Rehabilitation Plan for Lanxess 102 Amendment

Project Number:

LAN3111

Prepared for:

Lanxess Chrome Mining (Pty) Ltd

March 20155

Digby Wells and Associates (South Africa) (Pty) Ltd
(Subsidiary of Digby Wells & Associates (Pty) Ltd). Co. Reg. No. 2010/008577/07. Fern Isle, Section 10, 359 Pretoria Ave Randburg Private Bag X10046, Randburg, 2125, South Africa
Tel: +27 11 789 9495, Fax: +27 11 789 9498, info@digbywells.com, www.digbywells.com

This document has been prepared by Digby Wells Environmental.

Project Name:	**Rehabilitation Plan for Section 102 Amendment for Lanxess Chrome Mine**
Project Code:	**LAN3111**

Name	**Responsibility**	**Signature**	**Date**
Brett Coutts	Report Compiler		March 2015
Wayne Jackson	Reviewer		March 2015

EXECUTIVE SUMMARY

Digby Wells Environmental (Digby Wells) has been appointed by Lanxess to compile a rehabilitation plan for the Lanxess Chrome Mine for the expanded underground section and for the new proposed opencast section, in support of the Section 102 amendment 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.

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 on the earthmoving required to obtain a sustainable topography;
- Develop a conceptual post mining sustainable topography plan;
- Provide recommendations with respect to soil stripping, placement and soil management;
- Provide recommendations regarding vegetation re-establishment and re-enforcement;
- Assist with recommendations regarding water management;
- Provide recommendations for monitoring of rehabilitated areas and post closure environment; and
- Ensure that all recommendations comply with relevant local and national regulatory requirements.

Lanxess Chrome Mine is located 7 km east of Kroondal and 11 km south-east of Rustenburg and falls within the Rustenburg Local Municipality of the North West Province. The current mining rights of Lanxess cover various portions of the farms Kroondal 304 JQ, Rietfontein 338 JQ and Klipfontein 300 JQ. The extent of this area is 952.5 ha. The mine is part of a mineral deposit known as the Bushveld Igneous Complex which holds the majority of South Africa's chrome ore deposits. Currently the only mining that is taking place is done underground. The ore is broken underground and brought to the surface through conveyor belts.

The process will involve the authorisation of the proposed open pit mining operation on the farm Rietfontein 338 JQ (owned by the mine) and the proposed underground mining operations on portions of the farms Kroondal 304 JQ, Klipfontein 300 JQ and Brakspruit 299 JQ. Glencore Operations South Africa (Pty) (Ltd) (formally known as Xstrata) currently holds the mining rights for some of these areas which are currently in the legal process of being transferred to Lanxess.

According to the previous Environmental Management Plan undertaken in 2006, the post-mining land use should be restored to either grazing and/or cultivation and should represent the pre-mining land use, thus the post-mining land use considered for this rehabilitation plan is aligned with the previous EMP.

The rehabilitation of Lanxess Chrome 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, and stable topography (landscape);
- Ensure erosion free, sustainable vegetation;
- Rehabilitation (as far as possible) of the affected areas; and
- Minimise long term pollution potential.

The Lanxess Chrome Mining operation aims to employ concurrent rehabilitation methods (direct replacement) of overburden materials from the current mining strip to the completed mining strips (open voids) with the ultimate goal to return the project area as far as possible back to the most sustainable landscape either the original landscape/topography or to a novel topography that is free draining and matches the surrounding topography.

Based on preliminary calculations done thus far it is assumed that there should be enough material to backfill the open pit that will be left once mining has ceased. In addition to this there should be enough material to rehabilitate and profile the area back to the pre-mining topography or close enough to the pre-mining topography as possible. In the event that the area cannot be rehabilitated back to the pre-mining topography, then the area must be rehabilitated to a state that matches the surrounding topography. Special attention must be given when placing material back into the pit and profiling to ensure that the landscape is free draining and that no ponding of water occurs. It is always important to ensure that there is a reserve of topsoil material for the touch up applications, to fill small depressions that may occur as a result of subsistence.

Conclusion

The rehabilitation of Lanxess Chrome 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);
- Ensure erosion free, sustainable vegetation;
- Rehabilitation, as far as possible, of the affected areas; and
- Minimise long term pollution potential.

In this report two types of management areas (operational and rehabilitated management areas) have been identified which have and will be affected by mining and require rehabilitation. Overburden and soil stockpiles have been measured and the estimates indicate that sufficient material is available on site to create a stable and free draining environment at closure as close to the pre-mining topography as possible.

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SECTION 1:

Introduction and Background Information

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 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 Lanxess Chrome Mine (Pty) Ltd (Lanxess). 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

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- Provide recommendations regarding vegetation re-establishment and re-enforcement;
- Assist with recommendations regarding water management;
- Provide recommendations for monitoring of rehabilitated areas and post closure environment; and

- Ensure that all recommendations comply with relevant local and national regulatory requirements.

3 Legal Setting

Relevant legislation governing mine rehabilitation, closure cost assessment (closure provision), and closure planning is described in the Mineral and Petroleum Resources Development Act (Act No. 28 of 2002) (MRPDA). The definition for environmental management plan as stated in the MPRDA is '*means a plan to manage and rehabilitate the environmental impact as a result of prospecting, reconnaissance, exploration or mining operations conducted under the authority of a reconnaissance permission, prospecting right, reconnaissance permit, exploration right or mining permit, as the case may be*.' Specific sections include the following:

- Section 38 on 'Integrated environmental management and responsibility to remedy';
- Section 39 on 'Environmental management programme and environmental management plan';
- Section 41 'Financial provision for remediation of environmental damage'; and
- Supporting MPRDA Regulations include sections 53 – 57 and 60 – 62.

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 will be considered:

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

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

- Mineral and Petroleum Resources Development Act (Act 28 of 2002): Mineral and Petroleum Resources Development Regulations (2004);
- International Finance Corporation (IFC) Environmental, Health and Safety (EHS) guidelines;
- Mineral and Petroleum Resources Development Act (Act 28 of 2002);
- Amendment Bill of 2007;
- Constitution of the Republic of South Africa Act, 1996 (Act 108 of 1996);
- National Environmental Management Act (Act 107 of 1998), as amended;

- National Water Act (Act 36 of 1998);
- National Environmental Management: Waste Act 2008 (Act No. 59 of 2008), as amended;
- Mine Health and Safety Act (Act 29 of 1996);
- National Environmental Management: Air Quality Act (Act 39 of 2004);
- National Heritage Resources Act (Act 25 of 1999); and
- Conservation Agricultural Resources Act (Act 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 closure and rehabilitation plans to be updated and include updated financial provision. The review must also 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 and will be subjected the same requirements of the environmental management programme with regards to opportunities.

4 Study Area and Brief Project Description

Lanxess Chrome Mine is located 7 km east of Kroondal and 11 km south-east of Rustenburg and falls within the Rustenburg Local Municipality of the North West Province. The current mining rights of Lanxess cover various portions of the farms Kroondal 304 JQ, Rietfontein 338 JQ and Klipfontein 300 JQ. The extent of this area is 952.5 ha. The mine is part of a mineral deposit known as the Bushveld Igneous Complex which holds the majority of South Africa's chrome ore deposits. Currently the only mining that is taking place is done underground. The ore is broken underground and brought to the surface through conveyor belts.

The process will involve the authorisation of the proposed open pit mining operation on the farm Rietfontein 338 JQ (owned by the mine) and the proposed underground mining operations on portions of the farms Kroondal 304 JQ, Klipfontein 300 JQ and Brakspruit 299 JQ. Glencore Operations South Africa (Pty) (Ltd) (formally known as Xstrata) currently holds the mining rights for some of these areas which are currently in the legal process of being transferred to Lanxess.

The registered descriptions of the land for the amended applications are;

- Portion 95 of Kroondal 304 JQ;
- Portion 96 of Kroondal 304 JQ;
- Portion 97 of Kroondal 304 JQ;
- Portion 98 of Kroondal 304 JQ;
- Re of portion 2 of the farm Klipfontein 300 JQ;
- Re of portion 1 and portions 1, 14, 32, 34, 10 and 11 of the farm Rietfontein 338JQ.;
- A portion of mineral area No.2; and
- Wonderkop area: Portion 1 of the farm Spruitfontein 341JQ and portion 17, 18 and 19 (Portions of Portion 12), the remainder of Portion 12 and the Re Portion of the farm Brakspriut 299JQ.

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

- Haul roads;
- Waste dump;
- Open pit and underground workings;
- Office and workshop; and
- Carport.

5 Expertise of the Specialist

The specialist involved in the compilation of the rehabilitation plan was Brett Coutts. His curricula vitae can be made available upon request.

6 Methodology and Approach

There were a number of tasks that were involved in the compilation of this rehabilitation plan for the Lanxess Chrome 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.
- GIS mapping; and
- Report compilation.

7 Assumptions and Limitations

The following assumptions and limitations have been made:

- 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 Lanxess Chrome Mine alter the mining plan with respect to volumes of Chrome 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 rehabilitation plan is based on the current Life of Mine (LoM). If there is a significant change of either other mining areas, or infrastructure the rehabilitation plan will need to be updated to cater for this change;
- This report must be considered as a living document. The report will be updated as information becomes available and monitoring and rehabilitation progresses;
- The hydrogeological impacts associated with the post-closure environment are based on specialist studies conducted. 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;

SECTION 2:

Mining Activities and Baseline Environment

8 Mining Activities and Management

Currently the only mining that is taking place is done underground with the ore being broken underground and brought to the surface on conveyor belts.

Proposed future mining activities will include the expansion into the neighbouring Glencore underground areas as well as the opening of a pit within the existing Lanxess mining right area.

8.1 Opencast Mining

Access to the shallow resource will be made by an opencast pit cut, 1 374m in strike length and down to a vertical depth between 50m and 70m below surface. The programme indicates that there will be free digging up to ±14m.b.s where after opencast blasting operations will take over mining 100m x 300m block sizes at 10m cuts (using Load Haul Dump with excavators and dump trucks). The opencast mining sequence will start on the eastern side of the proposed pit area and progress towards the west. The final void area will be at the western extent of the opencast pit. Waste rock and topsoil will be stockpiled separately to the south of the opencast area. As the opencast mining progresses, the voids created will be backfilled with overburden from the progressive opencast mining, and then overlain by the various soil horizons and rehabilitated. The design of the highwall has been adapted to fit the topography and crown pillar position with an angle of 60°.

Ore production rate is estimated to be 40 000 tons per month with a LOM of 5 years for the opencast pit.

8.1.1 Underground Mining

The underground mining method used will be the standard bord and pillar system. The pillar dimensions and bord widths are such that a safety factor of 1.6 is maintained. Primary extraction is carried out by using drill rigs to drill the faces and conventional explosives. Access to the underground chrome reserves is gained by means of surface declines that are developed from the reef outcrop. Run of Mine clearance is facilitated by a series of conveyor belts fed by underground Load Haul Dump loaders.

It is calculated that the production rate will be 30000 to 40000 tons per month with a total LoM of 14 years.

8.1.2 Reprocessing of tailings

Lanxess has applied in terms of Section102 to obtain the rights to the PGM's in the orebody they are mining. If this is granted they intend to re-mine all the tailings facilities to extract the chrome left in the tailings. The tailings generated as a result of the re-miming of the tailings facilities, containing the PGM's will be sold to potential buyers. The volume of the dump has been surveyed and shows a contained volume of 1,735m^3 with an average content of chromite reporting to the tailings to be between 20% and 23% Cr_2O_3.

8.1.3 Mineral deposit

Lanxess produce four products namely; lumpy ore, metallurgical grade chrome ore, foundry grade chrome ore, and chemical grade chrome ore:

- Lumpy (metallurgical) ore with typically 38% – 41% Cr_2O_3 and a specified size distribution is sold to the ferrochrome industry where it is processed together with coal in an electric furnace to form ferrochrome. Ferrochrome is the master alloy used in the production of a wide range of corrosion and heat resistant stainless steel.
- Metallurgical grade chrome ore with 44% chrome is sold to the local ferrochrome industry where it is processed together with coal in an electric furnace to form ferrochrome.
- Foundry grade chrome ore with a Cr_2O_3 content of typically 46.5% and a strictly specified grain size distribution is used for the manufacture of casting moulds in foundries. The same material is also used in the production of refractory materials.
- Chemical grade chrome ore with a typical Cr_2O_3 content of 46.0% is the raw material for the production of sodium dichromate processed by Lanxess in their other operations (chemical plants), which is the main constituent of all chrome chemicals. Chrome chemicals are used for example as leather tanning agents.

8.1.4 Processing

The Lanxess Chrome Mine processing plant treats LG6 ore to produce the four chrome products by means of Heavy Medium Separation (HMS) in the HMS Plant and Gravity Concentration in the Gravity and Pilot Plants. The HMS plant has a capacity of 3600 tonnes per day and the gravity plant has a capacity of 1800 tons per day. This processing plant will remain in operation and will not be impacted by the proposed activities.

All products are sold to external clients. Chemical grade is also sold to other Lanxess business sites for the production of chrome chemicals. A high level block flow diagram of the processing plant is shown below.

8.2 Infrastructure Requirements

Lanxess is a well-established mine with existing infrastructure which has been operational since 1958. As a result minimal additional infrastructure will be required for the expansion of the activities as the plant has capacity for the proposed 80 000tpm.

8.2.1 Proposed Surface Infrastructure

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

- Haul Roads and Service Road – Approximately 3km of haul roads to accommodate two lanes of traffic. A service road will be constructed to provide access to opencast pit from the southern boundary of the site. These roads will be gravel or tarred;
- Dump – An additional waste rock dump will be required alongside the opencast pit for overburden removed during mining;
- Stockpile – An additional topsoil stockpile will be located between the waste rock dump and the N4 highway. This will be screened off by trees; and
- A small workshop, office block and parking area will be built in the area of the opencast pit.

No additional infrastructure is required for the underground areas.

9 Baseline Environment

9.1 Soils

The project area is dominated by dark well-structured clayey soils (Arcadia and Valsrivier). These soils accounted for 373.77 ha (97.3 %) of the 384.09 ha surveyed. The north-western portion of the site contained shallow rocky soils (Mispah and Glenrosa) type soils, which accounted for 10.32 ha (2.7 %). Table 9-1 provides a summary of the relevant soil survey information for the project.

Table 9-1: A summary table of the soil forms, depths, land capability, and land potential.

Soil form	Depth (m)	Final Land Capability Class
Arcadia (Ar)	1.2	III
Valsrivier (Va)	1.2	III
Mispah (Ms)/ Glenrosa (Gs)	< 0.3	VIII

The dominant land use in the Lanxess project area is that of cultivation (320.83 ha), sorghum is being grown in these heavy clay soils. The land use summary is as follows;

- Cultivated (320.77 ha);
- Grazing (13.04 ha);
- Natural (47.21 ha);
- Infrastructure (1.74 ha); and
- Disturbed (1.27 ha).

9.2 Flora and Fauna

The project area is located in the Savanna Biome of South Africa. The dominant vegetation type, according to literature for the proposed development area is Marikana Thornveld, formally classified as an Endangered vegetation type nationally with none conserved and 55% altered, primarily by cultivation (Mucina & Rutherford 2006).

A total of 71 plant species were recorded on the study site. Of these, one is regarded as SSC, *Boophone distcha*, with no plants on the national list of Protected Trees. Nine invasive species were recorded from Schedules 1 and 3 of Conservation of Agricultural Resources Act, 1983 (Act No. 43 of 1983) (CARA).

The findings for the faunal component of the flora and fauna assessment are presented below.

Table 9-2: A summary table of the Flora and Fauna aspects related to the site.

Faunal group	Findings
Mammals	No mammal species were recorded from the site. However, previous studies confirmed that five species of mammals have been seen in the area of interest (Digby Wells and Associates EIA/EMP report 2008), which are the following: ■ Steenbok; ■ Black Backed Jackal; ■ Yellow Mongoose; ■ Brown Hyena; and ■ South African Hedgehog.
Reptiles and amphibians	One reptiles and no amphibians were recorded
Birds	Twenty one bird species were recorded, none of which are protected.

9.3 Surface Water

The project area is located in the Crocodile West and Marico Water Management Area (WMA 3) within the A22H quaternary catchment. The eastern boundary of the project area lies on the catchment divide between A22H and A21K.

The main water course in the A22H quaternary catchment is the Hex River found on the western side of the Project area, this river joins the Elands River which is a tributary to Crocodile River.

There are two major tributaries to the Hex River namely Sandspruit and Waterkloofspruit. Sandspruit flows from the south of the Project area towards the north-west direction joining the Hex River and

Waterkloofspruit is located on the western side of the Hex River towards the Hex River and it flows towards the eastern direction to join the Hex River.

On the eastern side of the project area is the A21K quaternary catchment which consist of three rivers/streams namely; Sterkstroom Rivers, Kleinwater, Tshukutswe and Maretlwana River. Sterkstroom Rivers is the main river in the quaternary and it drains in the north east direction into the Crocodile River which is a tributary to the Limpopo River.

Within the project boundary, there were no streams or any other water resource that was identified during the site visits.

9.4 Geohydrology

Groundwater information is based on the previous EIA that was conducted.

9.4.1 Groundwater Quality

Regional water chemistry within the Rustenburg Layered suite indicates an average Electrical Conductivity (EC) of 105 mS/m with a very high variance over the geological body. Care should be taken when considering the water for human consumption due to possible elevated nitrate levels.

9.4.2 Acid Base Accounting (ABA)

Six samples were collected for ABA analyses from borehole GC5 to determine the potential for AMD formation. Five samples represented the overburden with the sixth sample being a composite of the ore material to determine if there are major differences in the chemical properties of the between the overburden and ore.

Based on the ABA test results all the samples were classified as having a Medium Neutralising Potential. The Medium Neutralising Potential and absence of sulphur and therefore acid generation potential indicates that no Acid Mine Drainage (AMD) will be formed. Neutral pH, with a high Total Dissolved Solids drainage will also not occur as no first step in the acidification occurs. Neutral Mine Drainage (NMD) is characterised by acidification followed by an adequate buffering capacity to result in a neutral pH, but high salinity from the release of sulphates, acidification and resultant neutralisation by carbonate minerals.

CHAPTER 3:

Rehabilitation Action Plan

10 Rehabilitation Objectives and Approach

10.1 Aims and Objectives

According to the previous EMP undertaken in 2006, the post-mining land use should be restored to either grazing and/or cultivation and should represent the pre-mining land use, thus the post-mining land use considered for this rehabilitation plan is aligned with the previous EMP.

The closure and rehabilitation objectives for the Lanxess Chrome Mine have been defined as the following:

- Return land that has been mined by opencast methods to a land use similar to that which existed prior to mining, so that the management level required to utilise the rehabilitated land is within the means of the farmer/community who uses it;
- Ensure that as little water as possible seeps out of the various sections of the mine, 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;
- Clean up/rehabilitate all stockpiles and loading areas to at least a grazing capability or the prescribed pre-mining landuse;
- 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 project life;
- Implement progressive rehabilitation measures, beginning during the construction and operational phases wherever possible;
- Leave a safe and stable environment for both humans and animals;
- To 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
- To 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 rehabilitation plan is comprised of five major components:

- Re-shaping of the landforms (topography plan);
- Operational and Post-closure water management;
- Replacement of Soils and stripping;
- Re-vegetation of the landscape; and
- Monitoring and Maintenance.

11 Landscape Re-shaping and Water Management

The Lanxess Chrome Mining operation aims to employ concurrent rehabilitation methods (direct replacement) of overburden materials from the current mining strip to the completed mining strips (open voids), with the ultimate goal to return the project area, as far as possible, back to the most sustainable landscape. Either to the original landscape/topography or to a suitable topography that is free draining and matches the surrounding topography.

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 the 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 (i.e. chrome) and thereafter how much will be left to replace for the rehabilitation of the landscape. This section describes the materials balance calculations for the Lanxess 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 30-40%.

Based on preliminary calculations done thus far, it is assumed that there should be enough material to backfill the open pit that will be left once mining has ceased. In addition to this there should be enough material to rehabilitate and profile the area back to the pre-mining topography, or close enough to the pre-mining topography as possible. In the event that the area cannot be rehabilitated back to the pre-mining topography, then the area must be rehabilitated to a state that matches the surrounding topography. Special attention must be given when placing material back into the pit and profiling, to ensure that the landscape is free draining and that no ponding of water occurs. It is always important to ensure that there is a reserve of topsoil material for the touch up applications, to fill small depressions that may occur as a result of subsistence.

11.1.2 Acid Mine Drainage Water Management

It can be anticipated that mining operations will impact on the local groundwater system in terms of quantity and quality. There is the potential for the formation of AMD. These impacts may only become apparent after mining has ceased and the area has been rehabilitated.

If AMD is encountered, there is a very high risk that there will be significant long term negative impact on surface water, groundwater quality, and on aquatic systems, unless the decanted water is effectively intercepted, collected, and treated (expected that decant will occur).

AMD can impact on aquatic environments and once created, metals are released into the surrounding environment and they become readily available to biological organisms. In water, for example, when fish are exposed directly to metal and H^+ ions through their gills, impaired respiration may result from chronic and acute toxicity. Fish are also exposed indirectly to metal through ingestion of contaminated sediments and food items (Jennings *et al*, 2008). The impacts from AMD on aquatic systems can have detrimental impacts to aquatic ecosystems leaving them devoid of most living organisms. This can be further compounded when people and other animals depend on the river system for drinking water and food.

Based on the findings of the ABA tests the risk for AMD formation is considered low, however in the event or risk of AMD formation increased the mitigations measures presented below could potentially be implemented.

If the correct mitigations are not implemented, AMD water could enter the environment and have major impacts on the local water resources. It is of crucial importance that risk associated with potential AMD formation is determined and the appropriate mitigation measure implemented to either mitigate the impact completely or reduce the impact to acceptable levels.

If water is allowed to cover the potential acid generating portions of the mining sequence for the foreseeable future and does not move through the area at a large flow rate, then it is assumed that the rate of oxidation of the these layers will be lower than expected, however the longer term impacts associated with AMD would need to be addressed. The topsoil layer and its vegetation will minimise the movement of oxygen from the atmosphere into rehabilitated areas.

Possible migratory measures could include the following:

- Undertake testing to determine the potential of AMD formation (geochemical testing) for all hard rock formations in the pit to confirm which ones will be the major source of AMD formation;
- Stockpile acid generating material separately from non-acid generating material;
- Place the acid generating material (discard, slurry and potential acid generating waste rock at the bottom of the pit and encapsulate this material with a clay layer (limited to the lower lying areas) to minimise the movement of oxygen between the acid generating and non-acid generating material (place acid generating material at the bottom of the pit);
- Rehabilitate the surface with vegetation as soon as possible to minimise the movement of surface water into the soil (infiltration of surface water);
- Identify groundwater and surface water monitoring locations that are related directly downstream of the decant positions;
- Monitoring these locations on a quarterly basis for the next 10 years to identify trends and to identify if AMD is occurring;
- Reducing groundwater recharge as much as possible;
- Preventing oxygen ingression by rehabilitating opencast areas with an upper layer of soil which is placed over a layer of weathered material or using a capping layer of clay;
- Disposal of all acid generating waste material below the predicted water table in the rehabilitated pits to minimise oxidizing conditions in the material; and
- Preventing water from ponding on rehabilitated areas and ensure a free draining environment over rehabilitated areas;
- If pollution control facilities are located within strategic areas (adjacent to proposed decant points consider utilising these facilities post closure to control decant;
- On-going biomonitoring post closure; and

- Investigations into the potential of constructing a water treatment facility post closure to treat AMD water.

11.2 Topography Design

The post-mining landscape needs to create a sustainable new topography. From the results of the bulking factor calculations, it is possible to return the landscape to a free-flowing environment to resemble the original landscape. The goal is to return the post-mining topography as close to the original landscape as possible.

The post-mining landscape should emulate the surrounding topography and be free draining as noted in the topography description. ***Topography Description*** - Average slopes for the western project boundary range from 0.7 % to -1.0 % for majority of the area, whilst the steeper slopes located at the western and eastern sides of the project area boundary range from 0.3 % to -2.1%.

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 five operational RMA's:

- Pit area;
- Workshop Area;
- Stockpiles (Hards and Soft);
- Topsoil Stockpiles; and
- Haul 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. Appendix A will also form a big role in the management of these areas as there are practical standard guidelines for 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 Rehabilitation and Re-Vegetation

The Lanxess Chrome Mine is dominated by dark well-structured clayey soils (Arcadia and Valsrivier). The north-western portion of the site contained shallow rocky soils (Mispah and Glenrosa) type soils, which accounts for a small portion of the site.

These soils can be stripped and stockpiled together for later use in soil replacement for rehabilitation. The replacement of these soils is aligned with the post-mining landscape and is critical in ensuring successful rehabilitation. 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. The information given in Appendix A will also form a big role in the management of these areas as there are practical standard guidelines for rehabilitation.

Re-vegetation of the backfilled and top-soiled areas is the final action step 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.

Table 12-1: 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	High	Sub-climax	Decreaser	Second season cover

Grass Scientific name	Common name	Perenniality	Grazing Value	Plant succession	Grazing status	Notes
		5 seasons)				

13 Monitoring and Maintenance

The purpose of monitoring is to ensure that the objectives of rehabilitation are met. 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. 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, the two tables given (Table 14-1 and

14-2) for the consolidated actions and activities associated with the rehabilitation of the Lanxess 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).

14.1.1 Stockpile Areas and the Waste Rock Dump

The following activities will take place at closure:

- Any residue stockpiles need to be removed and placed in the base of the final void (excluding the final waste rock dump that will remain);
- It is recommended that the Waste Rock dump be shaped to an 18° slope; and
- Topsoil will be spread over all disturbed areas and re-vegetated.

14.1.2 Open Pit

The following activities will take place at closure and during concurrent rehabilitation:

- The opencast, will start on the Eastern side of the proposed opencast area and progress towards the west;
- As the opencast mining progresses, the voids created will be backfilled with overburden from the progressive opencast mining, and then overlain by the various soil horizons and rehabilitated;
- There will be a final void at the end of life of mine and this will be filled with overburden material;
- The area will be blended in with the surrounding landscape and allowed to be free draining;
- Once the void has been backfilled, 300mm thick topsoil or soft overburden in place of soil will be spread on rehabilitated areas; and
- Once placed, the “growth medium” should then be fertilised, ripped and re-vegetated. A small topsoil stockpile should be left for remedial work.

14.1.3 Infrastructure Areas

The following activities will take place at closure:

- All surface plant, buildings and equipment will be removed from site;
- Foundations will be removed to a meter (1m) below surface and placed in the final void or disposed of at a registered landfill site if required;
- The surface areas will be levelled and vegetated; and

- All haul roads will be ripped and vegetated.

14.1.4 Sealing of the Shaft

The most important aspect in sealing adit shafts is to ensure that the safety considerations associated with such a shaft are met. For the shaft to be sealed adequately, inert building rubble must be backfilled into the shaft, thereby partially plugging the shaft. The sealant is reinforced by a concrete cap, dimensions of which are governed by the size and nature of the shaft. After sealing the adit, the final area will be covered with, sub-soil and 300 mm topsoil and vegetated. The possible formation of methane underground once the shaft has been sealed needs to be taken into account by placing venting boreholes strategically in the area.

14.1.5 Access Roads

Roads required for agricultural activities will be left. All others will be ripped and vegetated.

14.1.6 Power line and Electrical Infrastructure

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

14.2 Monitoring Post Closure

14.2.1 Air Quality

Air quality will continue to be monitored and the programmes used to guide rehabilitation activities until impact are understood and acceptable to a rural area.

14.2.2 Water Monitoring

Ground and surface water monitoring points will continue to be monitored until long term pollution trends are understood.

14.2.3 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 RMA's

Management Area	Aspect	Aim	Actions and Discussion
Pit area	Soil management.	Sustainable soil stripping for later use in rehabilitation.	Strip the soil types together and stockpile together: ▪ Strip the top 30cm of topsoil and stockpile separately from the remaining soil stripped up to a depth of 1.2m. 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.	Conduct direct replacement of hards during roll-over mining where possible. Replace material according to post-mining topographical plan.
Workshop Area	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	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.

stockpiles	Soil management.	Sustainable soil stripping for later use in rehabilitation	Strip the soil as noted above and stockpile the top 30cm separately from the remaining soil stripped.
	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.
Topsoil stockpiles	Soil management	Rehabilitation planning	Strip the soil as noted above and stockpile the top 30cm separately from the remaining soil stripped. Accurately demarcate the soil stockpiles and the type of soil for later use in rehabilitation activities.
	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 as noted above and stockpile the top 30cm separately from the remaining soil stripped.
	Water management	Clean and dirty water separation	Ensure the dirty water drainage leads to the existing pollution control facilities and not into the surrounding wetlands. Practice dust suppression to prevent excessive dust from entering the surrounding environment.

14-2: Rehabilitation, Maintenance and Monitoring Actions and Activities for Post-mining RMA's

Management Area	Aspect	Actions and Discussion
Terrestrial 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 types together and stockpile together: ▪ Strip the top 30cm of topsoil and stockpile separately from the remaining soil stripped up to a depth of 1.2m. 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.
	Vegetation management	See table 12-1 for the recommended see 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 may then occur once the entire project area has been reshaped and rehabilitate according to the post-mining landscape design contained herein. Monitoring needs to continue for a minimum of three 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 rehabilitation plan is updated near the end LoM to plan for monitoring of the rehabilitation efforts.

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.
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.
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 acidity and salt pollution analyses (pH, electrical conductivity and sulphate) at 0-250 mm soil depth every 10 ha; and ■ Fertility analysis (exchangeable cations K, Ca, Mg and Na and phosphorus) every 16 ha (400x400 m). 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 it causes significant erosion damage.
All rehabilitated areas	Groundwater	Groundwater monitoring must be undertaken to monitor potential ground water impacts. The appropriate management of groundwater resources must be implemented in the event of impacts occurring.
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	Area 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
	All Management Areas	Shaping and levelling	Shaping and levelling should be undertaken as the topography plans provided.
	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 available 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 taking	Volumes of material moved should be recorded

Sol Replacement	All Areas	Move soils when Dry	Move/replace soil stockpiles when they are dry
		Spread Overburden	Soft overburden material should be utilized over harder overburden and should be spread evenly over rehabilitated areas.
		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 0,15m; 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 100mm 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
		Seed mixture for wetland areas	Seed wetland 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 Conclusion

The rehabilitation of Lanxess Chrome 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);
- Ensure erosion free, sustainable vegetation;
- Rehabilitation, as far as possible, of the affected areas; and
- Minimise long term pollution potential.

In this report two types of management areas (operational and rehabilitated management areas) have been identified which have and will be affected by mining and require rehabilitation. Overburden and soil stockpiles have been measured and the estimates indicate that sufficient material is available on site to create a stable and free draining environment at closure as close to the pre-mining topography as possible.

Appendix A: General Rehabilitation Guidelines

1 Standard Land Preparation Guidelines

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.

1.1 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 is 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.

1.2 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.

1.3 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.

1.4 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.

1.5 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.

1.5.1 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.

1.6 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. If heavy machinery must be used, then compaction can be reduced by stripping and dumping as thick a cut as possible. Deposition of soils in a single track line may also reduce the compaction of the dumped or replaced soil.

1.7 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.

1.8 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.

1.9 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.

1.10 Multi-Layer Soil Profiles

Replacing soils in the same sequence as they occur in nature (and have been removed) would result in considerable benefits in the re-establishment of the natural soil fertility recycling processes since this will result in the organic-enriched, chemically fertile, soil zone being located in the zone of maximum plant root exploitation.

Multi-layer replacement of soils is not, however, ideal from a compaction point of view because each layer needs to be deposited and levelled before the next is replaced. Compaction of the re-created profile can be reduced, provided the correct equipment is used. Soils should also be dry when it is replaced in layers. In any event, ripping through all layers of the re-created multi-layer profile will be essential.

1.11 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.

1.12 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.

1.13 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 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

2.1 Vegetation Establishment

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

The main aim when re-vegetating the pits and infrastructure footprints is to restore the areas back to the pre-mining environment so that they are self-sustaining with a natural nutrient cycle in place and with ecological succession initiated.

Although the rehabilitated land may have variable land capability, including arable land capability for some areas (limited), the main aim of this re-vegetation process is to establish a stable, sustainable vegetative cover.

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.

2.2 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.

2.3 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.

3.1 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.

3.2 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.

3.3 Chemical, Physical and Biological Status of Replaced Soils

3.3.1 Erosion

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.

3.4 Surface Water

3.4.1 Drainage systems

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

3.4.2 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.

3.4.3 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.

3.5 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.

3.6 Alien Invasive Control

3.6.1 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.

3.6.2 Integrated Control Strategies

The satisfactory control of weeds and other invasive species is usually only achieved when several complementary methods, including biological control, improved land management practices, herbicides and mechanical methods, are carefully integrated. Such a strategy is termed an Integrated Control Strategy (ICS).

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

3.6.3 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.

Appendix B: Draft Alien Invasive Management Procedure

1. Purpose

The purpose of this procedure is to ensure the effective control and eradication of Alien Invasive Plants (AIPs). AIPs are plants that have been introduced either intentionally or unintentionally, into an area or ecosystem in which they do not naturally occur.

2. Scope

The application of this procedure is limited to AIPs. The procedure provides a generic control for the control and eradication of AIPs. In addition to the general principles outlined in this procedure Lanxess must compile and implement a declared invader control and management plan according to Alien and Invasive Species Lists, 2014 (GN R599 in GG 37886 of 1 August 2014) of the NEMBA (Act 10 of 2004).

3. Prerequisites

- Alien Invasive field survey with the key invasives identified and appropriate control procedures confirmed for each AIP
- Risk assessment for using hand axes and chainsaws;
- Appropriate PPE is utilised; and
- Ensure people are correctly trained in the machinery used.

4. Procedure

Pre task Activities

Undertake a desktop demarcation exercise, in order to demarcate the site into workable units or areas to be cleared of AIPs. Once demarcated, these areas are to be ranked according to priority, taking factors such as amount of vegetation occurring in the area, type of vegetation or AIPs, the location on site, and proximity to sensitive environmental features. If required, these areas can be further sub-divided into plots in order to allow for a systematic approach when undertaking clearing activities.

Clearing of AIPs is to be approached systematically according to highest priority areas first, then progressing to lower priority areas. All AIPs within demarcated areas are to be identified prior to clearing activities commencing, in order to allow for the availability of herbicides to be used, as well as to allow for the correct allocation of mechanical equipment to be used and to ensure that only AIPs are removed and no other natural vegetation that may occur within the demarcated area is affected by the removal of AIPs.

Clearing Activities

The following task should be undertaken during the clearing of vegetation:

1 Clearing activities must be supervised at all times.

2 Invasive Alien Plants can be controlled using one or a combination of three methods:

- Physical/Mechanical methods - felling, physical removal of plants, often in conjunction with burning;
- Chemical methods - using environmentally safe herbicides and
- Biological control - using species-specific insects and diseases from the alien plant's country of origin.

3 Often, an integrated approached is preferred, whereby a combination of the above methods is used in combination with follow up clearing and rehabilitation

4 Mechanical and chemical control are short-term activities, whereas rigorous and disciplined follow-up and rehabilitation are necessary in the medium term, biological control can provide effective control in the short and medium term in some cases, and it is often the only really sustainable solution in the longer term

5 Mechanical control options include the physical felling or uprooting of plants and their removal from the site. The equipment used in mechanical / physical control ranges from hand-held instruments (hand pruners, hand saws, loppers and axes) to power-driven tools such as handsaws, chainsaws, or a string trimmer outfitted with a circular saw blade, and even to bulldozers in some cases. Mechanical control is labour-intensive and thus expensive to use in extensive and dense infestations, or in remote or rugged areas.

6 Mechanical/physical control methods include:

- Hand pulling;
- Stem cutting of small trees (using hand pruners, hand saws, loppers and axes);
- Stem cutting of large trees (using mechanical / power driven tools and devices such as handsaws, chainsaws, or a string trimmer outfitted with a circular saw blade);
- Ring barking (de-barking, bark stripping);
- Felling;
- Mechanical removal using bulldozers; and
- Frilling.

7 Chemical control methods often involve some form of mechanical / physical control to aid in the application of herbicides. Protection of the environment is of prime importance. Riparian areas, where most AIPs infestation occurs, require a particularly careful approach. Only herbicides that are approved for use in riparian areas and aquatic environments should be used. It is recommended that the use of chemical

herbicides near aquatic environments be avoided and mechanical removal is undertaken.

8 Employees tasked with the handling, use and application of herbicides shall be informed of the risk of working with the selected chemicals and how to avoid that risk and shall receive appropriate hazardous chemicals training. The method and rate of application of all herbicides must be done according to label instructions.

9 Herbicide application must not take place in unsuitable weather conditions; e.g. foliar application in windy conditions. Application methods must be monitored for correct targeting, rates and to avoid spray drift.

10 Herbicides and equipment will be stored in a designated, demarcated site:

- Away from rest / eating areas;
- At least 20m from any water body (rivers);
- Away from indigenous vegetation/crops/gardens etc;
- Containers must be leak-proof;
- Containers must be UV resistant and stored in shade or under cover to prevent degradation of the herbicide;
- Containers must be clearly labelled, showing the herbicide concentration of the contents;
- Label must be on-site for each herbicide used on site;
- Containers must stand on a suitably absorbent material to absorb accidental drips and leaks;
- Refilling must be done using a funnel or spout to prevent spillage and on similar absorbent material;
- Refilling and mixing must not be done near natural water bodies or desirable vegetation;
- Washing and rinsing may not be done in natural water bodies or thrown away on site;
- Have a bucket, spade and absorbent material available in case of spills;

11 When handling herbicides in the field the following is to be adhered to:

- All the above handling instructions shall apply;
- Containers should stand on suitable absorbent material, e.g. a large piece of thick hesian sack, that will absorb minor drips, out of direct sunlight in a cool place;
- Containers must be kept at least 20m away from water bodies;

- Filling sites should be selected to prevent damage to desirable vegetation and to enable spillage to be cleaned up and disposed of;
- Spray mixture containers must be clearly labelled and only reused for the specific herbicide;
- Application equipment and containers should not be cleaned on site but at a suitable designated area at the store;
- Suitable PPE as described on herbicide label instructions must be worn by operators when handling and applying herbicides. At a minimum this is to include suitable protective clothing, overalls, rubber boots, gloves and eye protection;
- Cleared AIPs, vegetation and debris is removed and disposed in the appropriate manner.

12 When disposing of herbicides and herbicide containers and equipment the following is to be adhered to:

- Disposal shall take place in accordance with all site hazardous materials management and waste disposal procedures;
- The Health and Safety Officer shall ensure that disposal procedures are adhered to;
- Empty containers should be returned to the store for safe keeping and disposal;
- Arrangements can be made to return containers to the supplier;

13 Chemical control methods include:

- Foliar spray;
- Frilling;
- Basal bark;
- Cut stump; and
- Stem injection.

14 Rehabilitation should occur directly after control activities.

5. Responsibilities

The Table below provides roles and responsibilities of the people that will be responsible for implementing this procedure. The responsibilities of the contractor need to be documented in contract documents (Contractors Agreement).

Position	Responsibility
Environmental Officer	Maintain records of areas cleared and manage the clearing process

Contractor	Responsible for clearing I&APs
Specialist	Conduct survey for AIPs and define appropriate control measures for each AIP identified (with the assistance of the Environmental Officer)
All Employees	Ensure the procedure is followed when eradicating I&APs

6. Document Control

Document control will be as per Lanxess Environmental Management Systems, which should comply with a system like ISO or equivalent.