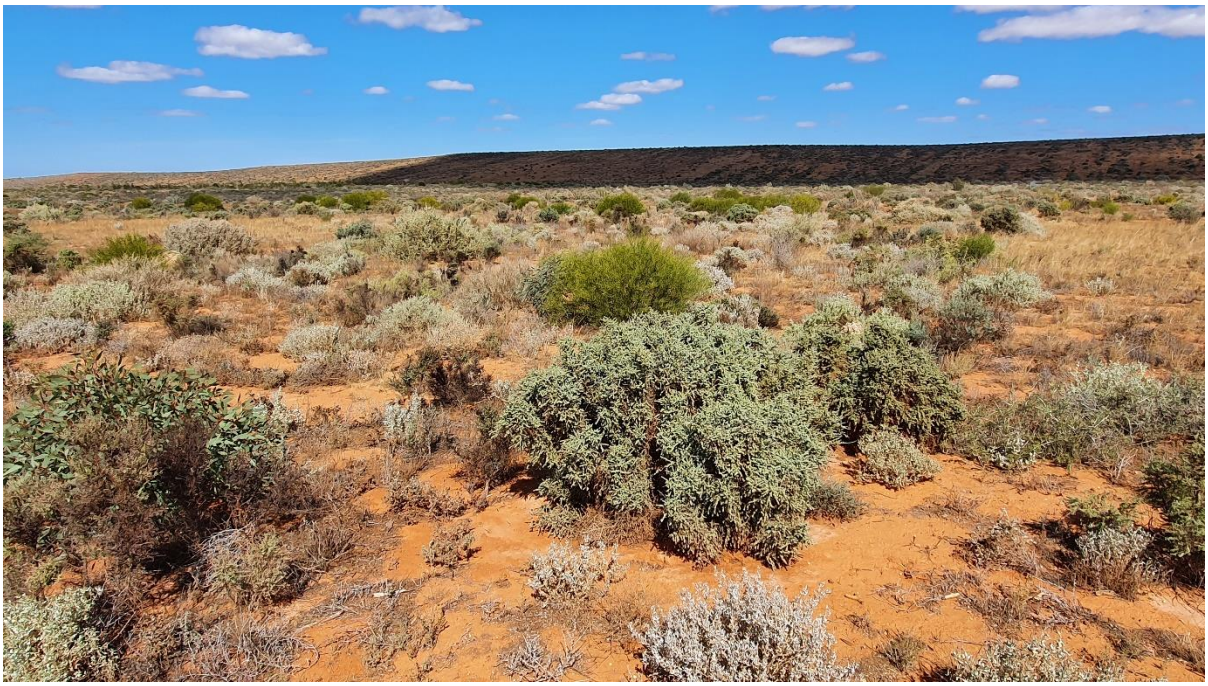
Appendix 3

Rehabilitation Plan Technical Supplement

(Total No. of pages including blank pages = 31)

Copi Mineral Sands Mine Rehabilitation Plan
Technical Supplement 1



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1. Preface (Scope and Limitations)

This document is intended to be used as a technical supplement to the Copi Mine Rehabilitation Plan. The authors understand that RZ Resources, the owner / operator of the Copi Mine, have commissioned two technical supplements from rehabilitation experts to be used in developing the Copi Mine Rehabilitation Plan. Supplement 1, this document, summarises the overall rehabilitation process at a regional level, with the supplement 2 addressing the physical aspects of rehabilitation such as overburden management, soil management and stabilisation and equipment selection in a mineral sands industry context.

This document provides recommendations regarding the direct seeding and plant propagation program as well as herbivore and weed management, based upon the practical experience and expertise from Tim Zwiersen and Alice Quarmby in rehabilitating mineral sands mines in Western NSW (near the Copi mine), W.A and S.A. Certain information has also been sourced from publications, as cited and listed in the references section.

The Copi mine Rehabilitation Plan is then expected to draw from the information contained within these two technical supplements and be used as the practical how-to manual for use by the Copi mine rehabilitation team and contractors.

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2. Rehabilitation objectives

The aim of the rehabilitation is to successfully achieve the long-term goals for closure, with closure criteria used to measure the progress and success of the rehabilitation.

The main objective of the post mine revegetation should be to create a self-sustaining vegetation community that is representative of the vegetation in the surrounding landscape, and conducive to pre-mining activities, such as light grazing. Full restoration in the arid rangelands, even without the issue of highly modified soil structures that are found post mining, is difficult if not impossible. For the Copi project, returning ecological function to a landscape degraded by almost a century of grazing and minimizing further loss of soil to wind or water erosion will be the primary concern.

As such, it is acknowledged that this will be a modified landscape, compared to the original landscape, due to the modified soil structure and limitations in returning the exact species composition that existed prior to mining.

3. Rehabilitation process

In order to achieve the rehabilitation objectives, the following general process is recommended:

- Conduct baseline flora and fauna surveys in order to set rehabilitation goals and completion criteria
- Initiate seed collection program for direct seeding and tubestock propagation program 1-2 years prior to planned site rehabilitation works, storing seeds until required for direct seeding
- Remove and store timber, topsoil and subsoil (pre-mining)
- Spread sub-soil, topsoil and then timber, if available (post-mining)
- Prepare the seed mix and sow immediately after soil and timber preparation has been completed
- Plant tubestock after a break in the season (when soil is moist), also set up irrigation (where appropriate)
- Monitor the performance of the rehabilitation and assess performance against the completion criteria
- Perform adaptive management actions where rehabilitation is not meeting the completion criteria (including herbivore and weed management)

This document provides further information regarding the direct seeding and plant propagation aspects in the above rehabilitation process. It also provides information on herbivore and weed management.

4. Direct seeding / plant propagation program

Direct seeding (mechanically broadcasting seeds) is expected to be used in order to return the majority of species to the revegetated landscape at the Copi Mine.

4.1. Species selection

The species used within the rehabilitation program have been chosen in order to reflect the rehabilitation objectives. Experience by the authors at other Heavy Mineral Sands (HMS) projects in the region have shown that for the majority of seasons it is possible to reinstate a chenopod shrubland that includes both pioneer species and long-lived perennial species.

Species to be used in the Copi Mine rehabilitation program have been chosen due to being either:

- local to the surrounding area, or
- similar (surrogate) species that performs the same habitation function as local species that are difficult to return the rehabilitated landscape

Individual species have also been selected based on probability of success in rehabilitated areas as well as ease of collection and storage capabilities (shelf life), with seeding rates based on:

- functional importance in the landscape,
- likelihood of success from direct seeding methods,
- previous experience in similar landscape,
- readily available in quantities that will make a positive contribution to the rehabilitation outcomes, and
- be of good value, that is deliver a reasonable return on financial investment (eg inclusion of endangered species)

Threatened species

Unfortunately, the inclusion of rare and endangered species in the direct seeding program is problematic. Special permits are required from an appropriate government agency, and then finding a source location at a time when it is fruiting requires a lot of time and resources. Even if seed is obtained, to consistently include it in the seed mixes requires such species to grown and harvested in a Seed Production Area (SPA). Even sourced from an SPA, quantities of seed may be not be of quantity to actually influence the revegetation outcomes, i.e. few if any individuals established in the rehabilitation. If species of endangered/rare species can be included, by their very nature they are likely to have very specific niches they occupy, e.g. soil structure, and are therefore unsuitable to post mine rehabilitation environments with highly altered soils and exposed niches. Inclusion of such species is a public relations exercise more than to support rehabilitation outcomes. If return of endangered species to the lands that RZ Resources has tenure on is an objective, it may be best to target revegetation of these species in non-mine areas within identified communities and soils, with appropriate fencing, i.e. biodiversity offset areas.

With the exception of *Austrostipa nullanulla,* most of the rare and endangered plant species that have been listed as occurring in the region surrounding the Copi Mine have not been recorded on site to date (EnviroKey, 2020). As such, it is intended that only *A. nullanulla* will be included in the direct seeding program, where (a) the appropriate permit/s are obtained, and (b) the seed is available.

Cover crops

In the past, agricultural cover crops of annual cereals or perennial grasses have been used to stabilize post mine landscapes in high rainfall areas. However, this is not a recommended practice for much of the Australian rangelands where nutrients and moisture are scarce. Native 'cover crops', suitable to the local area, should be utilised in preference to agricultural cover crops, with cover crops only to be used as a last resort (Greening Australia, 2021). If non-sterile agricultural cover crops are utilised, there is a risk that these will establish as weeds on the rehabilitated areas, becoming competition and actually inhibiting the establishment of desired perennial native species (Greening Australia, 2021).

The species list for Copi includes a number of native pioneer species that will quickly establish in the right conditions without competing with the longer-lived perennial species. The only situation where annual exotic cover crops might be considered is where topsoil replacement has occurred but it is outside the optimal window for seeding a native mix and there will be several months at least until the next opportunity. An established annual sward could be sprayed out with an appropriate herbicide before it sets seed and the resulting material above and below ground will aid carbon levels and help to reduce wind erosion of replaced soils. This method has not been tested in the region so would need to be approached carefully with timing and appropriate trial design.

4.1.1. Recommended seed mix

The recommended broad direct seeding mix (Table 1, below) has been based on the original species list from the baseline surveys. It has then been refined down to those species where species are conducive to direct seeding, likely to achieve the quantities required, and have adequate storage behaviour/requirements (Crawford et al. 2021). The broad seed mix should then be further tailored to suit the individual target communities, based almost exclusively on soil type and condition pre-mining. For example, in areas surrounding or including salt expressions (almost 30% of the proposed disturbance area), the seed mix will be restricted to only salt tolerant species.

The recommended grams per hectare for each species contained in this report are mostly arbitrary, with decisions made on a combination of cost effectiveness, the importance of the species to the landscape, the viable seed per kilogram, species ability to colonise a post mine landscape, and season availability heavily affecting final seed mix selection and overall rates.

While generic seeding rates of individual species have been provided, the actual rate is likely to be adjusted on an annual basis due to deficiencies in seed availability of some species (i.e. poor seasonal conditions resulting in less seed collected than expected). The rates of related species may also be increased in order to cover these deficiencies, enabling the overall seed mix g/ha total to remain similar. The objective is to maintain a mix that fills available niches with pioneer and long-lived perennial species.

Table 1 also indicates the potential seed collection/storage regime and likely seed source (Wild harvest or Seed Production Area (SPA)) for each species.

Mixing of seed

Seed should be generally mixed a few days prior to seeding, and in the case of other projects most of the seed is mixed during the seeding process. This allows for tweaks to be made to the seed mix, or for extra seed mix to be made during the revegetation program.

For the main chenopod mix, seed is best left unmixed until it needs to be used, to account for the disparity in shelf life of different species. This is less of a problem with native grass mixes and hard seeds such as Acacia species.

To maintain efficiency of the mixing process, when calculating seed mixes the grams per hectare need to be rounded off for each batch. For small batch species this should be to the nearest 10 grams and for species that comprise a larger component of the seed mix this should be to the nearest 100g/Ha. The seeding process lacks

precision on account of the range of seed bracts and attachments on the seed, with the seeding equipment subsequently designed to cope with that.

Seed can simply be mixed in a large volume compost tumbler or similar, then batched into hectare lots so output can be calculated against area as well as enabling tweaks to the seeding machinery output rates.

It is also intended that there will be multiple batches of each species that may be collected in varying years and locations. Where multiple batches exist, spanning varying collection years, a mixture of batches, utilising both older and younger batches, should be used during the annual seed mixing. This will enable the cycling of batches, and minimise viability loss through potential seed aging during storage.

Table 1. Optimal Copi Mineral Sands Mine rehabilitation seed mix

Scientific Name	Common name	Priority	Seeding Method	Seeding rate (g/ha)		Seed Collection / Storage Regime	Seed Source	Comments
				Flats	Batters			
Acacia colletioides	Wait-a-while	M	PNS	200 (±50)		Group 5	WH	While not abundant this Acacia is common in the region across a range of soil types and vegetation communities
Acacia rigens	Needle Wattle	M	PNS	75 (±25)		Group 5	WH	Should be targeted to sandy soil types
*Acacia nyssophylla^*		M	PNS	200 (±50)		Group 5	WH	Surrogate for *A. colletioides*
Acacia sclerophylla var. sclerophylla	Hard-leaved Wattle	M	PNS	75 (±25)		Group 5	WH	Should be targeted to sandy soil types
Atriplex holocarpa	Pop saltbush	H	DS	200	500	Group 3#	SPA/WH	Similar habit to *A. lindleyi*, this annual is a proven rehabilitation performer.
Atriplex lindleyi	Eastern Flattop Saltbush	H	DS	200 (±50)	500 (±250)	Group 2 or 3#	SPA/WH	Key pioneer species
Atriplex nummularia	Old man saltbush	H	DS	1000 (±500)	1000 (±500)	Group 3 or 4#	WH	Highly recommended species for rehabilitation in the region. Proven performer
Atriplex stipitata	Mallee Saltbush	H	DS	750 (±250)	500 (±250)	Group 2#	WH	Key pioneer species
Atriplex vesicaria	Bladder Saltbush	H	DS	2,000 (±1000)	400 (±100)	Group 3#	WH	Key species for medium term
Austrostipa nitida	Speargrass	H	GS	3500 (±1500)		Group 3#	WH	This species is available in vast quantities in good seasons, and is a pioneer species
*Austrostipa nullanulla**	Speargrass	H*	GS	#		Group 3#	SPA / WH	Is a threatened species but is a key species in area. Sowing rates will depend on seed availability
Austrostipa scabra	Speargrass	M	GS	3000 (±1500)		Group 3#	WH	This is second only to *A. nitida* as a useful grass species for rehabilitation
Boerhavia dominii	Tarvine	L	DS			Group 3#	WH / SPA	Proven in an SPA situation
Callitris glaucophylla	White Cypress Pine	M	PNS	100-250g/ha		Group 2 or 3#	WH (when available)	Seed only available every few years, and can have low success rates. Higher success rates with tubestock
Casuarina pauper	Black oak	M	PNS	150(±75)		Group 1,2 or 3#	WH (when available)	Seed only available every few years, and can have low success rates. Higher success rates with tubestock
Chenopodium curvispicatum	White Goosefoot	M	DS	150 (±50)	150 (±50)	Group 2#	WH / SPA	Chenopodium has been successfully installed in an SPA, but with poor results

Scientific Name	Common name	Priority	Seeding Method	Seeding rate (g/ha)		Seed Collection / Storage Regime	Seed Source	Comments
				Flats	Batters			
								when seeded. More seed biology work would be required if used
Dodonaea viscosa subsp. angustissima	Narrow leaf Hop-bush	L	PNS	#		Group 4 or 5#	WH	Good pioneer but can be considered a woody weed by pastoralists as it can take over and dominate the landscape. As such, if used it should only be at a low g/ha.
Einadia nutans	Climbing Saltbush	M	DS	50 (±25)	50 (±25)	Group 1,2 or 3#	WH / SPA	Proven in SPA, but not in the field
Enchylaena tomentosa	Ruby Saltbush	M	DS	100-300g/ha	100-300g/ha	Group 1 or 2#	WH / SPA	Proven in SPA & in the field
Enneapogon avenaceus	Bottle Washers	M	GS			Group 3#	WH / SPA	Pioneer species of disturbed sites, potential for SPA
Eragrostis dielsii	Mallee Lovegrass	L	GS	50 (±25)		Group 3#	WH / SPA	Only useful where water is expected to pool & hold in the soil (i.e. ephemeral wetlands), not recommended for general revegetation
Eucalyptus dumosa	White Mallee	H	PNS	100-250g/ha		Group 4	WH	Eucalyptus species are likely to be the most reliable of all the canopy species
Eucalyptus gracilis	Snap and Rattle	H	PNS	100-250g/ha		Group 4	WH	Eucalyptus species are likely to be the most reliable of all the canopy species
Eucalyptus socialis	Red Mallee	M	PNS	100-250g/ha		Group 4	WH	Eucalyptus species are likely to be the most reliable of all the canopy species
Exocarpos aphyllus	Leafless Ballart	L	PNS	#		unknown#	WH (when available)	Not an important rehabilitation species, is common but not abundant. Seed has dormancy issues & even tubestock will be difficult to grow
Frankenia foliosa	Frankenia	L	DS	50 (±25)	50 (±25)	Group 2 or 3#	WH	If considered important could be considered for the SPA, however it is listed as uncommon in the region & is likely to be just a minor ephemeral component in the landscape
Grevillea huegelii	Comb Grevillea	L	PNS	#		Group 3#	WH (when available)	Mainly included in rehabilitation program as tubestock. Seed is difficult to collect in bulk and subsequently expensive

Scientific Name	Common name	Priority	Seeding Method	Seeding rate (g/ha)		Seed Collection / Storage Regime	Seed Source	Comments
				Flats	Batters			
Maireana brevifolia		M	DS	200 (±100)	200 (±100)	Group 2 or 3#	WH	Key pioneer species and strong rehab performer
Maireana ciliata	Fissure Weed	M	DS	200 (±100)	200 (±100)	Group 2 or 3#	WH	If considered important could be considered for the SPA, however it is listed as uncommon in the region & is likely to be just a minor ephemeral component in the landscape
Maireana georgei	Slit-wing Bluebush	H	DS	750 (±250)	750 (±250)	Group 3	SPA/WH (when available)	Is suitable for SPA if good water quality available
Maireana microcarpa		L	DS	200 (±100)	200 (±100)	Group 2 or 3#	WH	Not likely to be collectable in quantities that will influence revegetation outcomes
Maireana pentatropis		M	DS	100 (±50)	100 (±50)	Group 3	WH	Key pioneer species for Mallee-chenopod communities
Maireana pyramidata	Black Bluebush	M	DS	250-500g/ha	250-500g/ha	Group 2 or 3#	WH	Key revegetation species both as a pioneer & medium-term perennial
Maireana sedifolia	Pearl Bluebush	M	DS	250-500g/ha	250-500g/ha	Group 2 or 3#	WH (when available)	Also potentially included as tubestock
Maireana triptera	Three-wing Bluebush	M	DS	100 (±50)	100 (±50)	Group 2 or 3#	SPA/WH	Useful pioneer species, has been successful in an SPA before
Marsdenia australis	Bush Banana, Doubah	L	DS	#		Group 3#	WH	Common but not abundant or useful as a rehabilitation species, it is a climax community species
Melaleuca lanceolata	Moonah	M	PNS	#		Group 4	WH	
Myoporum platycarpum	Sugarwood	M	PNS	100		Group 2 or 3#	WH (when available)	Also included as tubestock
Olearia muelleri	Mueller's Daisy Bush	M	DS	50 (±25)	50 (±25)	Group 3#	WH / SPA	Useful as an understorey component if attempting to re-instate mallee-chenopod communities
Osteocarpum acropterum	Wingless Bonefruit, Water Weed	L	DS	#		Group 2 or 3#	WH / SPA	If considered important could be considered for the SPA. Capable of colonizing scalded soils, especially in ephemeral areas.
Pittosporum angustifolium	Butterbush	M	PNS	#		Group 3#	WH	Also included as tubestock

Scientific Name	Common name	Priority	Seeding Method	Seeding rate (g/ha)		Seed Collection / Storage Regime	Seed Source	Comments
				Flats	Batters			
Podolepis capillaris	Invisible Plant	L	DS	50 (±25)	50 (±25)	Group 2 or 3#	WH / SPA	If considered important could be considered for the SPA, however it is listed as uncommon in the region & is likely to be just a minor ephemeral component in the landscape
Rhagodia parabolica		L	DS	50 (±25)	50 (±25)	Group 2 or 3#	WH / SPA	This species isn't common in the region and therefore unlikely to be collectable in quantity
Rhagodia spinescens	Thorny Saltbush	M	PNS	100	100	Group 2 or 3#	WH / SPA	Useful long-lived species
Rhagodia ulicina		M	PNS	50 (±25)	50 (±25)	Group 2 or 3#	WH / SPA	Useful long-lived species
Roepera apiculata	Common Twinleaf	M	DS	200g+/Ha		Group 4	WH	Proven rehabilitation species
Tecticornia halocnemoides	Samphire	L	DS	#		Group 2 or 3#	WH	Samphire species will be considered only for saltpan environments
Tecticornia indica subsp. leiostachya	Samphire	L	DS	#		Group 2 or 3#	WH	Samphire species will be considered only for saltpan environments
Tecticornia pergranulata subsp. Pergranulata	Samphire	L	DS	#		Group 2 or 3#	WH	Samphire species will be considered only for saltpan environments
Tecticornia tenuis	Samphire	L	DS	#		Group 2 or 3#	WH	Samphire species will be considered only for saltpan environments
Triodia scariosa	Porcupine Grass	M	GS	2000g+/ha		Group 3#	WH / SPA	Not suitable for weedmat SPA, would have to be broadacre. WH unlikely to consistently procure sufficient quantities, tubestock best option for inclusion in rehabilitation
Tripogon loliiformis	Fiveminute Grass	L	GS	#		Group 3#	WH / SPA	Not a useful species due to its presence in the landscape being associated with good rainfall events

* Not recorded on site but included due to regional threatened status, and key species in area

^ Surrogate species, # to be determined/verified

Priority= L=Low, M=Medium, H= High

Seeding Method: DS= Drum seeder, PNS= Precision Niche Seeder, GS=Grass Seeder

Seed Source: WH= Wild Harvest, SPA= Seed Production Area

4.1.2. Seed collection regimes

Individual species vary in their seeding frequency and storage capability (shelf life). As such, the species recommended for use in the seed mix have been divided into five collection regime groups (see Table 1, above), with a description of these groups in Table 2 (below).

Table 2. Seed collection & Storage regimes

Collection / Storage regime	Description
Group 1.	• Species with a very short shelf-life (less than 12 months). • Should only be included as 'fresh' seed, i.e. collected the season leading up to sowing. • Species are (1) available for collection most seasons, (2) are not necessarily a major component in the seed mix, or (3) can be produced using a seed production area.
Group 2.	• Species with a short or variable shelf-life (1-3 years). • Most species within this group have high seed fill and initial viability, therefore still have a reasonably high number of viable seeds per kg if used within two rehabilitation seasons. • Some keystone species are in this group that set seed infrequently but are not appropriate for utilization in a SPA (e.g. *Casuarina pauper* (Belah)). Therefore, there will be seasons where such species may only be returned to the rehabilitated landscape by other means, such as tubestock planting.
Group 3.	• Species with a medium shelf-life (3-5 years). • Includes the majority of species utilized in the rehabilitation of the Project. • Some are available in quantity only from a SPA, some are only available in good seasons, with many being available most seasons enabling a rolling stock to be held in storage.
Group 4.	• Species with a medium to long shelf-life (5-10 years). • Includes Eucalypts with non-dormant seed, as well as other species that have dormant seed. • In seasons of above average rainfall, many of these species fruit prolifically, so large quantities can be collected and stored for use across multiple rehabilitation seasons.
Group 5.	• Species with a very long shelf life, that effectively would exceed the life of mine (>10 years). • Includes hard coated legume species, such as Acacia and Senna species. • In seasons of above average rainfall, many of these species fruit prolifically, so large quantities can be collected and stored for use across multiple rehabilitation seasons.

4.1.3. Seed procurement

The majority of seed used should be sourced from either wild harvest by experienced seed collectors and purchased by RZ, or by collection by RZ staff. A proposed seed order should be supplied seed collectors in July of each year, as certain species are harvested in August. The seed order quantities required are calculated from the projected rehabilitation hectares and the recommended g/ha per individual species. Where possible, the orders should cover 2 years-worth of rehabilitation, maximising the likelihood of fulfilling the seed quantity targets (cannot guarantee that there will be enough seed produced every season), as well as allowing for flexibility in the actual hectares sown for a given year.

Ideally seeds will be sourced as close as possible to the Copi mine site. However, as individual populations do not necessarily set seed every year, either due to genetic or environmental conditions, seeds can be sourced from regions that share similar soil and climatic conditions to the mine site. This maximises the chances of plant genetics to be adapted to the conditions at the mine site (Harrison et al., 2021, Leimu & Fischer, 2008). As such, a maximum provenance distance has not been set, and allows seed to be sourced from interstate (South Australia or Victoria), where necessary.

The timing of collection is species dependent, with seed harvesting occurring during a certain 'collection window' during Spring, Summer, or Autumn. However, some species set seed in response to rainfall events, regardless of the time of year. Where seed set occurs outside of the expected collection season (i.e. set seed following Summer rainfall, when seed set usually occurs during Spring) the quality of seed may be reduced. Unless seed was not available during the expected 'collection' window, it should not be collected out of season.

It is expected that mature seed will be collected, and at the point of dehiscence (Sweedman & Merritt, 2006). If seeds are collected when they are immature they (a) may not be able to germinate (lack vigour), or (b) have a shortened storage shelf-life (rapidly decline in viability) (Crawford et al., 2021, Hay and Smith, 2003). As such seeds/fruit should be collected at the point of dispersal, easily indicated by seed/fruit already starting to disperse, or can disperse when lightly touched. Other indicators include the colour (e.g. seeds may turn from green to brown) and dryness of seed or fruit (e.g. legume pods beginning to split or rattle when full of dry seeds) (Crawford et al., 2021, Sweedman & Merritt, 2006).

However, some species have progressive ripening, with seeds/fruit at varying stages on individual plants. It can therefore be difficult to avoid some immature seed/fruit in collections.

4.1.4. RZ Internal Collections

Where possible, RZ staff will also collect a portion of the required seeds. These collections are expected to supplement the seed order quotas provided to the external seed collectors and target species that are harder to collect.

The RZ staff will require training from experienced native seed collectors in best practice harvesting, processing and storage prior to undertaking seed collection activities. Any RZ staff involved in seed collecting will need to obtain the necessary permits if collecting from threatened species. RZ would also have to invest in necessary seed collection and processing equipment, including (but not limited to) seed collection bags, bins, racquets, tarps, shade cloth, sieves and balances. A hothouse, installed on site, will also be required in order to enable the drying of collected seed (Plate 1). A processing area will also be required, ideally this should be sheltered and have a sealed base.

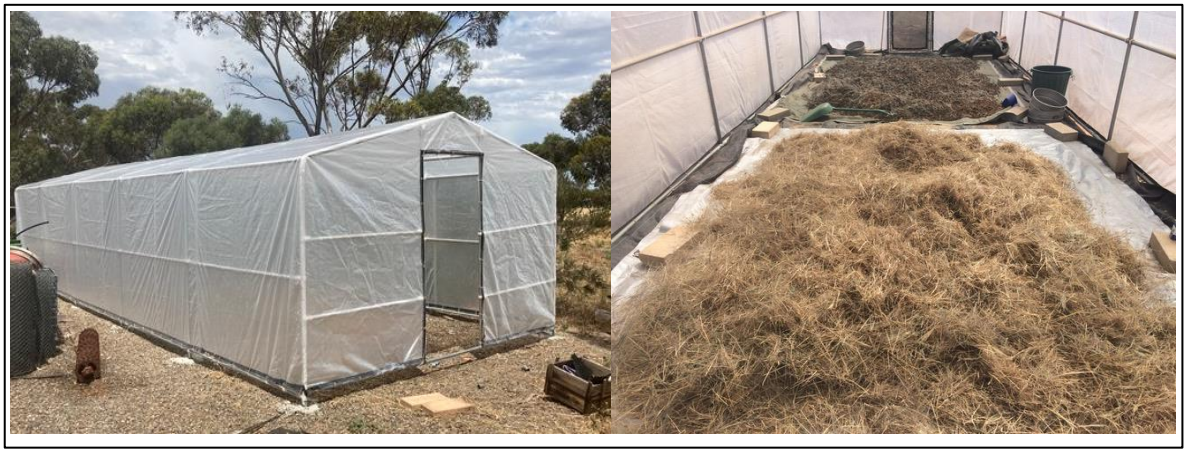

Plate 1. Use of a hothouse to dry seeds prior to cleaning (Photo credit: T. Zwiersen)

4.1.5. Seed Production Area

A Seed Production Area (SPA), sometimes colloquially referred to as 'seed orchard' or 'seed farm' are a proven mechanism for producing native seed (Pedrini et al. 2020, Gibson-Roy et al., 2021). While the majority of seeds are expected be sourced from wild harvest, a SPA should be built on site and used for those species that:

- have shelf life less than 12 months;
- may be common but not abundant;
- are hard to collect due to a small collection window between ripening and dispersal (may be a couple of days);
- only set seed in good seasons due to an ephemeral nature; or
- have a low growth habit that makes them difficult to collect.

The species that are recommended for the SPA are indicated in Table 1.

Historically SPA's were to select certain cultivars of tree species that had forestry value, though in the last two decades there has been an increase in the use of SPA's to increase the availability and diversity of grass and ground cover species especially for broadacre revegetation, where wild harvest cannot meet seed demands (Gibson-Roy et al., 2021, Hancock et al., 2020, Pedrini et al. 2020). SPA's can take the form of traditional plantations of long-lived woody species, a 'boxed' system (utilizing soil filled foam fruit boxes in a nursery situation), broadacre (paddock situation with subsurface, sprinkler or overhead irrigation) which is mostly for grass species, and a 'weed matt' system (Gibson-Roy et al., 2021). It is recommended that the Copi project consider a weed matt system, and possibly a small plantation of woody species, eg *Acacia acanthoclada ssp. Acanthoclada* on drip irrigation without weed mat.

Weed matt systems use a 110GSM woven weed matting product that is laid over a pre designed irrigation system utilizing in line drip tube (grass species), or tubing fitted with individual (& replaceable) emitters for shrub species. A poly belt edge is fitted around the perimeter, but is also used to denote sections of the SPA according to species. The edging helps to limit the ingress of soil and weed seed, provides a buffer when conducting weed spraying and helps to catch and retain seed (Plate 2).

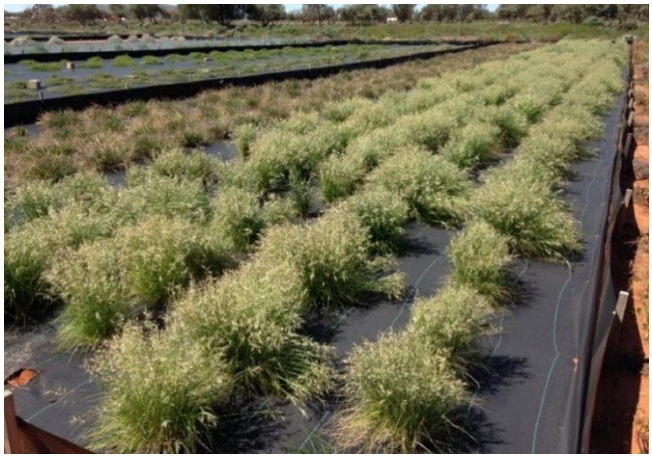

Plate 2. Growing native grasses (*Rytidosperma caespitosum*) on a Mat SPA (Image credit: T. Zwiersen)

A shade structure is considered essential, particularly in areas where summer surface temperatures are very hot, given the weed matt material is black. The main objective is to limit the stress on plants from extreme temperatures, though added benefits are limiting ingress of weed seed and soil, and removal of the seed by wind/thermals. It also takes into consideration that personnel conducting maintenance and harvesting operations will be less exposed to direct sunlight.

Seedlings in the SPA, given they are mostly annuals or short-lived perennials will need timely and regular replacement. These will have to be grown to order by a specialist native nursery, or ultimately grown on site if a nursery is constructed. Ideally seedlings used in the SPA should be grown from wild harvest seed, to ensure genetic variation is maintained (Gibson-Roy et al., 2021). However, this may not always be possible so a percentage of any seed harvested should be retained in the seed store so that seedlings can always be grown for the SPA.

It is expected that a SPA for Copi would require:

- Fencing to 1.8m high that will exclude goats, kangaroos and rabbits. Ideally an area large enough that will allow for future expansion;
- A target area of 5000-10,000 sqm of weed matt SPA;
- Water storage (Poly tank) and independently powered drip irrigation system;
- Water to be sourced from the Anabranch scheme water that is allocated to Warwick station. Poor water quality will affect the range of species that can be grown, the health of plants and subsequently the abundance and quality of seed. Experience has shown from other regional HMS projects that utilizing either Reverse Osmosis water or reclaimed wastewater is detrimental to many of the species suitable to an SPA;
- A poly belt (1mm thick Polyethylene) edge that is buried 150mm in the ground, with approx. 450mm out of the ground;
- A comprehensive horticultural shade structure (30% rated shade-cloth) that has both a roof and sides (similar to the examples in Plate 3);
- A small storage at the SPA- either a 20’ shipping container or garden shed- to store seed harvesting and maintenance equipment as well as irrigation spares; and
- A hand pushed grass harvester (ie Grass-grabber), large capacity vacuum (eg Greystone yard vac) as well as herbicide application equipment and sundry items.

Plate 3. Examples of a shade structure that may be suitable for the Copi SPA (Image credits: Greenlife Structures)

The operation of the SPA will be required to have a regular maintenance schedule and supervision, including provision of tubestock, watering, harvesting and processing of seed. Regular inspections and a maintenance program are required, otherwise seed yields and quality can be decreased due to seed germination or insect predation.

4.1.6. Small scale nursery

If high quality water is available for the SPA, and personnel are directly employed to operate it, it would also be worth considering the establishment of a small-scale nursery (approx. 5000 tubes with capacity for expansion) to supply seedlings for canopy species planting where direct seeding is unsuccessful, amenity planting, and to replace plants in the SPA.

4.1.7. Seed quality control

It is expected that all batches of seed that are purchased as part of the direct seeding program will be tested by an Australian native (as opposed to agricultural) seed testing laboratory for quality control prior to purchase. This is to ensure that the quality of the individual collections are within the expected ranges for each species purchased, and that money is not wasted on poor quality seed.

It is expected that the quality tests for each batch will include seed viability, seed purity and seed counts (seeds/kg and viable seeds/kg). For all batches with a value of greater than $1,000 the viability test should be conducted on 400 seeds, with purity and seeds/kg tests conducted using a minimum of 1000 seeds. Test sample quantities less than this are not recommended as they are unlikely to be representative of the quality of the overall collection. For smaller collections (value of less than $1,000) the number of seeds per test can be reduced to 200 for viability tests; and 500 seeds for the purity and seed counts.

Germination tests should be carried out on the initial seed batches of all species where the presence and type dormancy has not been confirmed (see Table 3 below). Where species are found to have dormancy, further trials may be required in order to determine the appropriate methods for overcoming these issues.

Germination tests should also be used for conducting long-term viability monitoring of individual seed collections in order to verify the suggested collection/storage regimes for individual species listed in Table 1. Germination tests should be conducted using 400 seeds per test, unless seed quantities are limited.

4.1.8. Seed storage

Ideally, there should be at least 2 years of seed of each species in storage, where possible. This is to account for the fact that the full range of species may not be available each year, and to allow flexibility in the hectares sown for any given year. Where species set seed infrequently, larger quantities of seed can be collected when available, then stored and broadcast over multiple years (Groups 3-5 in Tables 1 and 2).

Storage bag requirements

Historically, seeds used in large, broad-scale revegetation projects have often been stored in non-lined or lined woven polypropylene (WPP) bags (Plate 4). However, these bags are porous, with seed longevity reduced from fluctuating and/or high moisture levels (relative humidity of greater than 20%) in the surrounding environment, as well as from oxidation. In order to maximise the shelf life of the seeds, it is recommended that Copi seeds are stored within impermeable bags (either heat-sealed clear thick plastic bags (100-200um), or plastic-lined WPP bags). As these bags are impermeable, it is crucial that seeds are thoroughly dried (ideally less than 20% moisture content) before bagging, otherwise it can significantly reduce the longevity of the seeds (Merritt et al., 2021).

All bags should also be treated with CO^2, where possible, to further limit oxidation of seeds as well as acting as an insecticide treatment (suffocate insect larvae that may be within seeds or fruit), common especially in legume species (e.g. Acacia spp. and Senna spp.).

Each bag of seed should be labelled with a Batch identification code, Species name and current weight.

Storage facility requirements

A site-based seed storage facility should be considered so that valuable seed is both secure and accessible, especially when seeding operations are being undertaken. Ideally a seed storage facility should include:

- 120-200m3 of storage capacity (a 40' shipping container is approx. 60m3. This can be in the form of repurposed insulated shipping containers ('reefers'), standard shipping containers that have been lined with insulation, or a custom stand-alone facility made of insulation sandwich panel.
- It is paramount that any structure to be used as a seed store is fully sealed from mice entry. Past experience has shown that even a few mice can damage expensive seed significantly, and a regular baiting program is insufficient to prevent this.
- The conditions within the facility need to be cool and dry, at a temperature of approximately 20°C. Ideally the humidity should be of less than 25%, however dehumidification equipment is expensive for large volume facilities (Merritt et al., 2021). As very long term (ie 20> years) storage is not required, a combination of domestic reverse cycle air-conditioning and seeds stored within impermeable plastic bags is considered sufficient to maintain seed viability until use.
- A shade structure over the seed storage, in the form of an open sided shed that is larger than the storage footprint (ideally twice the area) to give a work area for personnel involved in seed collection, processing and seeding activities.
- Power will be required in order to run air conditioning and lighting.
- A concrete floor would be ideal, but given the expense a compacted road base floor would also suffice.

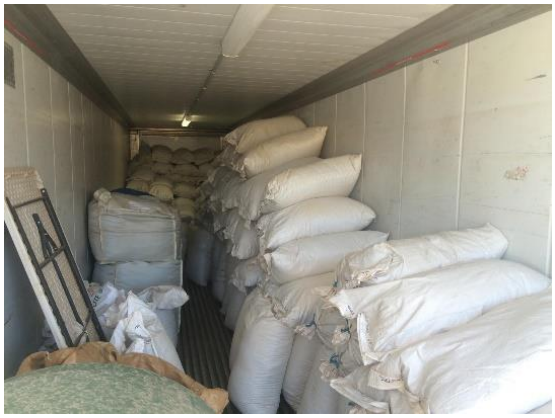

Plate 4. Example of a mine site seed store, with bulk chenopod seeds stored in WPP bags and wool bales (Image credit: T. Zwiersen)

4.1.9. Seed pre-treatments

While some of the species included in the seed mix are non-dormant and can germinate readily, several species have dormancy mechanisms that prevent seed germination occurring when conditions are conductive for germination, but prolonged seedling establishment is unlikely (Baskin and Baskin, 2014, Commander *et* al., 2021). The dormancy types and their recommended treatments for each of the species used in the seed mix, based on the experience of the authors, are shown in Table 3. It is noted that the presence and type of dormancy has not been verified for all species in the seed mix (indicated with an asterix), with further investigations required to determine if and what pre-treatments may be required for these species.

All legume species (e.g. Acacia, Senna and Swainsona species) are likely to have physical dormancy (PY), where by seeds have a hard seed coat that prevents absorption of moisture (imbibition), therefore restricting germination (Baskin and Baskin, 2014, Sweedman & Merritt, 2006). It can take several years for seeds to naturally overcome the physical dormancy in the field.

A hot water pre-treatment is often recommended for pre-treating physically dormant seeds (Commander *et* al., 2021, Sweedman & Merritt, 2006) however, this is usually when the seeds are sown while still moist and subsequently irrigated to promote immediate germination (e.g. under nursery settings). In a broadscale rehabilitation setting the hot water treatment is not recommended as the treated seeds will be dried prior to sowing. If treated seeds begin to absorb water before being dried out this process has the potential to damage seeds (Quarmby, 2015). As such, a dry mechanical scarification pre-treatment (tumbler with rotating sanding discs) is recommended for RZ seeds with physical dormancy, prior to sowing.

Physiological dormancy (PD) is common within grasses, daisies and some chenopod species (Baskin and Baskin, 2014). Species with physiological dormancy often have chemicals within the seeds or fruit (structure surrounding the seeds such as florets for grasses or bracts for chenopods) that restrict germination (Baskin and Baskin, 2014, Commander et al, 2021). Such species often require an “after-ripening” period (often cued by changes in seasonal temperatures and/or wet/dry cycling) that can take several months or a year to occur under field conditions (Baskin and Baskin, 2014, Commander et al, 2021). Chemical treatments such as gibberellic acid, smoke water or leaching can be used to increase germination of these species (Baskin and Baskin, 2014, Commander et al, 2021). Although these treatments are utilised in nursery or small-scale revegetation programs, they are not recommended as part of this program due to the potential to damage seeds as a consequence of the wetting/drying process (similar to the hot water treatment for physical

dormancy). The complete or partial removal of the fruit (bracts for chenopods or florets for grasses) can also increase the rate of germination (Baskin and Baskin, 2014), however, this process can cause damage to the seed, as well as increase the vulnerability of seed to predation or increased seed aging in the soil if seeds do not germinate immediately after sowing. As such, it is recommended that species with seeds that exhibit physiological dormancy are not pre-treated prior to being sown. They will 'after-ripen' with time and simply take longer than other species to germinate, therefore they may not be observed in the rehabilitation for 1-2 years after being broadcasted.

Morphophysiological dormancy (MPD) is present in *Exocarpos aphyllus* (South Australian Seed Conservation Centre, 2018). Seeds with MPD have both undeveloped embryos (Morphological dormancy) as well as PD (Baskin and Baskin, 2014). As such, the dormancy breaking mechanisms can be quite complex, and species specific (Baskin and Baskin, 2014). Further research will therefore be required on *E. aphyllus* seeds in order to determine the best approach for maximising their germination in the field.

Where pre-treatments are applied to overcome seed dormancy, it is intended that a proportion of seeds are left un-treated (e.g 30-50%). This is intended as a precaution for preventing all seed germinating in a single event where the young seedlings may not receive sufficient enough moisture to survive.

4.1.1. Seed broadcasting

The annual direct seeding should occur in late Autumn or early Winter, maximising seedling establishment when the growing conditions are optimized. This is based on winter rainfall events being more frequent than in spring and summer, with far lower evaporation rates. This favours the establishment of chenopods and cool season C3 grasses over tree, shrub and warm season C4 grasses, however it is more important to have an established cover than to hope for the right conditions (ie a *la nina* wet cycle) to establish the canopy species.

The nature of the chenopod species that make up the physical bulk of the seed mixes proposed for the Copi project, that is large bracts with a component of small sticks and leaves, means that seed will have to be broadcast by hand or via a mechanical drum seeder. Hand seeding is fine for small, flat areas. Where larger areas are needing to be revegetated (ie 5Ha>) mechanical seeding is the most efficient and safest option (hand seeding risks fatigue, exposure and trips/falls of personnel).

Table 3. Seed dormancy types present and relevant treatments (PY- Physical, PD- Physiological, MPD- Morphophysiological, ND- Non-Dormant, *to be determined)

Scientific Name	Common name	Dormancy Type	Treatment
Acacia colletioides	Wait-a-while	PY	Mechanical scarification
Acacia rigens	Needle Wattle	PY	Mechanical scarification
*Acacia nyssophylla^*		PY	Mechanical scarification
Acacia sclerophylla var. sclerophylla	Hard-leaved Wattle	PY	Mechanical scarification
Atriplex holocarpa	Pop saltbush	ND*	none
Atriplex lindleyi	Eastern Flattop Saltbush	ND	none
Atriplex nummularia	Old man saltbush	ND	None
Atriplex stipitata	Mallee Saltbush	ND	None
Atriplex vesicaria	Bladder Saltbush	ND	None
Austrostipa nitida	Speargrass	PD or ND*	None
Austrostipa nullanulla	Speargrass	PD or ND*	None
Austrostipa scabra	Speargrass	PD or ND*	None
Boerhavia dominii	Tarvine	unknown	None
Callitris glaucophylla	White Cypress Pine	ND	None
Casuarina pauper	Black oak	ND	None
Chenopodium curvispicatum	White Goosefoot	ND*	None
Dodonaea viscosa subsp. angustissima	Narrow leaf Hop-bush	PY	Mechanical scarification
Einadia nutans	Climbing Saltbush	ND*	None
Enchylaena tomentosa	Ruby Saltbush	ND	None
Enneapogon avenaceus	Bottle Washers	PD or ND*	None
Eragrostis dielsii	Mallee Lovegrass	PD or ND*	None
Eucalyptus dumosa	White Mallee	ND	None
Eucalyptus gracilis	Snap and Rattle	ND	None
Eucalyptus socialis	Red Mallee	ND	None
Exocarpos aphyllus	Leafless Ballart	MPD	*
Frankenia foliosa	Frankenia	ND*	None
Grevillea huegelii	Comb Grevillea	PD or ND*	Smoke water*
Maireana brevifolia		ND	None
Maireana ciliata	Fissure Weed	ND	None
Maireana georgei	Slit-wing Bluebush	ND	None
Maireana microcarpa		ND	None
Maireana pentatropis		ND	None
Maireana pyramidata	Black Bluebush	ND	None
Maireana sedifolia	Pearl Bluebush	ND	None
Maireana triptera	Three-wing Bluebush	ND	None
Marsdenia australis	Bush Banana, Doubah	ND*	None
Melaleuca lanceolata	Moonah	ND	None
Myoporum platycarpum	Sugarwood	ND	None
Olearia muelleri	Mueller's Daisy Bush	PD or ND*	None
Osteocarpum acropterum	Wingless Bonefruit, Water Weed	PD or ND*	None
Pittosporum angustifolium	Butterbush	PD or ND*	None
Podolepis capillaris	Invisible Plant	PD or ND*	None
Rhagodia parabolica		PD or ND*	None
Rhagodia spinescens	Thorny Saltbush	PD or ND*	None
Rhagodia ulicina		PD or ND*	None
Roepera apiculata	Common Twinleaf	PD	None
Tecticornia halocnemoides	Samphire	PD or ND*	None
Tecticornia indica subsp. leiostachya	Samphire	PD or ND*	None
Tecticornia pergranulata subsp. Pergranulata	Samphire	PD or ND*	None
Tecticornia tenuis	Samphire	PD or ND*	None
Triodia scariosa	Porcupine Grass	PD or ND*	None
Tripogon loliiformis	Fiveminute Grass	PD or ND*	None

4.1.2. Direct seeding machinery options

The authors of this paper are aware that RZ Resources have commissioned a separate review of rehabilitation techniques that will provide recommendations on specific earthworks machinery for the site.

In the authors experience, there are two suitable direct seeding machines that are commercially available and would suit the Copi Project and any subsequent HMS projects. They both incorporate the rotating drum design to meter seed out. Both of these seeders will meter the majority of native species with some accuracy, with the exception of grass species. Gessner Engineering of Toowoomba Qld have a simple design where the drum simply drops the seed onto the prepared soil surface. A modified version of this machine has been used successfully at other HMS mines in the region, mounted to both a bulldozer (Plate 5) and to a larger, high horsepower tractor.

Plate 5. Modified Gessner Drum seeder on bulldozer (Photo credits: T. Zwiersen)

The second machine is built by Ellworx Pty Ltd in Western Australia and is used extensively throughout arid land mine operations in the Goldfields, Pilbara and associated mining precincts (Plate 6). While it also uses a drum to meter seed, the seed is further distributed by an airflow which spreads it more evenly across the prepared surface. This machine is an update on the proven NuRally seeder design that was first deployed in the 1980's and has completed >10,000ha of mine rehabilitation seeding. It can also be fitted with a fertilizer dispenser if required. The unknown for this machine is whether it can be fitted successfully to a tractor. Typically hard rock mines, and HMS mine landforms require a bulldozer to rip and seed batters. However, there are significant efficiencies to be gained by using an appropriate tractor over flat areas (in the order of 100%).

Plate 6. Ellworx machine attached to dozer. Photo credits: Nick Ellwood (Ellworx)

It would be worth RZ Resources considering the commissioning of its own seeding machine for security of availability.

It is also worth noting that some arid land projects have been successfully sown using a self propelled or tractor mounted manure spreader (ie belt spreader). The advantages of this method is that it has a 2-300% efficiency gain over a bulldozer, and it will sow native grasses. The disadvantages are that it apparently requires a higher seed rate (20kg/ha rather than 8-10kg/Ha) and is unsuitable for batters that have had timber mulch placement. It will also require another machine to conduct the surface preparation.

It is also recommended that precision niche seeding (PNS) is used for tree and large shrub species, where species require a specific seed placement (5-10mm depth). Seed requires good soil contact to successfully establish, though as general rule most native species lack the energy to emerge from depth (>20mm burial). The precision niche seeder also creates a shallow furrow, directing rainfall runoff towards the placed seeds. Precision niche seeding should only occur shortly after decent rainfall when the there is adequate soil moisture ensuring that the seed is sown is not subject to burial by wind or water movement of soil. This timing also increases the chances of an immediate germination event. PNS seeding is undertaken after the main seeding event (chenopods, with the drum seeder) has been completed. In dry cycles, particularly drought years this activity may have to be postponed as the chances of successful establishment of tree and shrub species is significantly diminished. A Burford precision niche seeder has been successfully used in nearby HMS mines (Plate 7).

Plate 7. Burford seeder attached to Tractor, and seeding implemented in curved lines

4.1.3. Post soil replacement surface treatment- ripping

It is considered best practice to rip replaced soils at the same time as seeding to ensure that 1) compaction is ameliorated, and 2) good seed-seed soil contact is achieved.

Bulldozer ripping tines aren't ideal as the have the tendency to either invert the soil, or leave it open (burying seed and increasing evaporation potential). Using a bulldozer can't be avoided on steep, timber mulched batters, but for flat or gently sloped areas other options become available. The recommended ripping tine are those used on deep tillage plows. Deep tillage plows are used to ameliorate soils compacted by flood or overhead irrigation, and also on certain soils that are susceptible to compaction in dryland cropping systems. These tines are designed to minimize inversion of soils or leave open rip lines, and range in effective depth from 350mm to 1000m depending on weight and horsepower of the machinery used.

The tractor deployed to conduct the ripping-seeding process at other regional HMS mines had such tines, however it was found that even a dual rear wheel, 250hp tractor struggled in some instances (eg former haul road, stockpiles) to maintain a good ripping depth, or ripping speed (reducing seeding efficiency and making it difficult to calibrate seeding machinery).

In 2021 a contractor working at a local HMS mine fitted an Obrien laser bucket with a deep tillage ripper assembly. This replaced the scarifier tine assembly which didn't achieve the desired deep ripping objectives. Working to an average depth of 500mm, this combination was able to ameliorate highly compacted soils at approximately 1Ha/hour. This did require all the of the tractors 600hp to achieve, giving a measure of how compacted the replaced soils can get. While this will require long term monitoring, it is obvious that highly compacted soils limit deep soil moisture penetration and retention, and are not conducive to the establishment of deep-rooted perennial vegetation.

4.1.4. Seed data management

A purpose built "RZ Rehabilitation Database" is recommended in order to determine the annual seed requirements, based on proposed rehabilitation hectares and g/ha rates, and tracking of individual seed batches, including seed quantities and quality.

It is intended that seed consignments (delivery notes), annual seed mixes (including specifying individual batches), annual seed stocktakes and seed quality test data (provided by an external seed biologist) would all be easily imported into the database.

Swainsona Environmental Services has built similar databases for other regional HMS mines, and can be contracted to build the database for the Copi mine, including a comprehensive user-friendly manual.

4.2. Tubestock propagation/planting program

In arid land mine rehabilitation the use of tubestock is uncommon, and usually relegated to amenity plantings around accommodation camps and offices.

Where tubestock planting is used in broader rehabilitation areas it needs to consider the following:

- Its importance in the landscape and ultimately in a climax community
- The ability to protect the seedlings from frost, wind damage (exposure and sandblasting) and invasive herbivores
- The ability to supplement soil moisture during dry cycles or at least during establishment

Previous experience on other projects in the western NSW rangelands has proven that a low investment strategy in tubestock (ie, failing to address the second and third dot points) will result in very poor outcomes. Low investment in simple terms is mass planting with no follow water supply or protection from threatening processes.

It must be noted that, for the Copi mine, there will be a preference for direct seeding and that tubestock should only be considered if direct seeding has proved to be unsuccessful. It is also only recommended for areas where tree coverage is required. The majority of the mine site disturbance area does not contain canopy species.

Where tubestock is required, a high investment strategy will give a far better outcome, though not consistently. A high investment strategy in simple terms is the strategic inclusion of a small number of priority species, i.e. canopy trees, with investment in long term protection and supplementary water supply.

The following methods have been proven to work (at least in the short term), and are recommended for the Copi mine:

Fenced tree plots

- Approximately 2Ha size (150m square);
- Deep ripped (4-500mm) with a non tillage ripper assembly;
- 600-1000 tubes planted of canopy species;
- Standard fabricated wire stock fence (1.2m height) to deflect herbivores;
- The use of coreflute tree guards initially protect from wind and frost, then removed before summer heat to prevent trees from being catastrophically heat stressed; and
- The inclusion of an irrigation system using 13mm poly lines with individual 2Lph emitters, fed from a poly irrigation tank (14KL to 22KL) and powered by a petrol or diesel firefighter pump. These tanks are placed near an existing track network and filled by contractor water truck.

Individual tree plots

- 10-30 trees in a 500sqm area;
- Deep ripping of tree plot area;
- Individual tree guards made of 1m high mesh and 1m in diameter, secured by two 165cm star posts
- Water wells with a capacity of not less than 50L;
- Where soils have a high clay content this has been removed with an excavator and replaced with salvaged loam (from the timber clearing process) that contains a much higher carbon and organic materials; and
- Hand watered, or irrigated from small gravity systems (IBC bulker pods, placed on mounds with a Low Density Poly irrigation system.

Plate 8. Example of Individual Tree Plot (Photo Credit: T. Zwiersen)

Fenced direct seeded plots

- 2ha size (150m square);
- Deep ripped (4-500mm) with a non-tillage ripper assembly;
- Standard fabricated wire stock fence (1.2m height) to deflect herbivores;
- Instead of a mass tubestock planting, direct seeded lines are completed with a Precision Niche seeder, and the irrigation lines are placed in these;
- Canopy species are seeded at a higher rate than what would be used in general precision seeded areas, and the other species used in the PNS mix are also included, eg Acacia, to improve diversity of the tree plot;
- The inclusion of an irrigation system using 13mm in line dripper line, fed from a poly irrigation tank (14KL to 22KL) and powered by a petrol or diesel firefighter pump. These tanks are placed near an existing track network and filled by contractor water truck; and
- Additional tubestock can also be included where species that are unreliable from direct seeding need to be included, eg *Alectryon oleifolius.*

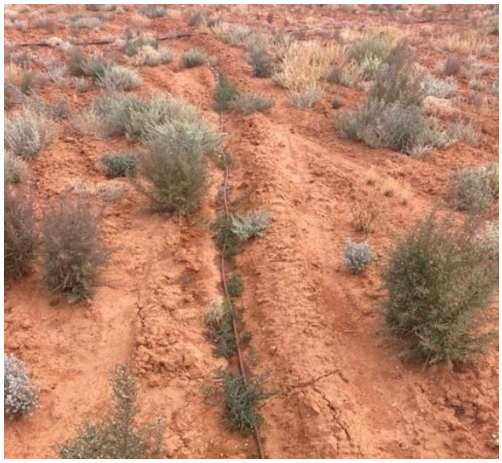

Plate 9. Irrigated Burford seeding line with high success rates (Photo Credit: T. Zwiersen)

Tubestock propagation/planting species

The species that are recommended for inclusion in the Copi tubestock propagation/planting program are shown in Table 4 (below).

These species have been selected due to two or more of the following reasons:

- Threatened status or keystone species;
- do not seed frequently;
- do not have a short shelf life;
- are not suitable for a SPA (e.g. tree species); or
- unreliable establishment at desired densities from direct seeding.

Where bulk seed is available, these species may also be also included in the direct seeding program.

Table 4. Copi mineral sands mine tubestock propagation/planting species.

Scientific Name	Common name	Life Form & Life cycle
*Acacia acanthoclada ssp. acanthoclada**	Harrow Wattle	Shrub (P)
*Austrostipa metatoris**	Spear-grass	Grass (P)
*Austrostipa nullanulla**	Speargrass	Grass (P)
Callitris glaucophylla	White Cypress Pine	Tree (P)
Casuarina pauper	Blackoak	Tree (P)
*Dodonaea stenozyga**	Desert Hopbush	Shrub (P)
Dodonaea viscosa subsp. angustissima	Narrow leaf Hop-bush	Shrub (P)
Eremophila sturtii	Turpentine Bush	Shrub (P)
Eucalyptus dumosa	White Mallee	Tree (P)
Eucalyptus gracilis	Snap and Rattle	Tree (P)
Eucalyptus socialis	Red Mallee	Tree (P)
Exocarpos aphyllus	Leafless Ballart	Shrub or Tree (P)
Grevillea huegelii	Comb Grevillea	Shrub (P)
Maireana sedifolia	Pearl Bluebush	Shrub (P)
Melaleuca lanceolata	Moonah	Tree (P)
Myoporum platycarpum	Sugarwood	Tree (P)
Pittosporum angustifolium	Butterbush	Tree (P)
Triodia scariosa	Porcupine Grass	Grass (P)

* Not yet recorded on site but included due to regional threatened status

5. Herbivore and weed management

5.1. Herbivore management

Exclusion of herbivores, specifically goats, kangaroos and other livestock is critical to the success of the revegetation, especially the establishment of long-lived perennial vegetation. Herbivore activity should be limited by the installation of fit-for-purpose fencing, however additional active herbivore management may be required. Further information on the recommended fencing and active herbivore management techniques are detailed below.

5.1.1. Fencing

All fencing recommended for the Copi project should use fabricated fence designs. 'Exclusion fence' refers to a product that is made by all manufacturers of fence materials that typically has a 15cm spacing between uprights (stock fences have 30cm spacing) and an integrated apron/skirt that sits out at 90 degrees from the bottom of the fence to stop animals either pushing or digging under the fence.

Mine leases (where rehabilitation activities will occur):

- The gold standard for the fences around the mine leases would be a 1.8m exclusion fence as it will exclude all large herbivores, though this type of fence is very expensive in terms of both materials and installation.

- The recommended fence is a 1.5m high exclusion fence, using 210cm star posts of both standard and heavy-duty design at maximum 7m spacings, and a 2.85mm high tensile plain selvedge wire that runs with the top wire of the fabricated fence (it is tied and clipped together to make a robust top wire).
- The minimum standard is a 1.2m high exclusion fence that uses 165cm star posts at 7m minimum spacing and the same 2.85mm high tensile plain selvedge wire on top of the fence. This has been found to be an effective design against goats, and about 70% of Kangaroo incursions.

Biodiversity Offsets (as per NSW government regulatory requirements):

- The recommended fence is a 1.2m high exclusion fence that uses 165cm star posts at 7m minimum spacing and the same 2.85mm selvage wire on top of the fence. This has been found to be an effective design against goats, and about 70% of Kangaroo incursions.
- The minimum standard of fence would be a fabricated fence using a 7/90/30 fabricated fence product, with a 2,5mm High tensile plain wire running with the top and bottom wire of the fabricated fence, and a single 1.8mm barbed wire on top of the fence. 165cm star posts are used at 7m spacing.

The minimum standard fence specified here would be the recommended fence for any general station fences, such as boundaries or haul roads where 'Dorper' sheep are being run as commercial livestock.

Plate 10. Example of exclusion fence with skirt (Photo Credit: T. Zwiersen)

Camp-Admin facilities and Seed Production Areas

Experience at other HMS operations in the region has demonstrated the need for a fence that excludes Kangaroos and feral Goats from the accommodation village. Goats present at other mines have created disturbance in camp (noise) and kangaroos have physically threatened residents.

As such, it is recommended that a 1.8m exclusion fence be erected around the accommodation village and the Seed Production Area.

5.1.2. Active herbivore management (mustering and/or culling)

At other HMS mines ongoing active management measures, such as mustering, and in certain instances culling, has been required within the mine leases and biodiversity offsets, however, this has been mainly caused by the presence of non-exclusion stock fences, where herbivores such as feral Goats and Kangaroos have been able to move through the boundary fences. The installation of the above recommended fences is therefore intended to limit the need for regular, active herbivore management. However, after the installation of the exclusion fencing some mustering and/or culling may be required in order to remove any herbivores that are already present on site.

5.1.3. Livestock Operations

The running of livestock could be allowed in any areas that are not mine leases or biodiversity offsets, as long as these areas are fenced appropriately to control stock movement. Given the extensive history of (over) grazing in the area, the landscape would benefit greatly from long rest periods, with grazing only occurring for short periods of time to capitalize on ephemeral pasture.

5.2. Weed management

The pastural properties that the Copi Mine spans contains almost one hundred years of grazing and already contains a significant weed presences and seed load. Weeds fall into two categories for the purposes of the Copi project:

1) Weeds that are declared plants and require control, such as Bathurst burr (*Xanthium spinosum)*, or Mesquite (*Proposis* sp.) Unless there is a major infestation usually these will require targeted control that include everything from hand chipping to remote retractable reel long line spray units.

2) Annual weeds, such as Wards Weed (*Carrichtera annua*) may need control in areas that are long prepared, that is post mine areas have had their topsoil replaced and have subsequent rainfall events before they have been seeded. If these annual weeds species are left intact then they will diminish the establishment of native species. In this instance the application of a broadleaf specific herbicide applied with a boom spray is the best option. A correctly applied broadleaf herbicide will leave any perennial or annual grass species intact, without affecting the outcomes when the site is direct seeded. Where areas are cleared of timber/shrublands and not stripped before they have received rainfall they may also require the application of a broadleaf herbicide to ensure a fresh seed bank is not spread over rehabilitation areas or stockpiled.

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