KLIPFONTEIN 2 SOLAR PV FACILITY DEVELOPMENT RE-VEGETATION AND REHABILITATION MANAGEMENT PLAN

Klipfontein 2 Solar PV Facility

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ACRONYMS AND ABBREVIATIONS

Acronym / Abbreviation	Definition
ECO	Environmental Control Officer
EMPr	Environmental Management Programme
NEMA	National Environmental Management Act (Act No.107 of 1998)
VVSG	Vaal Vet Sandy Grassland
WFSCG	Western Free State Clay Grassland
MAP	Mean Annual Precipitation
SCC	Species of Conservation Concern

Klipfontein 2 Solar PV Facility Development Re-vegetation and Rehabilitation Management Plan

1. INTRODUCTION

This Vegetation and Rehabilitation Management Plan has been prepared on behalf of Klipfontein 2 Solar PV Pty Ltd as part of the environmental authorisation process for the Klipfonteitin 2 commercial photo-voltaic (PV) solar power generation facility at Dealesville in the western part of the Free State Province (authorised by way of reference number: 14/12/16/3/3/2/726, as amended). This a project that forms part of a suit of projects called the Kentani Cluster.

It is desirable that an acceptable plan be in place prior to the commencement of construction activities to direct soil and water resource management efforts from the outset. This will facilitate the effective revegetation of affected areas in accordance with the sustainability principles of Integrated Environmental Management, as promoted by the National Environmental Management Act (Act No.107 of 1998) (NEMA). This plan will be included in the Environmental Management Programme (EMPr) for the area affected by the proposed development.

1.1 PURPOSE OF THE RE-VEGETATION AND REHABILITATION MANAGEMENT PLAN

The site contains primary grassland vegetation with high biodiversity value and very high conservation priority. The current land-use is commercial beef production.

The purpose of this document is to ensure that areas cleared or impacted during construction activities are rehabilitated with a plant cover that:
(i) reduces the risk of wind and water erosion from these areas;
(ii) reinstates key ecological processes;
(iii) restores ecosystem functioning to affected areas; and
(iv) softens the aesthetic impact of the development.

1.2 OBJECTIVES

The objectives of the Re-vegetation and Rehabilitation Management Plan are as follows:

- To achieve the long-term stabilisation of disturbed areas to minimise wind and water erosion potential.
- To re-establish vegetation cover with suitable local native plant species, creating habitat for fauna and reinstating ecological processes.
- To minimise visual impact of disturbed areas.
- To describe procedures to be followed to facilitate soil stabilisation and vegetation establishment.
- To provide a framework for monitoring and reporting on the success of the rehabilitation plan.

It should be recognised that the rehabilitation management plan is closely aligned with several other management plans and should be implemented in conjunction with these. The success of soil erosion control, alien plant species control, site management and revegetation efforts are interdependent, and employ overlapping practices.

1.3 PROJECT AREA OVERVIEW

The project area is located on the south-western outskirts of the town of Dealesville in the western part of the Free State Province (**Figure 3.1**). It is one of several solar PV electricity generation projects planned for the district. The project is situated on the transition zone between Vaal Vet Sandy Grassland (VVSG) and Western Free State Clay Grassland (WFSCG) and is part of the Dry Highveld Grassland complex of the Grassland Biome (SANBI, 2013).

The underlying geology over most of the southern part of the study area is Ecca Group shale and mudstone covered by wind-blown sand and surface limestone with localised dolerite intrusions. The soils are moderately deep to deep red apedal loamy sands overlying parent material or hard-pan carbonate. The Hutton and Clovelly soil forms predominate, reflecting a softer, more highly weathered sedimentary parent material and the influx of iron and clay particles from the prehistorically higher dolerite intrusions.

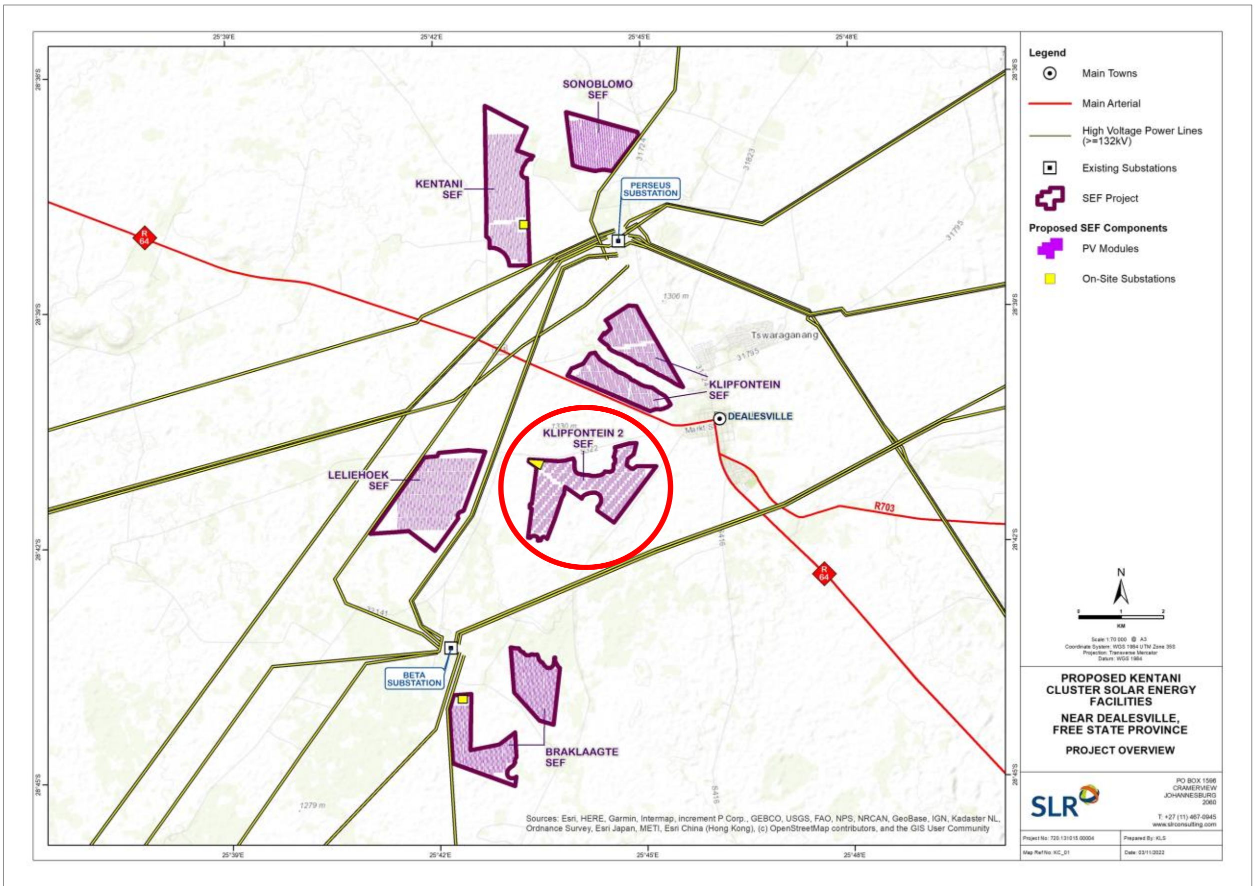

Figure 3.1: Location of the Klipfontein2 development site (circled) in relation to Dealesville, in the western part of the Free State Province.

The northern parts of the study area are dominated by shallow sandy-clay-loams of the Valsrivier and Swartland soil forms on underlying clay and dolerite parent material. These soils are characterised by a strongly structured, clay-rich pedocutanic B-horizon. The uplands in this area consist of shallow loams of the Mispah and Glenrosa soil forms overlying hard-pan carbonate or hard rock.

The landscape is generally expansive and flat and topographically dominated by scattered low, rocky hills. Slopes across the site are less than 1%. The primary land-uses are commercial beef production and communal livestock grazing. The area has a semi-arid rainfall regime, with a Mean Annual Precipitation (MAP) of 438mm (Water Research Commission, undated) mostly occurring as short, intense afternoon thunder showers (Lanz, 2015).

2. ECOLOGICAL CONTEXT

The Dry Highveld Grasslands group of vegetation types is dominated by Central Free State Grassland and VVSG and includes shrublands on rocky outcrops and ridges. The group includes five threatened vegetation types, with few areas under formal protection. The distribution of these rangelands coincides with important areas for maize production, gold mining (and the urban expansion associated with this), and intensive sheep and cattle production, and hence much of the primary vegetation has been irreversibly transformed. Most of these rangelands consist of semi-arid sweetveld that is drought-adapted and shows a significant amount of reproduction from seed. The plants are perennial, persisting vegetatively from year-to-year. However, new plants are able to establish from dormant seeds following droughts (known as serotiny).

The plant communities are adapted to a climate that is temperate with a moderate to high frequency of winter frost. These grasslands occur where rainfall is low (400-500mm MAP), strongly seasonal (in summer), and highly variable particularly as one moves west. The defining climatic characteristic is the low and highly variable summer rainfall. In these semi-arid ecosystems it is water, and not the duration and temperature of the growing season, that is the limiting factor to growth (SANBI, 2013). The unpredictable, semi-arid climate and nutrient-rich (unleached) soils result in nutritious year-round grazing. The rangelands are slow-growing due to low rainfall but are able to support animal production year-round. Grazing is also an important 'driver' of these ecosystems because it influences fire fuel load.

The plant life-history strategies in Dry Highveld Grassland ecosystems are driven by adaptation to drought. Most species are perennial and long-lived, persisting vegetatively for long periods, although a significant amount of reproduction takes place through seed production. Species are able to bridge drought periods by persisting as dormant seeds in the seed bank. This results in interesting cyclical shifts in species composition, such as when karroid shrubs spread into the more arid western parts of these grasslands during drier cycles but are replaced by grasses again when periods of higher rainfall return. Since seeds can remain dormant, these grasslands are resilient to impacts over the short-term (5 years) and may be expected to recover from inappropriate management over several growing seasons provided topsoil has not been lost.

The underlying geology is dominated by sandstones and mudstones, giving rise to deep, red soils. Dolerite sheets are associated with shallower, stony soils whilst in the west shallow red sands over calcrete occur. The underlying geology is an important determinant of biodiversity patterns and ecological processes. The presence of dolerite sheets gives rise to ecologically sensitive plant communities that show high levels of species richness and endemism.

Uys (2006) surveyed species composition and plant life-history strategy within rangelands across a rainfall gradient in the eastern part of South Africa. He concluded that rangelands with an MAP of ≥750mm had a substantially higher species richness, the bulk of this contained in the forb (or geophyte) component. The main driver influencing plant life-history strategy is fire, and most plants (grasses and forbs) resprout from underground storage organs following fire events. Annual rainfall is more reliable and bridging drought periods less of a factor driving plant survival. As a result, mesic grassland plants invest fewer resources in viable seed production, and more in carbohydrate storage. The sward is dominated by extremely long-lived tufts (some *Themeda triandra* tufts have been dated as 200 years old). Seed production is high, but only 2-3% is viable and the turnover of individual plants (and genetics) is extremely slow. There are also complex relationships between plant species and mycorrhizal fungi. As a result, the grasslands are resilient within the context of light disturbances such as fire or grazing but are highly sensitive to severe disturbances where plants are removed and soil disturbed. These disturbances are permanent.

In contrast, the rangelands in areas with less that 750mm MAP are of comparatively low species richness. There are substantially fewer geophyte species, and the non-grass component is dominated by karroid bushes. Rainfall is low and highly variable. Primary production is low because of the low rainfall, and fire events occur at lower frequency in response. As a result, plants produce large quantities of viable seeds to bridge drought periods. The rangelands are resilient to vegetation removal provided soil conditions remain amenable to plant growth. Although Uys' surveys did not occur in Dry Highveld Grasslands, the environmental factors were the same and the conclusions drawn are relevant.

3. POTENTIAL CONSTRAINTS TO SUCCESSFUL REHABILITATION

The main risks associated with the successful rehabilitation of the site are linked to the following aspects:

- Scale of clearing
- Climate seasonality
- Weed and alien plant infestation
- Seed availability
- Soil management
- Landform stability

3.1 SCALE OF CLEARING

The development of the Klipfontein 2 Solar PV Facility would require the removal of up to 250 ha of intact vegetation and most of this area is to be covered by banks of solar panels. The areas requiring revegetation will be the adjacent sides of access roads, drainage channels, and the gaps between the solar panel banks. The intended life-span of this project is 30 years, and this report does not include the post-closure rehabilitation strategy. This is seen as a separate project, with careful consideration of the intensity of intervention and management required to restore functional grassland to the landscape. Given the scale and nature of the transformation, it is suggested that the focus of rehabilitation should be the retention of topsoil, the promotion of rainfall infiltration into green spaces and the promotion of vigorous vegetation cover. This will ensure local ecological stability. It is important that the clearing, construction and rehabilitation be done sequentially to ensure the minimum exposure of bare soil to the elements.

3.2 CLIMATE SEASONALITY

The proposal area has a semi-arid, relatively low MAP that is strongly seasonal and highly variable. There is little access to irrigation water since the groundwater is likely to be brackish due to the high mineral content of the parent material (indicated by the occurrence of salt pans). The winters are dry with cold nights and frequent frosts. Hence revegetation is likely to be confined to the spring and summer months. The capture of rainfall off the solar panels and subsequent storage in JoJo tanks or sealed underground water tanks may allow the growing season to be extended via irrigation. This may also allow dry summer periods to be bridged. The seasonality of successful rehabilitation should be included in the construction schedule, since it is highly undesirable for large areas of dry, bare soil to be exposed to wind during the dry winter months. Any winter construction activities should include contingencies to prevent the loss of topsoil by wind.

3.3 WEED AND ALIEN PLANT CHALLENGE

The study area has a low incidence of weeds, with most old lands and bare areas invaded by *Tagetes minuta* and land grasses. Numerous karroid bushes, such as *Pentzia* spp, are also prone to dominating disturbed and degraded areas, although the impact of this is considered to be relatively benign since these are natural components of the local species composition. The challenge from alien invasive plant species is also considered to be low, with *Opuntia ficus-indica* and *Cereus jamacaru* present in low numbers in the veld within the project boundaries. Dealesville town contained several *Prosopis glandulosa* trees, and there are localised *Eucalyptus* woodlots distributed near several farmsteads. These did not appear to be invasive under local environmental conditions. Bare, disturbed areas are at risk of being colonised by pioneer weeds and alien invasive plants. However the risks associated with this are low within this particular landscape.

3.4 SEED AVAILABILITY

Extensive reseeding may be required due to the large area of the development. Commercial seed mixes often contain species that do not naturally occur within the surrounding native grasslands. These may encroach into adjacent intact primary grasslands, affecting their structure and species composition. Careful consideration should be given to the type of commercial grass species mix used to revegetate bare areas, ensuring that the species are compatible with environmental conditions and local grassland species communities.

The grasses in Dry Highveld Grasslands produce large quantities of viable seed in order to bridge periodic drought periods. An attractive (and cheaper) alternative would be to cut thatch when the intact grasslands are seeding and spreading these across the bare ground. Judicious irrigation from stored rainwater would encourage germination and establishment. Slopes and drainage swales should be vegetated with *Cynodon dactylon*, a creeping species that is drought tolerant and spreads rapidly to form dense mats. The species has also become a naturalised component of the landscape and is widespread on old lands in the area. Commercial seed is easily available. *Paspalum notatum* is also an option for more areas more prone to erosion.

There are several commercial veld-grass seed mixes available (e.g., Mayford, Sakata) that purport to be suitable for grassland rehabilitation for the various regions. These, however, do not provide species lists for their seed mixes. Table 3.1 indicates the dominant grass species found in the two vegetation types occurring within the study area. It is a concern that most of these species may not be used in commercial seed mixes. Any commercial seed mixes obtained should be compared to this table. If they are dominated by other species then they should be avoided. *Eragrostis curvula* and *Cynodon dactylon* are present in small numbers in the native veld. These species are, however, widespread and have been bred for particular traits such as palatability and productivity so that they can be used as a pasture grass in commercial agriculture. The seed purchased is unlikely to be genetically similar to the local species and may not be able to cope with the extremes of local conditions. There is also the risk of contaminating the genetics of the local species by introducing foreign genotypes of the same species.

Table 3.1: Dominant grass species occurring within the two vegetation types.

Vaal Vet Sandy Grassland	Western Free State Clay Grassland
Digitaria argyrograpta	*Digitaria argyrograpta*
Heteropogon contortus	*Heteropogon contortus*
Panicum stapfianum	*Panicum stapfianum*
Themeda triandra (highveld)	*Themeda triandra (highveld)*
Aristida diffusa	*Cymbopogon pospischilii*
Cymbopogon pospischilii	*Eragrostis curvula*
Eragrostis micrantha	*Aristida adscensionis*
Aristida congesta ssp barbicollis	*Aristida congesta ssp congesta*
Aristida congesta ssp congesta	*Brachiaria eruciformis*
Brachiaria marlothii	*Brachiaria marlothii*
Cynodon dactylon	*Chloris virgata*
Eragrostis chloromelas	*Cynodon dactylon*
Eragrostis lehmanniana	*Eragrostis chloromelas*
Eragrostis obtusa	*Eragrostis trichophora*
Eragrostis surperba	*Schmidtia pappophoroides*
Microchloa caffra	*Sporobolus centrifugus*
Schmidtia pappophoroides	*Tragus koelerioides*
Tragus koelerioides	*Eragrostis lehmanniana*
Trichoneura grandiglumis	*Eragrostis obtusa*
	Eragrostis surperba
	Trichoneura grandiglumis

3.5 SOIL MANAGEMENT

Topsoil is arguably the most important rehabilitation resource in the project area. Topsoil and subsoil that are removed from the construction footprint should be recovered and used in rehabilitation areas. Topsoil should be carefully managed and stockpiled to ensure that it does not become degraded. It should be used within three months of excavation to ensure that the seedbank remains viable, and soil microbial populations and relationships remain intact. The success of this process is one of the biggest risks associated with successful rehabilitation of disturbed areas.

3.6 LANDFORM STABILITY

The landscape is flat to gently undulating, with the steepest slopes at 1.2%. The deep sandy apedal soils associated with the VVSG are well drained and stable, and the risk of water erosion is low. The soils of the WFSCG are erodible, although the lack of gradient negates much of the risk. The landscape is stable, and the risk of water erosion is low. The main risk of ecological instability is from wind erosion from bare soil surfaces during the dry season.

4. REHABILITATION MANAGEMENT PLAN

The aim of the Re-vegetation and Rehabilitation Plan is to ensure that all impacts resulting from the disturbance or removal of native vegetation and habitat are addressed. These include loss of plant species (particularly species of conservation concern); loss of ecosystem functioning; disruption to ecosystem processes; and ecological degradation (soil erosion, alien plant infestation). The rehabilitation plan is outlined in four (4) phases, namely:

- **Phase 1**: Site clearing and vegetation removal
- **Phase 2**: Soil preparation and topsoil management
- **Phase 3**: Re-vegetation of disturbed areas using appropriate natural successional species
- **Phase 4**: Monitoring and management of the success of the rehabilitation by controlling aggressive indigenous plants, removing alien invasive plant species as soon as they are observed, and maintaining the re-vegetated areas to ensure the successful establishment of these re-vegetated areas.

4.1 PHASE 1: SITE CLEARING AND VEGETATION REMOVAL

Vegetation clearing should proceed in phases to retain vegetation cover as long as possible and minimise the exposure of bare soil surfaces to potentially erosive wind and rainfall. Uprooting of vegetation should be kept to a minimum and confined only to those areas where this is imperative. All other areas should remain vegetated. The Re-vegetation and Rehabilitation Plan is applicable to the following areas:

- Roadsides
- Swales and drains
- Berms and slopes
- Construction areas
- Designated storage areas
- Open areas within the development footprint

Prior to re-vegetation the target areas should be thoroughly searched for geophytic bulbs such as *Ammocharis coranica.* Shrubs are unlikely to survive translocation. Any bulbs found should be carefully lifted and either transplanted directly to a newly rehabilitated area or potted and placed in a nursery for future translocation. It is recommended geophytes be planted in clusters rather than scattered singly across the rehabilitated area. They should also be translocated to a similar environment from whence they came in terms of slope, aspect and soil depth. Plants should only be translocated from areas earmarked for clearing, and not from intact vegetation that will be unaffected by the development. This procedure should be undertaken by a suitably qualified specialist.

Grass and shrubs that are uprooted or brush-cut should be stockpiled and retained for rehabilitation purposes. The resulting mulch would contain seeds that would assist with the restoration by local species. All cleared vegetation should be used in the rehabilitation process, either as a protective mulch or as an influx of organic matter once composted. The dumping of cleared vegetation onto areas adjacent to the construction areas is to be avoided.

Vegetation should only be cleared and uprooted from sites designated as permanent access roads. Temporary vehicle access should rather entail driving over low vegetation along well marked tracks. Although the traffic may damage the vegetation, this would be expected to recover in time with little risk of soil erosion. However, off-road and off-track driving during the rainy season across clay soils is strongly discouraged because the resulting ruts may confine surface runoff, leading to the establishment of eroded gullies. The contractor should submit a site-clearing method statement to the Environmental Control Officer (ECO) prior to clearing. The statement should clearly indicate the phased methodology and methods of storage of cleared and mulched (chipped or chopped up) plant material.

4.2 PHASE 2: SOIL PREPARATION AND TOPSOIL MANAGEMENT

The most important objective for any rehabilitation project is the establishment of a permanent and dense cover of soil (Coetzee, 2016). Topsoil is considered to be the top-most layer (0-25cm) of the soil in undisturbed areas, and its importance lies in its nutrient content, organic matter content, seedbank, and populations of micro-organisms, fungi and soil fauna. All of these elements are necessary for soil processes such as nutrient cycling and supporting plant growth. The biologically active upper soil horizon is fundamental to the maintenance of the entire ecosystem.

Topsoil removed during construction must be immediately used in the nursery or to cover previously disturbed areas. Otherwise it should be stockpiled on site for subsequent rehabilitation once construction activities have ceased. The following management measures must be applied to maintain keep topsoil healthy:

- It is recommended that a 100—150 mm layer of topsoil is removed to prevent it mixing with deeper sterile subsoil that will lead to reduction in nutrient levels and a decline in plant performance on the soil.
- Wherever possible stripped topsoil should be moved directly to areas that will require rehabilitation to prevent double handling and to minimise stockpiling. The topsoil contains viable seed, nutrients and microbes that promote more effective revegetation than soil that has been stored.
- Soil stockpiles for post-construction rehabilitation should be placed in designated areas and shaped to be not more than 1.5 m high. They should be turned at regular (monthly) intervals to prevent compaction and the development of anaerobic conditions. The topsoil should be used as soon as possible, with the maximum limit for storage being three months.
- Appropriate measures should be implemented to protect soil stockpiles from erosion by wind and water, using hessian or similar material, not plastic sheeting.

To prepare the site for re-vegetation the following steps should be taken:

- All remnants of foreign or inorganic debris should be removed from the site.
- Compacted soil should be ripped using a tractor-drawn ripper to a depth of more than 250 mm to aerate the soil.

- The target areas should be covered with stockpiled or newly-stripped topsoil to the original topsoil depth.

4.3 PHASE 3: RE-VEGETATE DISTURBED AREAS

Active intervention (by replanting or sowing seed) is not always required to re-vegetate disturbed sites, and a site-specific approach should be adopted that considers prevailing ecological processes and conditions. In this case replanting or re-seeding should be used in conjunction with microclimate manipulation or mulching to restore plant cover on disturbed areas. In many cases providing some kind of treatment that results in an improved microclimate will also result in the germination of self-seeded plants. To revegetate a disturbed area the following needs to be taken into consideration.

4.3.1 Re-vegetation and Seeding

- The final vegetation cover should resemble the original indigenous vegetation composition and structure as far as possible (75% of original composition) to allow the continuation of existing ecological processes such as macro- and micro-herbivory, fire, and nutrient cycling.
- Planting of species should be done to coincide with rains if possible. However planting should commence as soon as possible after construction is completed to minimise soil erosion. If planting takes place outside of rainy season irrigation will be necessary.
- Seed should be collected from intact vegetation present near the site and should be used immediately or stored appropriately and used at the start of the following wet season. In this case grass seeds could be harvested towards the latter half of the wet season.
- The priority is to obtain healthy vegetation cover, which will protect the soil from the elements and initiate core ecological processes such as herbivory and nutrient cycling. Once grass cover has been established, seeds from karroid shrubs growing in neighbouring blocks of grassland will be able to disperse and become establish in accordance with the prevailing local and landscape climatic conditions.
- Grass and shrub seed can be gathered using a vacuum harvester and broadcast onto the soil surface. Seed may also be harvested by hand and dried appropriately. Thatching is another option whereby mature grass stems from nearby intact grassland are cut, gathered and spread across the bare soil. This has the added advantage of simultaneously applying a protective cover of mulch to the soil and a source of organic matter as the grass stems decompose. Care should be taken not to spread too thick a layer of thatch as this may inhibit seed emergence following germination.

  This has been used with some success in various rehabilitation projects throughout South Africa (Kirkman, 2013). Grasses usually flower from December through to March with different species flowering at different times of the season. The process of flowering involves:
  - Development of the inflorescence,
  - Pollination,
  - Development of the seed,
  - Ripening of the seed,
  - Seed fall.

The process should be monitored carefully to ensure the seed is harvested at the right time. Once the seed is ripe it can be harvested on a small scale by using gloves (the seed can be plucked from the inflorescence and stored in a suitable bag), or flowering stems can be cut using a sickle and collected.

Once the seed has been harvested it must be dried as soon as possible to prevent it from rotting (**Figure 4.1**). The most suitable way of drying the seed is to lay it out on a sheet in a suitably ventilated room. The seed should be turned over several times a day until it is dry. Then it can be placed in suitable bags for storage until the next growing season. The seed can be sown by hand at the beginning of the growing season using established techniques. Germination is usually slow and erratic compared to commercial crops, but experience has shown that germination percentages are reasonable (Kirkman, 2013), reasonable cover can be achieved and reasonable levels of biodiversity.

Figure 4. 1: Recently harvested indigenous grass seeds being aerated during the drying process (photo credit: Kevin Kirkman)

- Once vegetated, areas must be protected from construction equipment, vehicles, trampling and grazing animals (through fencing), and preventative erosion measures must be implemented.
- These application methods should ideally be applied in conjunction with measures to improve seedling survival such as scarification, mulching and low hessian fences that protect the soil surface by breaking up wind-flow.
- A commercial seed mix may be used but must be approved by the ECO and should include the following:
  - A mixture of annual and perennial plants.
  - Includes pioneer species.

- Selected species must be able to grow in the area where they are being used.
- Roots must have a binding effect on the soil.
- The final mixture must not cause an ecological imbalance in the area.

Cynodon dactylon occurs naturally within localised patches in the area (**Figure 4.2**). This is a rhizomatous grass species that forms a dense mat, is drought resistant, can withstand heavy grazing and has a dense adventitious root system that binds surface soil effectively. This species would be the ideal cover for areas where water runoff is anticipated, such as on roadsides or on the sides and bottoms of drainage swales.

Figure 4. 2: *Cynodon dactylon*, showing dense, creeping growth habit (photo credit: Doug McCulloch). This is ideal for protecting the soil surface and binding the topsoil. It also able to withstand heavy grazing and trampling. Ideal for vegetating slopes and drainage swales.

4.3.2 Mulching

- Mulching refers to the covering of the bare area with a thin layer of any partially decomposed organic matter such as leaves, twigs bark or wood chips, or grass (usually chopped quite finely). The main purpose of mulching is to protect and cover the soil surface as well as serve as a source of seed for revegetation purposes. It also adds valuable organic matter to the soil as it decomposes, and traps and hold moisture at the soil surface which enhances seed germination and growth.
- Mulch could be made from the vegetation that has been cleared for construction. This could be put through a wood-chipper or similar mechanical chopper.
- Mulch can be made from the tall vigorous grass sward of adjacent intact grasslands, particularly once it has cured during the dry season. The cut vegetation should be collected in windrows, and then chopped up using a mechanical mulcher. Hay from neighbouring rangelands could also be used provided this does not include ruderal species. The chopped-up vegetation should then be spread across the bare soil following seeding.

4.3.3 Additional Interventions and Notes

- In dry areas where seed, moisture and organic matter retention is low it is recommended that soil savers are used to stabilize the soil surface. The site has variable rainfall with dry winter months. Soil desiccation and wind erosion are substantial threats to successful rehabilitation. Soil savers are loose mats constructed of biodegradable materials such as hemp or jute that are placed over the bare soils surface and pegged down (**Figure 4.3**).
- Soil savers may be seeded directly as the holes in the material catch seeds and provide suitable micro-sites for germination. Alternatively fresh mulch containing seeds can be applied to the soil saver. Soil savers may only be necessary if rehabilitation is occurring during a particularly dry period within the rainfall months, or at the temporal edges of the rainfall season.

Figure 4. 3: Straw mulching together with an example of a biodegradable erosion control soil saver (photo credit: Tully Consulting Group)

- Erosion control must minimise water run-off and wind-blown dust. The application of low, porous fences to break down wind flow over the rehabilitated areas will further stabilise the rehabilitated areas. These also assist with trapping wind-blown dust, organic matter and seeds, depositing them within the area being rehabilitated.
- Rainfall harvesting infrastructure such as guttering and storage tanks should be included in the design of each component of the development rather than being installed at the end of the construction phase. This will allow the collection of rainwater to be used for irrigation should revegetation occur during a dry period.
- If erosion damage occurs after re-vegetation has taken place and forms channels/gullies or wash-aways, backfilling must be done to restore areas to an appropriate condition.
- Progressive rehabilitation is an important element of the rehabilitation strategy and should be implemented where feasible. This implies that the site is rehabilitated sequentially, with one phase of construction rehabilitated before the subsequent phase is initiated.
- Rehabilitated and revegetated areas should be protected to prevent trampling and erosion.

- Access to rehabilitated areas by vehicles, unauthorised people and large animals should be restricted. Sites located within areas grazed by cattle should be fenced off to prevent access. Fences may be removed once appropriate vegetation cover has been achieved.

4.4 PHASE 4: MONITOR AND MANAGE THE SUCCESS OF THE REHABILITATION

Rehabilitation success in semi-arid areas may be unpredictable, and regular monitoring and adaptative management is required to detect degradation in rehabilitated areas and implement follow-up actions. The following aspects should be monitored:

- Species composition to track development towards the pre-determined desired state
- Vegetation cover using a consistent standard method
- Plant vigour
- Soil stability, with erosion and pedicelling of grass tufts a key indicator.
- The presence of alien invasive plant species. If noted implementation of an approved Alien Invasive Management Plan must take place.

Monitoring should, be carried out every 6 months for a period of 18 months after rehabilitation. Rehabilitated areas showing poor surface coverage (<10%) within 12 months of revegetation should be prepared and the re-vegetation process repeated. Any areas showing signs of soil erosion should be reshaped and revegetated with rhizomatous grass species. Rehabilitation will be deemed successful once the desired plant cover has been established, erosion stopped, and there is no further requirement for frequent monitoring and management of the growth of alien species.

5. ROLES AND RESPONSIBILITIES

5.1 DEVELOPER

This refers to the project proponent/owner and has the following responsibilities (Hoare, 2021)s:

- Ensure adherence to all laws and standards relevant to the project.
- Appoint appropriately qualified Contractors to co-ordinate, supervise and expedite the different tasks.
- Ensure implementation of all aspects and specifications of the rehabilitation plan, EMPr and approved Method Statements.
- Ensure that the Contractor/s has a copy of the Rehabilitation Plan, EMPr and all agreed Method Statements (must be included in all contractual documentation and in the Environmental File on site). All parties involved in the construction of the facility are to be made aware of and be familiar with the Rehabilitation Plan and EMPr together with the mitigation measures contained therein.
- Ensure that the contractor has reflected and provided sufficient resources (cost, and personnel) for implementation of the rehabilitation plan requirements.
- Appoint an independent suitably qualified individual to perform the responsibilities assigned to the Environmental Control Officer (ECO), prior to the start of construction activities on site.

5.2 THE PROJECT MANAGER

The project manager of the proposed development will be responsible for:

- The overall implementation of the rehabilitation plan during the construction phase of the project.

- Establish and maintain proactive communications with the Developer, Contractor and ECO.
- Review and comment on environmental compliance assessments and/or reports. Review the Complaints Register.
- Report any significant environmental incidents or impacts to the relevant environmental authorities.
- Ensure that contractors are aware of the specifications, legal constraints and company standards and procedures pertaining to activities taking place during construction.
- Ensure that the Contractor develops and provides all required Method Statements for the proposed development.

5.3 CONTRACTOR

The Contractor's role is to implement, monitor and review construction activities and has the following responsibilities:

- Implementing the rehabilitation plan for all new infrastructure that will be built.
- Ensuring that the construction team complies with the requirements of this management plan.
- Review and interpretation of monitoring data.
- Keeping records of all activities/incidents on site in the Site Diary concerning the environment (including rehabilitation) and reporting these to the ECO.
- Reporting back on the environmental issues (including rehabilitation) at regular site meetings and other meetings that may be called regarding environmental matters.
- Inspecting the site and surrounding areas regularly (at least once per week) to ensure compliance with the EMPr as well as this Management Plan and reporting these findings at least monthly throughout the construction phase to the ECO and the applicant.
- Ensuring that all new contractor personnel coming onto site attend the environmental awareness training courses conducted by the Contractor or other responsible personnel.

5.4 ENVIRONMENTAL CONTROL OFFICER (ECO)

The ECO's role it to implement and monitor the rehabilitation Plan and EMPr for the proposed development and has the following responsibilities:

- Inspecting the site and surrounding areas regularly with regard to compliance with the EMPr as well as this Rehabilitation Management Plan and reporting these findings at least quarterly throughout the construction phase to the relevant environmental authorities and the developer.
- Completing start-up, monthly and site closure compliance checklists.
- Keeping records of all environmental incidents on site in the Site Diary and reporting these to the developer.
- Keeping a photographic record of rehabilitation progress and other actions affecting the environment of the site.
- Reviewing and approving construction method statements related to rehabilitation of the site.
- Recommending and/or developing corrective actions in the event of significant non-compliance.
- Implementing appropriate actions in the case of noncompliance with this plan.

6. CONCLUSIONS

- Re-vegetation and rehabilitation are costly. The best way to minimise costs is to make the development footprint as small as possible.
- Areas that have already been disturbed are of lesser ecological importance than intact areas, and consequently have lower risk attached. Disturbed areas should be incorporated into the development footprint wherever possible.
- Under circumstances where the topsoil is managed and applied correctly and post-rehabilitation conditions are favourable to plant growth, a rehabilitated sward species composition similar (75% of original species composition) to that of the intact vegetation is a realistic goal. This is because both woody and grass components produce sufficient viable seed to re-establish areas that have been denuded of vegetation because of drought. The establishment of geophytes, suffrutices and herbs may not be as realistic an objective within the timeframe of several decades because their growth and reproduction may be reliant on soil mycorrhizal relationships.
- The Applicant will ensure that this Re-vegetation and Rehabilitation Plan is reviewed for efficacy, and any necessary changes thereto will be reflected in the periodic revisions of this document. A summary of all rehabilitation monitoring activities and outcomes will need to be included in the annual performance monitoring report.

7. REFERENCES

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