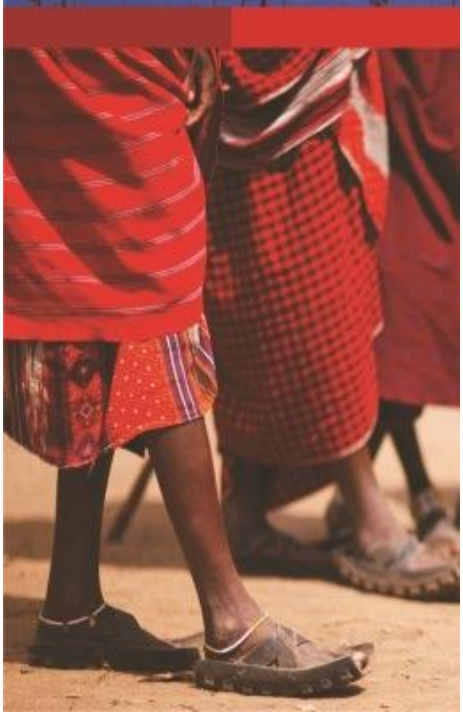

DIGBY WELLS
ENVIRONMENTAL

Basic Assessment Process for rehabilitation Activities at the Eskom Kilbarchan Colliery, Newcastle, KwaZulu-Natal

Rehabilitation Action Plan

Project Number:

ESK3520

Prepared for:

Eskom Holdings SOC Limited (Eskom)

June 2016

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Project Name:	**Basic Assessment Process for rehabilitation Activities at the Eskom Kilbarchan Colliery, Newcastle, KwaZulu-Natal**
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I, Kathryn Roy as duly authorised representative of Digby Wells and Associates (South Africa) (Pty) Ltd., hereby confirm my independence (as well as that of Digby Wells and Associates (South Africa) (Pty) Ltd.) and declare that neither I nor Digby Wells and Associates (South Africa) (Pty) Ltd. have any interest, be it business, financial, personal or other, in any proposed activity, application or appeal in respect of Eskom Holdings SOC Limited (Eskom) other than fair remuneration for work performed, specifically in connection with the Basic Assessment process for the Eskom Kilbarchan Colliery.

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Experience (years):	3 years

EXECUTIVE SUMMARY

A Basic Assessment process in accordance with the Environmental Impact Assessment (EIA) Regulations, 2014, of the National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA) has been applied for to ensure that Kilbarchan Colliery is socially and environmentally safely and sustainably closed. Digby Wells Environmental (Digby Wells) was commissioned to complete specialist studies to accompany these processes.

This Rehabilitation Action Plan aims to rehabilitate the Kilbarchan Colliery project area to a sustainable and stable environmental state; with specific focus on the following areas:

- Previously rehabilitated areas, including:
  - Discard Dump; and
  - Open Pit areas 1C and 2;
- Areas still in need of rehabilitation, including:
  - Landfill Sites.
- Areas of Decant under phytoremediation treatment (including Open Pit areas 1A and 1B).

The remnant infrastructure and housing village depicted on the layout plans are no longer the responsibility of Eskom. The property on which the remnant infrastructure and housing village is situated has subsequently been sold to Blaizing Sun Investments 35 (Pty) Ltd. (Blaizing Sun). In the Agreement of Sale, Blaizing Sun records that they are aware of possible environmental risks involved with the property and undertake to indemnify Eskom against any claims should any of the risk events occur.

The Rehabilitation Action Plan required input from various specialists including Soil and Land Capability, Fauna and Flora, Aquatic Ecology, Groundwater, Surface Water and Wetlands (Digby Wells, 2016). A specific concern of most specialists inputs were the erosion of soils and the associated impacts, presence of alien and invasive species and the poor water quality due to the mine affected water.

This Rehabilitation Action Plan provides rehabilitation activities for each of the target areas of the Kilbarchan Colliery as listed above. However, rehabilitation activities themselves will result in some direct impacts to the natural environment such as increased vehicular activity, soil compaction, alteration of wetland under phytoremediation treatment and risk of spread of alien invasive species. Given this, specific mitigation measures are discussed and therefore the overall rehabilitation activity is seen to be positive from the status quo. A maintenance and monitoring plan has also been recommended.

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1 Introduction

Kilbarchan Colliery is located 10 km south of Newcastle, KwaZulu-Natal and within the Newcastle Local Municipality (NLM) and Amajuba District Municipality (ADM). Kilbarchan Colliery was commissioned in 1954 and consisted of two underground mining sections: Roy Point in the north, excluded from this study, and Kilbarchan in the south, as well as open pit areas where the coal seam was less than 20 m below ground level (mbgl). Kilbarchan Colliery supplied coal to the Natal inland market and to the adjacent Eskom Holdings SOC Limited (Eskom) Ingagane Power Station until its decommissioning in 1992. Rehabilitation activities on site were undertaken until 2012, following which Eskom assumed responsibility for the liability of Kilbarchan Colliery.

In terms of section 24 and 24D of the National Environmental Management Act (No 107 of 1998), as read with the Environmental Impact Assessment (EIA) Regulations (2014): Government Notices R982 and R983, a Basic Assessment is required to be undertaken. Eskom has appointed Digby Wells Environmental (Digby Wells) to undertake the various specialist studies and authorisation applications for the Basic Assessment.

1.1 Project Background

Following the decommissioning of Kilbarchan Colliery in 1992, the underground workings, as well as open pit areas, began filling up with water at a rate of approximately 4 000 m^3 per day (Vermeulen and van Zyl, 2011). Decant of mine affected water was first recorded in April 2004 and is predominantly taking place to the south, southeast and east of the Discard Dump, underground workings and open pit sections (Proxa, 2014). The mine affected water is characterised as having high sodium and sulfate levels resulting in high electrical conductivity (EC) and total dissolved solids (TDS). In addition, there are also elevated levels of chloride, iron and manganese (Proxa, 2014). The mine affected water has a negative impact on the surrounding water courses it comes into contact with as it does not meet the Interim Water Quality Objectives (IWQO) of the Ngagane Catchment.

The description of the historic mining activities at Kilbarchan Colliery was predominantly sourced from Hodgson (2006). The historical Mines Works Programme was not available to feed into the Project background.

Underground mining commenced at the Kilbarchan Colliery in 1954 and utilised the bord and pillar mining method with an average coal seam height of 3.5 m. Early reports indicated that the extraction rate for the Colliery was 73% to 76%, but more recent reports suggested that the extraction rate was 50%; no detailed plans of the underground workings are available. The lower and more probable extraction rate of 50% is possibly due to the considerably greater depths of mining in the western extent of the Colliery, due to the increase in topography in this area, as well as the angle of the coal seam.

In addition to the predominant bord and pillar method utilised at Kilbarchan Colliery, stooping had been undertaken in selected areas, with the largest of the stooped areas being

25 000 m^2 in size. To extend the life of the mine, open pit mining was implemented where the coal seam was less than 20 mbgl. Five (5) open pit areas were mined as part of the Colliery (Open Pit 1, 2, 3, 4 and Slangdraai), with Open Pit 1A and 1B connecting to the underground workings. The areas of each of the above mining methods are summarised in Table 1-1.

Table 1-1: Mining Method Areas

Description	Area (m^2)
Underground workings	12 619 145
Stooped areas	1 183 775
Area connecting the open pit with the underground workings	213 055
Ash-filled areas	1 010 659

The Kilbarchan Colliery mining area is approximately 3 322 ha and its surface consists of a discard dump and an adjacent Pollution Control Dam (PCD) and electrical substation to its north. Remnant infrastructure and derelict buildings, that were once part of the Kilbarchan Colliery, are located west of the PCD and substation. The property on which the remnant infrastructure is situated has subsequently been sold to Blaizing Sun Investments 35 (Pty) Ltd. (Blaizing Sun) and is no longer the liability of Eskom. In the Agreement of Sale, Blaizing Sun records that they are aware of possible environmental risks involved with the property and undertake to indemnify Eskom against any claims should any of the risk events occur. Additional housing is located further west of the remnant infrastructure and is currently occupied. This village is also located on the property sold to Blaizing Sun.

The Kilbarchan Country Club golf course and associated residential area, which does not form part of the mine, is located to the north east of the Discard Dump. The N11 national road transects the mining area and is situated to the east of the Discard Dump, with the Ingagane River flowing northwards alongside the N11.

An aggregate quarry, owned and operated by Afrisam (Pty) Ltd, transects the most-southern extent of the mining area's northern boundary and does not form part of this study. The decommissioned Ingagane Power Station is located outside of the mining area and to the east of the Ingagane River, with the Ingagane community located further east.

The mining area fluctuates in elevation with the highest point being located in proximity to the south-western extent at approximately 1 470 m above mean sea level (mamsl), before the elevation reduces towards the N11 national road in the northeast and east (1 220 mamsl). The Ingagane Power Station is approximately 1 200 mamsl. The lowest point in the Project site is the Ingagane River at approximately 1 180 mamsl.

1.2 Terms of Reference

Digby Wells Environmental (Digby Wells) has been appointed by Eskom Holdings SOC Limited (Eskom) as the independent Environmental Assessment Practitioner (EAP) to complete the Rehabilitation Action Plan for the Kilbarchan Colliery; this includes the following:

- An in-field assessment of previously rehabilitated areas as well as areas still in need of rehabilitation attention, including the mine affected water areas and the review of all specialist studies undertaken within the project area to understand the current condition of the natural environment; including the following:
  - Aquatic Ecology;
  - Fauna and Flora;
  - Groundwater;
  - Surface Water;
  - Soils and Land Capability; and
  - Wetland Ecology;
- The development of an updated rehabilitation plan for the site to inform the long-term closure strategy; including:
  - Areas previously rehabilitated that require additional attention;
  - Areas still in need of rehabilitation action; and
  - A review of the Proposed Phytoremediation Project (Digby Wells, 2016) as part of the rehabilitation objectives to remediate and manage impacts of the decanting mine affected water;
- An updated Monitoring and Maintenance Plan to ensure the successful implementation of the long-term mine closure strategy.

The key legislation governing the requirements for legislation for rehabilitation is contained in the following acts:

- The Constitution of the Republic of South Africa. 1996 (Act No. 108 of 1996) (“The Constitution”);
- The National Environmental Management Act, 1998 (Act No. 107 of 1998), (NEMA);
- The National Water Act, 1998 (Act No. of 1998, NWA).

Other legislation that is applicable to rehabilitation includes:

- The Environment Conservation Act , 189 (Act No. 73 of 1989, ECA);
- The National Environmental Management: Biodiversity Act, 2004 (Act No. 10 of 2004, NEMBA);

- Conservation of Agricultural Resources Act, 1983 (Act No. 43 of 1983, CARA);
- National Forests Act, 1998 (Act No. 84 of 1998, NFA);
- National Heritage Resources Act, 1999 (Act No. 25 of 1999);
- Occupational Health and Safety Act of 1994;
- Atmospheric Pollution Prevention Act, 1965 (Act No. 45 of 1965);
- Hazardous Substances Act, 1973 (Act No. 15 of 1973);
- National Environmental Management: Air Quality, 2004 (Act No. 39 of 2004, NEM:AQA);
- National Environmental Management: Waste Management, 2008 (Act No. 50 of 2008);
- National Veld and Forest Fire Act, 1998 (Act No. 101 of 1998);
- Promotion of Access to Information Act, 2000 (Act No. 2 of 2000); and
- The Promotion of Administrative Justice Act, 2000 (Act 3 No. of 2000).

There are several guideline documents which provide recommendations on how rehabilitation should be undertaken. For the purpose of the plan, the following guideline documents were considered:

- Guidelines for the Rehabilitation of Mined Land. Chamber of Mine of South Africa/ Coaltech. November 2007;
- Surface Strip Coal Mining Handbook. South African Colliery Managers Association, Project SACMA 01/03. Compiled by R J Thompson, 2005; and
- Best Practice Guidelines (BPGs) series developed by the Department of Water Affairs (DWA).

2 Details of the Specialist

The following is a list of the Digby Wells' staff that were involved in the rehabilitation assessment study and compilation of the action plan:

- **Kathryn Roy:** Rehabilitation Specialist; received a Bachelor of Science in Ecology and Environmental Science and an Honours degree in Environmental Management from the University of Cape Town. She also has received her MSc in Restoration Ecology through the University of KwaZulu-Natal. Kathryn's roles and responsibilities include compiling rehabilitation plans and strategies and conducting field work.
- **Caroline Wallington:** Wetland Consultant; received a Bachelor of Science and Honours degree in Botany from the University of Cape Town and is an environmental consultant specialising in wetland assessments and land rehabilitation. Caroline is competent in land rehabilitation assessments, compilation of rehabilitation plans and

has experience in many part of South Africa including the Gauteng, Free State, Limpopo, KwaZulu Natal and Mpumalanga Provinces.

- **Brett Coutts:** Rehabilitation Unit Manager; received a Bachelor of Science and Honours degree in Zoology and Environmental Science from the University of Witwatersrand. Brett assists with the management and co-ordination of all relevant studies related to rehabilitation. This includes the compilation of rehabilitation plans and undertaking of rehabilitation assessments. In addition to this, Brett assists within the Biophysical Department with the management of specialist studies that are undertaken by the department and is also responsible for the compilation of the Geographic Information System (GIS) component of Biodiversity Land Management Plans (BLMP) and undertaking ecological assessments. He previously worked for Hydromulch, a company that specialises in vegetation rehabilitation.

3 Aims and Objectives

The main aim in developing a Rehabilitation Action Plan is to minimise and mitigate the impacts caused by mining and industrial activities and to restore land back to a satisfactory standard. This Rehabilitation Action Plan aims to inform the actions required to rehabilitate the Kilbarchan Colliery project to ensure that the area is socially and environmentally safe and sustainable. The overall rehabilitation objectives for the Project are as follows:

- Maintain and minimise impacts to the ecosystem within the study area;
- Re-establishment of the pre-mining land capability (if possible) to allow for a suitable post-mining land use;
- Maintain and minimise impacts to the functioning waterbodies within the area;
- Implement progressive rehabilitation measures;
- Establishing a sustainable cover to prevent erosion risk and enhance ecological succession;
- Prevent soil, surface water and groundwater contamination through the implementation of the phytoremediation project;
- Comply with the relevant local and national regulatory requirements; and
- Maintain and monitor the rehabilitated areas.

4 Assumptions and Limitations

The main assumptions and limitations of the wetland assessment are:

- The phytoremediation is assessed according to the preliminary proposed plan as of February 2016 (Digby Wells, 2016). If this changes, the contents of this report may need updating.

The main assumptions and limitations of the Fauna and Flora assessment are:

- Due to the timing and the brevity of the site investigation being in early April, the majority of the summer migrant species had already departed southern Africa and this had an impact on the full representative species diversity for the project site;
- Many of the identifying features of plants (such as seeds, flowers and leaves) were not present due to the time of sampling and as a result of this, not all plant species were recorded; and
- Field investigations did not include a night survey, and for this reason, nocturnal species (specifically bat species) were not recorded.

The main assumptions and limitations of the Aquatic assessment are:

- The phytoremediation design for the proposed project has not yet been approved or authorised.

5 Methodology and Approach

Rehabilitation planning encompasses multiple phases and is an iterative and evolutionary activity. Parts of the project area have already undergone rehabilitation and this project aims to assess these areas as well as areas still in need of rehabilitation. There are two main phases of the rehabilitation planning process that were involved in this study, namely the screening phase and the final phase where a Basic Assessment process in accordance with the EIA Regulations, 2014, NEMA has been applied for to ensure that Kilbarchan Colliery is socially and environmentally safe and sustainable. The methodologies employed in each phase are briefly described below.

- Screening Phase - Current State:
  - This phase has been completed and described the current state of the project area with respect to rehabilitation and included an in-field assessment. This phase gave the baseline environment and available information in preparation for the Basic Assessment for detailed planning and consolidation. The soils, vegetation and wetland assessments enabled objectives to be set and align rehabilitation objectives. Refer to this report for the findings (Digby Wells, 2014).
- Basic Assessment Phase – Compilation of Rehabilitation Action Plan:
  - This process included an on-site assessment conducted by the rehabilitation team as well as various specialist investigations of the project area. The assessments and resultant technical reports were used to compile the updated Rehabilitation Action Plan.

6 Rehabilitation Action Plan

The activities involved in the Rehabilitation Action Plan are discussed according to the different needs of the areas and these components are detailed in Figure 6-1 below and

these areas are shown in Figure 6-2. The remnant infrastructure that is no longer the liability of Eskom is also displayed in Figure 6-2.

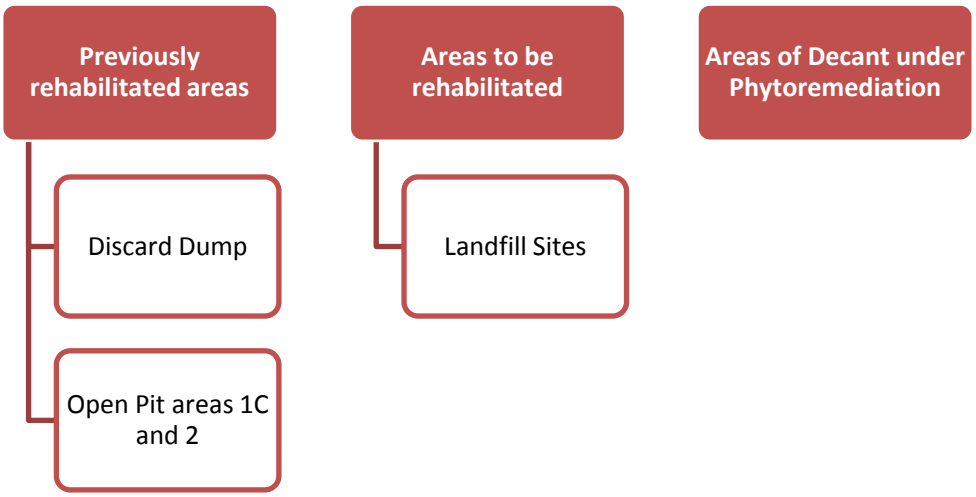

Figure 6-1: Areas of Rehabilitation Action

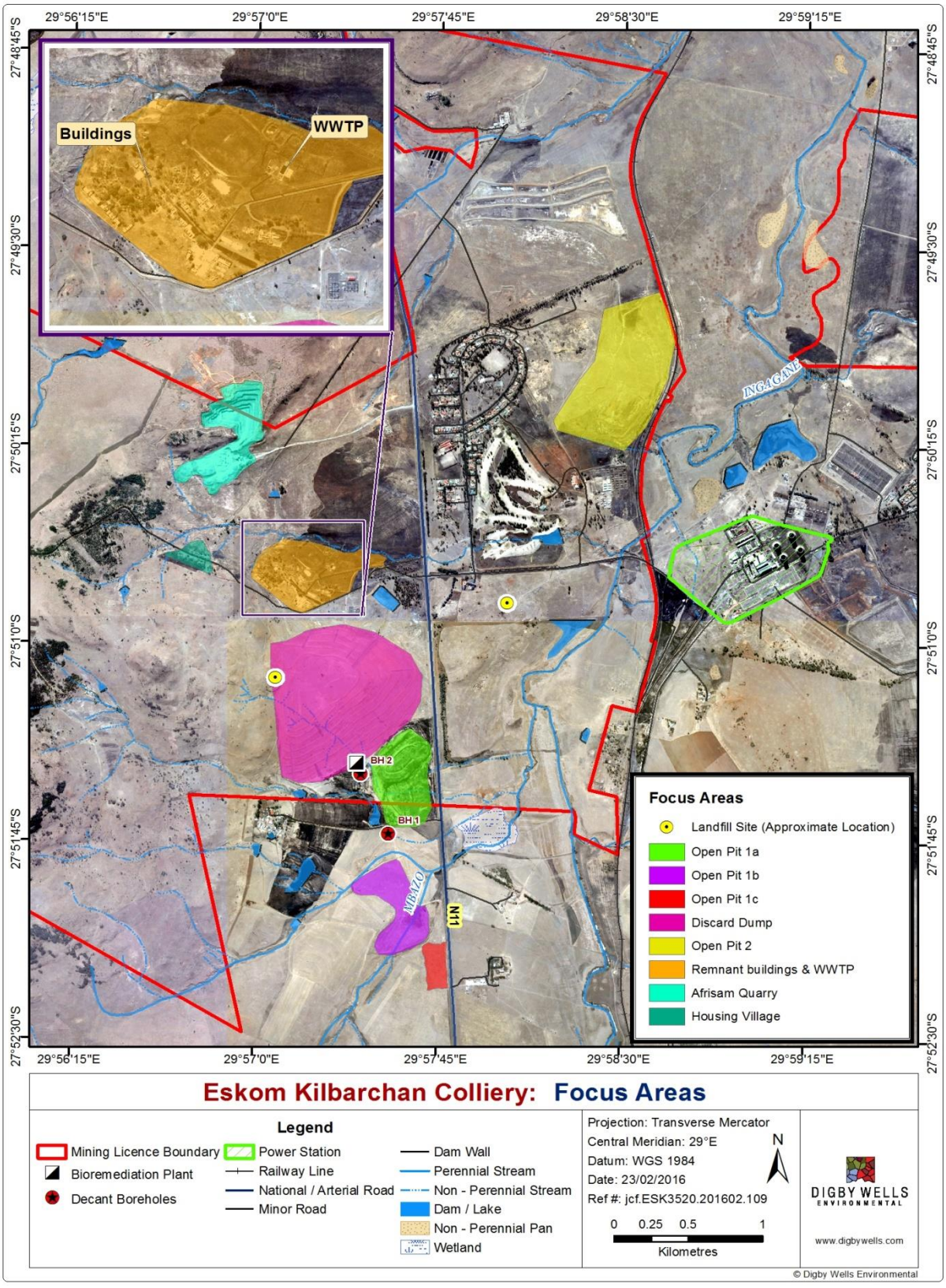

Figure 6-2: Rehabilitation Focus Areas

6.1 Previously Rehabilitated Areas

6.1.1 Discard Dump

The Discard Dump is being rehabilitated again due to erosion issues as well as high compaction and a limited soil layer (less than 150 mm in places). The following actions are therefore suggested:

- Address the causes of the erosion to rectify and prevent further erosion, such as;
  - The down-drains, gabion baskets that have been used in several locations need to be re-assessed and repaired as necessary;
  - The contour drains need to be repaired. Contour drains which should primarily convey water to the down-drains were eroded and hence subject to additional erosion pressure;
  - Repair gulley erosion; and
  - Prevent cattle from grazing.
- There remains considerable scope for the reshaping of discard facilities. The most important aspect is to ensure that they are free draining, erosion risk is minimised and that the sloping matches the surrounding topography. The slopes should not be more that 1:5 or 1:7. The length can be variable, however longer slopes may pose a greater risk of erosion. When assessments are done on the Discard Dump, the slope length and gradient should be inspected to ensure the risk of erosion is minimised. If erosion is present it may be as a result of the gradient being too steep or bare sections of soil that have been exposed. If erosion is identified, an assessment on the slope length and gradient should be undertaken and adjusted if necessary;
- Re-soil the Discard Dump, particularly the erosion hot-spots. This should be done to at least a 300 mm depth. Topsoil should be bought or acquired legally. If the soil is sourced from a borrow pit, the borrow pit should be rehabilitated, and revegetated to create sustainable cover that prevents erosion and enhances natural succession. This must be included in the monitoring programme. Should Eskom source topsoil from a supplier, the management and liability of that soil borrow pit will be the responsibility of that supplier;
- Compaction should be avoided and reduced (Soils and Land Capability Report (Digby Wells, 2016)) as compaction limits the effectiveness of replaced soils. See section 7.1.2 for more details;
- Ensure pollution is controlled (see Section 7.3);
- Reseed with the grass mix in Table 7-1. Table 7-2 may also be consulted for grass species;

- Remove alien invasive species on an on-going basis for at least 3 years after first rehabilitation planting;
- These rehabilitated areas are to remain as “No Go” areas and all livestock animals must be kept out of rehabilitated areas for at least 5 years. Thereafter grazing will need to be monitored to prevent over utilisation and associated degradation;
- If access roads are not required (such as access roads to the Discard Dump) for access to particular areas or for monitoring requirements then these access roads should be rehabilitated and also be seen as “No Go” areas. Before the access roads to the Discard Dump are rehabilitated and assessment of their future uses should be undertaken;
- Ensure continual monitoring and maintenance (see Section 8). Continuous monitoring and rehabilitation is necessary to avoid potential acid generation and release of heavy metals as well as soil erosion and loss of vegetation. Basal cover should be a minimum of 30%. Assessments should be carried out after each growing season, for 3 years. Bare areas of >4 m^2 need to be reseeded. These assessments should be carried out by a suitably qualified individual, such as a botanist or rehabilitation specialist – if staff have the capability and professional experience, then these assessments could be conducted internally; and
- Grasses on the Discard Dump will need some form of use. If not regularly defoliated they become moribund and die off. Defoliation is normally done by grazing or by mowing. For the initial growing seasons, grazing should be avoided and mowing should be implemented. It is recommended that grass cutting be conducted at the end of the growing season. Some of the grass cuttings should remain on the Discard Dump to allow important nutrients to be reintroduced back into the soil, if removed fertiliser may be required, such as potassium.

6.1.2 Open Pit Area 1C and 2

These areas require additional rehabilitation actions and are not found within the proposed phytoremediation areas. Although most of the areas are stable and showing signs of successful restoration, erosion hotspots are present and need to be addressed. It should be noted, that although these are referred to as open pits, they are no longer open as they have been backfilled. The following actions are therefore suggested:

- Soil must be replaced to a depth of at least 300 mm in erosion hotspots and areas of subsidence. Topsoil should be bought or acquired legally. If the soil is sourced from a borrow pit, the borrow pit from where the topsoil originates should be rehabilitated, and revegetated to create sustainable cover that prevents erosion and enhances natural succession. This must be included in the monitoring programme;
- Topsoil should be fertilised with 2:3:2 (2 parts nitrogen, 3 parts phosphorus and 2 parts potassium) at 350 kg/ha, if necessary, and ripped to 200 mm;

- Reshape the landform where necessary to ensure it remains a stable landform:
  - Shape and profile rehabilitated areas to be free draining and roughly emulate the surrounding surface topography;
  - Encourage a free-draining facility thereby limiting ingress and contributing towards the long-term integrity of local water resources;
  - Ensure that soil handling and the placement of soil is carried out as outlined in this rehabilitation plan;
  - Assessments on the fertility need to be undertaken at an accredited laboratory to determine if nutrient levels are favourable for plant growth. The first sign would be the potential die back of grasses, which could be an indication of fertility issues. Once results are obtained, correct fertility through the introduction of fertilisers should be implemented. Maintaining the fertility within the soil is crucial for vegetation establishment; and
  - If soils have been contaminated they must be cleaned up and disposed of appropriately or the rehabilitation of soils in situ.
- Ensure pollution is controlled (see Section 7.3);
- Reseed with grass mix in Table 7-1. Table 7-2 may also be consulted for grass species;
- Remove alien invasive species (see Section 7.5) on an ongoing basis for at least 3 years after activities have ceased;
- Controlled grazing will be permitted after 5 years, once the areas are stable and established; and
- Ensure continual monitoring and maintenance (see Section 8). Basal cover should be 30%. Assessments should be carried out after each growing season, for 3 years. Bare areas of >4 m^2 need to be reseeded.

6.2 Areas Still in Need of Rehabilitation

6.2.1 Landfill Sites

Two landfill sites are located within the Project area. Exposed waste materials were discovered on the east side of the natural ridge line and this constitutes a possible landfill site. An additional landfill site is located to the east of this site, across the N11. Depending on the contents of the possible landfills, different rehabilitation measures will be required. The following rehabilitation actions are recommended:

- Post-investigation of contents: if found to be non-hazardous through a groundwater monitoring programme:
  - Investigate causes of erosion and undertake appropriate measures to correct;

- Place soil on erosion hotspots to a depth of 300 mm;
- Revegetate with indigenous grasses (Table 7-1). Rocky outcrops may need to be planted with different grass species than the lower lying areas; and
- Ensure continual monitoring and maintenance (see Section 8). Basal cover should be 30%. Assessments should be carried out after each growing season, for 3 years. Bare areas of >4 m^2 need to be reseeded.

- Post-investigation of contents: if found to be hazardous through a groundwater monitoring programme:
  - Remove all contents of landfill. This must be done in a safe manner. Hazardous material locations and deposits require specialised assessment and analysis to determine how these materials should be decontaminated and to ensure that all residual hazardous materials are deposited in officially-sanctioned hazardous waste deposit sites.
  - Evaluate the condition of underlying material;
  - Remediate soil and rocky edges;
  - Reshape and place soil where necessary; and
  - Reseed with indigenous grasses (Table 7-1.). Rocky outcrops may need to be planted with different grass species than the lower lying areas;
- Ensure continual monitoring and maintenance (see Section 8). Basal cover should be 30%. Assessments should be carried out after each growing season, for 3 years. Bare areas of >4 m^2 need to be reseeded; and
- In addition, if the reservoir in close proximity to the western landfill site is going to be removed, the following rehabilitation actions will apply:
  - Infrastructure, including foundations, roads etc., should be removed, unless the liability is taken over by another party. If complete infrastructure removal is chosen, the re-usable items should be removed from the site. and the remaining structures should be demolished to 1m below surface and the demolition rubble removed;
  - Once the site has been cleared of all infrastructure and rubble, the exposed underlying materials should be reshaped to create a gently sloping, free-draining topography;
  - Appropriate topsoil should be replaced to a minimum of 300 mm thick in all rehabilitated areas. Topsoil should be bought or acquired legally. If the soil is sourced from a borrow pit, the borrow pit should be rehabilitated, and revegetated to create sustainable cover that prevents erosion and enhances natural succession. This must be included in the monitoring programme. Should Eskom

source topsoil from a supplier, the management and liability of that soil borrow pit will be the responsibility of that supplier;

- Compaction should be reduced (as highlighted in Section 7.1.2 and in the Soil and Land Capability Report (Digby Wells, 2016)) as compaction limits the effectiveness of replaced soils;
- Topsoil should be fertilised with 2:3:2 at 350 kg/ha, if necessary, and ripped to 200 mm;
- Reseed with grass mix in Table 7-1. Table 7-2 may also be consulted for grass species;
- Remove alien invasive species for at least 3 years (see Section 7.5) that will establish on the newly exposed soils, on an ongoing basis;
- Ensure pollution is controlled (see Section 7.3);
- These areas are to remain as "No Go" areas initially to allow recolonization of the vegetation and all livestock animals must be kept out. After 5 years, once the areas are stable and established, controlled grazing will be permitted. However, this must be monitored to prevent over-utilisation and the associated degradation; and
- Ensure continual monitoring and maintenance (see Section 8). Basal cover should be 30%. Assessments should be carried out after each growing season, for 3 years. Bare areas of >4 m^2 need to be reseeded.

6.3 Decant of Mine Affected Water

6.3.1 Phytoremediation Plan

Phytoremediation is being proposed to manage the impact of decanting mine affected water on the soil and surface water resources, as well as to lower the volume of water required for active treatment. This is fully detailed in a separate report titled "Proposed Phytoremediation of Areas affected by Mine Affected Water at the Eskom Kilbarchan Colliery, Newcastle, KwaZulu-Natal – Draft Report" (Digby Wells, 2016). Please refer to this report for full details; however a summary of the proposed planting scheme is below, which is shown in Figure 6-3:

- *Eucalyptus* and *Combretum* will be planted at the source point due to their deep penetrating roots so as to intercept mine affected water at the underground level. The aerial extent of the *Eucalyptus* and *Combretum* potential plantation is approximately 42 ha. In addition, *Combretum* and Vetiver grass is recommended for a further 11 ha;
- *Tamarix* is planted as intermediate plant that will address both surface flowing and groundwater and also hyperaccumulate the salt. The area identified for the potential *Tamarix* plantation is 66 ha; and

- *Sporobolus* and Vetiver Grass will be planted to deal with surface flowing mine affected water and also act as a water diffuse barrier before water enters nearby water resources. This accounts for approximately 56 ha.

The potential impact of using the larger (high transpiration rates) trees alone is that they may substantially reduce streamflow, reducing the volume of water available which would increase the concentration of salts in the water. An elevated salt concentration in the mine affected water may lead to higher salt levels flowing into nearby water resources. The salt load however is reduced. Existing wetlands can be enhanced by adding any carbon source (e.g. hay, wood) for sulphate reduction. This will reduce salinity and acidity.

The purpose of phytoremediation is to offer a long term - permanent solution to an environmental impact. The management of the phytoremediation is necessary to ensure the relevance and effectiveness to the impact. The seepage of mine affected water is not expected to cease in the foreseeable future and cannot be stopped; therefore it is recommended that the phytoremediation be implemented as a permanent feature.

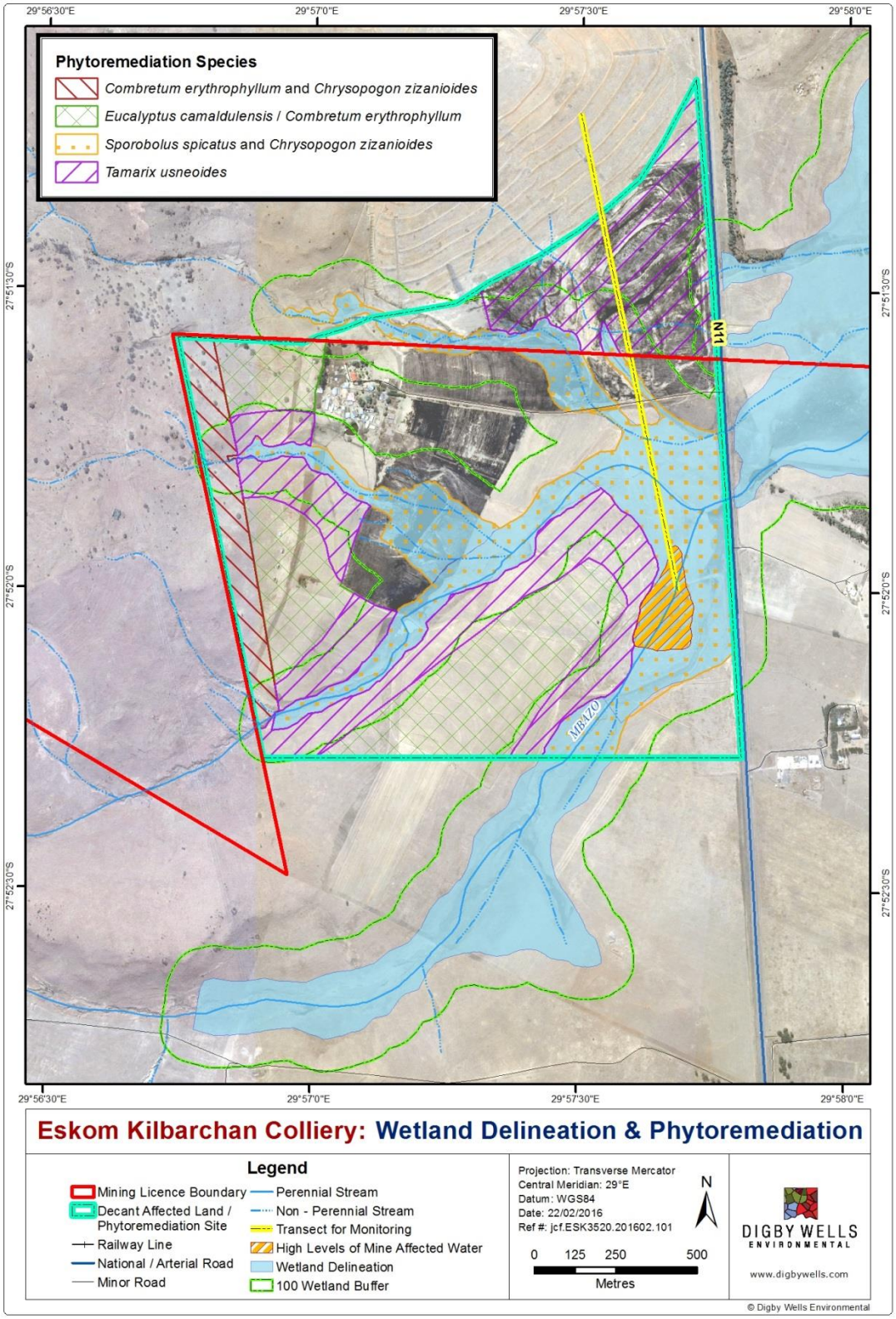

Figure 6-3: Wetland Delineation and Phytoremediation

6.4 Summary of Rehabilitation Actions

The below table is a summary of the details described above.

Table 6-1: Summary of Rehabilitation Actions per Area

Zone	Target Area	Summary of Current State	Main Action
Previously Rehabilitated Areas	Discard Dump	The Discard Dump needs to be rehabilitated again due to erosion issues as well as high compaction and a limited soil layer (less than 150 mm in places).	Replace topsoil on area to achieve a minimum of 300 mm depth; thereafter establish successful vegetation cover.
	Open Pit area 1C and 2	These areas require additional rehabilitation actions and are not found within the proposed phytoremediation areas. Although most of the areas are stable and showing signs of successful restoration, erosion hotspots are present and need to be addressed.	Erosion hotspots are to be levelled with additional topsoil and vegetation cover needs to be re-established.
	Open Pit area 1A and 1B		Area is under phytoremediation action. Implement and maintain phytoremediation plan.
Areas still to be rehabilitated	Landfill sites	Exposed waste materials were discovered on the east side of the natural ridge line and this constitutes a possible landfill site. An additional landfill is located to the east of this, on the opposite side of the N11. Depending on the contents of the possible landfills, different rehabilitation measures will be required.	If waste is found to be non-hazardous, re-soiling and revegetation should take place. If the waste is found to be hazardous, all waste will need to be removed and the underlying material evaluated. Soil remediation may need to take place, followed by re-soiling and revegetation.

Zone	Target Area	Summary of Current State	Main Action
Areas affected by mine affected water	Preliminary areas set for phytoremediation project	Decant is predominantly taking place to the east, south and southeast of the Discard Dump. The mine affected water is negatively impacting on the receiving catchment area.	Planting of specific species to passively address the decanting mine affected water through high evapotranspiration rates and high salt accumulation abilities.

7 General Rehabilitation Principles

The implementation of the above described actions has some commonalities in the manner in which they will be carried out. This section aims to describe general actions and principles that must be followed for the implementation of rehabilitation tasks.

7.1 Soils

Care must be taken when rehabilitation activities are undertaken to ensure that soil resources are protected and not lost through erosion, compaction or contamination. This is described below.

7.1.1 Erosion Prevention and Correction

Soil erosion might pose a problem once vegetation cover is removed. This was identified as a problem in the Kilbarchan project areas during the site assessment in January 2014. The impacts of erosion on Hutton and Clovelly soil forms are high due to the widespread occurrence and sandy nature of these soils in the area. Even after remedial action has been implemented the risk of erosion still needs to be managed and documented. This is a crucial aspect to ensure successful rehabilitation of areas associated with Kilbarchan.

The following management actions should be followed to prevent/reduce soil erosion:

- Ensure proper storm water management designs are in place;
- If erosion occurs, corrective actions (erosion berms) must be implemented to minimise any further erosion from taking place;
- Use stoloniferous grasses such as *Cynodon dactylon*;
- If erosion has occurred, usable soil should be sourced and replaced and shaped to reduce the recurrence of erosion; and
- Keep grazers out of the rehabilitation areas; however it is recommended that grass cutting be undertaken at the end of each growing season to prevent vegetation from becoming moribund.

7.1.2 Soil Compaction Prevention

Compaction should be limited (as highlighted in the Soils and Land Capability Report (Digby Wells, 2015)) as it reduces the effectiveness of replaced soils by restricting the rooting depth of vegetation. This should be completed through the following guidelines:

- Heavy machinery should not be used to spread and level soils during replacement. Instead, the truck and shovel method should be used (since it causes less compaction than, for example, a bowl scraper);
- When using trucks to deposit soils, the full thickness of the soil required can be placed in one lift. This does, however, require careful management to ensure that the correct

volumes of soil are replaced. Alternatively, end-tipping could be instituted so the trucks depositing the soil do not drive over tipped soils thereby increasing compaction;

- The soil piles deposited by the trucks will have to be smoothed before revegetating the area;
- Only the designated access routes are to be used to reduce any unnecessary compaction;
- The best time for replacement of soils is when soil moisture content is lowest ,which will be during the dry season, as this reduces the chance of compaction;
- Compacted areas are to be ripped (200 mm) to loosen the soil structure and vegetation cover re-instated; and
- Usable soil is to be moved when the soil is dry, as to reduce compaction.

7.2 Re-Vegetation Practices

The overall objectives for the re-vegetation of reshaped and top-soiled land are to:

- Prevent erosion;
- Avoid soil loss;
- Restore the land to the agreed land capability;
- Reduce sedimentation into aquatic ecosystems such as rivers and wetlands;
- Re-establish eco-system processes (succession) to ensure that a sustainable land use can be established without requiring fertilizer additions; and
- Restore the biodiversity of the area as far as possible.

Hydroseeding is an option for seeding at Kilbarchan. Planting is generally most successful when done at or immediately after the first rains and into freshly-prepared fine-tilled seedbeds. To stimulate germination, water retention in the seed zone is essential and can be aided by the use of light vegetation mulches. The rehabilitation seed mixes generally consist of grasses as they rapidly establish and provide excellent protection against surface erosion (Tanner *et al.*, 2007).

Table 7-1 is the grass seed mix advised for the rehabilitation areas of the Kilbarchan Colliery, highlighting the original seed mix (Digby Wells, 2014) as new species are now suggested for the site. Table 7-2 may also be consulted for grass species. The end land use is expected to be grazing therefore grasses suitable for grazing were included in the seed mix.

Woody species that are advised to be planted after the grasses are *Chrysanthemoides monilifera* (Tick Berry), *Cussonia paniculata* (Mountain Cabbage Tree), *Diospyros lycoides* (Blue Bush) and *Searsia rehmanniana* (Blunt-leaved Current) and *Euphorbia clavarioides* (Lion's Spore). These will help stabilise the surface and provide habitat for various

invertebrates, such as the Funnel Spider. A nursery is recommended to propagate these plants.

Table 7-1: Grasses for Rehabilitation

Species name	Common name	Properties	Grazing potential	Grazing status	Sowing rate (kg/ha)	% mix
Original species mixture						
Chloris gayana	Rhodes Grass	Short-lived perennial, stabiliser	High grazing value	Decreaser	4	14%
Digitaria eriantha	Fingergrass	Perennial	High grazing value	Decreaser	8	29%
Cynodon dactylon	Couch Grass	Mat-forming, stabiliser	High grazing values	Increaser 2	5	18%
Eragrostis tef	Teff	Annual, pioneer	High grazing value		2	7%
Additional Species						
Aristida congesta subsp. *congesta*	Tassel Three-awn	Short-lived perennial, stabiliser, pioneer	Low grazing value	Increaser 2	2	7%
Hyparrhenia hirta	Common Thatching Grass	Perennial	Average grazing value	Increaser 1	2	7%
Cenchrus ciliaris	Blue Buffalo Grass	Perennial	High grazing value	Decreaser	5	18%
Total					**28**	**100%**

Table 7-2: Naturally Occurring Grasses in the Local Vegetation Types

Northern KwaZulu-Natal Moist Grassland	*Alloteropsis semialata subsp. eckloniana, Aristida congesta, Cynodon dactylon, Digitaria tricholaenoides, Elionurus muticus, Eragrostis patentissima, E. racemosa, Harpochloa falx, Hyparrhenia hirta, Themeda triandra, Tristachya leucothrix, Abilgaardia ovata, Andropogon schirensis, A. appendiculatus, A. eucomus, Aristida junciformis subsp. galpinii, Brachiaria serrata, Cymbopogon caesius, C. popschilii, Cynodon incompletus, Digitaria monodactyla, D. sanguinalis, Diherteropoon amplectens, D. filifolius, Eragrostis chloromelas, E. plana, E. planiculmis, E. sclerantha, Festuca scabra, Heteropogon contortus, Hyparrhenia dregeana, Melinis nerviglumis, Michrochloa caffra, Panicum natalense, Paspalum scrobiculatum, Setaria nigrirostris* and *Sporobolus africanus.*

KwaZulu-Natal Thornveld	*Abiljaardia ovata, Andropogon eucomus, Aristida bipartita, A. congesta, Chloris virgata, Cynodon dactylon, Elionurus muticus, Eragrostis capensis, E, chloromelas, E. plana, E. racemosa, E. superba, Heteropogon contorus, Hyparrhenia hirta, Setaria sphacelata, Themeda triandra, Tristachy leucothrix, Andropogon appendiculatus, Brachiaria serrata, Cymbopogon caesius, C. marginatus, C. popschillii, Cyperus obtusiflorus var. obtusiflorus, Digitaria monodactyla, D. tricholeanoides, Diheteropogon amplectens, Eragrostis curvula, E. gummiflua, E. patentissima, Harpochloa falx, Microchloa caffra, Panicum natalense, Setaria nigrirostris, Sporobolus africanus,* and *S. pyramidalis.*

7.3 Pollution Control

Ensure pollution is controlled through the following guidelines:

- Hydrocarbons and hazardous substances must be stored in bunded areas and refuelling should take place in contained areas, when rehabilitation activities are undertaken;
- Ensure that oil traps are well maintained, if oil traps are utilised;
- Assessment of access roads to the PCDs should be undertaken to determine if they are required for monitoring or maintenance activities, if not they should be rehabilitated;
- Vehicles and heavy machinery used during rehabilitation should be serviced and checked on a regular basis to prevent leakages and spills;
- Implementation of storm water management system around hazardous materials or waste storage facilities in order to contain spills; and
- All hazardous waste should be removed by a suitably qualified service provider and disposed of to an approved permitted landfill site.

7.4 Impact Avoidance

It is important that the impacts of rehabilitation activities are minimised. Based on the ecological sensitivity, all medium and highly sensitive areas (as seen in Figure 7-1) should be avoided as far as possible including all traffic (e.g. people, animals, machinery).

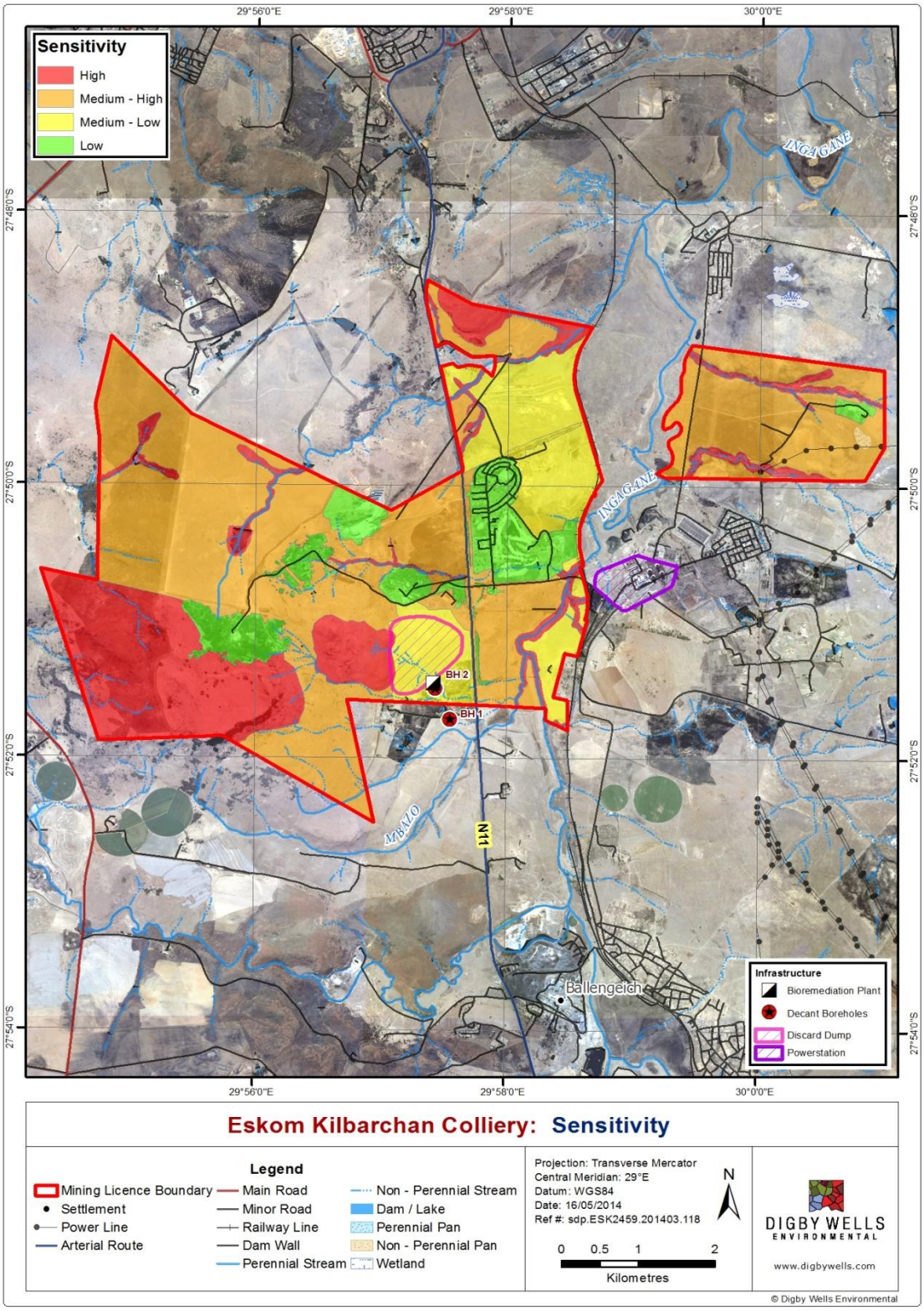

Figure 7-1: Ecological Sensitivity

7.5 Weed Control

Invasion of alien plant species erodes the natural capital of ecosystems, compromises their stability and is a growing problem in South Africa (Richardson and van Wilgen, 2004). Alien plant invasion for the Kilbarchan study area was extensive and well-established including alien bushclumps of approximately 6m in height, as well as an abundance of alien forbs (please refer to the Fauna and Flora Report (Digby Wells, 2016)).

Table 7-3 lists the alien species identified on site and examples of the alien species recorded from the site can be seen in Figure 7-2. These species should be removed from the rest of the project area where possible and must be managed to avoid the (re)establishment in unwanted areas. Control methodology will have to occur over at least three growing seasons to ensure the seed bank is depleted. Continuous monitoring will be required to control plant establishment from seeds being blown in from adjacent areas. It would be preferable to use mechanical control and biocontrol where possible as opposed to chemical control (refer to Table 7-3 for potential control methods).

According to the Fauna Flora Report (Digby Wells, 2016), *Eucalyptus camaldulensis* (Red River Gum*)* covers an area of approximately 116 ha. It is a category 1b species so the species is required by law to be removed. However, in this case, *E camaldulensis* can be left in situ and managed along with the *E. camaldulensis* that will be planted as part of the Phytoremediation Plan. It is also important to note that only sterile specimens of *Eucalyptus camaldulensis* should be planted for the Phytoremediation. Special permission will be required for the planting of this species.

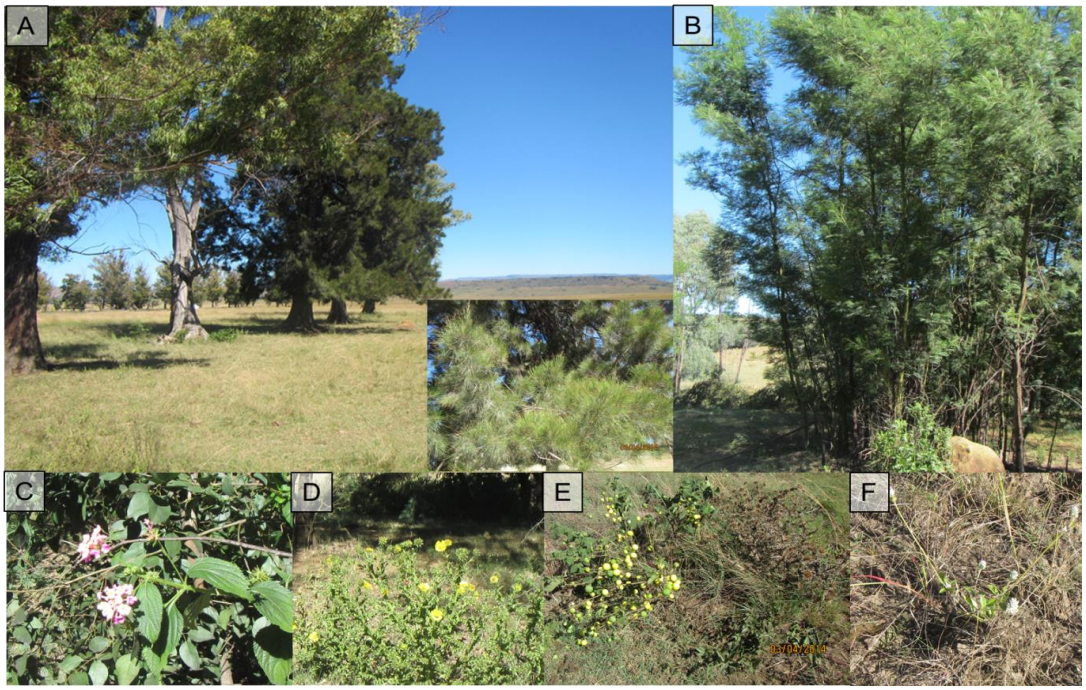

Figure 7-2: Examples of Alien Plant Species Identified on Site (A: Eucalyptus sp. (left) and *Pinus patula* (right); B: *Acacia decurrens*; C: *Lantana camara*; D: *Berkheya rigida* (native pioneer); E: *Solanum sisymbriifolium* and F: *Gomphrena celesioides*)

Table 7-3: Alien and Invasive Species Found at Kilbarchan Colliery[1]

Family	Species	Common Name	Category	Control Method
Amaranthaceae	*Gomphrena celosioides*	Bachelor's Button		This species is a weak competitor that rarely requires chemical control, but being perennial, may need a systemic herbicide once it is well established.
Asteraceae	*Acanthospermum australe*	Paraguayan Starbur		Most broadleaf herbicides are successful in controlling these weeds.
	Berkheya rigida	Disseldoring		No registered herbicides are available for this species and it is best controlled by physical removal. Repeated slashing is required to deplete the deep tap root.
	Bidens bipinnata	Black Jacks		Control this species using post-emergence herbicides.
	Cirsium vulgare	Scotch Thistle	1b	Control through regular cultivation. It is susceptible to hormone and contact-type herbicides. If possible, it should be controlled prior to flowering.
	Conyza bonariensis	Flax-leaf Fleabane		Susceptible to pre-emergence herbicides but this must be applied before plants form a rosette, in order to be effective.
	Cosmos bipinnata	Cosmos		Susceptible to cultivation and broadleaf-weed herbicides.
	Schkuria pinnata	Dwarf Marigold		Controlled by normal pre- and post-emergence herbicides
	Tagetes minuta	Khakibos		Susceptible to most pre-emergence herbicides. Long-term herbicide programmes are usually required, which incorporate post-emergence elements.
Convolvulaceae	*Ipomoea purpurea*	Common Morning Glory	1b	Sensitive to hormone-type herbicides. The ‘scrape and paint‘methodology is effective.
Fabaceae	*Acacia dealbata*	Silver Wattle	1b	Long term control of wattle is difficult as they coppice easily and produce large numbers of seeds. In
	Acacia decurrens	Green Wattle	2	
	Acacia mearnsii	Black Wattle	2	

[1] Control methods adapted from Bromilow (1995)

Family	Species	Common Name	Category	Control Method
				addition fire can result in germination of seeds. Plants must be felled, bulldozed or burnt with immediate follow up with herbicides. A combination of mechanical and chemical control is required, including the use of competitive crops. Young plants can be hand-pulled. Biocontrol is available.
Myrtaceae	*Eucalyptus camaldulensis*	Red River Gum	1b	Stumps should be treated with a suitable herbicide.
Pinaceae	*Pinus patula*	Cluster Pine	2	Large plants can be ring-barked or felled. Herbicide is not generally necessary. Seedlings and saplings can be easily hand-pulled.
Solanaceae	*Datura ferox*	Thorn Apple		Post-emergence herbicides.
	Solanum mauritanum	Bugweed	1b	Cutting, stem painting or foliar herbicides is effective. Young plants can be hand-pulled. Biocontrol is available.
	Solanum sysimbriifolium	Dense-thorned Bitter Apple	1b	Can be controlled with a foliar application of triclopyr.
Verbenaceae	*Lantana camara*	Lantana	1b	Eradication can be laborious and expensive. Chopping and then painting the stumps or spraying the regrowth with herbicide is the most effective method. Small plants can be hand-pulled. Follow up control is essential. Biocontrol is available.
	Verbena brasiliensis	Brazilian Verbena		Very young plants can be controlled by cultivation and with the usual broadleaf weed herbicides. The mature plant however is tough, wiry and more tolerant to herbicides.
	Verbena officianalis	Common Vervain		

8 Monitoring and Maintenance

The purpose of monitoring is to ensure that the objectives of rehabilitation are met and that the rehabilitation process is followed. The physical aspects of rehabilitation should be carefully monitored during the operational phase as well as during the progress of establishment of desired final ecosystems. The following items should be monitored continuously:

- Alignment of actual final topography to agreed planned landform;
- Depth of topsoil stripped and placed;
- Chemical, physical and biological status of replaced soil;
- Erosion status;
- Surface drainage systems and surface water quality;
- Groundwater quality at agreed locations;
- Vegetation basal cover;
- Vegetation species diversity;
- Faunal re-colonisation (Sherman and pitfall trapping); and
- Proportion of land that has been fully rehabilitated.

8.1 Final Topography

The topography that is achieved during rehabilitation should be monitored and compared to the planned topography. The final profile achieved should be acceptable in terms of the surface water drainage requirements and the end land use objectives. As rehabilitation has already occurred within the area the existing commitments made with respect to the final topography must be adhered too. It would be too costly at this stage to plan or change the initial rehabilitation design that was implemented; however improvement to this design can be done to increase the overall success of rehabilitation. In general, the rehabilitation efforts should match the surrounding topography and be free draining with efforts to limit soil erosion and promote vegetation establishment.

8.2 Soil

The soils monitoring plan guidelines should be put in place to ensure the best chances of rehabilitative success from a soils perspective. Progressive monitoring must take place at least on a quarterly basis during placement and should involve the following:

- Inspection of soil surfaces before replacing soil to ensure that contouring is appropriate and has been done properly topography is emulated;
- Random inspection of soil thickness on rehabilitated sections;
- Fertility analysis and amelioration procedures prior to re-vegetation; and

- Evaluating and readjusting the rehabilitation plan.

A final post-mining rehabilitation performance assessment must be completed. This involves:

- Assessment of rehabilitated soil thickness and soil characteristics by means of auger observations using a detailed grid;
- A post-mining land capability map based on soil thickness and characteristics;
- A proposed post-mining land use map;
- Erosion occurrences;
- Soil acidity and salt pollution analyses (pH, electrical conductivity and sulphate) at 0-250 mm soil depth every 4 ha (200m x 200m); and
- Fertility analysis (exchangeable cations K, Ca, Mg and Na and phosphorus) every 16 ha (400x400m).

8.2.1 Erosion

Erosion monitoring of rehabilitated areas should be undertaken and zones with active erosion should be identified.

8.3 Surface Water

8.3.1 Drainage systems

The functionality of the surface water drainage systems should be assessed on an annual basis. This should preferably be done after the first major rains of the season and then after any major storm. An assessment of these structures will ensure that the drainage on the recreated profile matches the rehabilitation plan as well as to detect early on when any drainage structures are not functioning efficiently. These can then be repaired or replaced before it causes significant erosion damage.

- Water quality of the streams should be monitored monthly during initial years. This can further be reduced to biannually (wet and dry season). Monitoring needs to continue for three years after the project has ceased, as is standard practice to detect residual impacts. The results should be compared to the baseline quality and the Instream Water Quality Objectives (IWQO);
- The process and the water quality downstream should constantly be monitored to check if the Phytoremediation is effective. Monitoring should be instantaneous where automatic flow meters are in place for real time measurements. Where there are no automatic flowmeters weekly monitoring needs to be done and in already rehabilitated areas monitoring can be done monthly and after severe storms are experienced.

8.4 Vegetation

A 1.5km line transect for monitoring has been determined (see Figure 6-3). Monitoring should occur at every 2 m along this transect line, whereby the species and basal cover at that point should be recorded.

8.4.1 Basal Cover

Basal cover refers to the proportion of ground at root level which is covered by vegetation and by the rooting portion of the cover plants. The line-transect method can be used to establish sampling positions. A target of at least 30% basal cover should be set for fully established vegetation. It is important to note the difference between basal cover and canopy cover, shown in Figure 8-1.

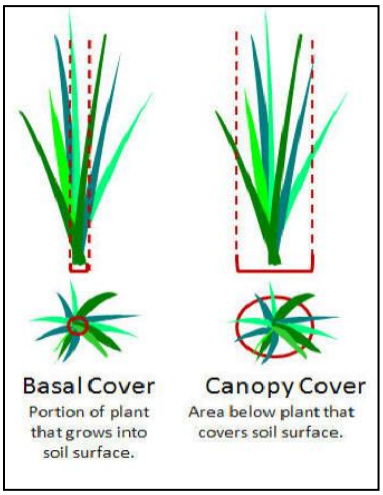

Figure 8-1: Diagram Comparing Basal Cover and Canopy Cover[2]

There are several techniques that could be utilised to measure basal cover and ground cover. The Point Intercept Technique" is a possible option A point is a very small "plot" that is measured to determine what plant or soil attribute occurs at that point.

At each point the species, vegetation type (i.e., grass, forb, or shrub), or ground cover (i.e., rock, bare ground, biotic crust, etc.) that intersects the point is recorded as a "hit." The formula to calculate cover is simply the proportion (%) of hits for a species or vegetation type:

Cover of Spp A = (#hits Spp A/total #points) x 100

Basal cover is most often and easily measured with a point technique. It is a quick and objective way to assess how much plant cover is on a site or landscape.

[2] (Image from Principles of Vegetation Measurement and Assessment and Ecological Monitoring & Analysis http://www.webpages.uidaho.edu/veg_measure/index.htm)

One common technique used on grasslands and shrublands for estimating ground cover is called the "Step-Point" method. This involves selecting a point to begin, setting a transect direction with a compass/GPS bearing, then following the bearing and recording what occurs at regular intervals along the transect, in this case, every 2 metres along the predetermined transect (refer to Figure 6-3 for the location of the transect).

Basal cover should be assessed on an annual basis for newly rehabilitated areas for a period of three years or until it is determined that natural succession has established. A suitably qualified botanist should be appointed to undertake such an assessment and can be conducted by an internal resource; however it is crucial that they are qualified to do such assessments.

8.4.2 Vegetation Species

Biodiversity assessments and surveys should be undertaken twice a year by qualified external botanical experts to establish the full range of plants that have become established. Summer and winter samplings should be done during these assessments. These assessments should be undertaken for newly rehabilitated areas for a period of three years or until such time that it can be proven that natural succession has been achieved. These results should be compared to natural areas within the area as a control.

8.5 Alien Invasive Plant Control Plan

Alien invasive species tend to out-compete the indigenous vegetation; this is due to the fact that they are vigorous growers that are adaptable and able to invade a wide range of ecological niches (Bromilow, 1995). They are tough, can withstand unfavourable conditions and are easily spread.

8.5.1 Alien Species Control

Alien invasive plant species are difficult to control. Methods should be used that are appropriate for the species concerned (refer to Table 7-3 for potential control methods), as well as to the ecosystem in which they occur. When performing the controlling methodology for weeds and invaders, damage to the environment must be limited to a minimum. The methodology must be performed for at least three growing seasons to ensure the seed bank is depleted. Continual monitoring will be needed for seeds that are likely to be blown in from adjacent areas. For newly rehabilitated areas this should be done 3-6 months after rehabilitation has been undertaken and then for a period of three years or until such time that control efforts have determined that alien species are under control. This should be done by a suitably qualified individual or company that has experience in controlling alien species.

8.5.2 Integrated Control Strategies

The satisfactory control of weeds and other invasive species is usually only achieved when several complementary methods, including biological control, improved land management

practices, herbicides and mechanical methods, are carefully integrated. Such a strategy is termed an Integrated Control Strategy (ICS).

Follow-up control of alien plant seedlings, saplings and coppice regrowth is essential to maintain the progress made with initial control work, and to prevent suppression of planted or colonizing grasses. Before starting new control operations on new infestations, all required follow-up control and rehabilitation work must be completed in areas that are originally prioritized for clearing and rehabilitation.

8.5.3 Additional Measures

The following additional measures are recommended to prevent the future introduction or spread of alien species, and to ensure the rehabilitation of transformed areas:

- There must be no planting of alien plants (e.g. Black Wattle and Pampas Grass) anywhere within the project area, with the exception of sterile Eucalyptus identified as part of the phytoremediation areas;
- Surveys aimed at updating the alien plant list and establishing and updating the invasive status of each of the alien species, should be carried out (can be done by Kilbarchan staff);
- The transportation of soils or other substrates that contain alien plant species seed should be carefully controlled;
- Benefits to local communities as a result of the alien plant control programme should be maximised by not only ensuring that local labour is employed and trained, but by also ensuring that cleared alien trees are treated as a valuable wood resource that can be utilised. It must be noted that the sterile *Eucalyptus camaldulensis* trees planted in the Phytoremediation Plan will not be included in this alien plant control programme;
- It is considered essential that appropriate veld management (particularly appropriate grazing levels and burning frequencies) should be applied to areas of secondary indigenous vegetation (e.g. secondary grassland of historically cultivated areas), and especially the grassland and wetland vegetation of untransformed habitats. Appropriate grazing levels and burning frequencies will not only ensure that good vegetation condition and biodiversity levels are maintained, but will also serve to control the spread and increase in cover of palatable alien species such as *Paspalum dilatatum*. Grazing capacity may vary from year to year due to fluctuating conditions and needs to be adjusted based on several factors, such as environmental conditions. The first step to determine the number of cattle (livestock) that the area (rehabilitated areas) can hold is to determine the forage production of the pasture in question. The second crucial aspect is to determine the number of animals allowed to graze and/or grazing time. For rehabilitated land the carrying capacity should not exceed 8-10 ha/animal unit/annum.

9 Mitigation of Impacts from Rehabilitation Actions

The rehabilitation actions listed herein, that aim to improve the overall environmental and social sustainability of the Kilbarchan project area, will realise some potential impacts to the natural environment. These impacts have been discussed and assessed in each specialist field, including Aquatic Ecology, Wetland Ecology, Fauna and Flora, Groundwater and Surface Water. Included in these assessments are recommended measures to mitigate against the assessed environmental impacts and risks. This section aims to summarise these mitigation measures and are included in the tables below.

Table 9-1: Summary of Mitigation of Impacts on Wetlands

Activities	Potential impacts	Phase	Aspects affected	Mitigation type	Time period for implementation	Compliance with standards
Phytoremediation	Loss of wetland habitat	Site preparation and planting	Wetlands	Compilation of an offset strategy for loss of wetland habitat.	Immediately	SANBI, in collaboration with the DWS report on "Wetland offsets: a best-practice guideline for South Africa" (ref: Macfarlane, *et al.* (2014))
		Site preparation and planting		Planting should not take place in wet season; and Wetland monitoring to identify and mitigate impacts.	Monitoring annually for 2-5 years	
		Phytoremediation		Assess Nganange floodplain for improved Present Ecological State (PES) due to decreased mine affected water.	Annually once Phytoremediation is fully established	
Clearing of landfill sites and rehabilitation	Invasion of alien species	Rehabilitation Phase	Fauna and Flora	Alien plant species monitoring; and Control of alien plants	Monitoring biannually for 2-5 years	Alien species in South Africa are categorised according to the Alien and Invasive Species Lists, 2014 (GN R599 in GG 37886 of 1 August 2014) of the NEMBA (Act 10 of 2004)
Phytoremediation		Site preparation and planting			Monitoring biannually for 2-5 years and then annually	
The storage of fuel and lubricant in temporary facilities for the duration of the site preparation and planting phase	Contamination of water course	Site preparation and planting	Aquatic ecosystems	The temporary storage area should be in a bunded area; The temporary storage facility should be cut-off from water resources through local cut-of trenches; and Refueling of vehicles and machinery should be performed in a specified lined area only	Immediately	The National Water Act, National Environmental Management: Biodiversity Act
Site clearance and topsoil removal across the Project area	Sedimentation of water course	Site preparation and planting		Establishment of a 100m buffer zone from the riparian edge to protect aquatic ecosystems areas from the proposed site clearing and planting within the study area. This would require that all transport and rehabilitation actions occur further than 100m from the riparian or wetland edge; No actions to occur in the floodplain area; and Place sediment trapping berms on the boundary of the 100m buffer or end of development	Upon commencement of site clearing and planting, site establishment processes	The National Water Act, National Environmental Management: Biodiversity Act
Vehicular activity and maintenance of the haul roads	Sedimentation of water course	Site preparation and planting		Construct sediment trapping berms on edges of the roads; Establish vegetation on berms and edges of the road; Monitor the roads on a monthly basis to identify and rectify any areas that have begun to erode and where water may be flowing towards wetland areas.	Upon the commencement of rehabilitation activities	The National Water Act, National Environmental Management: Biodiversity Act
Application of fertilizer and herbicides/pesticides	Contamination of water courses	Site preparation and planting		Establishment and enforcement of a 100m buffer from the edge of the riparian zone; and Controlled use of fertiliser and pesticides/herbicides Isolated storage of these chemicals away from potential water ingress	Upon the commencement of rehabilitation activities	The National Water Act, National Environmental Management: Biodiversity Act

Activities	Potential impacts	Phase	Aspects affected	Mitigation type	Time period for implementation	Compliance with standards
Hydrocarbon spills from storage tanks, vehicles and heavy machinery or hazardous materials or waste storage facilities.	Hydrocarbon contamination of the groundwater	Rehabilitation Phase	Groundwater	Hydrocarbons and hazardous materials must be stored in bunded areas and refuelling should take place in contained areas; Ensure that oil and silt traps are well maintained; Vehicles and heavy machinery should be serviced and checked in a demarcated area on a regularly basis to prevent leakages and spills; Hydrocarbon spill kits must be available on site at all locations where hydrocarbon spills could take place; Monitoring boreholes, particularly those located within the construction area, have to be monitored for both water level and quality to detect any changes in quality; and If a considerable amount of fluid is accidentally spilled, the contaminated soil should be scraped off and disposed of at an acceptable dumping facility.	Upon the commencement of rehabilitation activities	
Hydrocarbon spills from vehicles, heavy machinery and workshop areas.	Contamination of surrounding surface water resources through surface water runoff.	Rehabilitation Phase	Surface water	Hydrocarbons and hazardous substances must be stored in bunded areas and refuelling should take place in contained areas; Ensure that the bunded areas can contain 110% of the largest container and are constructed according the necessary SANS standards; Ensure that oil traps are well maintained; and Vehicles and heavy machinery should be serviced and checked on a regularly basis to prevent leakages and spills.	Upon the commencement of rehabilitation activities	

10 Conclusion and Recommendations

To work towards achieving a socially and environmentally safe and sustainably closed mine, significant rehabilitation actions are required. Rehabilitation activities on site were undertaken until 2012 and herein detailed is an updated Rehabilitation Action Plan for the area. The rehabilitation approaches will themselves have some negative impacts to the surrounding natural environment due to the nature of the actions.

The main negative impacts predicted are associated with the phytoremediation scheme that aims to address the mine water decant. This proposed approach will involve the planting of alien and invasive species (advised sterile) in a total area of 175 ha of which 52 ha is wetland. However, the decrease in the decant water reporting to the Ingagane River and wetlands from the success of the phytoremediation project will result in a positive impact.

In addition it is recommended that the following actions be taken:

- Regular monitoring should be undertaken to monitor the progress of areas that have been rehabilitated, refer to frequencies contained within this report;
- Implement the measures as outlined in the specialist studies to minimise the risk to surface/groundwater contamination from the operations during rehabilitation;
- There is no mitigation for the loss of wetlands and therefore it is recommended that an offset strategy be implemented to compensate for the wetlands that would be lost due to the proposed project prior to any development on site. For more details, see the Wetlands Report (Digby Wells, 2016);
- There should be a constant interaction and communication with local stakeholders, so that their requirements can be taken into consideration in the rehabilitation process; and
- Monitoring and maintenance of the rehabilitated areas should take place regularly.

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