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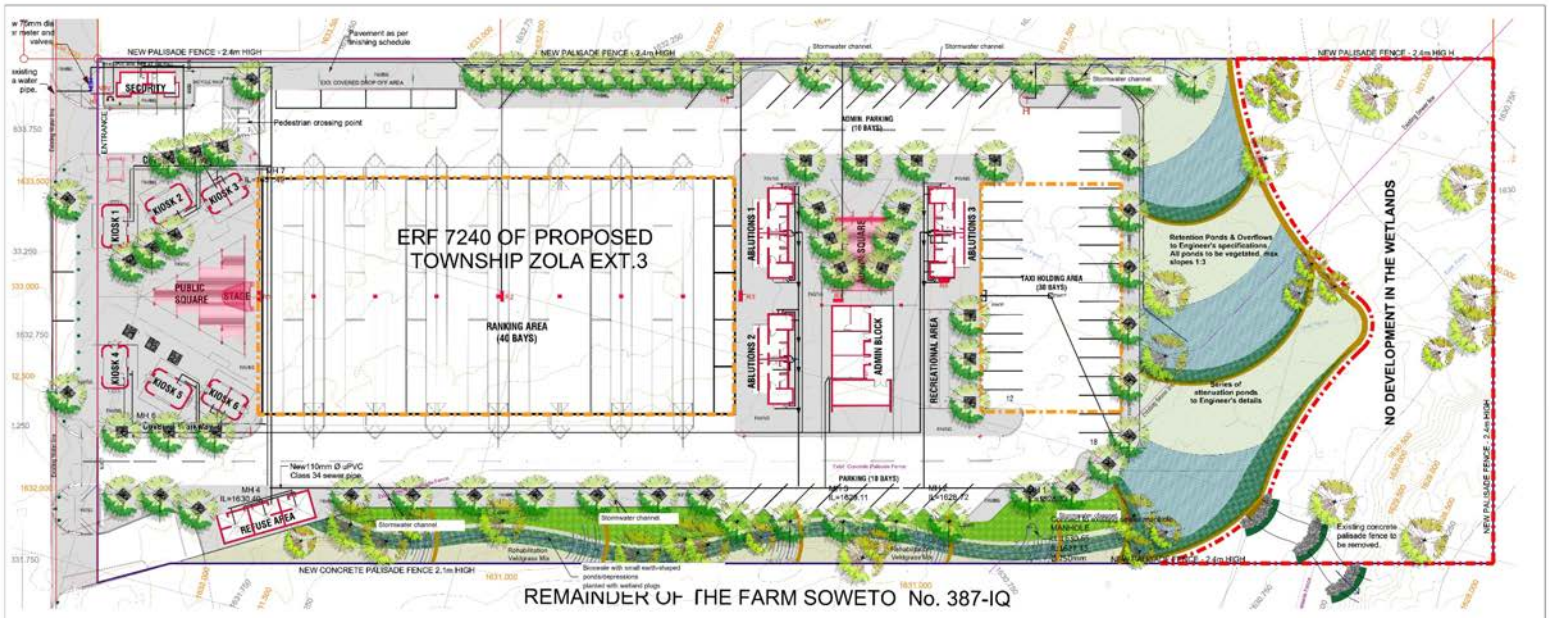
DEVELOPMENT OF AN ECOLOGICAL STORMWATER MANAGEMENT & REHABILITATION PLAN FOR SUBMISSION AS PART OF WATER USE LICENCE APPLICATION FOR THE PROPOSED TOWNSHIP ZOLA EXTENSION 3 in order to accommodate the EMENDENI PUBLIC TRANSPORT FACILITY ON A PART OF THE REMAINDER OF THE FARM SOWETO 387 IQ – GAUTENG.

PROPOSED PREFERRED LAYOUT PROPOSAL



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ACRONYMS

PES	Present Ecological State
WSUDS	Water Sensitive Urban Drainage Systems

1 Introduction

1.1 Background

Habitat Landscape Architects were appointed to develop a rehabilitation plan with the focus on quantitative and qualitative improvement of the runoff from the proposed the proposed Zola Emendeni public transport facility on a part of the remainder of the farm Soweto 387 IQ – Gauteng. The principle aim on the rehabilitation plan is to apply the principles of Water Sensitive Urban Drainage Systems (WSUDS) to the proposed development.

This rehabilitation plan aims to satisfy the following statement from the conclusion of the Ecological report:

> *The proposed taxi rank is however located outside the wetland unit, but he proposed storm water attenuation dam and a portion of the parking is located in the buffer zone for the wetland. The impact of the development on the wetland unit is expected to be of low to moderate significance, which can be partially mitigated though appropriate management of the site and implementation of a soft stormwater system. The attenuation pond must be vegetated with appropriate vegetation indigenous to the area.*

1.2 Rehabilitation in the South African Context

The extensive rehabilitation of rivers, streams, wetlands and riparian areas is increasingly becoming a worldwide phenomenon. Countries such as America, Australia, the United Kingdom and others have developed a number of technical guideline documents on rehabilitation. Within the South African context only limited efforts have been made to rehabilitate riparian areas and the applicability of the various technical manuals have not yet been established (Quinn 2003: 1). Although the rehabilitation of the stormwater channel is limited to the local context we have, where relevant, drawn on various international and local (see references) literature sources and case studies to inform the design and method statement.

1.3 Purpose of this report

The purpose of this report is to provide a localized rehabilitation plan to describe the landscape interventions associated with the stormwater system at the proposed new Zola Emdeni Public Transport Facility.

2 Rehabilitation design methodology

To gain a thorough understanding of this section of the stormwater channel and the proposed rehabilitation it is important to understand the context of the area, including the vegetation, important river features and habitats that the proposed rehabilitation will have to respond to.

Within the context of this project the following two key concepts will be integrated:

- **Rehabilitation:** Making the land useful again after a disturbance. It involves the recovery of ecosystem functions and processes in a degraded habitat (Dunster & Dunster 1996). Rehabilitation does not necessarily re-establish the pre-disturbance condition but does involve establishing geological and hydrological stable landscapes that support the natural ecosystem mosaic.

- **Restoration:** The re-establishment of the structure and function of the ecosystem. Ecological restoration is the process of returning an ecosystem as closely as possible to pre-disturbance conditions and functions. Implicit in this definition is the fact that ecosystems are naturally dynamic. It is therefore not possible to recreate a system exactly. The restoration process re-establishes the general structure, function and dynamic but self-sustaining behaviour of the ecosystem.

As a general recommendation all rehabilitation measures considered in this project must contribute to general ecosystem functions that encourage ecological processes to create and sustain the following ecosystem characteristics:

- ecosystem complexity, diversity and change;
- ecological connectivity;
- riparian interactions;
- floodplain connectivity;
- species diversity, adaptation and survival;
- water quality and water quantity;
- Invertebrate production and sustained food-web function.

3 Rehabilitation concept

3.1 Current stream conditions

Vegetation and the distribution of the various vegetative components within the stream corridor can be used as particularly good indicators of habitat integrity as well as ecological functionality. Vegetation plays important structural and functional roles in the riparian zone. Structural diversity (varying heights, shapes, orientation and distribution of species) contributes to habitat value and largely dictates the diversity of associated vertebrate and invertebrate communities (Water and Rivers Commission 1999: 2). Loss of vegetation cover in riparian zones is one of the major causes of surface and in-stream erosion. The root system of all vegetation strata plays an important role in reducing soil

erosion through the provision of a root matrix, which effectively binds the soil. Shallow-rooted perennials, such as rushes and sedges, are effective at surface soil binding, and deeper-rooted perennials for stabilizing at depth. Alien plant control and the re-establishment of floristic and faunal diversity are central to biodiversity enhancement. Alien plant control is necessary for long-term sustainability of the riparian system, and for the recovery of indigenous vegetation functions.

From the Ecological assessment the following has important bearing on the rehabilitation proposal:

> ***Present Ecological Status (PES)***
> *This wetland has an overall PES in class C, which is Moderately Modified. The PES score for the hydrology of the wetland is in class D, which is Largely Modified, while the geomorphology is Largely Natural (PES class B) and the vegetation is Moderately Modified. The PES is determined across the historical extent of the wetland, but since this is not know exactly, the PES scores may have some inaccuracies. The scores do however reflect the current status of the wetland fairly accurately.*
>
> ***Hydrology*** *– The hydrology of the wetland is mostly modified by the development surrounding the wetland. The development is fairly dense and the extent of impermeable surfaces in the catchment were increased significantly. The stormwater drains from the development enters the wetland, where it resulted in artificial canals in the wetland.*
>
> ***Geomorphology*** *– This is likely the least accurate of the PES scores since the method does not adequately reflect the impact extent of the infill on the wetland. It is however clear that the significant increase in runoff and the erosion features in the wetland has an impact on geomorphology of the wetland.*
>
> ***Vegetation*** *– Portions of the wetland vegetation has been lost due to the infill, while other portions has been infested by alien and invasive plant species. It is possible that the vegetation in the majority of the wetland has been altered from grass/sedge dominated to dominated by Typha capensis, since this is the type of vegetation expected in this type of wetland, when not surrounded by development.*

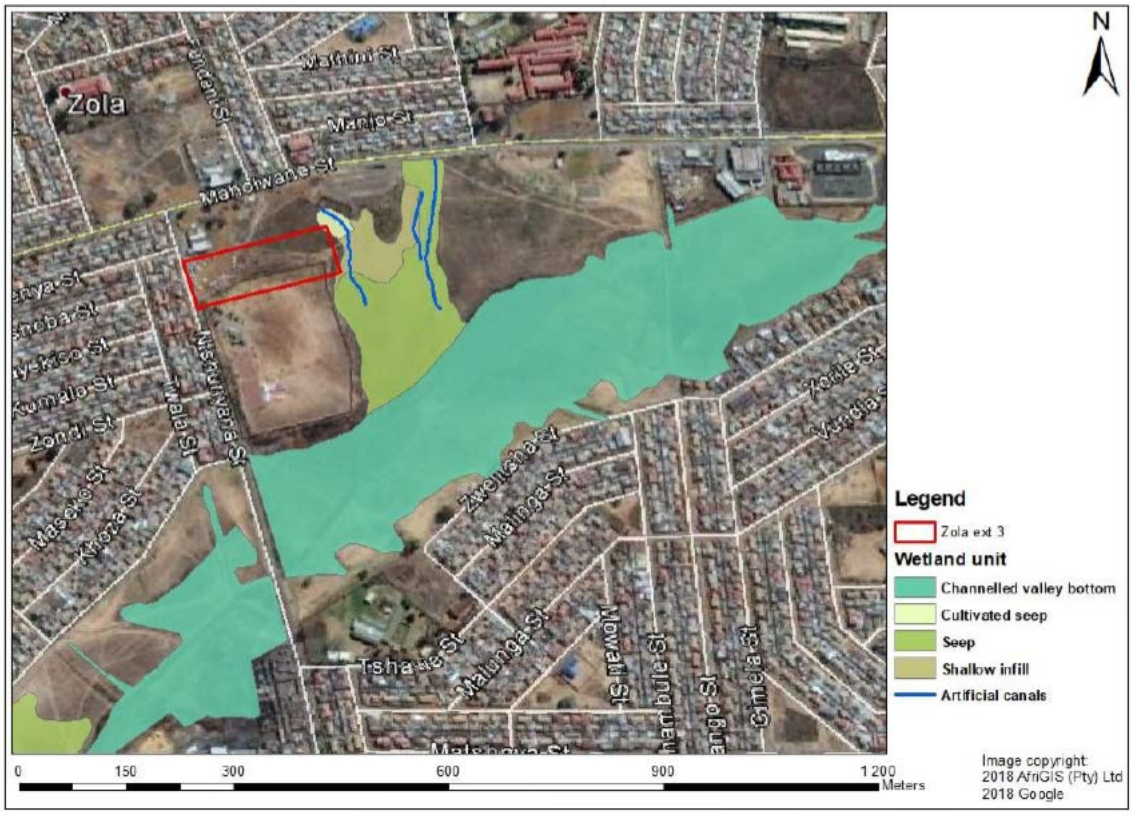


Figure 1: Illustrates identified and demarcated wetland units in proximity to the study area demarcated in red.

3.2 Vegetation

Vegetation can be regarded as a key component in rehabilitation and restoration Vegetation can be considered for:

- High-energy environments
- Exposure of large areas of bare soil
- Biodiversity concerns
- Isolation
- Water filtering capacity
- Aesthetics

The selection of vegetation for the different functional rehabilitations must be based on both functional plant characteristics as well as ecosystem integrity. In addition, it should be kept in mind that one of the key elements to rehabilitation is species diversity and the associated robustness of the vegetation. In an environment that is subjected to dynamic and often rapid changes the more diverse the vegetation composition, the better are the chances of successful re-colonization.

When it comes to the actual re-vegetation process, the suitability of the soil medium is critical. This is especially important in an environment with high flow velocities. If the growth medium is optimized and other growth factors such as the season and soil moisture conditions are optimal, vegetation re-

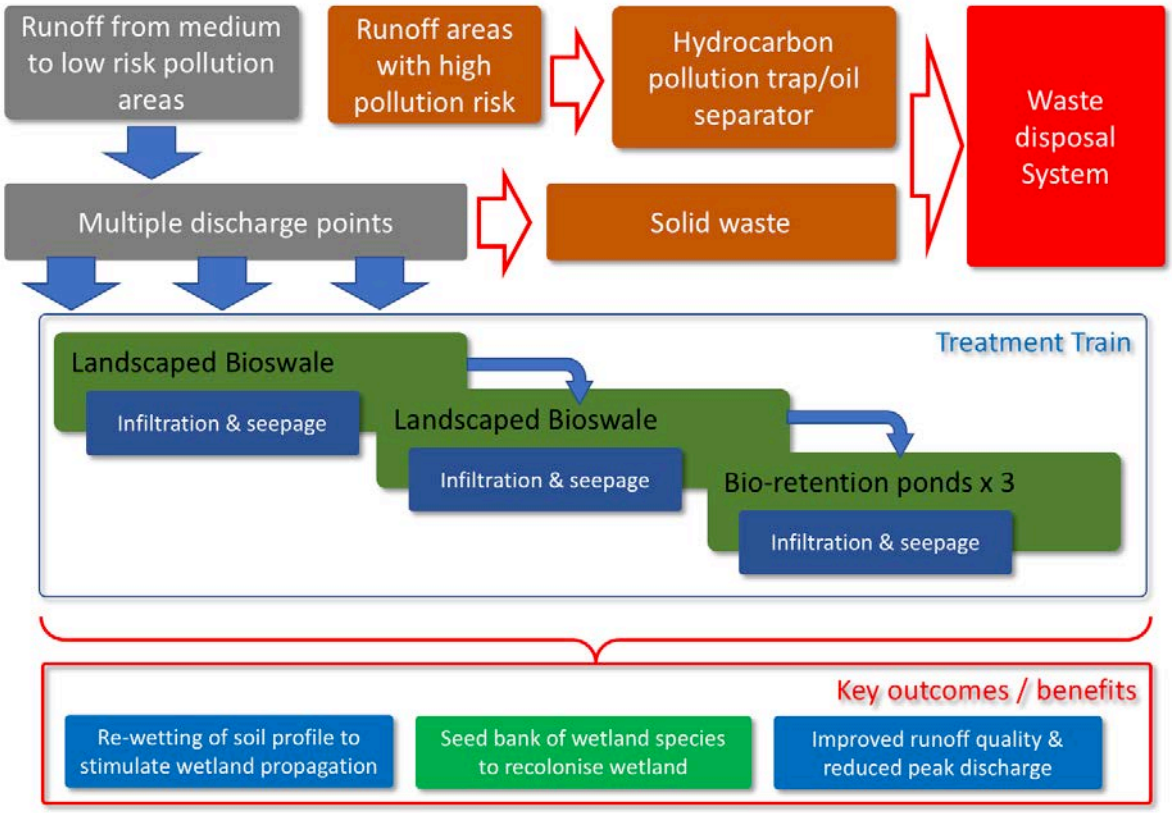
establishment can be rapid and will reduce the risk of erosion as well as the need for remedial maintenance or perhaps replanting.

Within the context of the proposed stormwater rehabilitation of the study area it is proposed that the following methods be used to re-establish vegetation:

- **Seeding**: Suitable species can be re-seeded using a variety of techniques such as hand seeding or hydro seeding.

- **Planting**: Planting of plugs, 2 kg and 4 kg plants should be limited to areas that will offer protection from the stream flow.

3.3 Rehabilitation proposal:



The concept for the rehabilitation and improvement of the wetland makes use of multiple modes of quantity and quality improvement in that:

1. High risk hydrocarbon contamination zones are provided with appropriate oil separators. These have to be managed according to the relevant Waste Management procedures for Hydrocarbon systems
2. Stormwater is distributed across the site with multiple discharge points that drain into landscaped Bioswales.

3. Landscaped bioswales are interlinked to function both individually and collectively. These are simple landscaped beds designed to accommodate runoff and planted with a mix of wetland and other species optimised to grow under conditions of temporary saturation. These also play an important role in the removal of solid waste and localised sedimentation. Lastly they provide an important plant seed base for recolonization of the downstream wetland system.

4. During intensive storm events where the holding capacity of the landscaped bioswales are exceeded water flows to a series of Bio-retention ponds before discharging into the adjacent wetland system.

5. All outlet structures are designed to reduce energy and flow velocities during peak stormwater events.

6. Overflow from one pond moves to the next with the final pond discharging into the adjacent channel.

7. The connection between the retention ponds and the existing wetland system will aim to disburse flow and reduce flow velocity. The outlet connection will be provided with riprap to protect against channel incision. These will consist of a trench excavated perpendicular to the flow direction and filled with a bolder clay matrix (the boulders need to be hydrologically sized based on the flow velocity in the system).

   These structures allow for the natural cycles of deposition and erosion depending on the flow events during the season or multiple seasons forming a series of pools and riffles. This option also allows for horizontal migration of the stream / braids cross the channel bottom without further channel incision. The aim of the intervention will be to get the system back to a state of natural equilibrium where scour and deposition are within acceptable limits.

   We would not recommend the installation of Gabion or Reno mattresses as these have a number of longer-term maintenance implications. Localised incision of the bed with associated deposition will be controlled by the Riprap/ groynes formed by the bolder clay matrix.

4 Rehabilitation Plan:

Figure 2: Rehabilitation plan drawing

4.1 Rehabilitation method statement

The time between construction and rehabilitation must be kept as short as practically possible. It will be ideal for the rehabilitation implementation phase to commence in early spring to maximise on the summer growing season.

The proposed rehabilitation must include the following steps:

4.1.1 Demarcation of work area

It is important to demarcate the rehabilitation area with droppers and danger tape and not to disturb any areas outside the proposed rehabilitation area. Avoid pedestrian and livestock access. Any damage caused to areas outside the rehabilitation areas shall be made good at the Contractor's expense, to the complete satisfaction of the Landscape Architect.

The construction camp and material stockpiles must be outside of the 1:100-year flood line and must be fenced.

4.1.2 Soil conservation

Vegetation must only be cleared immediately before earthworks commence (not to leave soils exposed for long periods) and the removal of vegetation must be kept to the minimum.

Once the existing vegetation has been cleared the 200 mm topsoil over the construction zones must be stripped and stockpiled in the materials holding area.

Spoil material from excavations must be stockpiled separately from the topsoil and river sediments. Impacts associated with compaction by vehicles or poor storage methodology, contamination or careless handling of topsoil must be avoided.

To prevent compaction and the loss of soil structure, the following soil handling techniques will be employed:

- Repeated handling of soil must be avoided
- Soil must not be handled during windy conditions (or else it should be dampened to reduce dust production)
- All stripped soil will be stockpiled for use in rehabilitation
- If possible, soil stockpiles must be limited to 2 meters high
- Stockpiles shall be placed in a sheltered site protected from wind erosion, outside the working area, where it will not be compacted by traffic and away from drainage lines so that there is no risk of wash-away
- Alien plants must be removed as they germinate to control the risk of colonization of stockpiles by invasive plants

4.1.3 Commencement of construction

Following an inspection by the Landscape Architect, construction may commence. The Contractor shall make every effort to preserve the natural assets to minimize environmental disturbance and to inform his employees on the site as to the ecological sensitive areas.

The Contractor shall be responsible for any avoidable damages to the environment resulting from the actions of any of his employees. No movement outside of the demarcated works zone will be allowed. During construction the Contractor shall protect all areas susceptible to erosion by installing all necessary temporary and permanent drainage works and by taking such other measures as may be necessary to prevent the concentration of surface water and the scouring of slopes, banks and other areas.

All erosion, such as runnels, channels or sheet erosion that develops during the Construction Period, Establishment Period or Maintenance Period shall be backfilled and consolidated and the areas restored to their proper condition at the Contractor's expense. The Contractor shall not allow erosion to develop on a large scale before effecting repairs and all erosion damage shall be repaired as soon as possible.

4.1.4 Reshaping and earthworks

Once the construction of the new parking area is nearing completion the Contractor shall allow for the construction of a series of bioswales and ponds.
All slopes shall be worked off to the same gradient as the surrounding slopes but limited to a maximum of 1:4 unless indicated otherwise. The top and bottom intersection of the diagonal slope line and stream bed level shall be worked off concave and convex respectively to ensure that contour lines knit and create even slopes.

4.1.5 Erosion protection

All erosion protection will be done according to the Engineer's specifications. It is proposed that a combination of bio jute, reinforced eco-logs and riprap be used in the project. Bio-jute will be used to induce a microclimate for vegetation establishment across all areas to be rehabilitated, riprap will be used as an energy dissipater at outlets (minimum 1 meter wide 100-200 mm diam. approved rock) . Bio-retention ponds and associated outlet structures will be constructed in accordance with the engineer's specification. All retention ponds will be landscaped and rehabilitated to form a bioretention facility. All slopes around these retention ponds shall be limited to a maximum of 1:3 unless indicated otherwise.

Bolder groins will be installed perpendicular to the flow direction in the locations as pointed out by the Landscape Architect. These will consist of selected spherical boulders with a diameter of 250-400mm placed at a rate if 1 cubic meter per square meter. The bolder trench will be excavated 1m deep and 1 meter wide with the trench extending minimum 2 meters beyond the top of the bank. Excavated material will be placed along the trench. Selected riprap will be placed/ packed in layers and the voids filled with excavated material. Such material shall be compacted in layers not exceeding 150mm. This process is to be continued until such time as the bolder groin is max 300mm above the pre-existing final level.

4.1.6 Re-vegetation

All re-vegetation work must be undertaken by a reputable horticultural contractor and be in accordance with the Working for Wetlands Program: Best Management Practice Manual (See Russel et al. 2009: 291-303). Vegetation to be used in this project include the following species:

a) Retention ponds
The veldgrass mix for this this zone may include the following species:

Andropogon eucomus
Eragrostis capensis
Eragrostis gummiflua
Leersia hexandra
Setaria sphacelata
Sporobolus africanus

b) Wet Embankment

The veldgrass mix for this this zone should include the following species:

Andropogon appendiculatus
Andropogon eucomus
Eragrostis capensis
Eragrostis gummiflua
Leersia hexandra
Setaria sphacelata
Sporobolus africanus

c) Active stream (Rehabilitated existing channel)

The veldgrass mix for this this zone should include the following species:

Andropogon appendiculatus
Andropogon eucomus
Eragrostis capensis
Eragrostis gummiflua
Leersia hexandra
Setaria sphacelata
Sporobolus africanus

d) Riparian Rehabilitation Mix

The veldgrass mix for this this zone should include the following species:

Aristida congesta
Brachiaria serrata
Digitaria monodactyla
Eragrostis chloromelas
Eragrostis curvula
Heteropogon contortus
Panicum natalense
Themeda triandra

e) Plug planting

Species list for bio swales and wetland retention ponds and in-stream planting include the following:

Cyperus obtusiflorus
Imperata cylindrica
Juncus krausii.
Cyperus spp.

f) Proposed trees:

Celtis Africana (White stink wood)
Combretum erythrophyllum (River Bushwillow)
Ziziphus mucronata (Buffalo Thorn)

g) Existing wetland

Where alien invasives have been removed from the existing wetland, the disturbed areas must be handseeded with a selection of grasses from the Active Stream Mix (c).

Site clearance

The Contractor shall allow for the removal of unwanted material (litter, building rubble, gravel), on all the proposed seeding and planting areas indicated on the Contract Drawings and identified by the Landscape Architect at the scheduled Site Meeting. The Contractor shall allow for the localized treatment and spraying of invader grasses such as *Pennesetum clandestinum* and any other invasive plants .

Clearance of alien and invasive plants

All identified alien and invasive plant shall be cleared in accordance with the Conservation of Agricultural Resources Act (Act No. 43 of 1983) guidelines prior to the commencement of construction.

Soil preparation

All proposed seeding and planting areas shall be ripped by machine or manually to a depth of 300 mm. The ripped surface shall be lightly and evenly firmed and reduced to a fine tilth.

The Contractor shall, at all times, ensure that the general shape, profile and levels of all proposed planting and seeding areas are not materially altered during the soil preparation.

All slopes (cut and fill areas) shall be worked off to a gradient not exceeding 1:3 unless indicated otherwise. The top and bottom intersection of the diagonal slope line and natural ground level shall respectively be worked off concave and convex, so as to ensure that contour lines knit and create even slopes.

The various areas to be seeded shall be prepared as follows:

(a) Where the area to be grassed consists of suitable growth medium it shall be scarified to a minimum depth of 75 mm with furrows spaced at 250-300 mm centres. Scarifying along slopes shall run parallel to the contours, forming horizontal terraces. All loose stones and other excess material shall be removed.

(b) Where areas to be grassed consist of unsuitable material which, in the opinion of the Landscape Architect, cannot be improved sufficiently to support good plant growth by the addition of soil amendments, topsoil shall be placed. Only approved topsoil shall be used.

Where topsoil is required the surface shall be left slightly rough during trimming to ensure a proper bond between the topsoil and the subsoil. Topsoil shall be placed on the prepared surfaces and trimmed to the uniform thickness required. A layer of topsoil (layer thickness as specified) shall be placed. The topsoil shall be scarified as described in (a). The soil shall be moist to a depth of at least 300 mm while being worked, prior to seeding.

Topsoil *(only if necessary)*

A 150 mm layer of topsoil shall be evenly spread across the surface areas as indicated on site. Topsoil shall be the uppermost layer of soil and shall consist of fertile loamy soil with a minimum of 2% organic

material, selected from areas showing a good coverage of natural vegetation, preferably grasses. It shall be free from deleterious matter such as large roots, stones, refuse, heavy clays, noxious weeds, etc. which would adversely affect its suitability for planting vegetation

Imported topsoil will only be approved of once a soil analysis has been done by an approved institution and a certificate as proof hereof has been handed to the Landscape Architect. The Contractor must allow for this in the Schedule of Quantities.

Fertilizing

The Contractor shall have the top 150 mm of the prepared surfaces tested for growth suitability and the results submitted to the Landscape Architect to determine the amount and type of fertilizer required for establishing proper growth conditions for grass. The choice of the type of fertilizer to be used and the application thereof shall be the responsibility of the Contractor but shall be approved by the Landscape Architect before application. The fertilizer should be applied with the hydroseeding.

Planting of manicured species in parking area

The contractor shall allow for the planting of plugs at a rate of 25 per square meter, 2 kg at 12 per square meter and 4 kg plants at 5 per square meter. Plants and trees will be planted on the same level as the parking surface to assist with stormwater management.

Planting of wetland species

The contractor shall allow for the planting of plugs at a rate of 25 per square meter, 2 kg at 12 per square meter and 4 kg plants at 5 per square meter in the bioswales and retention ponds.

- *Cyperus obtusiflorus*
- *Imperata cylindrica*
- *Juncus krausii.*

All plant material must be inspected and approved by the Landscape Architect prior to the commencement of planting. Due to the nature and complexity of the planting it is suggested that all plant material be brought to site and packed out in position to confirm the spacing and location of plug planting.

The Contractor shall have completed all soil preparation (and installation and testing of the irrigation system if it is decided to be implemented) prior to the commencement of any planting.

All plants shall be well- bushed with a high leaf density, with a well-developed, fibrous root system.

A pit shall be excavated to adequate size to easily accommodate the root ball of the plant. During planting out, the root system shall be disturbed as little as possible and the time between removal from the container, backfilling in the pit and watering shall be kept to a minimum.

Hydroseeding

The time between the completion of the site clearance, soil preparation and the hydroseeding of the grass seed shall be kept to a minimum.

The specified seed mix and necessary fertilizer shall be added to the required amount of water and applied using an approved hydroseeding machine. Unless otherwise specified the rate of application of slurry shall not be less than 30 cubic metres per hectare and shall be applied in such a manner as to have even distribution of seed and fertilizer. Additional components may be added and included in the slurry. These additional components may be mulch (suitable for use in the hydroseeder), cellulose pulp, organic fibre, chemical binder or any other material required to assist in the application of the slurry or to enhance the germination and growth of the seeds. Additional water may be needed to make the slurry workable but the required mass of seed and the necessary fertilizer and other components per hectare shall nevertheless be applied.

As a minimum, cellulose pulp shall be added to the hydroseeding mix at a rate of 20 kg of pulp per kilolitre of water used.

Hydroseeding shall be carried out by an approved Contractor at a rate of application of 40 kg Seed Mixture per hectare. It is proposed to apply the following wetland mix:

- *Eragrostis teff*
- *Andropogon appendiculatus*
- *Andropogon eucomus*
- *Eragrostis capensis*
- *Eragrostis gummiflua*
- *Leersia hexandra*
- *Setaria sphacelate*
- *Sporobolus africanus*

An anti-erosion compound such as Verdyol shall be mixed with the hydroseeding mixture before application on cut and fill slopes with a gradient of 1:4 and steeper. The amount of cellulose pulp shall be decreased by one-third to a half, depending on the amount of compound added.

Hand seeding

Where applicable and agreed with the Landscape Architect, areas may be hand seeded. The area to be seeded shall be wet to a depth of at least 300 mm before any seeding takes place. The seed mixture and fertilizer, if any, shall be mixed, halved and applied evenly in two successive applications, the second application following immediately after the first. Immediately thereafter the seeded area shall be rolled, or compacted, by an approved method to the satisfaction of the Landscape Architect. Seeds shall not be covered by more than two millimetres of soil. The seeded area should be well watered until suitable coverage has been achieved.

4.1.7 Maintenance and Establishment Period

All rehabilitated areas shall be maintained during the Establishment Period by adequate watering at frequent and regular intervals in order to ensure proper germination of seeds and growth of grass

until an acceptable grass cover has been established and thereafter until the end of the Period of Maintaining of the grassed areas. The amount and frequency of watering shall be at the discretion of the Contractor but shall at least be a minimum weekly rate of 20 mm which shall be in applications of 8-12 mm/h. Where hydroseeding is carried out, the commencement of watering may be postponed until a favourable time of the year. Watering shall, however, commence and continue as soon as the seeds have germinated, and growth begins.

Weeds shall be controlled by means of extraction, cutting or other approved means.

Any bare patches where the grass has not taken or where it has been damaged or dried out, shall be re-cultivated, planted, hydroseeded or hand seeded at the Contractor's own expense. All grassed areas shall have an acceptable cover at the end of both the Establishment Period and the Maintenance Period.

It is proposed that a **3-month maintenance** period (Growing-in Phase) be included in the contract of the rehabilitation contractor.

5 Project implementation, monitoring, maintenance and management

Monitoring, Maintenance and Management are key components to a successful rehabilitation project. Each of these components has to be included in the planning, design, construction, maintenance and operational phase of the project. During the implementation phase this rehabilitation plan must form the basis for the preparation of the final rehabilitation details, specifications and contract documentation by the Landscape Architect to procure the services of a suitable implementation agent and that will form the basis of the monitoring and maintenance phase of the project.

Further to this the following needs to be highlighted:

Monitoring: The importance of monitoring progress, successes and failures during the rehabilitation phase of the project cannot be over emphasized. Monitoring allows for the early recognition of trends that can save considerable time and money.

Maintenance: Regular maintenance is especially important in the establishment phase of re-vegetation projects. Maintenance will have to include some remedial work and it is best practice to have one agent responsible for the implementation/construction phase of the project as well as the initial establishment phase. Long term maintenance of the river environment will have to be ecologically orientated and include the re-establishment of natural fire regimes.

Management: The key to the success of this project will hinge on the area being managed as a single unit. It is proposed that an inclusive management committee be established that will include representatives from key municipal functions as well as the adjacent landowners. Such management committee must meet on a regular basis and oversee all actions within the river corridor.

6 Conclusion

Stream corridor restoration is a very complex process and requires a multidisciplinary approach to limit the risk of failure. Internationally and locally there is an extensive body of literature and case studies on the art and science of stream corridor restoration. In many respects it is not an exact science as we are working with a constantly changing and dynamic stream environment.

The study area can be effectively rehabilitated if this plan is implemented in combination with a rigorous design, management and monitoring process. From a wetland and hydrological perspective, the proposed project will result in improved PES with increased wetland seepage, species diversity and improved runoff quality and quantity.

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