identifying harvestable seed patches.
- In field seed testing
- Hand harvesting
- Long pole harvesting

SEED PROCESSING TRAINING

- Overall workplace safety and safe work procedures
- Communication with other team members, including team supervisor
- Healthy eating and hydration
- Plant identification
- Seed hygiene
- Seed processing techniques including: hand sieving and using, Winnower machine, thresher, brush thresher.
- Multiple species seed cleaning requirements
- Labelling, bagging and weighing.

THREATS AND RISKS, INCLUDING WEEDS, FIRE, FERAL ANIMALS AND MORE WEEDS

The most significant risks to the success of the ecological restoration program are the following threatening processes:

WEEDS (PARTICULARLY GAMBA GRASS, GRADER GRASS AND CALOPO)

All serious weed species should be controlled for 2-3 years prior to revegetation works with the aim of eliminating them from the area before planting/seeding.

UNCONTROLLED FIRE

Annual burning program to reduce fire risks. Fire should be kept out of newly rehabilitated areas for at least 5 years.

FERAL ANIMALS (ESPECIALLY PIGS AND BUFFALO)

Ongoing feral animal culling program to reduce numbers and limit damage to sensitive areas.

MONITORING AND EVALUATION

A comprehensive monitoring and evaluation program will be developed for rehabilitation areas at the Rum Jungle site.

The monitoring and evaluation will focus on feeding information and learnings back into ongoing rehabilitation work. Through this the project will aim for constant improvement, applying learning from past results directly to current and future areas. All data collected needs to be directly applicable to the practical outcomes of the project.

The key components of this program are:

- Annual or biannual whole of site weed survey to guide weed control works.
- Annual rapid whole of site erosion assessment to guide erosion control and remediation works.
- 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 on revegetation.
- LFA survey of each rehabilitated area within 6 months of seeding/planting to guide future rehabilitation works and provide baseline data on underlying system drivers.
- Additional targeted analogue surveys to assess species densities of vine forest species and other special species in the surrounding landscape to provide appropriate planting/seeding targets.

WEED SURVEYS

A Weed Management Plan for the site will be needed to help manage this risk. A monitoring plan for weeds will be incorporated into that Plan. Top End Seeds recommend that weed surveys and inspections will be conducted once or twice a year during the growing season. They should target all key weed species and cover the whole of site.
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.

EROSION ASSESSMENTS

Erosion assessments will be carried out towards the end of the wet season or as required after large rainfall events. They will focus on areas most prone to erosion such as batters, drainage lines and water management and collection structures. Erosion assessments can be included in Vegetation Surveys/LFA monitoring where appropriate.
Datasets will be very basic and focussed on directly informing ongoing erosion control and remediation works. Results from these assessments can also be used to improve landform design and construction on future rehabilitation areas.

VEGETATION SURVEY

Detailed vegetation surveys will be carried out approximately 18 months after seeding/planting. Waiting for 2 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 also the expected high mortality rates in the first year. Follow up surveys will be conducted 5-8 years after seeding/planting to better understand the trajectory of the revegetation. The vegetation survey will be detailed but focussed on applicable data. 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/individual plant

LANDSCAPE FUNCTION ANALYSIS

Landscape Function Analysis (LFA) monitoring transects will be established in newly rehabilitated 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 again in 5-8 years.

The LFA framework was developed by David Tongway and CSIRO, and 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 has been specifically adapted for use in monitoring mine site rehabilitation.

- **Stability index**- surface resistance to erosion. Stability is increased where there is good rock mulch cover, well designed shaping and well executed ripping.
- **Infiltration index**- potential of surface soils to infiltrate water. Infiltration is improved where there is good topsoil spread and accurate ripping.
- **Nutrient cycling index**- potential of surface soils to cycle nutrients back into the soil. Nutrient cycling is improved where there is good topsoil spread 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 increase in LFA index values.

STRUCTURAL SPECIES BASELINE SURVEY

Additional targeted and rapid, analogue surveys to assess species densities of vine forest species and other special species in the surrounding landscape to provide appropriate planting/seeding targets.

The survey will focus on quantifying stems per hectare for each core structural species.

LEARNINGS FROM PREVIOUS PROJECTS

Apart from the learnings documented within the draft EIS, Top End Seeds has substantial local experience, including at Woodcutter's mine. These learnings are likely to be more relevant to the Rum Jungle biogeography. **Woodcutters Mine** care and maintenance site, nearby to Rum Jungle, have the following observations regarding lessons learned in revegetation works:

- Using a specifically designed species mix developed for the site using 73 native species.
- Deep ripping the surface of the site to a depth of 200-600mm.
- Direct seeding has been carried out in the wet season after the first good rains, late Dec- early Jan.
- Seeding as late as March has also been successful.
- Using a seeding rate of 4kg for tree and shrub seeds has worked well in this location in some pretty average rainfall years. Some areas has also included a native grass seed mix using an additional rate of 3kg/ha.
- It is worth focusing on weed control, especially Gamba grass, over a number of years before seeding rather than trying to control after seeding.
- Importance of machinery hygiene- washing down machinery before working in the rehab areas to limit weed seed introductions.
- Direct division techniques were used to transplant some species into riparian wetland areas.
- Local indigenous involvement in the seeding and transplanting as well as ongoing weed control works has been successful.
- Darwin Cycads can be successfully transplanted as part of a major earthworks project.
- Gamba Grass is an on-going issue and requires an annual targeted campaign.
- Local employment has also been generated by utilising a local Traditional Owner business to supply tube stock to the project.

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