DIGBY WELLS ENVIRONMENTAL

Proposed Open Pit Magnetite Mine and Concentrator Plant, Mokopane, Limpopo Province

Conceptual Rehabilitation Plan

Project Number:

VMC3049

Prepared for:

Pamish Investments No. 39 (Pty) Ltd

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This document has been prepared by Digby Wells Environmental.

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Project Name:	**Proposed Open Pit Magnetite Mine and Concentrator Plant, Mokopane, Limpopo Province**
Project Code:	**VMC3049**

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I, Brett Coutts 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 Pamish Investments No. 39 (Pty) Ltd. other than fair remuneration for work performed, specifically in connection with the Proposed Open Pit Magnetite Mine and Concentrator Plant, Mokopane, Limpopo Province.

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EXECUTIVE SUMMARY

Digby Wells Environmental (Digby Wells) has been appointed by Pamish Investments No. 39 (Pty) Ltd (Pamish) to compile a rehabilitation plan for the Open Pit Magnetite Mine and Concentrator Plant in support of the the Mining Right Application undertaken in terms of the Mineral and Petroleum Resources Development Act, 2002 (Act No. 28 of 2002) (MPRDA).

The rehabilitation plan is based on all associated surface infrastructure that will be constructed in support of the additional mining activities proposed for the site.

This conceptual rehabilitation plan is comprised of five major components:

- Re-shaping of the landforms (topography plan);
- Operational and post-closure water management;
- Stripping and replacement of soils;
- Re-vegetation of the landscape; and
- Monitoring and maintenance.

The overall objectives of this report are as follows:

- Minimise impacts that have occurred within the area and avoid further degradation of the environment;
- Provide recommendations with respect to a post mining topography and land use;
- Undertake a preliminary materials balance to determine the size of the final voids and the volume of material available;
- Provide recommendations for the decommissioning of the Tailings Storage Facility (TSF);
- Develop conceptual post mining sustainable topography and land use options;
- Provide recommendations with respect to soil stripping, placement and soil management;
- Provide recommendations regarding vegetation re-establishment and re-enforcement;
- Provide recommendations for monitoring of rehabilitated areas and the post closure environment; and
- Ensure that all recommendations comply with relevant local and national regulatory requirements.

The study area is situated approximately 38 km north-west of the town of Mokopane, Limpopo Province. The site is bound to the west by the Mogalakwena River, a major watercourse for the Limpopo Province and a tributary of the Limpopo River. The study area falls within the farms: Vogelstruisfontein 765 LR, Vriesland 781 LR, Vleigekraal 783 LR, Schoonoord 786 LR and portions Re/1, Re/2, 3, 4, 5 and 6 of the farm Bellevue 808 LR. The N11 national route is situated 5 km east and the R518 regional road is situated 2.5 km south of the proposed project area respectively. Numerous secondary roads run through the project area. The primary land-use is crop and livestock agriculture, which has contributed to some alteration of the natural landscape.

Based on the preliminary calculations done thus far and assuming an average depth of the pit at closure (80 meters), the final void size for Pit 1 (Pit size 129 ha – without backfill) and 2 (Pit size 66 ha – without backfill) will be approximately 125 ha and 59 ha in size respectively (this is after 80 % of the waste rock material has been placed back into the pit). Thus there will be a deficit of material and two final voids will remain, which will need to be managed at closure and post closure. There is potential that underground mining could be undertaken at a later stage however the feasibility of such still needs to be assessed.

Conclusion

The rehabilitation of the Open Pit Magnetite Mine will require significant levels of control and monitoring during implementation if the desired objectives are to be achieved. In brief, these objectives are:

- Produce a free draining, stable topography (landscape-excluding the management of the final voids);
- Post closure management of the TSF and open voids is crucial, with particular emphasis on mitigation measures and management post closure to minimise impacts as far as possible;
- Ensure erosion free, sustainable vegetation;
- Rehabilitation of the affected areas; and
- Minimise long term pollution potential.

The biggest risks to manage post closure will be the Tailings Storage Facility and the open voids and special attention will need to be paid to the management of these facilities post closure.

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1 Introduction

It is recognised that post mining landscape rehabilitation is essential to reinstate a functional end land use which positively contributes towards the future biophysical and societal demands of the people and the animals living in proximity to a disturbed environment. 'Effective rehabilitation', is defined as *"rehabilitation that will be sustainable, in the long term, under normal land management practices*" according to the Chamber of Mines (2007). Mining activity in South Africa has a legacy of poor rehabilitation post extraction however this has changed substantially in recent years due to legislation, enforcement and increased environmental responsibility by Mining houses.

Mine rehabilitation must be considered as an on-going process aimed at restoring the physical, chemical and biological quality or potential of air, land and water regimes disturbed by mining to a state acceptable to the regulators and to post mining land users (Whitehorse Mining Initiative, 1994).

The rehabilitation plan contained herein is compiled for the Open Pit Magnetite Mine and Concentrator Plant. This report builds on the existing work for the area and addresses the overall rehabilitation objectives set. It should be seen as a living document and will be updated during the life of the project as additional information becomes available.

2 Terms of Reference

Digby Wells Environmental (Digby Wells) has been appointed by Pamish Investments No. 39 (Pty) Ltd (Pamish) to compile a conceptual rehabilitation plan for the Open Pit Magnetite Mine and Concentrator Plant in support of the the Mining Right Application undertaken in terms of the Mineral and Petroleum Resources Development Act, 2002 (Act No. 28 of 2002) (MPRDA).

The conceptual rehabilitation plan is based on all associated surface infrastructure (including pits and the TSF) that will be constructed in support of the mining activities proposed for the site.

The overall objectives of this report are as follows:

- Minimise impacts that have occurred within the area and avoid further degradation of the environment;
- Provide recommendations with respect to a post mining topography and land use;
- Undertake a preliminary materials balance to determine the size of the final voids and the volume of material available ;
- Provide recommendations for the decommissioning of the Tailings Storage Facility (TSF);
- Develop conceptual post mining sustainable topography and land use options;

- Provide recommendations with respect to soil stripping, placement and soil management;
- Provide recommendations regarding vegetation re-establishment and re-enforcement;
- Provide recommendations for monitoring of rehabilitated areas and the post closure environment; and
- Ensure that all recommendations comply with relevant local and national regulatory requirements.

3 Legal Framework

Relevant legislation governing mine rehabilitation, closure cost assessment (closure provision), and closure planning is described in National Environmental Management Act, as Amended (NEMA). Section S24(R)(3) of the NEMA now deals with Mine Closure. This Section states that every holder, holder of an old order right or owner of works must plan, manage and implement such procedures and requirements in respect of the closure of a mine as may be prescribed. In support of this is Regulation GN R 982, which provides information associated with what a closure and rehabilitation plan must contain.

There are several guideline documents which provide recommendations on how rehabilitation and closure should be undertaken. For the purpose of the plan the following guideline documents was 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 Sanitation (DWS).

In addition to the abovementioned guideline documents, further regulations must be considered pertaining to closure and rehabilitation. These are as follows:

- International Finance Corporation (IFC) Environmental, Health and Safety (EHS) guidelines;
- Constitution of the Republic of South Africa Act, 1996 (Act No.108 of 1996);
- National Environmental Management Act, 1998 (Act No.107 of 1998) (NEMA), as amended;
- National Water Act, 1998 (Act No. 36 of 1998)(NWA);
- National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008) (NEM:WA), as amended;

- Mine Health and Safety Act, 1996(Act No. 29 of 1996);
- National Environmental Management: Air Quality Act, 2004 (Act No.39 of 2004);
- National Heritage Resources Act, 1999 (Act No.25 of 1999); and
- Conservation Agricultural Resources Act, 1983 (Act No.43 of 1983).

Recently, the NEMA has undergone two amendments; these amendments have now included provisions related to financial provision and rehabilitation contained within Sections 1 (f), 7 (a), (c) and Clause 7 Amendment of Section 24 P of the third amendment to NEMA. These amendments now specifically stipulate that activities triggered in terms on NEMA must have a closure and rehabilitation plan compiled, which needs to include aspects related to financial provision and rehabilitation of mining related activities.

In addition to this Draft Regulation pertaining to the Financial Provision for Rehabilitation, the Closure and Post Closure of Prospecting, Exploration, Mining or Production Operations (GN.940 of 31 October 2014, in terms of NEMA) have been published for comment. These regulations will also need to be taken into account when promulgated and they will influence how closure costs are calculated and indicate that financial provision must be included for rehabilitation, decommissioning and closure activities and remediation and management of latent or residual environmental impacts. In addition to this an annual assessment must be undertaken for the above mentioned and thus resulting in the need for closure and rehabilitation plans to be updated and to include an updated financial provision. The review must be undertaken by a specialist team which must include a mining engineer, a surveyor and an environmental assessment practitioner and must be audited by an independent auditor and submitted for approval to the Minister responsible for mineral resources within 15 months of the effective date of issue of the right.

For rehabilitation purposes, this regulation stipulates what information will be required for the final rehabilitation plan. The final rehabilitation, decommissioning and closure plan will form a component of the Environmental Management Programme (EMP) and will be subjected to the same requirements of the environmental management programme with regards to opportunities.

4 Study Area

4.1 Study Area

The study area is situated approximately 38 km north-west of the town of Mokopane, Limpopo Province. The site is bounded to the west by the Mogalakwena River, which is a major watercourse for the Limpopo Province and a tributary of the Limpopo River. The study area falls within the farms: Vogelstruisfontein 765 LR, Vriesland 781 LR, Vleigekraal 783 LR, Schoonoord 786 LR and portions Re/1, Re/2, 3, 4, 5 and 6 of the farm Bellevue 808 LR. The N11 national route is situated 5 km east and the R518 regional road is situated 2.5 km south of the proposed project area respectively. Numerous secondary roads run through the project area. The primary land-use is crop and livestock agriculture, which has contributed to some alteration to the natural landscape.

5 Expertise of the Specialist

The specialist involved in the compilation of the conceptual rehabilitation plan was Mr Brett Coutts. His Curricula Vita can be made available upon request.

Brett is the Rehabilitation Unit manager and has been appointed to assist with the management and co-ordination of all relevant studies related to rehabilitation. This includes the management of rehabilitation projects, 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) ad undertaking ecological assessments.

Prior to his appointment, he gained experience as a junior project manager on environmental rehabilitation projects at Hydromulch and then was appointed by Terra Pacis as an Environmental Consultant where his roles and responsibilities included the compilation of Basic Assessment (BA) reports, Scoping &Environmental Impact Reports, compilation of Environmental Management Plans (EMP), GIS mapping and Biophysical Studies.

6 Methodology and Approach

There were a number of tasks that were involved in the compilation of this conceptual rehabilitation plan for the Open Pit Magnetite Mine namely:

- Project initiation;
- Review of all existing information;
- Setting objectives and planning around central themes such as:
  - Topography;
  - Material volumes;

  - Water;
  - Soil; and
  - Vegetation.
- Geographic Information System (GIS) mapping; and
- Report compilation.

7 Assumptions and Limitations

The following assumptions have been made and limitations identified, during the compilation of this report:

- The information provided in this report is based on information gathered from site visits undertaken to date and specialist studies that were conducted;
- The full analytical evaluations of materials (material that will be stripped, such as topsoil, softs and overburden is based on information provided by the client and could change if the Open Pit Magnetite Mine mining plan alters with respect to volumes of material extracted (specifically for the opencast mining operations). In the event of this occurring the analytical evaluation of materials and the topography plan will need to be updated to cater for this;
- The information contained within this conceptual rehabilitation plan is based on the current LoM. If there is a significant change of either other mining areas, or infrastructure the conceptual rehabilitation plan will need to be updated to cater for this change;
- Several options have been consisted for the post mining topography and land use, none of these options are considered as the preferred option as each of the options needs to be assessed with respect to feasibility;
- This report must be considered as a living document. The report will be updated as information becomes available and monitoring and rehabilitation progresses; and
- The hydrogeological impacts associated with the post-closure environment are based on specialist studies conducted in 2015 and include a Geochemistry and Waste Classification and Groundwater Report. In the event that there is a change in the mining method it is recommended that the hydrogeological impacts associated with the post closure environment are remodelled as the recommendations provided for water management are based on the current LoM.

8 Mining Activities and Management

8.1 Mineral Resource

The project is located on the Bushveld Igneous Complex (BIC). The BIC consists of a lower sequence of layered mafic and ultramafic rocks known as the Rustenburg Layer Suite (RLS) and an overlying unit of granites known as the Lebowa Granite Suite. These layered rocks occur in three areas known as the Western, Northern and Eastern limbs. The project is located in the Northern Limb of the Bushveld Complex.

Within the project site, two titano - magnetite zones have been identified, namely the vanadium-rich Main Magnetite Layer (MML) and the iron and titanium-rich P-Q zone. The MML consists of two massive titano-magnetite layers separated by a parting consisting of lower concentrations of titano-magnetite.

The target mineral for the proposed mine is vanadiferous titano-magnetite of the MML, which will be processed to produce magnetite concentrate which will ultimately be processed into Vanadium[1]. Other minerals which may be found in association with the MML and have been included in the Mining Right Application are: Vanadium, Titanium, Iron Ore, Phosphate, Platinum Group Metals, Gold, Cobalt, Copper, Nickel, Chrome and all minerals found in association with these elements. The MML resource occurs up to a depth of 120 m whilst the P-Q Zone occurs at a depth of 400 m. The A,B and C zones are the zones determined as potential future resource zones with A and C being referred to as *low* grade hanging wall and Zone C being referred to as *lower* grade hanging wall.

8.2 Infrastructure

The following associated surface infrastructures will be constructed in support of the additional mining activities proposed for the site:

- Overburden Stockpiles (Waste Rock Dumps - WRD);
- Low/Lower Grade Stockpiles;
- TSF;
- Clean and dirty water management systems, including treatment of water;
- Pollution control facilities;
- Waste management facilities;
- Power lines and associated transformers;
- Haul roads and other ancillary roads;

[1] The processing of the magnetite concentrate into Vanadium has not been considered as part of this EIA process and is subject to a separate environmental authorisation approval process, to be undertaken by the relevant applicant.

- Sewage treatment plant;
- Conveyors;
- Pipelines;
- Hazardous material storage area; and
- Offices, workshops etc.

8.3 Mining Method

Open pit mining is considered the optimal mining method based on the thickness and positioning of the mineral resource.

Open pit mining is proposed to be undertaken outwards from the middle of the strike length advancing north and south to an initial depth of 20 m below the surface then to 40 m and thereafter to 60 m, and 80 m. A bench height of 10 m will be used to allow for the separate loading of the two ore layers and the parting. There are two open pits planned, which are separated by the D4380 Provincial Road, the approximate footprint of the north (Pit 1) and south (Pit 2) open pits are 129 ha and 66 ha respectively.

The LoM is approximately 30 years with a RoM of up to one million tpa. The open pit mining and processing will involve the activities as described in the sections below.

8.4 Mining Sequence

The mining of the two pits will be sequential with Pit 1 being mined before Pit 2. Pit 2 top soil stripping activities will commence during the final two years of Pit 1 to allow for the deposition of low and lower grade hanging wall ore from Pit 2 into the defined deposition dump areas.

It is necessary to mine the various defined mineral horizons in an overall ratio through-out the mines life to ensure that the later years of the mines life are not encumbered with high low grade to high grade mining ratios.

8.5 Mineral Processing

Ore will be transported from the open pit to the concentrator plant by dump trucks. A concentrator plant will be constructed for initial processing. Ore processing will commence with crushing which is undertaken in three stages and produces material with a size of 44 millimetres (mm). Based on typical industry performance, the plant is assumed to perform for 5 500 operational hours per annum (i.e. 358 operating days per annum, with an 80% utilisation of 80% availability).

Material from the crushed material stockpile will then be reclaimed and processed through a conventional rodmill-ballmill combination to produce a product of 53 micrometres (µm). Following grinding, magnetite will be recovered through a three-stage low intensity magnetic separation circuit. The magnetic separation product will be dried by a filter press and stockpiled for further processing in a concentrate shed, while the non-magnetic waste will be thickened and disposed of at the proposed TSF through a tailings pipeline. The concentrator will also include a laboratory, plant office, water treatment plant, workshop/ yard and control room. Additional infrastructure will also include internal road network, piping and concentrate stockpile area. Refer to Figure 8-1 for a flow diagram of the proposed concentrate process.

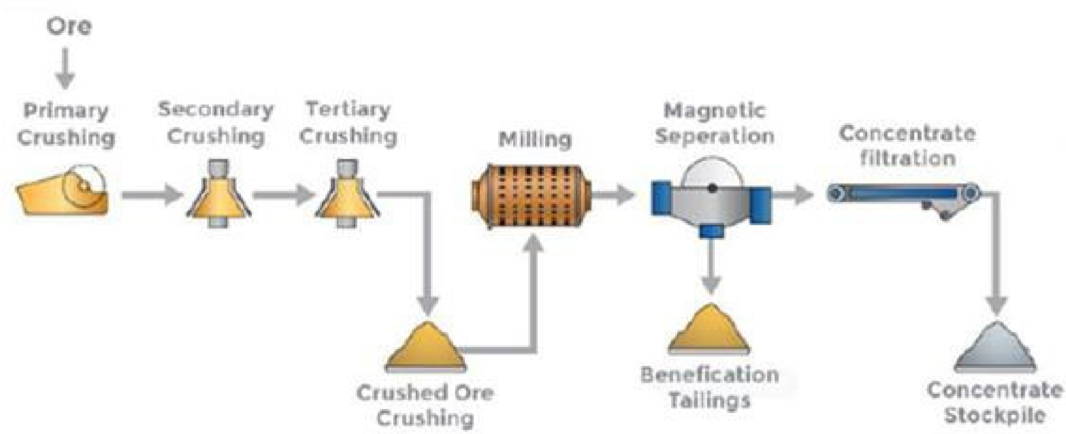


Figure 8-1: Process Flow Diagram of the Concentrator Plant

Source: VMIC, February 2014

8.6 Waste Rock Dumps and Low/Lower Grade Stockpiles

Due to the nature of the resource the mining waste volumes are relatively low in that what would in a typical open pit mine be designated as overburden or waste is actually a potential resource.

The Waste Rock Dump (WRD) will be created during the development of the open pits. It is proposed that approximately 80% of waste rock produced will be deposited on the working benches from mining activities. The remaining 20% of the waste rock will be disposed of at a WRD, using Load Haul Dump (LHD) vehicles. There are two proposed WRDs, the northern WRD is located adjacent to the plant area and will be 4 ha in area, whilst the southern WRD will be approximately 7.5 ha in area. Both WRD are expected to reach a maximum height of 18 m.

Storm water diversion trenches or swales will be constructed around the upstream sides of the WRD to direct clean surface water run-off around and away from the WRD. A drainage trench around the WRD will be constructed to divert run-off from the side slopes of the WRD.

As discussed above, the A, B and C zones are the zones determined as potential future resource Zones with A being referred to as low grade ore and Zone C being referred to as lower grade ore. Each pit therefore has an associated low grade and lower grade ore stockpile. The footprints of the low grade and lower grade ore stockpiles for Pit 1 are 70.5 ha and 59.5 ha respectively. The footprints of the low grade and lower grade ore stockpiles for

Pit 2 are 60 ha and 43.5 ha respectively. The low and lower grade stockpile areas will not exceed 70 m in height.

8.7 Tailings Storage Facility

The TSF will be constructed as a conventional tailings dam. Tailings material will be pumped to the TSF at 327 000 tpa. The slurry will contain 30% solids. The tailings material will have a particle size 80% smaller than 75 µm. The total volume of the TSF will be 9.8 million tonnes with a footprint of 58 ha and a height of 30 m.

A penstock system will decant water off the top of the TSF, which will then be pumped back to the plant via the return water dam. The tailings material has been classified as a Type 3 Waste (according to the NEM:WA Regulations) and will be lined with a Class C Liner.

Storm water diversion trenches or swales will be constructed around the upstream sides of the TSF to direct clean surface water run-off around and away from the TSF. Paddocks will be constructed around the perimeter of the TSF to contain run-off from the side slopes.

A 6 m wide waste rock road will be constructed around the perimeter of the facility for access during operations, routine inspections and maintenance. A perimeter fence around the TSF will be installed.

There are currently two options under consideration for the development of the TSF. The tailings material generated from the concentrator plant is proposed to be thickened by either conventional thickening or paste thickening. In terms of past thickening, the underflow can contain up to 75% to 85% of solids. There are several benefits to paste thickening, these include:

- Reduction of water sent to the tailings dam by 50%, resulting in a significant overall reduction in water consumption;
- Reduction of the footprint area required for a tailings dam, due to the high solids content;
- Reduced seepage from the TSF as a result of less free water in the tailings material;
- Energy savings due to the reduction in slurry volume being deposited through pumping; and
- Once deposited, the paste dries out similarly to conventional thickener underflow.

Paste thickening requires careful design of the entire deposition system, with displacement pumps typically required to move the material. It must be physically possible to produce paste tailings and also the financial feasibility needs to be assessed. The potential advantages and disadvantages of the different tailings technology will be discussed in the Alternatives section below.

9 Baseline Environment

9.1 Soils

9.1.1 Soil Types

The magnetite project area is dominated by the Arcadia soil form with small portions of Oakleaf soils to the west, and Shallow Glenrosa/Mispah soils on the hills towards the east as shown in Figure 9-4.

These soils are described in more detail in the sections below.

9.1.2 Arcadia Soil Form

9.1.2.1 Description

The Arcadia soil form consist of deep Vertic A horizons (>1,2m). On site these soils are black in colour and are more commonly known as “Turf soils” or “Black cotton soils”. They have a high clay percentage (> 55% clay).

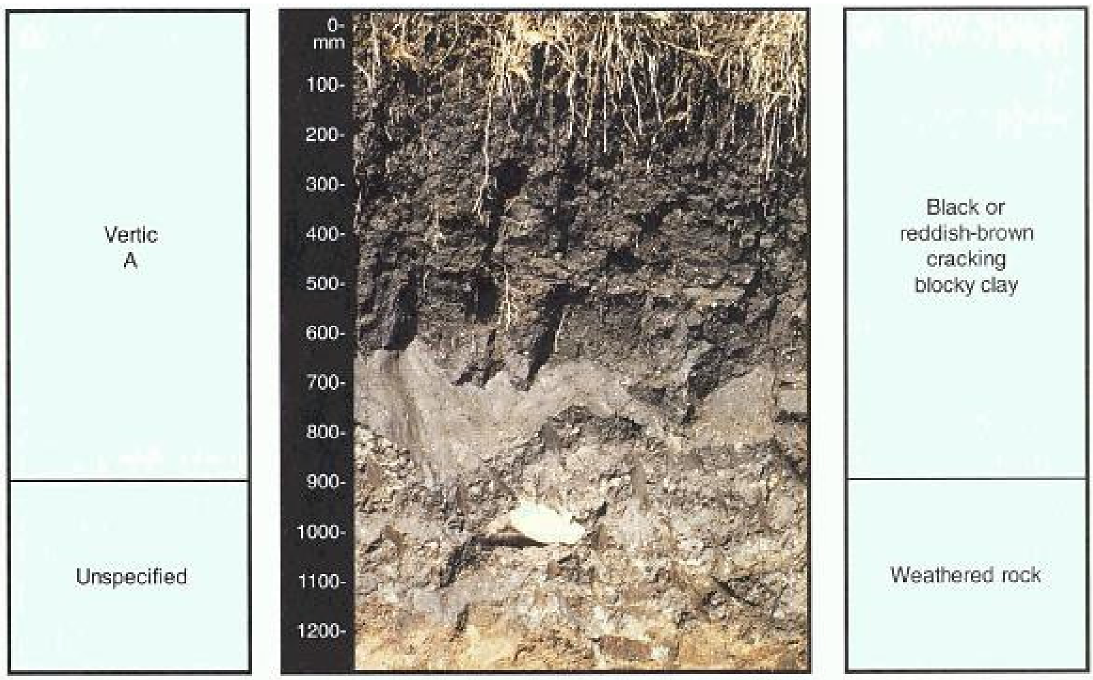


Figure 9-1: a typical cross section of the Arcadia soil form (SASA, 1999)

9.1.2.2 Behaviour

Arcadia soils are extremely physically active. They shrink when dry and swell when wet (Fey, et al. 2010). The soil moves objects to the surface know as heave and can exceed 100 mm, this upward movement can lift buried pipes and poles to the surface. With the start of the rainy season, Arcadia soils are dry and cracked and water infiltration is high bypassing the soil body and potentially recharging the groundwater or downslope soils. When it rains, the soil swells and the cracks close and infiltration rate slows (Fey, et al. 2010). Arcadias have typically inverted profiles and lack horizons due to the random mixing when wet, therefore are not sensitive to disturbance (Soil Classification Working Group 1991). Additionally, the soils store large amounts of organic carbon (Smith 2006).

9.1.2.3 Suitability

Arcadia soils hold large amounts of water which often is not available for crops. Therefore, dry climates often do not support dryland cropping on these soils. Despite this, Arcadia soils can accommodate a selected composition of vegetation such as grazing vegetation for cattle or strong rooted crops such as sorghum, cotton and sunflower.

9.1.3 Oakleaf Soil Form

9.1.3.1 Description

The Oakleaf soil form are deep (>1.2 m) soils that consist of an Orthic A horizon, overlying a Neocutanic B, overlying a subsoil with no signs of wetness due to A and B horizons having good internal drainage properties. They generally have moderate clay percentages (15 – 25% and 25 – 40% clay in A and B horizons).

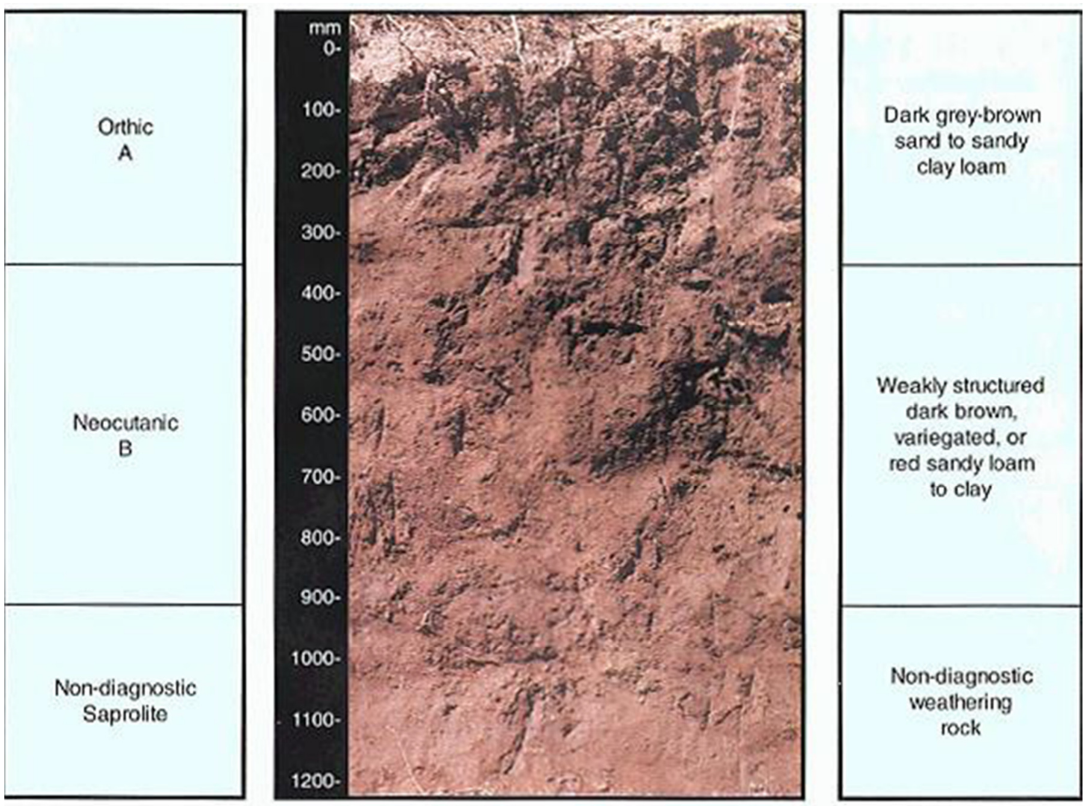


Figure 9-2: a typical cross section of the Oakleaf soil form (SASA, 1999)

9.1.3.2 Behaviour

Oakleaf soils are physically and chemically inactive. The soils are slightly sensitive to erosion. The subsoil is more sensitive to erosion and should preferably not be exposed.

9.1.3.3 Suitability

Oakleaf soils are moderately suitable for crop production but irrigation is limited by availability of water and climate.

9.1.4 Glenrosa Soil Form

9.1.4.1 Description

The Glenrosa soil form consists of an Orthic A horizon which forms on soft, thoroughly decomposed and porous rock, often rich in clay (known as saprolite) forming a lithocutanic B subsoil which merges into parent rock material. These soils are generally shallow. They are generally are clayey texture (15 - 25% and 35 - 45% clay in the A and B horizons respectively).

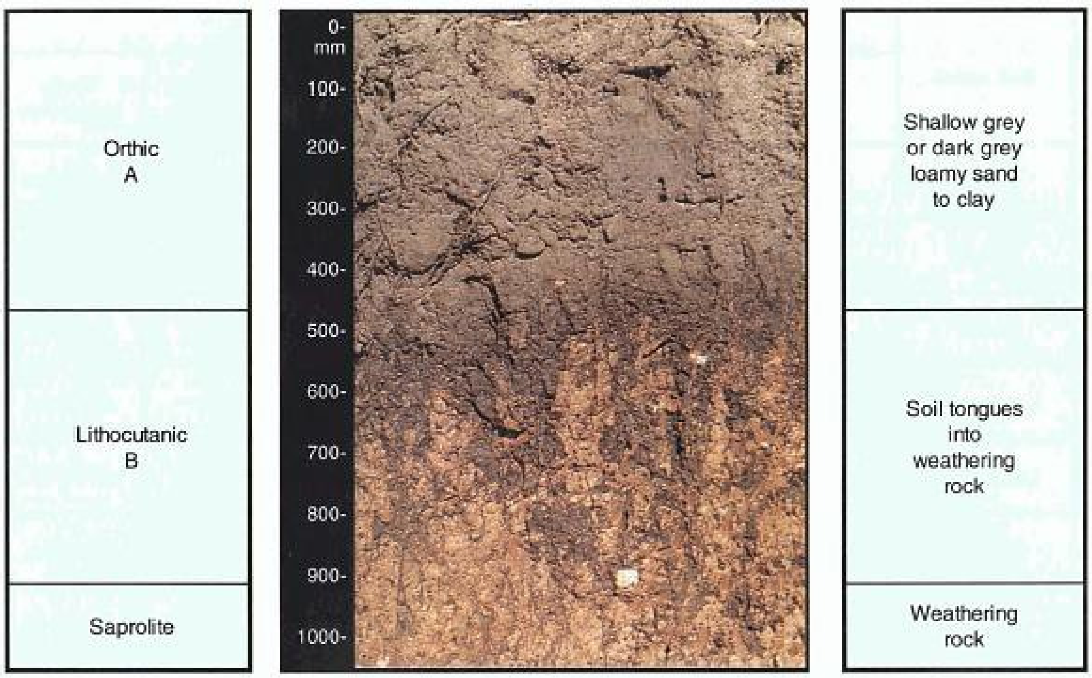


Figure 9-3: a typical cross section of the Glenrosa soil form (SASA, 1999)

9.1.4.2 Behaviour

They are moderately physically active. The soils are moderately sensitive to erosion. The subsoil is usually sensitive to erosion.

9.1.4.3 Suitability

Glenrosa soils are generally too shallow and have a low agricultural potential.

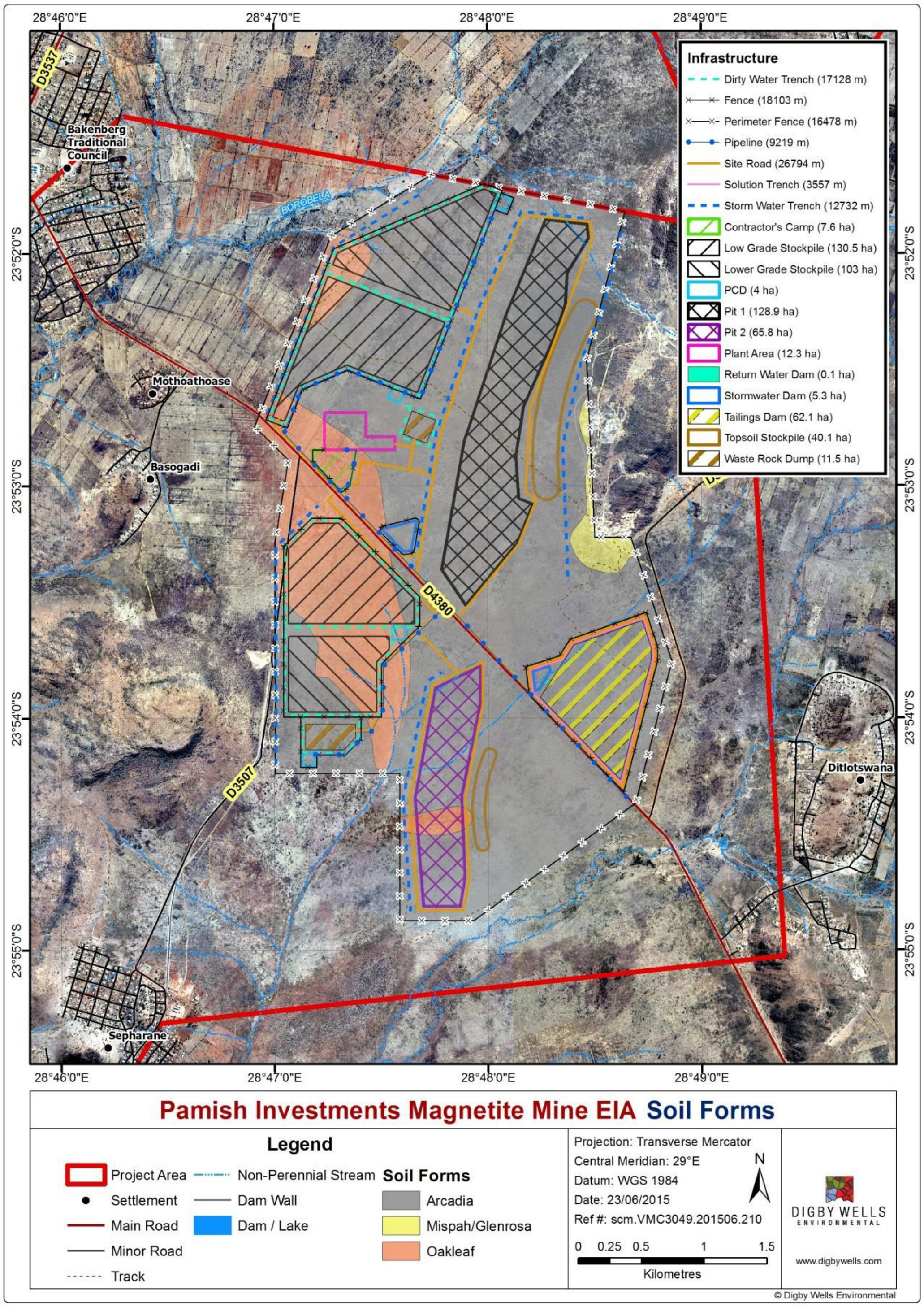


Figure 9-4: The Soil Forms Delineated as per the Field Survey Finding for the Magnetite Project Area

9.1.5 Land Capability

The land capability is dominated by the Class IV (moderate grazing) land capability, the Class IV land capability coincides with the Arcadia soils, and although these soils are deep their high clay percentage and shrink/swell properties make them very difficult to manage from an agricultural perspective.

The Class III (moderate cultivation/intensive grazing) land capability coincides with the Oakleaf soils, which are better drained and more easily managed in comparison with the Arcadia soil. They are situated to the west of the site and the low/lower grade stockpiles would be situated on them.

The Class VIII (wilderness) land capability can be found in the eastern portion of the project site and is linked to the shallow/steep Glenrosa/Mispah soils.

9.1.6 Land Use

The land use that is dominant within the project area is the natural veld that is used for grazing with a small portion in the north east being used for subsistence agriculture.

These land uses are driven by climate and land capability. The dominant soil in the project area is the Arcadia soil form. These soils are very difficult to cultivate and as a result have been left to natural veld. The Oakleaf soils are high in clay but do not have the same restrictions as the Arcadia soils and have therefor been used as subsistence agricultural fields.

9.2 Flora and Fauna

9.2.1 Flora

The Proposed Magnetite Open Pit Mine is situated in the Savanna Biome, within the Makhado Sweet Bushveld and Central Sandy Bushveld regional vegetation types. Habitat classified within the site included three vegetation units, namely: *Acacia borleae – Eragrostis rigidior* Black Turf Savanna; *Acacia tortilis – Eragrostis rigidior* Savanna and *Commiphora marlothii – Heteropogon contortus* Rocky Woodland.

A total of 75 plant species were recorded on site, three of which hold a conservation status, namely: *Combretum imberbe* (Leadwood) – nationally protected, *Scadoxus puniceus* (Royal Paint Brush) – provincially protected and Sclerocarya birrea (Marula) –nationally protected.

A toal of 17 mammal, 102 bird, 8 reptile and 11 herpetofaunal species were recorded on site. A Baboon Spider *(Harpactirinae sp)* was found in low-lying areas associated with the *Acacia borleae – Eragrostis rigidior* Black Turf Savanna. This species has not yet been positively identified but its nesting site has been recorded. All Baboon Spiders have been assigned protected status by NEMBA.

With regard to sensitivity, the study area is not situated within any protected area earmarked for future protection, threatened ecosystems or Important Bird Areas. The site-specific sensitivity assessment showed that the *Commiphora marlothii – Heteropogon contortus* Rocky Woodland was assigned high sensitivity. This habitat was intact and supported species that are restricted to rocky outcrops.

The impacts of the proposed development were rated from minor negative to moderate negative and included loss of habitat, loss of Species of Special Concern and impaired ecosystem services. In addition to Red Data and protected species, six medicinal plant species were recorded. It is likely that additional species are employed for medicinal use by the local community. Relocation strategies were recommended, to minimise the impacts on flora and fauna, for plant Species of Special Concern, the medicinal plant species and the Baboon Spiders. There is no mitigation for loss of habitat but should the development go ahead, the infrastructure should occupy as little area as possible and should be kept linear.

Monitoring of habitat is recommended after the construction phase. Inclusive is alien invasive plant monitoring which should take place up to 7 years after development.

9.3 Surface Water

The Project area is located within the boundaries of the quaternary catchment A61G and A62B found in the Limpopo River catchment which is Water Management Area number one (WMA 01).

The Project area consists of perennial and non-perennial streams which traverse through the project area. The identified non-perennial streams were found to be dry during the site visit conducted on the 15^{th} of January 2015. A river named Mogalakwena which is a tributary to the Limpopo River is found on the western side of the project site flowing towards the northern side into the Limpopo River. Another river called Sterkriver also traverses through the Project area on the western side of Mogalakwena River. Sterkriver is a tributary to Mogalakwena River. A non-perennial stream called Borobela exist on the east side of the Mogalakwena River and it flows from the eastern side towards the west feeding into the Mogalakwena River, this stream was dry at the time of site visit.

The Mogalakwena River is one of the 13 tributaries in South Africa of the main Limpopo River basin (LBPTC Scoping Study, 2010).

9.4 Geohydrology

9.4.1 Groundwater Quality and Yields

The project area is located on a part of the northern limb of the Bushveld Complex. Groundwater occurrence of the Rustenburg Layered Suite of the Bushveld Igneous Complex (BIC) is associated mainly with deeply weathered and fractured mafic rocks. The groundwater yield potential is classified as poor since most of the boreholes produce less than 2 L/s. Faulting in the Lebowa Granite Suite plays a very important role in the transmission and recharge of groundwater. The granites of the Lebowa Suite are crystalline such that they have a poor permeability and water is only stored in areas of deep weathering and in faulted zones. The average transmissivity for the project area was 33 m^2/day, varying between 0,2 m^2/day and 56 m^2/day.

During the hydrocensus it was possible to sample 36 open and accessible boreholes. Six groundwater samples collected during the hydrocensus and five samples collected during aquifer testing. Groundwater samples collected during a recent (i.e. 2014) hydrocensus presented generally the regional geogenic/ambient groundwater quality with a Ca -Mg- -HCO3 water type as represented by literature of DWS groundwater samples for the region.

The Ca -Mg- -HCO_3 facies suggests weathering of silicate and ferro-magnesian minerals as a major source of mineralization. The Ca- Mg--HCO3 water facies indicates a relatively young groundwater (HCO3 instead of Cl dominance for older, more evolved water).

9.4.2 Numerical Model and Impacts at Closure

During the closure phase groundwater levels will recover towards their original state. The probability of decant occurring at the site is low, however should decant occur it would be at the north western corner of Pit 1. The decant volume would be in the order of 0.5 l/s (maximum). There are no mitigation measures for groundwater level rebound and the impact would be low. The open pit area should be backfilled using suitably graded materials to mimic the natural groundwater environment as far as possible.

The stockpile areas should be cleared and vegetated during the closure phase, while the waste rock dump slopes should be vegetated and graded to allow runoff and prevent infiltration of rainwater to the material. The overall impact rating for these features is low. The simulated contaminant migration plume for the TSF in the base case scenario remained contained at the pit area and concentrations decreased to less than 5% after 25 years. The base case TSF impact rating for the closure phase was medium, however should the TSF be suitably vegetated and capped during closure the impact rating would be low. The simulated contaminant migration plume for the TSF in scenario 1 remained contained at the pit area, remaining at the Pit 2 area for the full closure simulation period, and concentrations decreased to less than 10% after 25 years. The simulated contaminant migration plume for the TSF for scenario 2 remained contained at the pit area for 50 years into the closure phase, but began migrating south from 50 years onwards. The concentrations were simulated to remain at ~50% for the full closure phase. The simulated contaminant migration plume for the TSF in scenario 3 remained contained at the pit area, migrating slightly south of Pit 2 after 75 years, and concentrations decreased to less than 20% after 25 years. The TSF impact rating for the closure phase was medium due to the continued migration of contaminant simulated for scenarios 2 and 3. However, should the TSF be suitably vegetated and capped during closure the impact rating would be low.

9.4.3 Acid Base Accounting (ABA) and Net Acid Generation (NAG)

Based on the ABA and NAG results the following can be concluded:

- The waste rock samples show no potential for acid generation with a high neutralising potential and thus ARD formation is not a risk and high metal leach or seepage of contaminants due to an acidic environment is not seen as a potential environmental impact;
- The two tailings material samples show a low risk for acid forming potential. However, a neutralising capacity is also observed due to the mineralogy. The ARD potential of the material is however uncertain and a larger amount of samples is recommended to be tested to allow a statistical distribution and a higher level of certainty; and
- The acid generating potential in the tailings material is most likely due to the siderite content being exposed to alkaline conditions that can potentially lead to siderite forming small amounts of acid.

9.4.4 Waste Classification

Based on the classification the following can be concluded:

- The pH of all samples show a neutral range with low electrical conductivity values confirming the low metal leach (ML) potential from the waste material; and
- The outcome of the sample classification is a Type 3 waste for all samples (Moderate risk/hazard) due to some elements being above the ideal TCT0 concentrations and if disposed, the facility should be designed in accordance with the specifications for a Class C landfill site (Old GLB+ landfill facilities).

10 Rehabilitation Objectives and Approach

10.1 Aims and Objectives

The post-mining land use should be restored to either grazing and/or cultivation and should represent the pre-mining land use, if possible.

The closure and rehabilitation objectives for the Open Pit Magnetite Mine have been defined as the following:

- Return land that has been mined by opencast methods to a land use that is sustainable and accepted both from a legal requirement perspective and meets both the environmental and social needs identified;
- Ensure that as little water as possible seeps out of the various sections of the mine (during closure), and where this is unavoidable, ensure that the water is contained or treated, if the volume is significant and/or if it does not meet statutory water quality requirements;

- Demolish all mine infrastructure that cannot be used by the subsequent land owners or a third party. The areas that are demolished will be rehabilitated to at least a grazing land capability or the prescribed pre-mining land use. Where buildings can be used by a third party, arrangements will be made to ensure their long term sustainable use;
- Rehabilitate the TSF to ensure that any risk of pollution emanating from the facility is minimised;
- Consider options for the low/lower grade stockpiles (either rehabilitation of these stockpiles or processing);
- Rehabilitation of the WRDs;
- Follow a process of closure that is progressive and that is integrated into the short and long term mine plans. The process must assess the closure impacts proactively at regular intervals throughout the project life;
- Leave a safe and stable environment for both humans and animals;
- Prevent any soil, surface water, and groundwater contamination by managing all water on site;
- Comply with local and national regulatory requirements;
- Form active partnerships where possible with local communities to take responsibility for the management of the land after mining; and
- Maintain and monitor all rehabilitated areas following re-vegetation or capping, and if monitoring shows that the objectives have been met, then an application for closure can be made.

This conceptual rehabilitation plan is comprised of five major components:

- Re-shaping of the landforms (topography plan);
- Operational and post-closure water management;
- Stripping and replacement of soils;
- Re-vegetation of the landscape; and
- Monitoring and maintenance.

11 Landscape Re-shaping and Water Management

The Open Pit Magnetite Mine operations will not employ concurrent rehabilitation. Eighty percent (80%) of the waste rock will be placed back onto the benches and the remaining will be stockpiled and will need to be shaped and top soiled and rehabilitated. Water management will need to be adopted to ensure that clean and dirty water is separated, especially when considering water management associated with the TSF (clean and dirty water management systems).

A material balance analysis was completed for the mining blocks. The results are discussed below in the Bulking Factor and Profiling section, to determine if it is possible to return the landscape back to original ground level with the amount of material left post-mineral extraction. This information and planning is largely driven by the need to manage water on the site and across the impacted areas. The topographical design is directly related to water management.

11.1 Material Balance Analysis

Post-mining topography is one of the most important factors to be considered in the rehabilitation and closure processes. Generally, contouring of the filled in areas aims to achieve the approximate original contours that existed before mining (SACMA, 2005). In order to plan or model this process, a materials balance is needed for the full mined out area to determine the volume of material that will be removed and thereafter how much will be left to replace for the rehabilitation of the landscape. This section describes the materials balance calculations for the proposed mining operations, and gives the recommended post-mining landscape topography plan.

11.1.1 Bulking Factor and Profiling

A critical factor in the calculations of material volumes, and final landform design, is the swell/bulking factor of the removed materials, and thereafter the replaced materials. The physical act of excavation breaks the rocks up into various sizes, which introduces air pockets and increases the volume of the materials. In its simplified format, calculating the bulking factor is done by dividing the Loose Cubic Meters (LCM) by the Bank (original) Cubic Meters (BCM) (Heit, 2011). Soils and other fine materials will result in a negative bulking factor as this handling generally leads to compaction after placement. In reality, the final bulking factor is influenced by many variables including the geological properties of the material and the design of the blasting methods. Although unpublished, an industry norm for the bulking factor of overburden is 30% to 40%. Based on the information provided thus far a 1.3 (30% - swell factor), it has been assumed that the waste rock material will swell by 30%.

The operation proposes to mine two pits .i.e. Pit 1 Pit 2. Both pits will be mined to extract the Target Ore. This will entail mining and stockpiling of waste rock material, low grade and lower grade ore. The low grade and lower grade ore will be stockpiled for potential processing in the future and thus will not be put back into the open void during the mining operations. It is assumed that 80% of the waste rock will be backfilled into the pit onto the benches that will be established during the mining process.

One scenario has been calculated based on the assumed bulking factor (~30%). For Pit 1 approximately 44 million cubic meters (m^3) of material will be removed. Of the total volume of material removed from the pit the waste rock component is 6 166 186 m^3. Eighty percent (80%) of this material will be placed back into the pit and the remaining 20% will be stockpiled on surface, which will remain at the LoM. Pit 2 will consist of approximately 36 million m^3 of material being removed, of which 5 087 681 m^3 will be waste rock material. As noted above 80% of this material will be placed in the pit and the remainder stockpiled.

Based on the preliminary calculations done thus far and assuming an average depth of the pit at closure (80 m), the final void size for Pit 1 and 2 will be approximately 125 ha and 59 ha in size respectively. Thus there will be a deficit of material and two final voids will remain, which will need to be managed at closure and post closure. There is potential that underground mining could be undertaken at a later stage however the feasibility of such still needs to be assessed.

11.1.2 Topography Design and Post Closure Land Use

Before planning the post mining topography and potential end land use, one needs to understand the material available to fill voids or open pit areas, cover overburden and/or waste rock material etc. in addition to this an understanding of the post mining impacts that could occur after closure needs to be considered before a post closure land use can be considered. Lastly social aspects associated with closure also need to be considered, for example, will the community utilise the land after mining.

In terms of a post mining landscape, a sustainable topography should be created. The bulking factor calculation has indicated that both the pits will be in deficit of material required to backfill them to natural ground level, thus two voids will remain. Having two final voids left and a deficit of material to fill these voids, other options need to be considered with respect to the final post mining topography, which will ultimately affect the post mining land use and capability. With respect to the post mining topography and post mining land use, the following has been considered, which is discussed in further detail below:

- Ensure that the side walls of the pit are stable, create a berm using overburden (waste rock around the pits and then fence off the pits with signage;
- Potentially consider the option to utilise the voids as land fill sites (required approval will need to be sought and impacts associated with utilising the voids as landfill sites need to be assessed; and
- Sourcing waste rock material from other mines/quarries in the area that have a surplus and using this material to fill the voids left at closure.

11.1.2.1 Post Mining Land Use Potential for the Open Pits

Several options have been considered regarding the post mining land use and topography and are driven mainly by the materials balance to determine if enough material is available to fill the final voids, post mineral extraction. Based on the preliminary calculations, there will be two final voids remaining. The options considered for the post-mining land use primarily focus on what can be done with the voids post closure. Currently three options have been considered thus far, however none of the options have been selected as a preferred option as the feasibility of each option needs to be investigated, taking into account several factors such as the following:

- Potential for future mining of the resource;
- Liabilities associated with managing the post closure environment;
- Potential pollution plumes migrating away from the project area; and
- Environmental and social aspects, such as what will the land be utilised for post closure i.e. will the community utilise the area for crop cultivation and/or grazing.

Below is a brief summary of the alternatives that have been considered thus far.

11.1.2.1.1 Management of Voids Post Closure

In the event underground mining does not proceed the voids must be managed to prevent pollution and secured as it may pose a safety risk to the communities.

Consideration needs to be given to the water quality that will accumulate in the open voids and the potential groundwater contamination plume that may migrate post closure (Refer to Groundwater Report for specific details regarding management of water post closure). This option thus far only considers the physical aspects associated with the open voids. It is suggested that a 5 m berm be constructed around each void, utilising waste rock. The slopes of the final voids potentially will need to be shaped or stabilised to prevent rock fall. The berm that is created can be top soiled and vegetation planted. In addition to the berm it is advised that a fence be erected around each void and signage be erected indicating the safety risks associated with the voids.

11.1.2.1.2 Sourcing Additional Waste Rock Material to Fill Voids

The second option considered is potentially sourcing surplus waste rock from other mines or quarries in the area in an attempt to fill the remaining voids, in order to return the land back to its original land capability. If waste rock is sourced, specific tests will need to be undertaken on the waste rock, such as Acid Base Accounting. In addition to this this activity will also require environmental authorisation.

11.1.2.1.3 Potential for a General Landfill Site

The third option that has been considered is potentially utilising the voids as general land fill sites post mining. With this option several factors need to be considered. The feasibility of undertaking this option needs to be assessed in detail, such as assessing potential groundwater impacts of having general waste within the pit, who will be responsible for the liabilities associated with the landfill site, how close the land fill site can be to communities etc.

11.2 Acid Mine Drainage and Groundwater Contamination

Five samples were taken and all samples were sent to the Waterlab (Pty) Ltd where standardised methods were used to prepare and analyse the samples. Samples FS7520, FS7508 and FS7481 were hanging wall samples representing the waste rock material to be temporarily stored on site with samples MMLA and MMLB being two samples compiled from a tailings material sample. All material were sampled by the client and delivered to Digby Wells for processing and test work.

The project will include both low and lower grade stockpiles on site. However, only waste rock and tailings samples were tested and the assumption is made that the low and lower grade material will be made up of the waste rock material teste

Based on the results from the numerical groundwater model and the geochemistry and waste classification reports the following is recommended with respect to the post closure environment:

11.2.1 Waste Rock Material

- Only waste rock samples were tested and the assumption is made that the low and lower grade material will be made up of the waste rock material tested;
- The waste rock material showed a high neutralising potential in both the mineralogical and acid rock drainage (ARD) assessments and tests, and both ARD and metal leach (ML) potential is low;
- The neutralising nature of the waste rock material was confirmed in the paste pH of the ABA results and also the pH of the resultant leachate quality abstracted from the distilled water leachate tests;
- The waste rock material was classed as a Type 3 waste according to the NEM: WA guidelines due to total concentrations of some elements being above the recommended TCT0 values; however
- No elements leached out in concentrations above the LCT0 values and in most cases were below the detection limits with a very low risk of contamination or seepage based on the conservative methods followed as per NEM: WA regulations; and
- Overall from the available data and test results the waste rock material is deemed to be a low environmental contamination risk and the Type 3 classification of the waste rock is too conservative and not a true reflection of the low risk nature of the material.

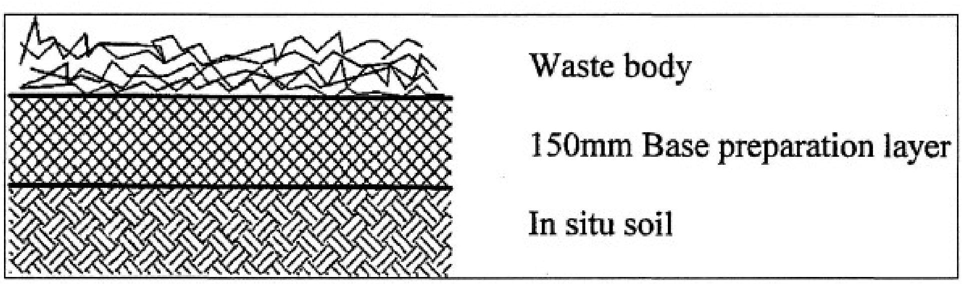
11.2.2 Tailings material

- The tailings material showed a marginal potential for ARD, but the ARD potential is uncertain based on the current available data;
- The neutralising nature of the tailings material was confirmed in the paste pH of the ABA results and also the pH of the resultant leachate quality abstracted from the distilled water leachate tests; however
- The remaining parameters tested for and evaluated do show a marginal potential for ARD development that can lead to a potential for contaminants to leach out of the material;
- The acid producing potential of the tailings material is most probably caused by the siderite mineralogy;
- The tailings material was classed as a Type 3 waste according to the NEM: WA guidelines due to total concentrations of some elements being above the recommended TCT0 values; and
- Overall from the available data and test results keeping in mind the potential acid forming nature of the tailings material, the Type 3 classification of the tailings material is an accurate classification.

From the above conclusions Digby Wells recommends the following:

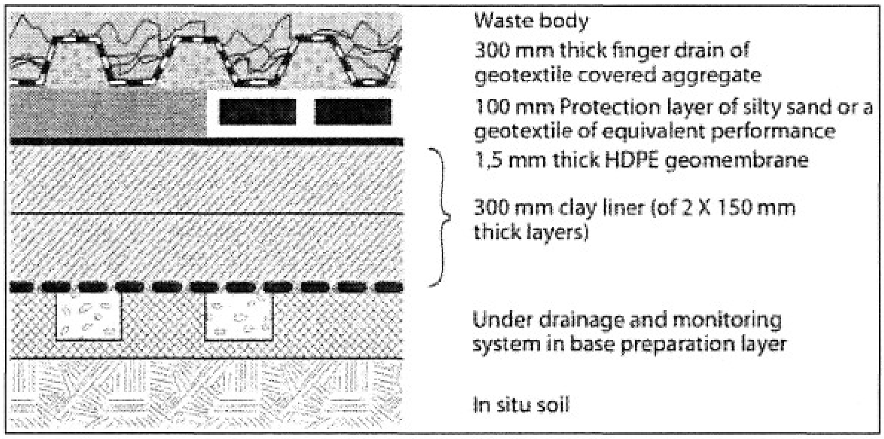
- The waste rock material is a low environmental risk and it is recommended that during the licensing process negotiations with both the DMR and the DWA are entered into to authorise a liner design in accordance with a Class D disposal facility as shown below.

(d) Class D Landfill:



- The tailings material is a Type 3 waste and should be disposed of at a Class C waste facility or a disposal facility with the liner designed in accordance with the NEM: WA guidelines for a Class C landfill as shown below.

(c) Class C Landfill:



- Monitoring of the receiving environment in the vicinity of the waste facilities should be planned and implemented to act as an early warning system and to evaluate any potential environmental impacts over time.
- Digby Wells recommends that future work include more representative samples of tailings samples to be tested to increase certainty on both the ARD and seepage potential of the material.

11.3 Rehabilitation Management Areas (RMA's)

11.3.1 Operational

The operational infrastructure areas need to be managed with rehabilitation in mind. There are therefore six operational RMA's:

- Pit area;
- TSF and other dams;
- Workshop Areas, offices and associated infrastructure;
- Stockpiles (waste rock, low and lower grade ores);
- Topsoil stockpiles; and
- Haul roads and other ancillary roads.

During the operational life of the mine, these areas will require certain actions and these are described in Section 14 and Table 14-1. Please also refer to Appendix A for general/practical standards associated with rehabilitation.

11.3.2 Post-mining

The project area will need to be managed and maintained once rehabilitation activities have been completed. Soil replacement, soil quality, vegetation establishment, and water management are the most important features.

12 Soil Stripping, Soil Replacement and Re-vegetation

There are two major soil groups in the project area and these soils will be stripped separately as shown in Figure 12-1.

The Arcadia soils are heavy black clay soils with shrink swell properties. The top 30cm of these soils are to be stripped and stockpiled in one stockpile (**S1**). The remaining 90cm (up to depth 120cm) are to be stripped separately and stockpiled in another stockpile (**S2**).

The Oakleaf soils are red and somewhat freely draining. The top 30cm of these soils are to be stripped and stockpiled in one stockpile (**S3**). The remaining 90cm (up to depth 120cm) are to be stripped separately and stockpiled in another stockpile (**S4**).

The top 30cm of soil is stripped separately to conserve the natural seed bank as well as the natural fertility that has been accumulated in this layer. This layer is also to be replaced last to increase the chances of rehabilitation success.

These soils are stockpiled separately as to maintain their natural structures, and cannot be mixed under any circumstances. This would compromise their ability to rehabilitate.

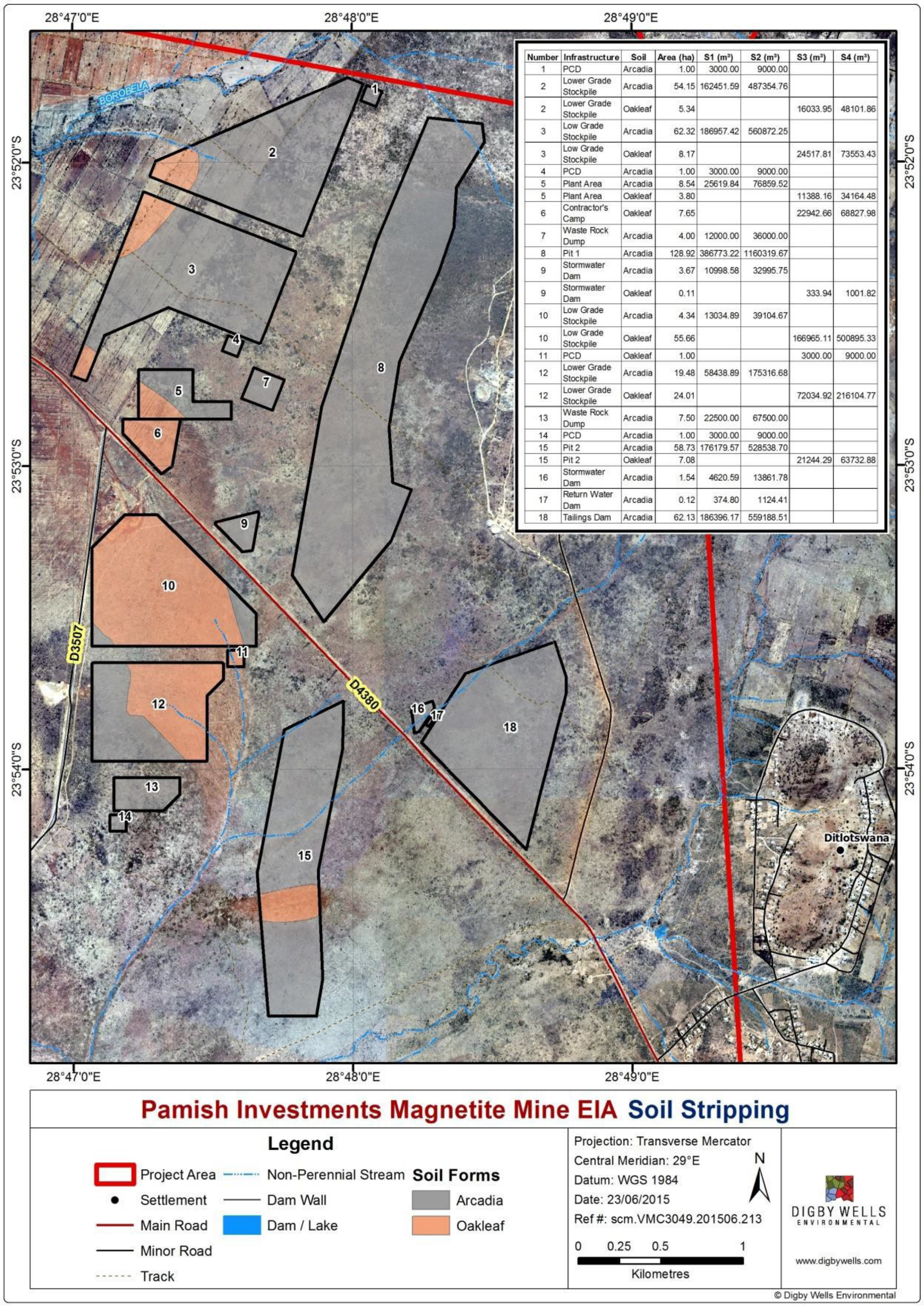
These soils are to be stripped in the dry season only.

Table 12-1 shows the infrastructure within the project site and which soils are to be stripped and to which stockpile they should be assigned too. All S1 stripped soils are to be placed together and the same with S2 through to S4. The volumes of these have been tabulated for closure and rehabilitation purposes.

Table 12-1: Soil Stripping Areas and Volumes for the Various Infrastructures/Activities as well as the Soils to be Stripped and which Stockpiles they are to be assigned to

No.	Infrastructure	Soil	Area (ha)	S1 (m^3)	S2 (m^3)	S3 (m^3)	S4 (m^3)
1	PCD	Arcadia	1.00	3000.00	9000.00		
2	Lower Grade Stockpile	Arcadia	54.15	162451.59	487354.76		
2	Lower Grade Stockpile	Oakleaf	5.34			16033.95	48101.86
3	Low Grade Stockpile	Arcadia	62.32	186957.42	560872.25		
3	Low Grade Stockpile	Oakleaf	8.17			24517.81	73553.43
4	PCD	Arcadia	1.00	3000.00	9000.00		

No.	Infrastructure	Soil	Area (ha)	S1 (m³)	S2 (m³)	S3 (m³)	S4 (m³)
5	Plant Area	Arcadia	8.54	25619.84	76859.52		
5	Plant Area	Oakleaf	3.80			11388.16	34164.48
6	Contractor's Camp	Oakleaf	7.65			22942.66	68827.98
7	Waste Rock Dump	Arcadia	4.00	12000.00	36000.00		
8	Pit 1	Arcadia	128.92	386773.22	1160319.67		
9	Stormwater Dam	Arcadia	3.67	10998.58	32995.75		
9	Stormwater Dam	Oakleaf	0.11			333.94	1001.82
10	Low Grade Stockpile	Arcadia	4.34	13034.89	39104.67		
10	Low Grade Stockpile	Oakleaf	55.66			166965.11	500895.33
11	PCD	Oakleaf	1.00			3000.00	9000.00
12	Lower Grade Stockpile	Arcadia	19.48	58438.89	175316.68		
12	Lower Grade Stockpile	Oakleaf	24.01			72034.92	216104.77
13	Waste Rock Dump	Arcadia	7.50	22500.00	67500.00		
14	PCD	Arcadia	1.00	3000.00	9000.00		
15	Pit 2	Arcadia	58.73	176179.57	528538.70		
15	Pit 2	Oakleaf	7.08			21244.29	63732.88
16	Stormwater Dam	Arcadia	1.54	4620.59	13861.78		
17	Return Water Dam	Arcadia	0.12	374.80	1124.41		
18	Tailings Dam	Arcadia	62.13	186396.17	559188.51		
Totals			**531.26**	**1 255 345.56**	**3 766 036.68**	**338 460.84**	**1 015 382.52**



Number	Infrastructure	Soil	Area (ha)	S1 (m³)	S2 (m³)	S3 (m³)	S4 (m³)
1	PCD	Arcadia	1.00	3000.00	9000.00		
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2	Lower Grade Stockpile	Oakleaf	5.34			16033.95	48101.86
3	Low Grade Stockpile	Arcadia	62.32	186957.42	560872.25		
3	Low Grade Stockpile	Oakleaf	8.17			24517.81	73553.43
4	PCD	Arcadia	1.00	3000.00	9000.00		
5	Plant Area	Arcadia	8.54	25619.84	76859.52		
5	Plant Area	Oakleaf	3.80			11388.16	34164.48
6	Contractor's Camp	Oakleaf	7.65			22942.66	68827.98
7	Waste Rock Dump	Arcadia	4.00	12000.00	36000.00		
8	Pit 1	Arcadia	128.92	386773.22	1160319.67		
9	Stormwater Dam	Arcadia	3.67	10998.58	32995.75		
9	Stormwater Dam	Oakleaf	0.11			333.94	1001.82
10	Low Grade Stockpile	Arcadia	4.34	13034.89	39104.67		
10	Low Grade Stockpile	Oakleaf	55.66			166965.11	500895.33
11	PCD	Oakleaf	1.00			3000.00	9000.00
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15	Pit 2	Oakleaf	7.08			21244.29	63732.88
16	Stormwater Dam	Arcadia	1.54	4620.59	13861.78		
17	Return Water Dam	Arcadia	0.12	374.80	1124.41		
18	Tailings Dam	Arcadia	62.13	186396.17	559188.51		

Figure 12-1: Soil Stripping Areas and Volumes for the Various Infrastructures/Activities as well as the Soils to be Stripped and which Stockpiles they are to be assigned to

Soil fertility analysis will be needed of the stockpiled soils to determine whether fertilisation is needed for replacement and seeding. Table 14-2 gives actions for the post-mining landscape. Also refer to Appendix A, for general rehabilitation guidelines, with respect to soil stripping replacement and re-vegetation.

Re-vegetation of the rehabilitated and top-soiled areas is the final action in the rehabilitation process. The table below is a summary of the grass species recommended for the seed mix. If possible, commercially available and indigenous nitrogen fixing plants could be added to the seed mixture in very small quantities i.e. not more than 5% of the total seed mixture. It is also suggested that if commercially available, indigenous grass species that locally occur in the area could be substituted into the seed mixture.

Table 12-2: Rehabilitation Species Mix for Terrestrial Areas

Grass Scientific name	Common name	Perenniality	Grazing Value	Plant succession	Grazing status	Notes
Eragrostis chloromelas *5%*	Curly leaf (narrow)	Perennial tufted grass (grows for more than five season)	Average	Sub climax/ climax	Increaser 2 grass	
Cynodon dactylon *40%*	Couch grass	Creeping grass	High	Pioneer	Increaser 2 (alien invasive)	Provides valuable erosion control in less favourable niches
Digitaria eriantha *25%*	Common Finger grass (Smuts Finger)	Perennial tufted grass (grows for longer than 5 seasons)	High	Climax	Decreaser	
Chloris gayana *30%*	Rhodes grass	Weak perennial tufted grass (grows for 2 to 5 seasons)	High	Sub-climax	Decreaser	Second season cover

13 Monitoring and Maintenance

The purpose of monitoring is to ensure that the objectives of rehabilitation are met. In general, the following items should be monitored continuously:

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

14 Mine Closure and Rehabilitation Actions and Activities

The following is a brief summary of mine closure actions that should be undertaken. In addition, Table 14-1 and Table 14-2 explain the consolidated actions and activities associated with the rehabilitation of the Open Pit Magnetite Mine project area and the consequent monitoring and maintenance needed. Lastly additional tables have been provided for the management of landscape re-shaping, general soil management and vegetation management (refer to Table 14-3 Table 14-4, and Table 14-5).

14.1 Waste Rock Dump Area

The following activities will take place at closure:

- Any residue stockpiles need to be removed and placed on the benches in the final voids (80% of the material concerned, remaining 20% will be stockpiled and will require rehabilitation);
- It is recommended that the WRD be shaped to an 18° slope;
- 300 mm of soil should be placed over the WRD and re-vegetated using the suggested seed mixture; and
- Topsoil will be spread over all disturbed areas and re-vegetated.

14.2 Open Pit (2 voids that will remain)

The following activities will take place at closure during rehabilitation:

- There will be two final voids at the end of LoM;
- Construct a 5 m berm around the pits utilizing waste rock material;
- Place 300 mm of topsoil on the waste rock and vegetate with the recommended seed mixture;
- Once placed, the “growth medium” should then be fertilised, ripped and re-vegetated. A small topsoil stockpile should be left for remedial work.
- Erect a fence around each of the voids and put up signage warning people of the danger;
- Ensure that the slopes of the pits are stable;
- Clean water cut off trenches may need to be created around the voids to channel clean stormwater away from the voids; and
- If channels are constructed they must be designed with energy dissipaters at the point of discharge to reduce surface water movement and prevent erosion gullies from forming.

14.3 Low/Lower Grade Stockpiles

Three options regarding rehabilitation of the low/lower grade stockpiles have been considered and are summarised below:

- Option 1 – Reprocess these stockpiles when the market demand allows for it. The footprint of these stockpiles will need to be rehabilitated;
- Option 2 – If the market does not allow for the processing of these stockpiles, then these stockpiles need to be shaped and 300 mm of topsoil placed on them and rehabilitated; and
- Option 3 - If the market does not allow for the processing of these stockpiles, then the option to place this material back into the pit should be considered and the footprint rehabilitated.

14.4 Infrastructure Areas (Workshops, Offices, etc.)

The following activities will take place at closure:

- Evaluate the potential future need of surface infrastructure such as pipelines, powerlines and offices to be utilised post closure;
- All surface plant, buildings and equipment that has no further use will be removed from site;

- Foundations will be removed to a meter (1 m) below surface and placed in the final void or disposed of at a registered landfill site if required;
- If material is contaminated with hydrocarbons or chemicals, this material must be disposed of at a registered landfill site;
- The surface areas will be levelled and vegetated; and
- All haul roads will be ripped and vegetated.

14.5 Tailings Storage Facility and Dams

The minimum objectives for the rehabilitation of the TSF must be to prevent air and water pollution in accordance with the requirements of the relevant regulations and with good international practice. The intended end-use should take into consideration the prior land-use and the location with respect to current and potential future socio-economic development.

The closure plan for the TSF will be developed during the life of the facility. The purpose of preparing a closure plan is to ensure that the TSF design, construction and operational procedures are compatible with the achievement of final closure and rehabilitation to acceptable environmental standards and at a reasonable cost. It is anticipated that the closure plan will be updated periodically before the preparation of the final closure plan. The closure plan will be prepared in accordance with “best practice” and the requirements of the environment.

In view of the above, the closure considerations can be summarised as follows:

- The required final side slope and top surface geometries will be achieved during the operational phase;
- The side slopes and the final top surface will be covered with a vegetated layer. The purpose of the cover is to stabilise the tailings surface (erosion and dust generation) and to minimize the infiltration of water and oxygen; and
- All surface structures (i.e. pumps, pipelines, power lines etc.) will be removed.

The following measures will need to be implemented for the preparation of the TSF area in order to conserve as much topsoil as possible that will be utilised for rehabilitation and closure:

- Strip and stockpile all available topsoil from the TSF footprint;
- Topsoil is defined as unconsolidated soil with sufficient organic content and moisture retaining capacity to sustain vegetation growth;
- Topsoil stripped from the TSF footprint for re-use in the rehabilitation and closure phases;
- Implement erosion control measures around the topsoil stockpiles located at the TSF to minimise and limit soil erosion; and

- Avoid the use of chemicals in and round the stockpiles to be located at the TSF to avoid contamination.

It must be noted that the engineered cover must be designed by a qualified specialist. Normally store and release covers are designed to manage rainwater on TSF facilities. This should include slope lengths and steepness.

14.6 Dams

The importance of keeping the remaining dams that will be associated with the project needs to be assessed. If the dams can be utilised post closure, then it is suggested that they remain, however the quality of the water within the dams will also determine if the dams can be utilised for example for crop irrigation or as watering points for cattle. An assessment should be undertaken on the potential to keep the pollution control dams in place at closure as these facilities could be utilised to capture and store dirty water from areas that have been impacted, such as run off from the TSF.

14.7 Powerlines and Electrical Infrastructure

All powerlines and electrical infrastructure will be removed from site where there is not reasonable prospect they will be needed for agricultural, housing and/or industrial activities.

14.8 Monitoring Post Closure

14.8.1 Air Quality

Air quality should be continued to be monitored for a short period until it is certain that all rehabilitation measures are in place and stable at which time monitoring will no longer be increased;

14.8.2 Water Monitoring

Groundwater and surface water monitoring needs to be undertaken post closure to detect unexpected problems Monitoring of groundwater should be undertaken to detect of the pollution plumes develops according to the predicted models. Surface water monitoring should be undertaken to determine if surface water becomes polluted in excess of the amounts predicted. An emergency plan should be developed as a “what if” plan – what will be done in the event that monitoring post closure picks up excessive pollution in relation to what was predicted.

14.8.3 Social Aspect

Social issues will continue to be monitored in line with the Social and Labour Plan.

Table 14-1: Rehabilitation Actions and Activities for Operational Rehabilitation Management Areas

Management Area	Aspect	Aim	Actions and Discussion
Pit Area	Soil management	Sustainable soil stripping for later use in rehabilitation.	Strip the soil according to the guidelines provided for in Section 12 of this report. See Section 1, Appendix A, for preparation guidelines for the mining area.
	Continuous rehabilitation	Minimise financial provision required for final closure and rehabilitation and ensure that appropriate rehabilitation is undertaken.	Rehabilitate areas that can be rehabilitated during the operational phase. Replace material according to post-mining topographical plan.
Tailings Storage Facility	Soil management	Sustainable soil stripping for later use in rehabilitation.	Strip the soil according to the guidelines provided for in Section 12 of this report. Utilise this soil for rehabilitation of the TSF at closure and ensure that these topsoil stockpiles are vegetated and monitored.
	Water management	Clean and dirty water separation	Ensure the dirty water drainage leads to existing pollution control dams and is not allowed to enter the environment. Practice dust suppression to prevent material fines from entering the surrounding environment.

Management Area	Aspect	Aim	Actions and Discussion
Surface Infrastructure i.e. Workshop Areas etc.	Water management	Clean and dirty water separation	Ensure the dirty water drainage leads to existing pollution control dams and is not allowed to enter the environment. Practice dust suppression to prevent material fines from entering the wetland and surrounding environment.
	Soil management	Rehabilitation planning	Accurately stockpile topsoil for later use for rehabilitation of the area.
Hards and Softs Stockpiles	Water management	Clean and dirty water separation.	Ensure water coming from the stockpiles is not polluted in any way before being released into the environment.
	Soil management	Sustainable soil stripping for later use in rehabilitation	Strip the soil according to the guidelines provided for in Section 12 of this report.
	Vegetation and water management	Ensure protection of wetland and surrounding environment.	Vegetate the stockpiles with desired species. Do not allow alien species to establish and spread into the adjacent wetland and into the environment.
Low/Grade and Lower Grade Ore	Water management	Clean and dirty water separation.	Ensure water coming from the stockpiles is not polluted in any way before being released into the environment. Appropriate clean and dirty water channels need to be constructed around these stockpiles to capture dirty water and channel clean water away from these stockpiles.
Topsoil Stockpiles	Soil management	Rehabilitation planning	Strip the soil according to the guidelines provided for in Section 12 of this report. Accurately demarcate the soil stockpiles and the type of soil for later use in rehabilitation activities.

Management Area	Aspect	Aim	Actions and Discussion
	Vegetation management	Establishment of Vegetation	Vegetate the stockpiles with desired species. Do not allow alien species to establish and spread into the adjacent wetland and into the environment. Ensure vegetation cover is in a good condition to prevent erosion of the soils.
Haul Roads	Soil management	Sustainable soil stripping for later use in rehabilitation	Strip the soil according to the guidelines provided for in Section 12 of this report.
	Water management	Clean and dirty water separation	Ensure the dirty water drainage leads to the existing pollution control facilities and not into the surrounding environment. Practice dust suppression to prevent excessive dust from entering the surrounding environment.

Table 14-2: Rehabilitation, Maintenance and Monitoring Actions and Activities for Post-mining Rehabilitation Management Areas

Management Area	Aspect	Actions and Discussion
All Areas	Water management	Ensure that clean and dirty water separation is put into place to prevent dirty water from entering into areas that are not disturbed.
	Soil and Erosion management	Strip the soil according to the guidelines provided for in Section 12 of this report. See Section 1, Appendix A, for preparation guidelines for the mining area. The soils need to undergo fertility analysis prior to placement to discern whether or not fertilisation is needed to assist in rehabilitation success.

Management Area	Aspect	Actions and Discussion
	Vegetation management	See table 12-1 for the recommended seed mix for the re-vegetation efforts.
All Rehabilitated Areas	Monitoring	Seasonal monitoring of the soil, water and vegetation must occur during any concurrent rehabilitation. Bi-annual monitoring (twice a year) may then occur once the entire project area has been reshaped and rehabilitated according to the post-mining landscape design contained herein. Monitoring needs to continue for a minimum of five years and needs to continue if the rehabilitation efforts are not successful. See section 3, Appendix A, for additional guidance on monitoring. It is advised that this conceptual rehabilitation plan is updated annually. 7 years before closure a detailed closure plan needs to be developed prior tp cessation of mining..
All Rehabilitated Areas	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. The survey department should do an assessment of the reshaping carried out on the site and signoff should be obtained from the rehabilitation specialist before the topsoil is replaced. Options regarding the final land use, taking into consideration the deficit of material to fill the voids needs to be considered and the feasibility of each option evaluated in detail.
All Rehabilitated Areas	Topsoil Depth	The recovery and effective use of the usable topsoil available is very important. It is essential to undertake regular reconciliation of the volumes stripped, stockpiled and returned to the rehabilitated areas. A topsoil balance must be used to keep track of soil resources on the mine. In addition to this detailed records of available topsoil should be marinated and also the volume and depth of topsoil replaced.

Management Area	Aspect	Actions and Discussion
All Rehabilitated Areas	Replaced Soil Qualities	A final rehabilitation performance assessment should be done and information should be adequate for closure applications that involve: ▪ Assessment of rehabilitated soil thickness and soil characteristics by means of auger observations using a detailed grid; ▪ Erosion occurrences; ▪ Soil samples should be taken post replacement to determine if additional ameliorants are required; ▪ Soil acidity and salt pollution analyses (pH, electrical conductivity and sulphate) and Fertility analysis (exchangeable cations K, Ca, Mg and Na and phosphorus) 1 sample for every 16 ha. ▪ Maintenance fertilization will be required to ensure that the soil fertility is adequate to support satisfactory plant growth, as this is the main factor preventing erosion.
All rehabilitated areas	Erosion	Erosion monitoring of rehabilitated areas should be undertaken and zones with excessive erosion should be identified. Erosion can either be quantified or the occurrence there-of simply recorded for the particular location.
All rehabilitated areas	Surface Water	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 they cause significant erosion damage.
All rehabilitated areas	Groundwater	Groundwater monitoring must be undertaken to monitor potential groundwater impacts. The appropriate management of groundwater resources must be implemented in the event of impacts occurring.

Management Area	Aspect	Actions and Discussion
All Rehabilitated Areas	Fauna and Flora	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 (or the quadrat bridge) method can be used. A target of approximately 15% basal cover should be set for fully established vegetation. Biodiversity assessments and surveys should be undertaken to establish the full range of plant species that have become established. Biodiversity and basal cover assessments should be undertaken annually with a rotation of summer and winter assessments.
All Rehabilitated Areas	Settling	Re-colonisation of fauna species through species assessment (Sherman and pitfall trapping).
All Rehabilitated Areas	Re-vegetation failure	Areas that settle and result in ponding will need to be topped-up from the reserve stockpiles.
All Rehabilitated Areas	Erosion	Areas in which the re-vegetation is not successful must be investigated. Once the cause has been established remedial action must be undertaken, e.g. fertilization, ripping and replanting.

Table 14-3: Landscape Reshaping Activates

Aspect	Management Area	Aim	Actions
Shaping and Leveling	All Management Areas	Shaping and levelling	Shaping and levelling should be undertaken as per the final rehabilitation plan compiled.
	All Management Areas	Clean and dirty water separation for rehabilitated areas	Implement clean and dirty water separation as noted above.
Erosion	All Management Areas	Filling of erosion gullies that have formed.	If erosion gullies are formed they will need to be filled with stockpiled soil and reshaped.

Table 14-4: Soil Management Activities

Aspect	Management Area	Aim	Actions
Compaction Reduction	All Areas	Stop excess traffic over reshaped areas	Limit the amount of vehicular movement over re-profiled areas to prevent unnecessary compaction of replaced soils
		Awareness of compaction	Ensure that all workers/contractors are aware of the goal of minimizing compaction throughout the rehabilitation process
		Record keeping	Volumes of material moved should be recorded
Sol Replacement	All Areas	Move soils when Dry	Move/replace soil stockpiles when they are dry

Aspect	Management Area	Aim	Actions
		Spread cover mix	Replacement of soils with respect to depth should be aligned with the post mining capability. The following criteria can be used as a guideline: ▪ Arable: soil depth will exceed 0.6 m; ▪ Grazing: soil depth will be at least 0.25 m; ▪ Wilderness: soil depth is less than 0.25 m but more than 0,15 m; and ▪ Wetland: depths as for grazing but use wetland soils which have been separately stockpiled.
Smoothing and Spreading	All Areas	Smooth surface	Rough level all topsoil using a dozer (not grader).
		Dozer spreading	All soil piles should be smoothed, by dozer, before fertilization
Fertilizing	All Areas	Improve growth properties	Undertake testing on soil to determine the appropriate fertilizer applications and rip through soil at least 100mm into underlying spoil material..
Ripping	All Areas	Rip soils	Rip to a depth of at least 100 mm into the underlying spoil

Table 14-5: Vegetation Management Activities

Aspect	Management Area	Aim	Actions
Soil Dressing	All Areas	Sustain microbial activity	Ensure organic content sufficient within the soils which are replaced. Mulch 1 t/ha of locally mowed grass and spread. The rate should be around 1t grass/hectare, so that it gives some erosion control in addition to indigenous seed.
		Improve growth properties	Once the soil properties have been established a qualified specialist should make recommendations as to fertilizer applications including timing and ratios.
		Spread fertilizer	A commercial spreader should be used. Calibrate this using a sheet/tarpaulin. Check that the spread is uniform. It is recommended that a competent contractor is used to do the work, and that the prep work and fertilization and seeding always has close supervision .
Re Vegetation	All Areas	Plant areas with recommended species	Vegetate rehabilitated areas with recommended seed mixture.
Alien Invasive Species Management	All Areas	Limit the alien invasive species colonization	Implement various control methods including selective/non-selective, contact/systemic herbicides as per regulations. Refer to Appendix B for a Draft Procedure for Alien Invasive Management.

15 Comments and Response

What will happen to the open pits once mining is completed?	Ellias Hlongwane	Leyden Village	30 September 2015	Village Meeting	As part of mine closure, 80% of the waste rock produced will be backfilled into the pit, and rehabilitated. It must be noted that despite the backfilling of waste rock, the open pit will not be completely backfilled due to a small waste rock volume. The remaining pit area will be rehabilitated and stabilised, prior to closure.

16 Conclusion

The rehabilitation of The Open Pit Magnetite Mine will require significant levels of control and monitoring during implementation if the desired objectives are to be achieved. In brief, these objectives are:

- Produce a free draining, stable topography (excluding the final voids);
- Post closure management of the TSF and Open Voids, with particular emphasis on mitigation measures and management post closure to minimise impacts as far as possible;
- Ensure erosion free, sustainable vegetation growth;
- Rehabilitation, as far as possible, of the affected areas; and
- Minimise long term pollution potential.

Areas affected by mining will require rehabilitation. The biggest risk to manage post closure will be the TSF and the open voids and special attention will need to be implemented for the management of these facilities post closure.

Appendix A: General Rehabilitation Guidelines

1. Standard Land Preparation Guidelines(Chamber of Mines Guideline, 2007)

The following points should be considered during the construction phase of the project:

- Mine planning should minimise the area to be occupied by mine infrastructure. The affected area should be kept as small as practically possible and should be clearly defined and demarcated;
- Care should be taken around sensitive landscapes e.g. areas of critical habitat to ensure that impacts to them are minimal;
- Construction crews should restrict their activities to planned areas. Clear instructions and control systems should be in place and compliance to the instructions should be policed;
- All soil and overburden stockpiles should be located in areas where they will not have to be removed prior to final placement. Materials should thus be placed in their final closure location or as close as practicable to it;
- Soils which cannot be replaced directly onto rehabilitated land should be stockpiled. All stockpiles should be clearly and permanently demarcated and located in defined no-go areas, re-vegetated and monitored on an annual basis;
- Infrastructure should be designed with closure in mind. Infrastructure should either have a clearly defined dual purpose or should be easy to demolish. This aspect of rehabilitation should be considered if changes in the mine design are made;
- Soil stripping is a very important process which determines rehabilitation effectiveness. It should be done in strict compliance with the soil stripping guidelines, which should define the soil horizons to be removed; and
- Include rock quarries and borrow pits in the construction environmental plans.

Soil Stripping

This section explains the correct measures that should be followed during the stripping of soil. This is a key rehabilitation activity because soils lost cannot be regenerated in the lifetime of the mine.

Correct stripping of soils will firstly ensure that enough soils are available for rehabilitation and secondly, that the soils are of adequate quality to support vegetation growth and thus ensure successful rehabilitation.

The steps that should be taken during soil stripping are as follows:

- A soil plan of the mining area is compiled and soils should be stripped making use of this;
- Determine stripping depths, which are dependent on the type of soil identified in the area to be cleared;

- Ensure that mining operations do not impact on soil that is stripped or going to be stripped;
- Demarcate the boundaries of the different soil types;
- Define the cut-off horizons in simple terms so that they are clear to the stripping operator;
- Stripping should be supervised to ensure that the various soils are not mixed;
- Soils should only be stripped when the moisture content will minimise the compaction risk (i.e. when they are dry);
- The subsoil clay layers which can be found under certain hydromorphic soils need to be stripped and stockpiled separately. This clay material can be used as a compacted clay cap over rehabilitated pit areas that will become wetlands post-rehabilitation (stripping of wetland soils should be avoided, however if stripping does occur the above is recommended for stripping and stockpiling);
- Where possible, soils should be stripped and replaced in one action i.e. soils should only be handled once instead of moving it around two or more times.
- Truck and shovel should preferably be used as a means of moving soil, instead of bowlscrapers.

Supervision

A very important aspect is the supervision and monitoring during the stripping process. Close supervision will ensure that soils are being stripped from the correct areas and to the correct depths, and placed on the correct stockpiles with a minimum of compaction. Monitoring requires an assessment of the depth of the soil, the degree of mixing of soil materials and the volumes of soils that are being replaced directly or being placed on stockpiles.

Contracts for the stripping of soils should not only be awarded on the volumes being stripped but also on the capability to strip and place soil accurately.

Stripping Method

Soils should be stripped and replaced using the truck and shovel method as far as possible. This method will limit the compaction of soils. If bowl scrapers are used then the soils must be dry during stripping to minimise compaction.

Stockpiling

This section explains the correct measures to be followed during the stockpiling of soil. Stockpiling should be minimised as far as possible since it increases compaction and decreases the viability of the seed bank. Stripped soil should not be stockpiled but placed directly wherever possible.

The steps that should be taken during soil stockpiling are as follows:

- Mark stockpile locations accurately on a plan to ensure that re-handling is minimised (i.e. soils will not have to be moved a second or third time);
- Ensure that the location is free draining to minimise erosion loss and waterlogging;
- Minimise compaction during stockpile formation. The soils should be kept loose by, preferably, tipping at the edge of the stockpile not driving over the stockpile (avoid end-tipping as this causes compaction);
- Re-vegetate with a native seed mixture (stockpiles that will remain standing for several years); and
- Ensure that the stockpiled soil is only used for the intended purposes.

Stockpile Location

Appropriate mitigation measures for the management of these stockpiles needs to be implemented to ensure that wetlands and drainage paths are not affected and that the loss of topsoil is mitigated against.

Progressive monitoring of the stripping, stockpiling, shaping of spoil surfaces and replacing of topsoil will ensure successful post-mining land and soil reclamation. Assessing post-mining soil characteristics and associated land capability and land uses is necessary, but there is insufficient opportunity to correct failures during the rehabilitation process. A detailed mine rehabilitation plan is thus required to ensure sound rehabilitation practices are adhered to.

The detailed stripping plan should include the following information:

- Location of soil types than can be stripped and stockpiled together;
- Stripping depths of different soil types; and
- The location, dimensions and volume of planned stockpiles for different soil types.

Free Draining Locations

Soils should normally be replaced in the landscape positions they were stripped from. Well drained soil should therefore be replaced in high landscape positions while the wet soil is replaced in lower lying landscape positions.

The locations of the soil stockpiles should be on a topographical crest to ensure free drainage in all directions. If this is not possible then an alternative is a side-slope location with suitable cut-off berms constructed upslope.

Stockpiles that are placed in drainage lines result in soils becoming water logged and a loss of desirable physical and chemical characteristics. Such situations also result in a loss of soils due to erosion. If stockpiles need to be placed here, hydromorphic soils should be stockpiled in the wetter sections.

Compaction

Soils should be stockpiled loosely. Achieving this will depend on the equipment being used during the stripping and stockpiling process.

Soils should be dumped in a single lift if truck and shovel methods are used. If the dumps are too low, then the height could be increased by using a dozer blade or back actor bucket to raise the materials.

The use of heavy machinery should be avoided as it results in the compaction of soils and destruction of the soil structure. It is not recommended that a bowl scraper or grader be used to level and shape the stockpiles.

Soil Stockpile Management

Established stockpiles should be managed to ensure that soil losses are minimised and that additional damage to the physical, chemical or biotic content is minimised. Stockpile soil health, volume and biotic integrity can potentially be harmed by factors including erosion, ‘borrowing’ for other purposes, contamination and water logging.

Stockpiles should be re-vegetated to avoid soil loss due to erosion and weed colonisation if stockpiles remain in the same location for more than one growing season and have not re-vegetated naturally. The looseness of the soil in stockpiles should be preserved (assuming stripping and construction of the stockpiles are done correctly) by fertilising and seeding by hand, hydroseeding or seeding aerially to minimise the introduction of compaction. If stockpiles are already compacted, standard agricultural equipment can be used to establish grass cover. Weed infestation should also be controlled on the stockpiles by approved methods and herbicides.

It is very important that soils are only used for the intended purposes. The dumping of waste materials next to or on stockpiles, contamination by fly-rock from blasting and the pumping out of contaminated water from pit areas are hazards to stockpiles. Employees must be made aware of these hazards and a detailed management and monitoring programme should be put in place.

Compaction and Equipment used during Soil Replacement

Compaction limits the effectiveness of replaced soils. The equipment used during the replacement of the soils has a major impact on the compaction levels. Ideally heavy machinery should not be used to spread and level soils during replacement. 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. The soil piles deposited by the trucks will have to be smoothed before re-vegetating the area.

Compaction and Soil Moisture

The soil moisture content is a determining factor in the degree to which the soils are subject to compaction. Each soil type has a moisture content at which the compactability is maximised. The aim during the replacement (and removal) of soils should be to avoid the moisture content of maximum compaction when moving soils. The best time for stripping and replacement of soils is thus when soil moisture content is lowest which will be during the dry season.

Smoothing Equipment

The soils that are deposited with trucks need to be smoothed before re-vegetation can take place. A dozer (rather than a grader) should preferably be used to smooth the soils since it exerts a lower bearing pressure and thus compacts less than wheeled systems.

If the top- and sub-soils have been mixed during the stripping process then the seed-bank has been diluted excessively and the creation of a seed-bed for planting purposes will be required.

Post-Mining Conceptual Landform Design

The conceptual framework should be set during the permitting phase of the project and this should thus be the end target for the mine planners, managers and other parties involved. The final topography will be a function of the original topography, the mining method and the reshaping strategy.

The landform design should take the following into consideration during the planning phase:

- Volumes of product removed from the pit;
- Expected bulking factors for the remaining materials;
- The requirement to create a final surface with a satisfactory surface water drainage system; and
- Structures used to keep water out of the mined area during the operational phase should be effective post-closure as well.

Drainage Channel Designs

The construction of erosion control channels on the rehabilitated areas should be avoided as far as possible. This can be done if reshaping and soil replacement are done during the dry months, the slopes are short and stabilising vegetation cover establishes in the first rains. In areas where surface water drainage systems are unavoidable, care must be taken that these structures do not make erosion worse.

The consolidation of mine spoils (waste rock and TMF/TSF material) takes many years to complete and once mining stops the water table re-establishes and the wetting-up of the overburden materials may result in further settlement. This can be countered by constructing slopes in the contour banks that are significantly steeper than their equivalents on unmined land and by making sure that the batters are higher. The steeper slopes might result in scouring within the channel but the risk of contour banks or drains breaking will be greatly reduced. All drainage channels, if needed, should be designed by a "competent person" (usually an engineer), who has experience in designing such structures on rehabilitated ground.

2. Vegetation Establishment

This section explains the general principles to be adopted during vegetation establishment and application of fertilisers for rehabilitated areas.

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

- Prevent erosion;
- Re-establish eco-system processes to ensure that a sustainable land use can be established without requiring long-term fertilizer additions; and
- Restore the biodiversity of the area as far as possible.

Climatic Conditions

Planting will be most successful when it is done after the first rains and into freshly prepared fine-tilled seedbeds (provided the soil material is not prone to crusting). Water retention in the seed zone will stimulate germination and can be supported by the application of light vegetation mulches.

Vegetation Conservation

If rare and protected flora species are found on the mining area during construction or operational activities, they should be conserved by removing and relocating them to another section of the project area which is suitable. The rare/protected plants can be kept in a nursery; the plants can then be replanted during rehabilitation of the disturbed areas.

Control and management of alien vegetation will contribute to the conservation of the natural vegetation. The alien species should, therefore, be removed from site and control measures must be implemented to ensure spreading of these species does not occur to other parts of the project area or the surrounding lands. Refer to Appendix B for a Draft Procedure for control of Alien Invasive Plants.

3. General Monitoring and Maintenance Guidelines

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; and
- Proportion of mined land that has been fully rehabilitated.

Final Topography

The topography that is achieved during rehabilitation should be monitored and compared to the planned topography. The rate of development of the pits will determine the intervals between these assessments. The final profile achieved should be acceptable in terms of the surface water drainage requirements and the end land use objectives. The survey department should do an assessment of the reshaping carried out on the site and signoff should be obtained from the rehabilitation specialist before the topsoil is replaced. Particular attention in terms of final topography and achieving the end goals set out would be to monitor the progression of rehabilitation of the Waste Rock Dump. In addition to monitoring vegetation establishment of the Waste Rock Dump is to monitor the topsoil stockpiles on an on-going basis to ensure that these stockpiles are adequate to be used for rehabilitation in terms of amount of topsoil and the conditions of the stockpiles to be used.

Depth of Topsoil Stripped and Replaced

The recovery and effective use of the usable topsoil available is very important. It is also important to undertake regular reconciliation of the volumes stripped, stockpiled and returned to the rehabilitated areas. A topsoil balance can be used to keep track of soil resources on the mine.

A final post-mining rehabilitation performance assessment should be done and information should be adequate for closure applications that involve:

- 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;
- Fertility analysis and soil analysis;
- Representative bulk density analysis.

Erosion Monitoring

Continuous erosion monitoring of rehabilitated areas should be undertaken and zones with excessive erosion should be identified. Erosion can either be quantified or the occurrence there-of simply recorded for the particular location.

Surface Water

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 structures can then be repaired or replaced before they causes significant erosion damage.

Water quality

The quality of all water leaving the property should be monitored on a regular basis to ensure compliance of the various constituents with the standards approved by the government. Samples should be analysed for particulate and soluble contaminants as well as biological.

Additional monitoring should include aquatic biomonitoring (invertebrates, habitat, water quality and fish) on a bi-annual basis (high and low flow) to determine the ecological functioning and health of the rivers and streams, in and around the rehabilitated areas. The ecological functioning of the wetlands should similarly be assessed on an annual basis.

Groundwater

The groundwater levels and quality should be measured and monitored in a similar way to the surface water to determine the impact of the mining activities on the groundwater resources. A hydrogeologist, together with the relevant authorities, should determine the locations of the monitoring boreholes. The monitoring frequency will be determined by the regulator.

Vegetation Species

Biodiversity assessments and surveys should be undertaken by external experts to establish the full range of plants that have become established. Summer and winter samplings should be done during these assessments.

Alien Invasive Control

Alien Species Control

Invasive alien plant species are difficult to control. Methods should be used that are appropriate for the species concerned, as well as to the ecosystem in which they occur.

When controlling weeds and invaders, damage to the environment must be limited to a minimum.

There are four basic methods by which encroachers or weeds are controlled:

- Physical (mechanical):
  - Uprooting (hand pulling);
  - Cutting back;
  - Chopping, slashing and felling; and
  - Ring-barking (girdling).
- Chemical:
  - Foliar application;
  - Stem notching and application;
  - Stump treatment; and
  - Soil treatment.
- Biological treatment which involves the use of host-specific natural enemies of weeds or invaders from the plant's country of origin, to either kill or remove the invasive potential of these plants; and
- Use of chemical treatment must be undertaken by a qualified or trained individual and the chemicals used must be approved by authorities.

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.

Additional Measures

The following additional measures are recommended in order 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 anywhere within the mining area;
- Annual surveys, aimed at updating the alien plant list and establishing and updating the invasive status of each of the alien species, should be carried;
- The transportation of soils or other substrates infested with alien species should be strictly 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, but by also ensuring that cleared alien trees are treated as a valuable wood resource that can be utilised.