DIGBY WELLS ENVIRONMENTAL

Environmental Impact Assessment for Sibanye Gold Limited's West Rand Tailings Retreatment Project

Rehabilitation Report

Project Number:

GOL2376

Prepared for:

Sibanye Gold Limited

July 2015

This document has been prepared by Digby Wells Environmental.

Report Type:	**Rehabilitation Report**
Project Name:	**Environmental Impact Assessment for Sibanye Gold Limited's West Rand Tailings Retreatment Project**
Project Code:	**GOL2376**

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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 Sibanye Gold Limited, other than fair remuneration for work performed, specifically in connection with the proposed West Rand Tailings Retreatment Project, Gauteng Province.

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EXECUTIVE SUMMARY

The activities proposed by Sibanye Gold Limited (Sibanye) included in their West Rand Tailings Retreatment Project require a Rehabilitation plan. This report describes the rehabilitation plan developed by Digby Wells Environmental (Digby Wells). The activities involved in the rehabilitation of all proposed infrastructure, processing plant and Tailings Storage Facilities (TSF's) associated with this project are therefore described.

The specialist studies that will be conducted have aided in the compilation of the rehabilitation plan. Rehabilitation and closure objectives need to be tailored to the project at hand and be aligned with the Environmental Management Plan (EMP). The rehabilitation objectives for the project are as follows:

- Maintain and minimise impacts to the ecosystem within the study area;
- Provide practical rehabilitation measures for rehabilitation of the Driefontein Dumps (DRI3 and DRI5), the Cooke Dump, Ezulwini South and the Regional TSF (RTSF);
- Identification of suitable end post reclamation land capability and land use and potential identification of what the future land use could be for these areas;
- Provide suitable vegetation establishment techniques that can be adopted for the two dumps that will be reclaimed and for the RTSF;
- Implement progressive rehabilitation measures where possible;
- Reduction in dust contamination and generation of dust from historic facilities through rehabilitation efforts and concurrent rehabilitation;
- Prevent soil, surface water and groundwater contamination by removing old tailings off dolomites and reducing the risk of sinkhole formation;
- Comply with the relevant local and national regulatory requirements; and
- Maintain and monitor the rehabilitated areas post reclamation and final capping of the RTSF.

The Sibanye Gold Study Area is located mainly within the Far West Rand Goldfield between Carletonville and Krugersdorp, North West of Johannesburg. The Far West Rand Goldfied includes all the mines occurring to the south of the Witpoortjie gap and west of the West Rand syncline. Traditionally this Goldfield incorporated the mines between Randfontein and the Mooi River, and between the Wonderfonteinspruit and Fochville. The Far West Rand goldfield is separated from the West Rand Goldfield by the Witpoortjie fault.

The rehabilitation phase is regarded to include activities which are largely positive, however ineffective management and implementation may result in negative impacts that could occur post closure and require mitigation to reduce the risk to the receiving environment. The report provides recommendations for particular aspects, however are not limited to the to what is discussed in this report and further consideration with respect to post closure mitigation can be extracted from the various specialist studies conducted.

The following concerns are noteworthy with regards to this project. Successful implementation of the rehabilitation plan should result in these concerns being limited.

- Risk of erosion on the RTSF;
- Wind erosion as a result of poor physical cover will have a negative effect on the surrounding areas should rehabilitation not be successfully implemented. It is common that grass covers are short-lived on gold TSF's. This should be avoided as best as possible;
- Access to site and potential exposure to radiation levels that exceed the recommended levels. Until the area is successfully remediated and the levels radiation confirmed to be within the guidelines, access to these areas needs to be controlled;
- Access should be limited to the TSF, RTSF and plant areas through the installation of fences and effective security to ensure that people and animals are not exposed to harm and hazards; and
- Monitoring should be undertaken to ensure that rehabilitation efforts have been successful.

In conclusion the overall positive impacts of the proposed project and for the additional phases may outweigh the negative impacts associated with the project and the historical impacts that have occurred as a result of historical mining in the area. This project is crucial with respect to rectifying historical impacts and minimising future environmental disasters that could occur if the proposed project is not undertaken. The proposed project itself does have its own risks and impacts associated with post closure. If rehabilitation and post closure mitigation is adopted correctly minimisation of these impacts could be achieved through appropriate management and responsible care.

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1 Introduction

The activities proposed by Sibanye Gold Limited (Sibanye) for the West Rand Tailings Retreatment Project (WRTRP) require a Rehabilitation plan. This report describes the rehabilitation plan developed by Digby Wells Environmental (Digby Wells). The activities involved in the rehabilitation of all proposed infrastructure, processing plant and Tailings Storage Facilities (TSF's) associated with this project are therefore described.

It is widely recognised that landscape rehabilitation, post mining is essential in order 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).

Gold and uranium mining operations commenced in the late 1800s in the Witwatersrand Basin gold fields of South Africa, and have resulted in the accumulation of substantial amounts of tailings and other mine residues (Mokgalaka-Matlala *et al.*, 2010).

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.

Problems such as Acid Mine Drainage (AMD), radioactivity and Cyanide pollution must be considered in the rehabilitation of this project. The rehabilitation of footprints of reclaimed TSFs needs to be considered in the long term. It is vital that the rehabilitation is relevant to the end land-use objectives. It is impossible to determine the rehabilitation measures or objectives with the aim of achieving mine closure unless the future land use has been determined in the context of societal and economic expectations (Liefferink M *et al*. 2014).

The rehabilitation of this project 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).

This report should be seen as a living document and will be updated during the life of the project, as additional information becomes available.

1.1 Project background

Sibanye Gold (Registration Number 2002/031431/06) (formerly known as GFI Mining South Africa (Pty) Limited, Registration Number 2002/031431/07) was prior to February 2013, a subsidiary within the Gold Fields Group. In early 2013 Gold Fields unbundled its Kloof Driefontein Complex (KDC) and Beatrix gold mines in the Free State to create Sibanye Gold and listed them as a fully independent company on both the Johannesburg Stock Exchange (JSE) and the New York Stock Exchange (NYSE).

In parallel, in 2012 Gold One International Limited (Gold One) acquired Rand Uranium Limited (Rand Uranium) and in the same year acquired the Ezulwini Mining Company (Pty) Ltd (Ezulwini) in an agreement with First Uranium Corporation.

Subsequently, in October 2013, Sibanye Gold purchased the interest held by Gold One in Rand Uranium and Ezulwini. These Gold One assets are now part of Sibanye Gold, and include the Cooke Operations (underground mining and surface reclamation operations), that currently produce gold and uranium.

Prior to the creation of Sibanye Gold, Gold Fields had embarked on a project known as the West Wits Project (WWP), aimed at retreating several TSFs on the West Rand to recover residual gold, uranium and sulphur, where viable, and storing the tailings on a new Central TSF (CTSF). Similarly Rand Uranium had embarked on the Cooke Uranium Project (CUP) which endeavoured to treat the Cooke TSF for gold, uranium and sulphur and ultimately deposit the tailings on to the Geluksdal TSF. Essentially two independent projects with similar processing infrastructure and deposition sites, within a 25 km radius of each other.

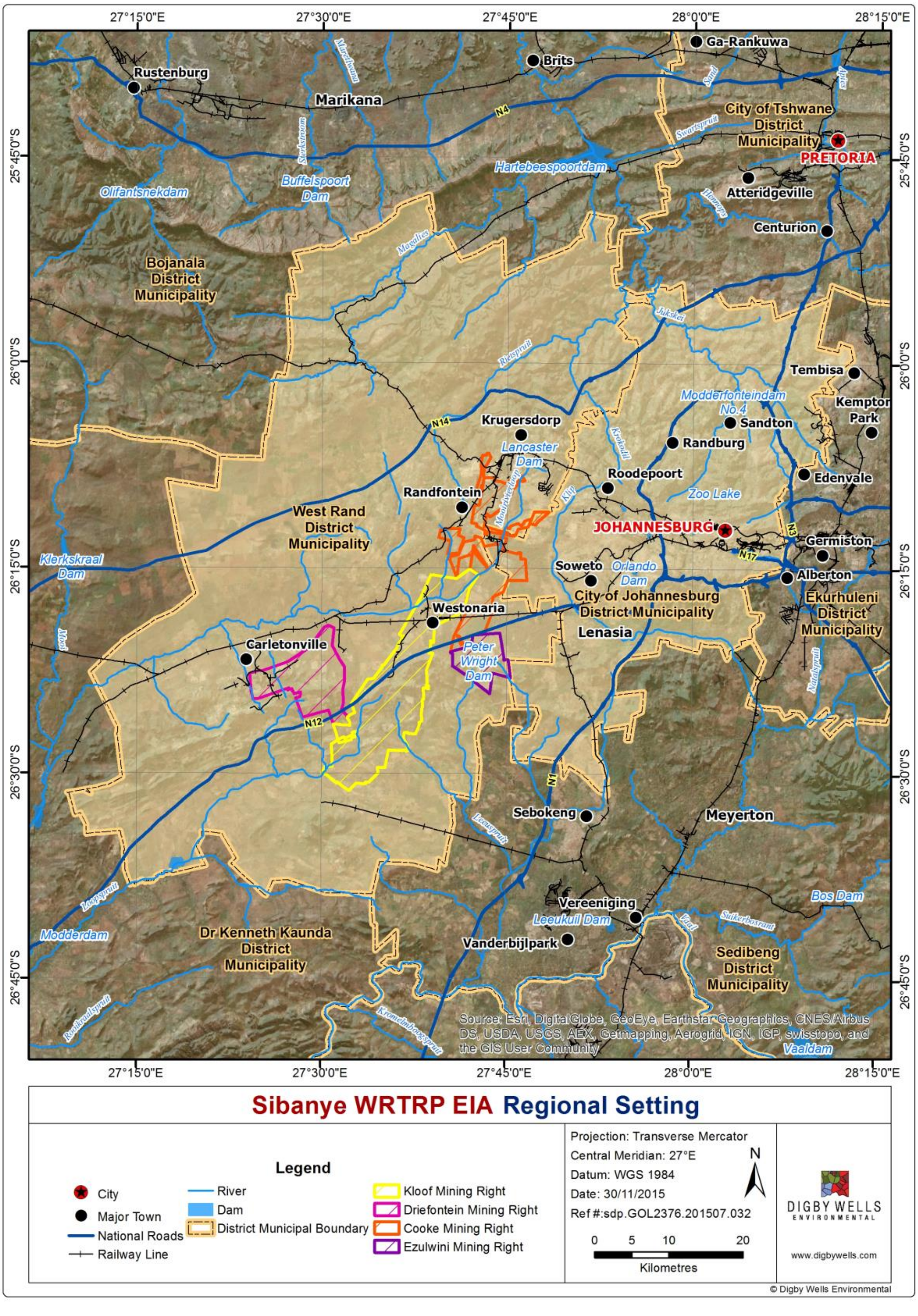
The WRTRP now integrates the WWP and CUP into one project, where all the surface TSFs and current arisings, previously under the control of Gold Fields, Rand Uranium and Ezulwini, will be centrally processed through the Central Processing Plant (CPP) and the residue deposited onto a new Regional TSF (RTSF).

Sibanye's holdings in the West Rand can be divided into three block areas or clusters; the Northern, Southern and Western Cluster/ Blocks, see Plan 1. Each of these blocks contains historical TSFs and each will be reclaimed in a phased approach with the Driefontein 3 and 5 TSFs being the first TSFs to be reclaimed as part of the Western Cluster area. The areas are classified as follows:

- **Western Block comprises**: Driefontein TSF's numbers 1, 2, 3, 4 and 5, and Libanon TSF;
- **Northern Block comprises**: Cooke TSF, Venterspost North TSF, Venterspost South TSF and Millsite Complex (38, 39 and 40/41 and Valley); and
- **Southern Block comprises**: Kloof No.1 TSF, Kloof No.2 TSF, South Shaft TSF (future), Twin Shaft TSF (future), Leeudoorn TSF and C4S TSF.

Once commissioned, the project will initially reclaim and treat the TSFs at a rate of 1.5 Million tons per month (Mt/month). Reclamation and processing capacity will ultimately ramp up to 4 Mt/m over an anticipated period of eight years. At the 4 Mt/m tailings retreatment capacity, each of the blocks will be reclaimed and processed simultaneously.

The tailings material will be centrally treated in the CPP. In addition to gold extraction, uranium will also be extracted and ultimately the sulfur will be extracted to produce sulfuric acid, an important reagent required for uranium leaching.



Plan 1: Regional setting

The tailings reclamation process is essentially a hydraulic mining operation, where the TSFs will be hydraulically reclaimed to the natural ground level in nominal 12 m to 15 m benches and the footprint rehabilitated to a suitable land use. Water will be supplied to the reclamation sites, from existing impacted mine water sources, and then pressurised through a high pressure pumping system before reporting to the top of the TSFs. Monitoring guns will be used at the reclamation site to slurry the tailings material. The reclaimed material, in the form of slurry, will flow through an open channel via screens to remove oversized debris from the slurry before it enters a tank. A series of pumps will then pump the slurry from the tanks to the CPP for gold, uranium and ultimately sulfur extraction.

Current practice is that AMD is neutralised with lime/limestone (through a High Density Separation (HDS) process), causing uranium and other metals to co-precipitate with gypsum, which results in the formation of radioactive sludge. This is not Sibanye's preferred methodology. The WRTRP will employ ion exchange technology to selectively remove uranium from tailings before lime neutralisation, resulting in non-radioactive sludge and a useful uranium by-product.

In order to minimise the upfront capital required for the development of the CPP and to launch a viable economic start to the larger project, only the floatation cells and a gold processing unit will be developed during the initial phase. Existing and available infrastructure will be used to process the uranium until the volumetric increase in tonnage necessitates the need to expand the CPP for uranium treatment. The Ezulwini Gold and Uranium Plant will be used to receive uranium concentrate from the CPP and recover the uranium and residual gold. The tailings from the CPP to the Ezulwini plant, being approximately 50 000 t/m, will be mixed with the current Ezulwini plant tailings and disposed of at the currently operational Ezulwini North TSF. The CPP will be developed in modules from the original 1 Mt/month to the ultimate 4 Mt/m.

The construction and operation of a new deposition site for the residue from the CPP is to be located in an area that has been extensively studied as part of the original WWP and CUP. The "deposition area" on which the project is focussing, has been termed the RTSF and is anticipated to accommodate the tonnage from the district. The RTSF, if proven viable, will be one large facility as opposed to the two independent deposition facilities proposed by the WWP and CUP respectively.

In Figure 1-1, a high-level overview is provided of the process to be used as part of the proposed WRTRP.

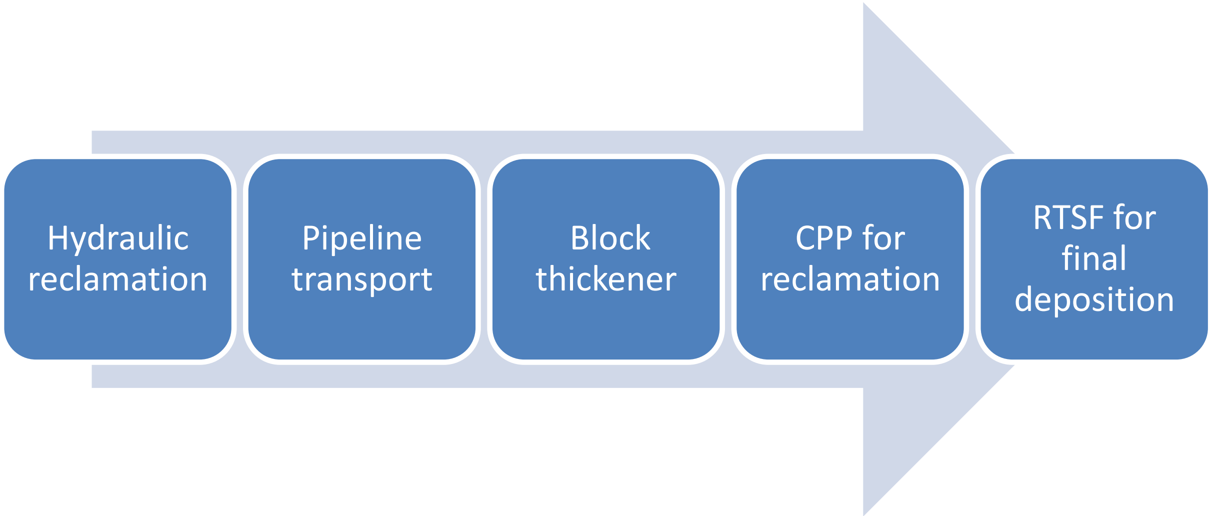


Figure 1-1: Basic process flow diagram

The WRTRP will be developed in a phased approach. The various phases and anticipated commissioning dates are detailed below:

- **Phase 1:** This phase is a continuance of the current surface reclamation operation through the existing Cooke Plant. The existing Cooke Plant is currently operational and processing TSFs called Dump 20 slime and Lindum North at a rate of 400 000 t/m with deposition into existing open pits. During this phase, Dump 20 and Lindum will be depleted and a portion of the Millsite complex reclaimed. Phase 1 will continue whilst the CPP, RTSF and associated infrastructure are being constructed. This phase is expected to continue to 2018 or until the pit deposition is exhausted;
- **Phase 2:** Design and construct the CPP (one gold module and floatation plant) to treat 1 Mt/m from the Driefontein 3 and 5 TSFs in the Western Cluster. The resultant tailings will be deposited onto the new RTSF. A high grade uranium concentrate, produced at the CPP, will be transported to Ezulwini (50 000 tonnes per month) for the extraction of uranium and gold. The tailings from this process will be deposited on the existing operational Ezulwini North TSF. Once the Driefontein 3 and 5 TSFs have been depleted the remainder of the Western Cluster TSFs, namely; Driefontein 1, 2 and 4 and the Libanon TSF will be processed through the CPP;
- **Phase 3:** The reclamation of the Cooke TSF will commence during this phase. This will necessitate the construction of the first uranium module of the CPP which will entail a uranium plant with a roaster and acid plant. An additional (second) floatation/gold plant will also be constructed as part of the module. The mining of the Southern Cluster will be initiated during this phase which includes:
  - Kloof 1, 2, Old 4 and Leeudoorn TSF; and
  - The tailings resulting from this phase will be deposited onto the RTSF.
- **Phase 4:** This phase sees the introduction of the Northern Cluster. The CPP will be expanded with another floatation/gold module, a uranium module and a roaster and

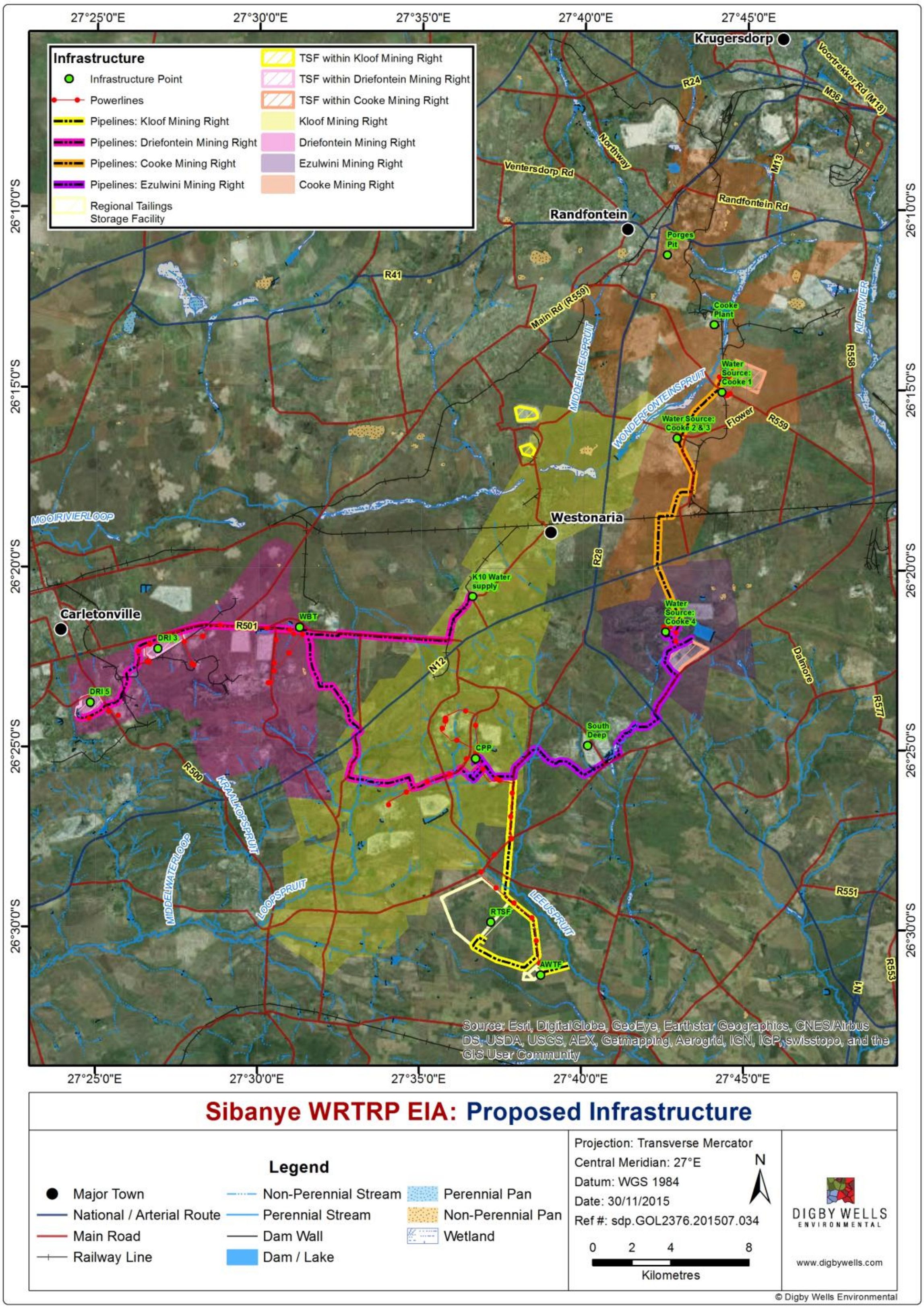
acid plant. The TSFs to be reclaimed include Venterspost North and South and the balance of Millsite. The reclamation of the Driefontein (Western cluster) and Kloof TSFs (Southern cluster) will continue as per phase 2 and 3 with all the tailings being deposited on the RTSF.

The following primary activities of the WRTRP need to be assessed. Refer to Plan 2 depicting the proposed infrastructure.

Table 1-1: Primary activities of the WRTRP

Category	Activity
Kloof Mining Right area	
Infrastructure	Pipeline Routes (residual tailings).
	Central processing Plant (CPP) incorporating Module 1 float and gold plants and uranium, roaster and acid plants.
	The Regional Tailings Storage Facility (RTSF), RTSF Return Water Dam (RWD) and the Advanced Water Treatment Facility (AWTF). Collectively known as the RTSF complex.
Processes	Abstraction of water from K10 shaft
	Disposal of the residue from the AWTF.
	Gold, uranium and sulfur extraction at the CPP (tailings to RTSF)
	Water distribution at the AWTF for discharge.
Pumping	Pumping of up to 1.5 Mt/m of tailings to the RTSF.
	Pumping water from the RTSF return water dams to the AWTF.
	Discharging treated water to the Leeuspruit.
Electricity supply	Power supply from Kloof 1 substation to the CPP.
	Power supply from Kloof 4 substation to the RTSF and AWTF.
Driefontein Mining Right area	
Infrastructure	Pipeline Routes (water, slurry and thickened tailings).
	West block Thickener (WBT) and Bulk Water Storage Facility (BWSF) complex.
	Collection sumps and pump stations at the Driefontein 3 and 5 TSFs
Processes	Hydraulic reclamation of the Driefontein 3 and 5 TSFs.
Pumping	Pumping water from K10 to the BWSF located next to the WBT.
	Pumping water from the BWSF to the Driefontein TSFs that will be reclaimed.(Dri3 & 5 TSFs)
	Pumping slurry from the TSF sump to the WBT (for Driefontein 3 and 5 TSFs).

Category	Activity
	Pumping the thickened slurry from the WBT to the CPP.
Electricity supply	Power supply from West Driefontein 6 substation to Driefontein 3 TSF.
	Power supply from West Driefontein Gold substation to Driefontein 5 TSF.
	Power supply from East Driefontein Shaft substation to WBT and BWSF.
Cooke Mining Right area	
Infrastructure	Pipeline Routes (water, slurry and thickened tailings).
	Cooke thickener and BWSF.
	Collection sumps and pump stations at the Cooke TSF.
Processes	Abstraction of water from Cooke 1 shaft.
	Hydraulic reclamation of the Cooke TSF (which include temporary storage of the slurry in a sump).
Pumping	Pumping 500 kt/m of tailings from the Cooke TSF to the Cooke thickener.
	Pumping from the Cooke thickener to the CPP via Ezulwini.
Electricity supply	Power supply from the Cooke substation to the Cooke thickener.
	Power supply from the Cooke Plant to the Cooke TSF
Ezulwini Mining Right area	
Processes	Uranium extraction at Ezulwini (tailings to Ezulwini North Dump).
	Abstraction of water from Cooke shaft.
Pumping	Pumping water from Cooke 4 Shaft to the C4S TSF for reclamation.
	Pumping slurry from the TSF sump to the CPP.
Electricity supply	Power supply from Ezulwini plant to the C4S TSF



Plan 2: Proposed infrastructure within Sibanye Gold Study Area

1.2 Terms of reference

1.2.1 Legal Requirements

Relevant legislation governing mine rehabilitation, closure cost assessment (closure provision) and closure planning is described in the Mineral and Petroleum Resources Development Act, 2002 (Act No. 28 of 2002) (MRPDA). The definition for an 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'; 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, 2002 (Act No. 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, 2002 (Act No. 28 of 2002);
- Amendment Bill of 2007;
- Constitution of the Republic of South Africa Act, 1996 (Act No. 108 of 1996);
- National Environmental Management Act, 1998 (Act No. 107 of 1998), as amended;
- National Water Act, 1998 (Act No. 36 of 1998);

- National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008), as amended;
- Mine Health and Safety Act (Act No. 29 of 1996);
- National Environmental Management: Air Quality Act (Act No.39 of 2004);
- National Heritage Resources Act (Act No.25 of 1999); and
- Conservation Agricultural Resources Act (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.

2 Details 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) and undertaking ecological assessments.

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

3 Aims and Objectives

The main aim in developing this rehabilitation plan is to mitigate the impacts caused by mining and industrial activities and to restore land back to a satisfactory standard that is ultimately sustainable and aligned with the end land use. It is best practice to develop the rehabilitation plan as early as possible so as to ensure the optimal management of rehabilitation issues that may arise. It is critical that a closure and rehabilitation plan is defined and understood from before mining progresses and is complimentary to the rehabilitation goals. Internationally and in the South African context, the broad rehabilitation objectives include three schools of thought, explained below:

- Restoration of previous land capability and land use;
- No net loss of biodiversity; and
- What the affected community wants, the affected community gets.

In accordance with applicable legislative requirements for mine closure, the holder of a prospecting right, mining right, retention permit or mining permit must ensure that:

- The closure of a prospecting or mining operation incorporates a process which must start at the commencement of the operation and continue throughout the life of the operation;
- Risks pertaining to environmental impacts must be quantified and managed proactively, which includes the gathering of relevant information throughout the life of a prospecting or mining operation;
- The safety and health requirements in terms of the Mine Health and Safety Act, 1996 (Act No. 29 of 1996) are complied with;
- Residual and possible latent environmental impacts are identified and quantified;
- The land is rehabilitated, as far as is practicable, to its natural state, or to a predetermined and agreed standard or land use which conforms with the concept of sustainable development; and
- Prospecting or mining operations are closed efficiently and cost effectively.

The specialist studies that were conducted have aided in the compilation of the rehabilitation plan. Rehabilitation and closure objectives need to be tailored to the project at hand and be aligned with the EMP. The rehabilitation objectives for the project are as follows:

- Maintain and minimise impacts to the ecosystem within the study area;
- Provide practical rehabilitation measures for rehabilitation of the Driefontein Dumps (DRI3 and DRI5), the Cooke Dump, Ezulwini South and the RTSF;
- Identification of suitable end post reclamation land capability and land use and potential identification of what the future land use could be for these areas;
- Provide suitable vegetation establishment techniques that can be adopted for the two dumps that will be reclaimed and for the RTSF;
- Implement progressive rehabilitation measures where possible;
- Reduction is dust contamination and generation of dust from historic facilities through rehabilitation efforts and concurrent rehabilitation;
- Prevent soil, surface water and groundwater contamination by removing old tailings off dolomites and reducing the risk of sinkhole formation;
- Comply with the relevant local and national regulatory requirements; and

- Maintain and monitor the rehabilitated areas post reclamation and final capping of the RTSF.

This Rehabilitation plan aims to inform the rehabilitation of the following aspects:

- Providing rehabilitation measures for footprints of the Driefontein Dumps (DRI3 and DRI5), Cooke Dump, Ezulwini South Dumps and once reclamation activities are complete, including the following:
  - Recommendations on the potential future land use;
  - Re-vegetation techniques (shaping and seeding); and
  - Monitoring after rehabilitation.
- Provide rehabilitation measures for the associated pipeline routes after construction activities have been undertaken and rehabilitation post closure of the pipelines with specific emphasis regarding the following:
  - Specific recommendations regarding remediation measures to be implemented for sensitive environments, such as rocky outcrops and wetlands, if applicable;
  - Recommendations regarding re-vegetation techniques;
  - Follow up monitoring; and
  - Alien Invasive Plant Management.
- Rehabilitation of the CPP Plant footprint;
- Rehabilitation of the RTSF footprint to include the following:
  - Recommendations for shaping and capping of the RTSF;
  - Re-vegetation techniques;
  - Long term monitoring and follow up rehabilitation; and
  - Possible recommendations associated with decant management.

4 Methodology

4.1 Literature review and desktop assessment

Various legal requirements served as guidelines to the compilation of this rehabilitation plan. Other documents that were reviewed include:

- Previous and current environmental studies;
- Academic papers relating to best practice,
- Recent findings and the analysis of aerial imagery for the Sibanye Gold study area (hereafter study area); and

- The Draft Regional Closure Strategy for the far West Rand Goldfield and the West Rand Goldfield (Council of Geoscience Reports).

4.2 Site Visit

A site visit to the study area was conducted at the end of April 2015. The site visit served to orientate and identify the various structures within the proposed landscape.

5 Assumptions and Limitations

The following assumptions and limitations have been made:

- This report must be considered as a living document and should be updated annually or when updated information is available and monitoring and rehabilitation progresses; and
- The various environmental studies (Groundwater, Surface Water, Ecological Studies etc) of the area have not yet been completed and accordingly long-term uranium pollution issues have not been fully identified or dealt with. This will have to be done in subsequent iterations of the closure report when the hydrogeology of the site is fully understood.

6 Sibanye Gold Study Area Baseline Environment

6.1 Sibanye Gold Study Area

The Sibanye Gold Study Area is located mainly within the Far West Rand Goldfield between Carletonville and Krugersdorp, North West of Johannesburg as indicated in Plan 2. The Far West Rand Goldfied includes all the mines to the south of the Witpoortjie gap and west of the West Rand syncline. Traditionally this Goldfield incorporated the mines between Randfontein and the Mooi River, and between the Wonderfonteinspruit and Fochville. The Far West Rand goldfield is separated from the West Rand Goldfield by the Witpoortjie fault.

The reasons why regional mine closure strategies are needed for the mines in the Far West Rand Goldfield is mainly related to the geology and geohydrology of the area. The connections between mines and dolomitic compartments will ultimately control the flow of water once re-watering occurs (Council of Geoscience Reports, 2008).

6.1.1 Current Land Use and Zoning within the Sibanye Gold Study Area

Major land uses within the study area include agriculture, grazing, residential, mining and business uses. Residential land use comprises both formal and informal uses. Formal structures are either occupied by land users who rent properties from mining companies and farm owners, or landowning families farming on privately owned property. Informal structures are commonly occupied by farm workers and their families, as well as illegal occupants. All the proposed infrastructure options, except for the pipe and transmission lines from the CPP to Ezulwini, coincides with residential land use, with the largest encroachment along the transmission line connecting the East Drie Substation to the West Block Thickener (WBT) and Bulk Water Storage Facility (BWSF).

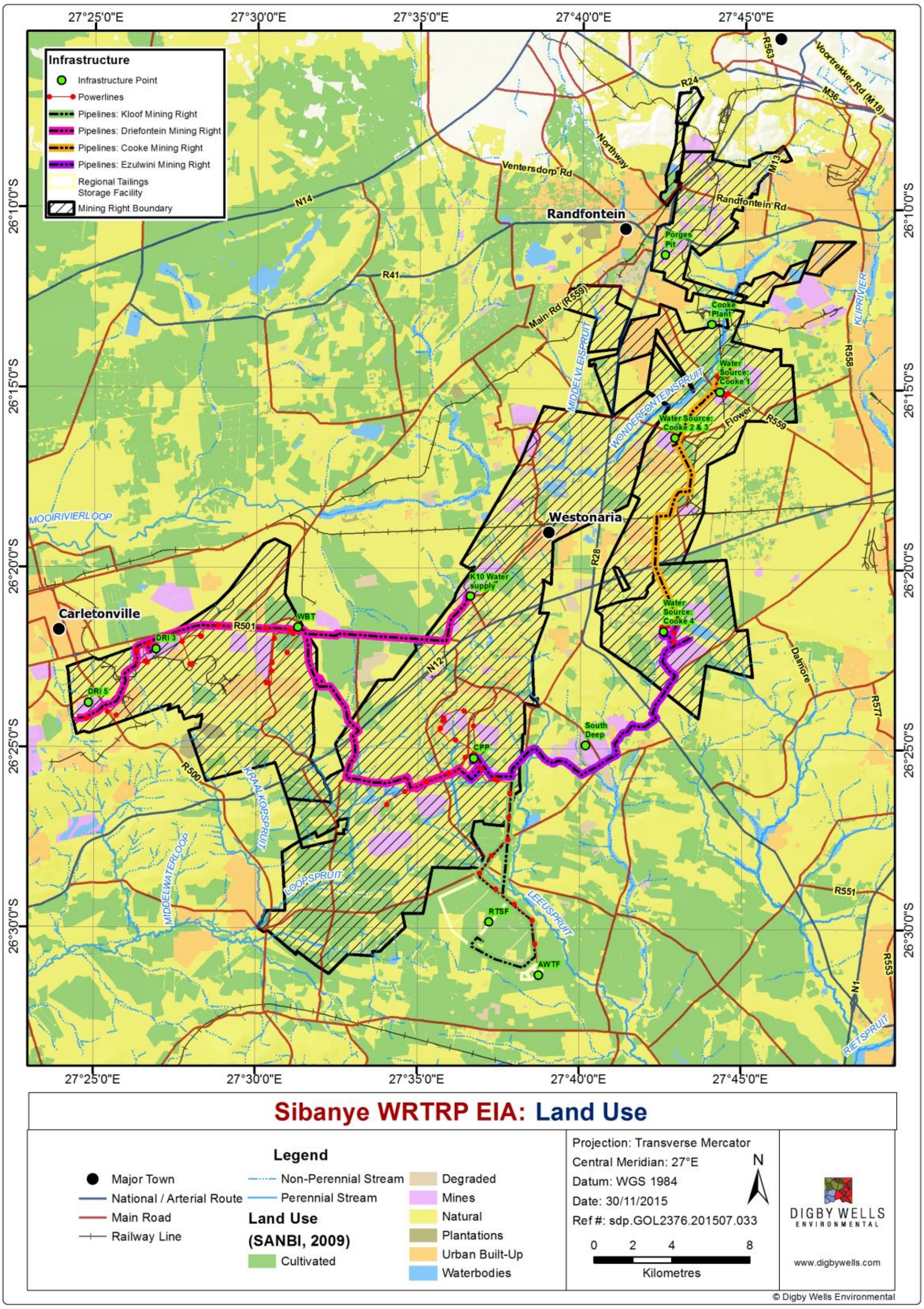
Agricultural activities within the study area comprise commercial maize and soya farming, as well as livestock grazing. The largest section of commercial farming land coinciding with the primary study area is located within the proposed RTSF site. This is followed by the area within the proposed CPP site. Livestock, mostly cattle, also graze throughout the primary study area.

Sensitive heritage areas, including graves, are found inside this study area. Known sites are located within the proposed RTSF site and along several of the pipeline routes. For more detailed information regarding the location and nature of these sites, reference can be made to the Heritage Impact Assessment (2015) compiled for the Project by Digby Wells.

Infrastructure and facilities in the study area include formal and informal dwellings, buildings used for business purposes (e.g. commercial farming infrastructure, mine infrastructure and roadside shops), privately owned infrastructure (e.g. access roads, boreholes and dams), public infrastructure (roads and transmission lines), mine accommodation, as well as several abandoned residential structures. A large number of roads traverse the study area including both tarred and gravel roads. These roads are used on a daily basis to commute between farms and mines, as well as to and from urban centres such as Carletonville and Fochville.

As was mentioned, mining is another prominent land use in the study area. Existing mining pits and infrastructure coincide with several sections of the primary study area Proposed Infrastructure within the Sibanye Gold Study Area.

Refer to Plan 3 for the current land use.



Plan 3: Land Use Plan

6.2 Soils

6.2.1 Kloof Mining Right Area

The soils in the Kloof mining right area have relatively high land capabilities and this can be confirmed by the current land use. The land use was predominantly cultivation.

The RTSF site was dominated by the plinthic catena soils of the Avalon, Westleigh, Dresden, and Tukulu forms. These accounted for 77.5% of the RTSF site. The plinthic horizons were dominated by >30% of iron and manganese concretions.

The RTSF site was dominated by the Class II and Class III land capabilities occupying 83.2% of the area.

The pipeline runs from the CPP with a Ba1 land type to the RTSF site with a Bb23 land type.

The Ba1 land type is dominated by a mix of deep red Hutton soil on the midslopes and shallow rocky Mispah soils on the crest positions.

The Bb23 land type is dominated by midslope and footslope landscape positions. The midslope positions are dominated by the Longlands and Wasbank soil forms, and the footslopes are dominated by Valsrivier soils.

The pipeline falls within a Class III land capability (moderate Cultivation) according to the land type database (Land Type Survey Staff, 1972 - 2006).

The CPP falls within the Ba1 land type (mix of deep red Hutton's in the midslopes and shallow rocky Mispah's on the crest).

The CPP falls within a Class III land capability (moderate Cultivation).

6.2.2 Driefontein Mining Right Area

The pipeline route moves into four land types and three land capability classes.

The pipeline section from the DRI 5 TSF to the DRI 3 TSF is mainly within the Fb15 land type (Shallow rocky Soils, Mispah), which has a Class VI land capability (moderate grazing). It then crosses into the Ab7 land type (deep well drained red soils, Hutton), which has a Class II land capability (intensive cultivation) just before reaching the DRI 3 TSF site.

The pipelines sections from the DRI 3 TSF to the WBT/BWS, and then to the K10 water supply are all within the Ab7 land type (deep well drained red soils, Hutton), which has a Class II land capability (intensive cultivation).

The pipeline sections from the WBT/BWS site moving south towards the CPP, crosses three different land types and land capability classes. Starting on the Ab7 land type (deep well drained red soils, Hutton), which as a Class II land capability (intensive cultivation) at the WBT/BWS. It then moves south crossing the Fb15 land type (Shallow rocky Soils, Mispah), which has a Class VI land capability (moderate grazing) into the Ba1 land type (mix of deep red Hutton's in the midslopes, and shallow rocky Mispah's on the crest), which has a Class III land capability (moderate Cultivation).

The pipeline section towards the Kloof processing plant falls within the Fb5 land type (Shallow rocky Soils, Mispah), which has a Class VI land capability (moderate grazing).

The DRI 5 TSF site is situated in the Fb15 land type. The Fb land type is dominated by shallow rocky soils, most likely the Mispah soil form. The DRI 5 TSF falls within the Class VI land capability (moderate grazing).

The DRI 3 TSF site falls within the Ab7 land type. The Ab land type is dominated by freely draining deep red soils, most likely to be the Hutton soil form. The DRI 3 TSF site falls within the Class II land capability (intensive cultivation).

6.2.3 Cooke Mining Right Area

The Cooke TSF site falls within the Ab7 land type. The Ab land type is dominated by freely draining deep red soils, most likely to be the Hutton soil form. The Cooke TSF site falls within the Class II land capability (intensive cultivation).

The pipeline sections coming from the Ezulwini mining right area to the Cooke TSF, moves from the Fb5 land type (Shallow rocky Soils, Mispah) to the Ab7 land type (deep well drained red soils, Hutton). The pipeline sections coming from the Ezulwini mining right area to the Cooke TSF, moves from the Class VI land capability (moderate grazing) to the Class II land capability (intensive cultivation).

6.2.4 Ezulwini Mining Right Area

The Cooke 4 South TSF is situated in the Fb5 land type (Shallow rocky Soils, Mispah). The Cooke 4 South TSF is situated in the Class VI land capability (moderate grazing).

The pipeline sections for the Ezulwini mining right area start at the CPP site, in the Ba1 land type (mix of deep red Hutton's in the midslopes and shallow rocky Mispah's on the crest) and move into the Fb5 land type (Shallow rocky Soils, Mispah) at the Cooke 4 South TSF site. The pipeline sections for the Ezulwini mining right area start at the CPP site, in the Class III land capability (moderate Cultivation) and move into the Class VI land capability (moderate grazing) at the Cooke 4 South TSF site.

6.3 Fauna and Flora

6.3.1 Flora

The vegetation communities delineated within the project area through field work procedures include remnant natural vegetation communities and vegetation which has been largely and completely transformed:

- Grasslands;
- Ridge areas;

- Wetlands; and
- Agriculture and Alien Vegetation Plantations.

Further detail regarding these communities can be found below.

6.3.1.1 Grassland Community

The grassland is composed of a dominant and well-developed graminoid component as well as a healthy forb component. Within the broad grassland vegetation community 50 flora species were identified. Within this broad community three sub communities were identified, which displayed different composition and dominant species namely; *Eragrostis gummiflua – Themeda triandra*; 2. *Cymbopogon excavates – Themeda triandra – Acacia karroo* open to closed woodland and 3. *Themeda triandra – Hyparhennia hirta* grassland.

6.3.1.2 Ridge Areas

The ridge area vegetation differs from the grassland vegetation. Similar species do exist, however, the increased rockiness and shallow soils mean that these areas have largely escaped anthropogenic disturbances and transformation. Ridges provide diverse habitat and refuge for a number of species and are generally regarded to be sensitive habitats due to the high levels of biodiversity that they host. The ridges within the project area are elevated above the grassland and host abundant woody species. These species are not present in the grassland community. There is increased shade as a result which provides habitat for shade loving graminoids and forbs. Ridges are regarded as sensitive habitats as many of these species are specifically adapted to this microclimate.

Forty five (45) flora species were identified within the ridge areas. Species identified within these areas are typical of Andesite Mountain Bushveld and Gauteng Shale Mountain Bushveld types within which these areas fall according to Mucina and Rutherford (2006). Woody species include Velvet Bushwillow (*Combretum molle),* Buffalo Thorn *(Ziziphus mucronanta),* Star Apple *(Diospyrous lycoides)*, as well as a number of flora species specifically adapted to rocky areas occur in these areas. Alien invasive vegetation was minimal (1 species) while nine medicinal species were encountered.

6.3.1.3 Wetland/Riparian Vegetation

Wetland vegetation is distinctly noted within the landscape by the presence of species such as Cotton Wool Grass (*Imperata cylindrica), Schoenoplectus corymbosus*, various sedges (Cyperaceae sp) and moisture and clay loving grasses and forbs such as *Berkheya sp.* and Golden Bristle Grass (*Setaria sphacelata*). Thirty six (36) flora species were identified to occur within the wetland vegetation community type. Common Reed *(Phragmites australis)* and Bulrush *(Typha capensis)* form dense stands in the riparian areas. The dominance of these two species indicates degraded river health as they are generally indicators of nitrification and sedimentation. This is thought to be the result of mining and agriculture in the area. Wetlands are important habitats and are protected by the National Water Act, Act 36 of 1998 (NWA, 1998).

6.3.1.4 Transformed

Large portions of natural vegetation have been replaced by both alien vegetation which is comprised of exotic tree stands, disturbed areas which have been colonised by alien invasive vegetation and agricultural lands.

6.3.1.4.1 Exotic Vegetation

Alien vegetation features prominently in the grassland landscape however whole areas occur in which the natural grassland vegetation has been transformed, and replaced with exotic vegetation. This is typically in the form of stands of exotic trees have been planted, usually for the uptake of water. Red River Gum (*Eucalyptus camaldulensis*) surrounds much of the mining areas, often planted for their robust nature and ability to take up toxic leachates from the groundwater surrounding retention dams. Pampas grass (*Cortaderia selloana)* is a similarly robust plant which has been planted in an effort to rehabilitate areas which have been mined. These transformed areas, dominated by high numbers of alien invasive and exotic species are typically.

6.3.1.4.2 Agriculture

Agricultural crops which have replaced natural vegetation include Maize (*Zea mays*) which is the primary crop in the area, Soybean (*Glycine max*) and Sunflowers (*Helianthus annulus*). Small plots of commercial vegetables, Lucerne and Peaches also occur in the area. Livestock farming (including sheep and cattle) is also popular, which has resulted in degradation of the natural grassland biodiversity. This is evident through the presence of Bankrupt Bush (*Seriphium plumose)*, which has overtaken numerous fields in the area, as well as a number of other problem plants and general assumed diminished species richness.

6.3.2 Fauna

Fauna expected to occur on site include assemblages within terrestrial and wetland ecosystems: mammals, birds, reptiles, amphibians and invertebrates. Each of these assemblages occurs within unique habitats and the ecological state of these habitats directly relates to the number of species found within them. The main habitats occurring in the project area are grassland plains and pans, with little altitudinal variation.

6.3.2.1 Mammals

A database search for mammal species that have been recorded in the three Quarter Degree Square (QDS) grids (2627 AD, 2627 BC and 2627 DA) on the virtual museum of the Animal Demography Unit (ADU) (http://www.adu.org.za). This database forms part of the Department of Biological Science at the University of Cape Town. No recent records of mammals have been recorded in the study area. Mammal species that have been recorded in the Gauteng Province, and could possibly occur in the area of interest are discussed below.

Mammal species expected to occur in the area of interest include 5 species Table 6-1 as per ADU database searches. The variety of vegetation types occurring in the area of interest ensures an ecologically diverse assemblage of plant species which in turn could support a variety of mammal species, therefore the current expected species list could be more extensive than is currently thought.

Table 6-1: Expected mammal species

Family	Genus	Common Name	Red List Category
Sciuridae	*Xerus (Geosciurus) inauris*	South African Ground Squirrel	LC
Bovidae	*Taurotragus oryx*	Eland	LC
Bovidae	*Hippotragus niger*	Sable	LC
Bovidae	*Antidorcas marsupialis*	Springbuck	LC
Bovidae	*Kobus ellipsiprymnus*	Water Buck	LC

6.3.2.2 Avifauna

Birds have been viewed as good ecological indicators, since their presence or absence tends to represent conditions pertaining to the proper functioning of an ecosystem. Bird communities and ecological condition are linked to land cover. As the land cover of an area changes, so do the types of birds in that area (The Bird Community Index, 2007). Land cover is directly linked to habitats within the study area. The diversity of these habitats should give rise to many different species. According to the South African Bird Atlas Project (SABAP2), 324 species of birds have been identified in the area (Appendix A of the screening report); the majority of these birds are comprised of Grassland species. All birds that could be present within QDS 2627 AD, 2627 BC and 2627 DA are listed in Appendix E of the screening report. Of these species, 10 have been assigned an international Red Data status with one Endangered, six Near Threatened, and three Vulnerable species recorded. These species are listed in the Table 6-2 below.

Table 6-2: Red Data bird species

Common Name	Scientific Name	Red Data Status
Maccoa duck	*Oxyura maccoa*	Near threatened
Lesser flamingo	*Phoenicopterus minor*	Near threatened
Grass owl	*Tyto capensis*	Vulnerable
Black winged pratincole	*Glareola nordmanni*	Near threatened
Blue Korhaan	*Eupodotis caerulescens*	Near threatened
European Roller	*Coracias garrulus*	Near threatened
Pallid Harrier	*Circus macrourus*	Near threatened
White Backed Vulture	*Gyps africanus*	Endangered
Cape Vulture	*Gyps coprotheres*	Vulnerable
Secretarybird	*Sagittarius serpentarius*	Vulnerable

6.3.2.3 Reptiles

Reptiles are ectothermic (cold-blooded) meaning they are organisms that control body temperature through external means. As a result reptiles are dependent on environmental heat sources. Due to this many reptiles regulate their body temperature by basking in the sun. Substrate is an important factor determining which habitats are suitable for which species of reptile. The presence of few rocky out crops within the study area is could mean few reptile species are present.

According the ADU's virtual museum a total of 40 species have been recorded in this QDS in the past (http://sarca.adu.org.za/). These species are listed in Table 6-3. Four species in this list are designated as endemic.

Table 6-3: Expected reptiles

Genus	Species	Common Name	Status	Endemic
Agama	*Aculeate, distanti*	Distant's Ground Agama	NE	Yes
Agama	*atra*	Southern Rock Agama	NE	0
Aparallactus	*capensis*	Black-headed Centipede-eater	NE	0
Rhinotyphlops	*lalandei*	Delalande's Beaked Blind Snake	NE	Yes
Crotaphopeltis	*hotamboeia*	Red-lipped Snake	NE	0
Boaedon	*capensis*	Brown House Snake	NE	0
Dasypeltis	*scabra*	Rhombic Egg-eater	NE	0
Lamprophis	*aurora*	Aurora House Snake	NE	Yes
Pachydactylus	*affinis*	Transvaal Gecko	NE	Yes
Pachydactylus	*capensis*	Cape Gecko	NE	0
Gerrhosaurus	*flavigularis*	Yellow-throated Plated Lizard	NE	0

6.3.2.4 Amphibians

Amphibians are viewed as good indicators of changes to the whole ecosystem because they are sensitive to changes in the aquatic and terrestrial environments (Waddle, 2006). Most species of amphibians are dependent on the aquatic environment for reproduction (Duellman and Trueb, 1986). Additionally, amphibians are sensitive to water quality and ultra violet radiation because of their permeable skin (Gerlanc and Kaufman 2005). Activities such as feeding and dispersal are spent in terrestrial environments (Waddle, 2006). According to

Carruthers (2001), a number of factors influence the distribution of amphibians, but because amphibians have porous skin they generally prosper in warm and damp habitats. The presence of suitable habitat within the study area should provide a number of different species of amphibians.

According to Carruthers (2001), frogs occur throughout southern Africa. A number of factors influence their distribution, and they are generally restricted to the habitat type they prefer, especially in their choice of breeding site. The choices available of these habitats coincide with different biomes, these biomes in turn, are distinguished by means of biotic and abiotic features prevalent within them. Therefore a collection of amphibians associated with the Grassland biome will all choose to breed under the prevailing biotic and abiotic features present. Further niche differentiation is encountered by means of geographic location within the biome, this differentiation includes, banks of pans, open water, inundated grasses, reed beds, trees, rivers and open ground, all of which are present within the area of interest. No previous records of amphibians that occur on site were found on the Southern African Reptile Conservation Assessment (SARCA) website (http://sarca.adu.org.za/).

6.3.2.5 Invertebrates

Butterflies are a good indication of the habitats available in a specific area (Woodhall, 2005). Although many species are eurytropes (able to use a wide range of habitats) and are widespread and common, South Africa has many stenotrope (specific habitat requirements with populations concentrated in a small area) species which may be very specialised (Woodhall, 2005). Butterflies are useful indicators as they are relatively easy to locate and catch, and to identify. Red Data species expected to occur on site are the Marsh sylph (*Metisella meninx*), Roodepoort Copper (*Aloeides dentatis dentatis VU*) and Highveld Blue (*Lepidochrysops praeterita EN*).

6.4 Wetlands

The project area was surveyed and 18 different wetland units were delineated that interact with the project infrastructure in the study area. Due to the diverse terrain, valley bottom wetlands characterise the area, both channelled and unchannelled. In addition, in the flatter areas there are pans present. Most wetlands were rated a Present Ecological Status (PES) of ‘D’ (moderately modified) but some were rated ‘E’ (largely modified). It can be concluded with confidence that the wetlands in the Witwatersrand and surrounding gold mining areas have been subject to major hydrological and chemical alterations from the century of gold mining that defines the area. This was true for the study area and many wetlands are directly impacted by open pit and underground mining as well as the surface processing and waste facilities. This has led to serious impacts to the quality of these systems and has contributed to direct loss of wetland habitat. The road infrastructure is extensive in the area and has led to considerable impacts to wetland connectivity and natural flow of water.

The proposed development and operation of the new WRTRP will have direct impacts to these wetlands. The main impact to the wetlands will be the loss of 96.9 ha of wetland habitat due to the proposed infrastructure placement. There are also significant potential threats to the wetlands if unplanned events are to occur.

6.5 Surface Water

The summary of the findings are described below:

- The average Sulfate loads in the Leeuspruit West will show an increase of approximately 70% due to the additional volume of water being discharged. This is based on the assumption that discharge will be treated to the discharge water quality specifications of the AWTF (Sulfate – 350 mg/L). The concentrations of Sulfate will decrease from 417 mg/L to a minimum of 350 mg/L due to increased flows of on average 15 000 m^3/day. A decrease in concentrations of Sulfate of around 13% is anticipated due to increased flows of better quality water;
- Based on the groundwater study (Environmental Impact Assessment for Sibanye Gold Limited's West Rand Tailings Retreatment Project, Digby Wells, 2015), the reclamation on the current TSF's and placement on one large facility are positive in the long run for the catchment, as they are currently a source of pollution. Based on average Sulfate concentrations of 322 mg/L measured at the 1 m pipeline outlet, estimated decrease in salt loads range from 37 to 55%;
- A floodline assessment was undertaken for the section of the Leeuspruit located north of the RTSF and associated infrastructure, together with the unnamed tributary located south of the RTSF. Flood modelling results show that the current placement of the RTSF and associated infrastructures is located outside of the 1:100 year floodline and the 100 m river buffer. The floodline assessment was also undertaken at various river crossings so as to determine the 1:50 and 1:100 year flood elevations at these crossings to allow for adequate designs to be implemented; and
- Major surface water impacts identified include the decrease in flows to the Wonderfonteinspruit and the increase in flows to the Leeuspruit.

Refer to the Surface Water Specialist Report for further detail.

6.6 Groundwater

The groundwater study was conducted to evaluate the potential impact and management plans related to the groundwater environment arising from the reclamation of the historical TSFs and deposition at the proposed RTSF. The study was conducted following a desktop study, hydrocensus, geophysical surveying, borehole drilling, aquifer testing, and numerical modelling.

- The main findings that are relevant to the historical TSFs include:
- The existing historical TSFs are either located directly on dolomitic strata or on the Transvaal sequence that overlie the dolomite;
- These TSFs are all unlined; and

- Although a short-term acid generation during operation can occur due to the TSF disturbance and exposure to oxygen and moisture, the impact on groundwater as a result of the reclamation is anticipated to be positive in the long run since the TSFs, which are potential sources of contamination, will be removed.

The main findings in the area of the RTSF include:

- There is no dolomitic risk in the area of the RTSF, since the dolomite is found at a depth of more than 1 km below surface;
- The baseline groundwater quality is good, with uranium concentrations below the detection limit (<0.004 mg/L). The baseline sulfate concentration is less than 32 mg/L in all of the hydrocensus boreholes. This is well below the River Quality Objective (RQO) of 500 mg/L;
- The main elements of concerns that are expected to seep from the RTSF are sulfate and manganese, although arsenic, uranium and iron can be expected;
- In the area of the RTSF, the hydraulic gradient is approximately 0.0051. The average permeability of the top aquifer is 0.207 m/d and that of the deeper fractured aquifer some 30 m below the top aquifer is 0.180 m/d. The average groundwater flow velocity along the weathered zone (top aquifer) is therefore 0.001 m/d and in the fractured aquifer is 0.0009 m/d;
  - Considering the RTSF length of 3000 m, this is equivalent to a flow rate of 75 m^3/d in the top aquifer and 67.5 m^3/d in the fractured aquifer.
  - The average TDS of the boreholes in the vicinity of the RTSF is 201.4 mg/L. This corresponds to a salt load of 15.1 kg/d in the top weathered aquifer and 13.6 kg/d in the fractured aquifer.
- Groundwater flow mimics the topography and is towards surface water drainage courses as baseflow; generally from the northwest to southeast. Overall the local streams are fed by the groundwater and are at risk if the groundwater is contaminated;
- Seepage from the RTSF, without mitigation can negatively influence the groundwater quality in the underlying aquifers during operation and after closure;
- Contamination plumes are expected to reach approximately 2 km down-gradient (towards southeast) and can potentially impact private boreholes if no mitigation is undertaken; and
- Seepage from the RTSF can also impact the Leeuspruit (located immediately to the north) and its tributary in the south. Once the plume reaches the stream, it can migrate at a faster rate compared to the speed of groundwater flow and could have a negative impact on the down-gradient riverine ecosystem and communities without mitigation.

A number of options have been considered to minimise the potential impact of the RTSF. Please refer to the Groundwater Specialist Report for further detail.

7 Rehabilitation plan

Due to the complexity of the proposed project and for the purpose of simplicity the various project activities have been divided into different Groups as described in Table 7-1 below

Table 7-1: Activity grouping for the different project activities

Group	Activity and Infrastructure
A	Reclamation of D3
	Reclamation of D5
	Reclamation of Cooke TSF
	Reclamation of Ezulwini South
B	CPP Rehabilitation
	RTSF Rehabilitation
C	All associated pipelines (water and slurry pipelines

The rehabilitation of the TSF footprints in Area A is largely reliant on the findings following the reclamation process. The steps to be undertaken will be guided by the radiation content of the soils.

7.1 Rehabilitation plan

7.1.1 Rehabilitation Vison

For large scale projects a regional approach to closure and rehabilitation needs to be considered. As noted in the Regional Gold Mining Closure Strategy for the Far West Rand Goldfields document the main vision of regional mine closure is to prevent or minimise adverse long-term socio-economic and environmental impacts, and to create a self-sustaining natural ecosystem or alternative land use based on an agreed set of objectives (Council of Geoscience Reports). Thus noting that set objectives need to be agreed upon it is important that all role players involved are engaged regarding closure and rehabilitation objectives, specifically related to long term impacts and end land use.

The objectives that should be considered as outlined in the Council of Geoscience Reports are the following:

- To encourage the development of comprehensive closure plans that return all mine sites to viable, and wherever practicable, self-sustaining ecosystems, and that these plans are adequately financed, implemented and monitored within all jurisdictions;
- To manage the closure of mines in an demarcated area in an integrated and sustainable manner;

- To encourage mines in a demarcated area to work together to achieve the goal of leaving behind a self-sustaining ecosystem after closure;
- To ensure that mines do not impact negatively on the livelihood of adjacent/interconnected mines in a demarcated area;
- To promote a strategic approach to managing water at mining and mineral processing sites so that water in more efficiently managed and valued;
- Set out the strategic issues that mining and mineral processing operations needs to consider for sustainable mine closure in an area in order to manage risks and identify opportunities for continuous improvement; and
- Provide high level guidance on issues that should be addressed in developing a post-closure mine water strategy for an area.

Thus it is important that closure and rehabilitation for this proposed project considers the above objectives where practical and possible.

7.1.2 Rehabilitation Activities

The rehabilitation plan is comprised of five basic stages, which will be undertaken for each area according to the activity grouping:

1. Removal of existing infrastructure;
2. Re-shaping of the landforms;
3. Replacement of soils;
4. Re-vegetation of the landscape; and
5. Monitoring and maintenance. (Including annual Radiometric surveys).

Site-specific rehabilitation activity tables including these stages and more detailed recommendations are described in the sections below.

7.2 Rehabilitation plan Activities for each area within the Sibanye Gold Study Area

7.2.1 Group A – Reclamation of the TSF Facilities and Dumps

7.2.1.1 Radiation Surveys and Radon Assessments

Once reclamation of the various facilities has been undertaken and depending on the desired end land use, it is highly recommended to assess the potential of residual radiation remaining and to identify possible latent environmental impacts remaining. This is important to ensure that once the land is handed over that there is no potential further risk to the land owners.

The National Nuclear Regulator (NNR) has set the level for gamma radiation, for which regulation is not required, below 500 Bq (Becquerel) per kg. Direct radiation originates from uranium, which is a common mineral associated in the reefs that contain gold and is contained within the slimes material. The Radiation Assessment should measure the gamma radiation emanating from the decaying of the uranium atoms.

In terms of release of radioactively contaminated land, the Safety Standards and Regulatory Practices, under section 5.4, specifies that a site used in the conduct of an authorised action may be released for unrestricted use provided that it is demonstrated that the radioactive contamination and radioactive materials which can reasonably be attributed to the authorised action have been removed from the site, or in the case of naturally occurring radioactive nuclides, have activity concentrations below the levels of exclusion. The end land use will be dependent on the findings of such an assessment and will determine if these sites could be utilised or released for unrestricted use.

7.2.1.2 Environmental Risk Assessments

It is advised that a detailed environmental risk assessment be conducted for these facilities prior to final rehabilitation and application for closure certificates. The environmental risk assessment needs to take into account potential end land uses and an evaluation of each proposed end land use should be undertaken and should be supplemented with specialist studies such as groundwater and surface water. The environmental risk assessment can be utilised as the benchmark to assess the potential risk identified that require remedial action. By assessing the risks after reclamation one is able to identify where risks have been managed, alleviated or removed altogether and what potential future risks could arise.

By assessing the current status of the potential risks on the sites, new management measures can be drawn up for the short and long term management of the sites to ensure that closure is achieved.

7.2.1.3 Rehabilitation of Reclaimed Sites

Prior to rehabilitation commencing, the land must be surveyed and a Radiation Assessment undertaken to identify areas of concern on the sites. The areas of concern need to be mapped. It is suggested that a grid pattern is adopted to ensure that no areas of contamination or concern are missed.

Normally it is suggested that a Radiation Assessment be conducted once all tailings material has been cleared from site to the underlying soil layer. Once this has been undertaken the assessment can be conducted. If soil is identified to be contaminated this soil must be removed to a depth of 300 mm and replaced with sourced topsoil. It is advised that a follow up assessment is conducted to eliminate the potential risk of and residual impacts post remediation of contaminated material. Once no contamination is present soil can be placed back on the footprints. Once soil is replaced the soil can be ripped and fertiliser applied to the soil. The fertiliser requirements will be dependent on soil fertility results at the time of placement as it is assumed direct replacement will not be adopted, thus fertiliser will be required. Once this has been undertaken seeding can be done as per the recommended seed mixture. Monitoring will be required post rehabilitation to determine the success of rehabilitation efforts and to monitor erosion. In addition to this an Alien Invasive Management Plan will need to be adopted.

7.2.2 Group B – Rehabilitation of the RTSF and CPP

The basic principles recommended for rehabilitation and eventual closure of the RTSF and CPP are described below.

7.2.2.1 Rehabilitation of the RTSF

7.2.2.1.1 Side slopes

It is important to maximise the stability of the deposited material by minimising the risk of excessive erosion. This risk can be minimised by decreasing the slope of the final landform thereby lowering the expected rate of erosion and averting costly implications to re-profile the RTSF at final closure. Additionally the creation of a sustainable vegetation cover will support the side slopes from erosional processes like wind and water.

Information associated for rehabilitation of the side slopes and erosion risk was extracted from previous studies undertaken (Golder, 2009 and SLR, 2015). Assuming the same modelling for erosion rates of the final cover as previously undertaken and vegetation covers and slope angels it is important to ensure the final slope angels are correct to minimise the risk of erosion. It is recommended that the final landform must have size slopes at a 1:4.5 (V:H). The angle of the side slopes should be considered at the time of deposition of material to avoid re-shaping, thus reducing the financial provision in the long term and associated maintenance costs.

Surface water diversion and management measures will need to be left in such a state as to control erosion around the RTSF i.e. any upslope water will need to be permanently diverted around the site.

7.2.2.1.2 Landform Covering

As previously noted the recommendations provided below have been sourced from several past studies undertaken regarding capping and are only recommendations at this stage.

Selecting a cover system for the rehabilitation of the RTSF is crucial. Based on the Definitive Feasibility Study (DFS) Report is has been advised that a constant outer slope should be achieved and movement away from the step-ins which create a steeper intermediate slopes, which increase the risk of erosion and limit vegetation establishment. Based on this the slope has been set at 1:4.5 as this slope has been found to be far more erosionally stable. In addition to this, this slope angle will allow for easier access for placement of cover material and vegetation establishment.

In terms of the cover material selected is has been suggested that a cover material consisting of topsoil, subsoil and rock mix is placed onto the side slopes and then ripped into the surface. The mix will consist of roughly 250 mm of topsoil and 100 mm of waste rock. The rock that will be introduced will allow for protrusions that may be advantageous for plant growth as they would mimic natural slopes and dissipate the kinetic energy of rain drops as they strike the surface (SLR, 2015).

It is recommended that the RTSF be capped and covered for the following reasons:

- To limit the ingress of precipitated water into the tailings and prevent seepage from the tailings into the surrounding environment as well as to surface and groundwater;
- Decrease percolation and reduce the salt load on the environment;
- Provide a suitable growth medium for vegetation and to store and release water to the vegetation and into the environment through evapo-transpiration; and
- Buffer any radiation from the tailings material and eliminate fugitive radiation dust that could otherwise originate from the tailings (Golder, 2009).

The RTSF should be capped and covered with the following material:

- The store-and-release cover as recommended in the DFS.

When rehabilitating the top surface of the RTSF care must be taken to avoid the formation of a bowl. To this end it was decided to ‘paddock’ off the top surface of the RTSF to rather have many smaller catchments with resulting smaller ponds after storms, as well as shorter slope lengths. The paddocks have only been sized to store fairly average and frequent rainfall events, with the runoff from larger storm events then spilling over and accumulating at the central low point. This spilling over will attenuate the flood hydrograph as well as hold back some of the runoff within each paddock (SLR, 2015).

The top surface will be covered with 200 mm of topsoil mixed into the 100 mm of the tailings beach. In addition to this a large rock clad berm will also be constructed around the crest of the RTSF at closure. This will serve to contain large storm events and reduce wind erosion on the crest (SLR, 2015). It is proposed that 0.25 m of topsoil will be stripped from the RTSF footprint (25% contingency built into the stripping ratio to cater for loss of soil). This will allow for a 200 mm layer of soil to be utilised as a capping, with additional material being utilised from the starter wall.

7.2.2.1.3 Vegetation Establishment

In addition to capping the final landform indigenous vegetation will be planted on the RTSF to reduce percolation through transpiration of water. It will also assist in stabilising the side slopes of the tailings, preventing wind and water erosion and minimise dust generation.

The option to undertake concurrent rehabilitation should be investigated. If concurrent rehabilitation is possible (does not pose a risk to the stability of the facility) the following should be undertaken:

- Profiled outer slopes should be rehabilitated as soon as possible. This will ensure that rehabilitation takes place prior to final closure and should any corrective action be required then this can be implemented whilst the RTSF is still operational; and
- The objectives for the vegetation of the sides and tops of the TSF are to:
  - Prevent erosion;
  - Introduce a vegetation layer to evapo-transpirate rainwater falling on the RTSF;
  - Re-establish eco-system processes to ensure that a sustainable land use can be established without requiring fertilizer additions; and
  - Restore the biodiversity of the area as far as possible.

Irrigation will be required to assist in establishing vegetation on the top and sides of the RTSF. It is recommended that the water extracted from the groundwater interception drains (refer to the surface and groundwater reports compiled by Digby Wells) be used for this purpose as.

In addition to this the DFS makes the following recommendations regarding vegetation requirements:

- Hydroseed and establish vegetation cover on the sides lopes of the RTSF;
- Growing and planting of specified 1 litre container pants to side slopes (400 per ha);
- Growing and planting of specified 5 litre container plants to side slopes (25 per ha);
- Growing and planting of specified 10 litre container plants to side slopes (5 per ha);
- Growing and planting of specified 100 litre container plants to side slopes (2 per ha);
- Hydroseeding and establishment of vegetation on the surface of subsoil and topsoil borrow areas;
- Supply and apply chemical fertilisers to rehabilitated side slopes on an annual basis based on soil monitoring results;
- Supply and apply organic material; and
- Filling in of gulleys with soil.

7.2.2.1.4 Concurrent Rehabilitation

The RTSF will be constructed in a manner that the side slopes of the lower benches can be fully rehabilitated while deposition still takes place on the upper benches. To achieve this, the RTSF will be constructed in the following manner:

- Construct the lower bench at its final 1:4 slope gradient;
- After a step-in is made, construct the upper benches at a 1:3 gradient;
- Once the second bench reaches its final height and the step-in is made to start with the third bench, re-shape the second bench to the final 1:4 profile;

- Repeat this method until the RTSF reaches its final height; and
- Construct a parapet wall at the top perimeter of bench which is to be rehabilitated to prevent spillages from the upper bench onto the lower bench that is being rehabilitated.

In this way the rehabilitation of the lower bench can be done concurrently with the deposition on the upper bench. The advantage of this approach is that this will significantly reduce environmental impacts and eliminate the need for continuous re-vegetation of the slopes until final rehabilitation can be done once all deposition has stopped. By following the proposed concurrent rehabilitation process, only the last bench and top surface will have to be rehabilitated at scheduled closure (Golder, 2009). Refer to Figure 7-1 for a schematic indicating cover construction and concurrent rehabilitation that can be implemented for the concurrent rehabilitation of the RTSF.

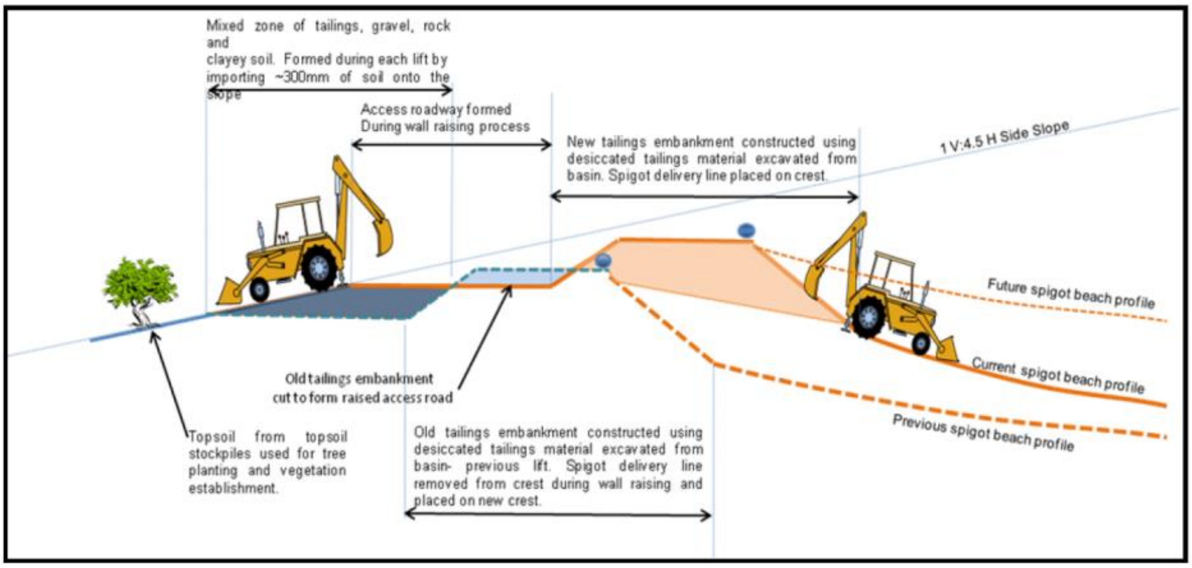


Figure 7-1: Concurrent Rehabilitation and Cover Construction (SLR, 2015)

7.2.2.1.5 Under Drainage System

An under drainage system will need to be designed for the RTSF with the purpose of the following:

- Improving the side slope stability by lowering the phreatic surface;
- Reducing long term seepage and thereby facilitating a reduction in ground and surface water impacts;
- Reduce post-closure settlement; and
- Increase the return water to the plant.

These drains have been included in the inner and outer toe of the starter embankment, a blanket drain has been included in the pool zone and a seepage cut-off drain will be constructed to intercept shallow seepage emanating from the RTSF footprint.

7.2.2.2 Rehabilitation of the CPP Footprint

The first step associated with the decommissioning of any infrastructure is to assess and identify structures that could potentially be utilised post closure.

Once the CPP has ceased production, pipelines and associated infrastructure, must be removed to meet the requirements of the post-closure land use. It must be noted that some offices and buildings may be gainfully used by the subsequent land-user. Once these structures have been identified the remaining structures need to removed or demolished.

Removing and demolishing structures poses safety risks to those involved, thus, attention must be given to managing these risks carefully.

All infrastructure planned for removal and demolition will need to be assessed for their viable re-use or recycling opportunity. Items to be removed will need to be separated and disposed of at a permitted waste disposal facility, while any hazardous waste will need to be disposed of at a permitted hazardous waste disposal facility.

After the infrastructure has been removed it is recommended that a contaminated land assessment be conducted for the footprint of the CPP and surroundings to determine if remedial action is required. If soil has become contaminated, this soil must be removed and disposed of at a hazardous landfill site and then replacement soil sourced. In situ remediation could be considered as an option and is dependent on the extent of the contamination and the type of contamination.

In cases where the foundations of the structures are impractical to remove, the foundations should be covered with a combination of soft overburden and a layer of topsoil. The placement of topsoil is dependent upon the availability of topsoil. Undisturbed topsoil must not be stripped for placement in disturbed areas.

7.2.2.2.1 Final Landform

Once the site has been cleared of all infrastructure and rubble, the exposed underlying materials should be reshaped to create a gently sloping, free-draining topography where possible. Any topsoil that was removed should be replaced, fertilised and vegetated. Those areas underlying topsoil dumps used for rehabilitation or those gravel roads requiring rehabilitation should be ripped and vegetated so that indigenous vegetation can re-establish itself as quickly as possible.

The steps that should be taken during the reshaping of the CPP area are as follows:

- Develop the post-project landform concept during the planning stage of the project;
- Prior to the project the land capability classes i.e. areas with certain land capabilities, should be recreated while also meeting the water management requirements;

- Drainage channels and water ways should be used in areas where the slope length is excessive in order to reduce erosion risk;
- Analyse the effects of changes in the project plan on the final landform;
- Major modifications to the final landform will result in changes to the Environmental Impact Assessment/Environmental Management Plan (EIA/EMP) report; and
- An integrated approach should be followed to ensure that the optimal balance between conflicting final requirements is achieved (Tanner, 2007).

7.2.3 Group C – Rehabilitation of the associated pipelines and servitudes

It can be anticipated that there will most likely be some tailings/slurry spills along the pipeline routes. The likely origin of these spills will be from leaks and/or breakages along the pipelines and/or from maintenance activities along the pipelines. The spills that are not addressed during the operational phase of the proposed project will need to be cleaned up. This will involve material being picked up and trucked onto the top of the RTSF before the final covering is placed on the top. It is anticipated that at the end of the life of the project the slurry lines will needs to be removed, including any concrete plinths. The future use of water pipelines will need to be assessed as there is an option to potentially utilise these for other options such as the transport of potable water to industrial or residential areas.

7.3 General Rehabilitation Principals

7.3.1 Standard Land Preparation Guidelines

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

- Planning should minimise the area to be occupied by 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 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 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.

7.3.2 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 a project.

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 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 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 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; and
- Truck and shovel should preferably be used as a means of moving soil, instead of bowl scrapers.

A high level soil balance has been provided indicating the depth, volume and provides and provides an indication of what soils can be stockpiled together. Refer to Table 7-2 for the volume of soil that is available for rehabilitation, approximate volumes and which soils can be stockpiled together. "S" denotes the stockpile number. For example if two soils types have an "S1" these soils can be stockpiled together.

Table 7-2: Stripping volumes and soil stockpiling

Soil Forms		Area (ha)	Stripping Depth (m)	Estimated Volume (m^3)	Stockpile Allocation
Avalon	Topsoil	653	0.3	1 959 000	S1
	Subsoils		0.5	3 265 000	S2
Dresden	Topsoil	218	0.3	654 000	S1
	Subsoils		N/A	N/A	N/A
Clovelly	Topsoil	37	0.3	111 000	S1
	Subsoils		0.7	259 000	S2
Westleigh	Topsoil	7	0.3	21 000	S1
	Subsoils		N/A	N/A	N/A
Tukulu	Topsoil	168	0.3	504 000	S1
	Subsoils		0.5	840 000	S2
Arcadia	Topsoil	263	0.3	789 000	S3
	Subsoils		0.3	789 000	S4

7.3.3 Supervision

A very important aspect is the supervision and monitoring during the soil 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.

7.3.4 Soil 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.

7.3.5 Soil Stockpiling

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.

7.3.6 Soil Stockpile Locations

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

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 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.

7.3.7 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 soils should be 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.

7.3.8 Soil 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.

7.3.9 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 and the pumping out of contaminated water from contaminated 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.

7.3.10 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.

7.3.11 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.

7.3.12 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.

7.3.13 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 planners, managers and other parties involved.

7.3.14 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.

7.3.15 Vegetation Establishment

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

7.3.15.1 Vegetation Establishment

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

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

7.3.15.2 Re-vegetation Steps

The following steps should be taken during the re-vegetation of disturbed areas:

- Ensure that the soils have been replaced correctly;
- All soils are to be ripped to full potential rooting depth to correct compaction;
- Analyse the topsoil to determine the lime and fertilizers requirements;
- Prepare the soil by adding lime and fertilizer and ploughing the area, followed by tillage to prepare the seed bed;
- Plant a grass seed mixture consisting of a range of indigenous or non-invasive naturalised species;
- Inspect the area after a good rainfall event;
- Eradicate weeds where necessary;
- Repeat the procedure for the next growing season;
- Define and establish the long-term land management system;
- Leave pasture to allow natural grasses to become re-established; and
- Conduct annual monitoring (repeatable demarcated transect surveys).

7.3.15.3 Species Selection

Some of the criteria that should be considered during the selection of the appropriate species for rehabilitation include:

- Use species which are perennial and well adapted to the area;
- The species should be tolerant of adverse soil conditions;
- Species should have a large biomass and prolific root system; and
- As areas of rehabilitation expand, maintenance costs increase, so species selected should be those with minimal maintenance cost, or with production and financial returns that exceed the cost.

Given below is the recommended seed mixture for rehabilitation:

- Seed Mix: 26 kg/Ha:
  - *Chloris gayana* (Rhodes grass) 6 kg/Ha;
  - *Digitaria eriantha* (Finger grass) 10 kg/Ha;
  - *Cynodon dactylon* (Kweek) 7 kg/Ha;
  - *Eragrostis teff* (Teff) 3 kg/Ha (Nursing Crop – Annual Species).

7.3.15.4 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.

7.3.15.5 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.

7.3.16 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 land that has been fully rehabilitated.

7.3.17 Final Topography

The topography that is achieved during rehabilitation should be monitored and compared to the planned topography. The final profile achieved should be acceptable in terms of the surface water drainage requirements and the end land use objectives. 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.

7.3.18 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.

A final post 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 land capability map based on soil thickness and characteristics;
- A proposed post land use map;
- Erosion occurrences;
- Fertility analysis and soil analysis; and
- Representative bulk density analysis.

7.3.19 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.

7.3.20 Surface Water

7.3.20.1 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 significant erosion damage is caused.

7.3.20.2 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. (Please refer to the Groundwater and Surface Water Reports compiled by

Digby Wells for details associated with monitoring – monitoring plans contained within these reports)

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.

7.3.20.3 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 reclamation and other project 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.

7.3.21 Vegetation Species

Biodiversity assessments and surveys should be undertaken by external experts to establish the full range of plants that have become established. The assessments should be undertaken during summer and winter months.

7.3.22 Alien Invasive Control

7.3.22.1 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;
  - Ring-barking (girdling);
- Chemical:
  - Foliar application;
  - Stem notching and application;
  - Stump treatment;
  - 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.

7.3.22.2 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.

7.3.22.3 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 project 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; and
- 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.

8 Potential Long Term Impacts

The rehabilitation phase is regarded to include activities which are largely positive, however ineffective management and implementation may result in negative impacts that could occur post closure and require mitigation to reduce the risk to the receiving environment. The following sections provide recommendations for particular aspects, however are not limited to the to what is discussed in this report and further consideration with respect to post closure mitigation can be extracted from the various specialist studies conducted in support of this project and relevant authorisations.

8.1 Groundwater Contamination Plume Management

Information contained in this section has been extracted from the Interim RTSF DFS conducted by SLR Consulting and supplemented with information extracted from the Groundwater Study undertaken by Digby Wells (2015).

Several scenarios regarding the management or mitigation of groundwater impacts associated with the RTSF have been considered. Based on the work conducted to date the following has been recommended to mitigate the migration of the groundwater contamination plume:

- Instillation of a Class C liner without the instillation of blast curtain; and
- Instillation of a blast curtain, with an average height of 30 m down gradient of the RTSF.

Further mitigation measures have been provided for both in the Groundwater Report (Digby Wells, 2015) and the DFS (SLR Consulting, 2015).

It is important to note that authorisation of the above measures will need to be obtained from the relevant authorities and which measure that will be adopted is subject to the respective competent authorities buy in to the proposed measures.

After closure it is expected that a detailed monitoring programme will need to be implemented to monitor groundwater impacts into the future. This report does provide some recommendations regarding rehabilitation of the RTSF in terms of minimising ingress of surface water into the RTSF, thus potentially reducing the amount of water moving through the system which could potentially result in assisting post closure as to reduce the extent of contamination plumes migration.

One measure is utilising concurrent rehabilitation of the side slopes of the RTSF, which reduces the net infiltration of rainfall through the side slopes, which reduces the amount of water reporting as seepage to groundwater or the underdrains. This will also reduce dust emissions and improves runoff quality and infiltration quality from surrounding land (SLR, 2015). Taking the above into account concurrent rehabilitation should be considered, if possible as one of the mitigation measures associated with groundwater, surface water and air quality impacts.

8.2 Dust Fallout

Improper rehabilitation will result in large areas of the RTSF and old tailings footprints being exposed. If this happens it can be expected that increased dust fall out would be expected. Maintenance post closure is also crucial to mitigate against dust fall out.

The re-vegetation of the RTSF, TSF and Plant area needs to be closely monitored. Reclamation operations have resulted in an increase in toxic and potential radioactive dust fallout as a result of the removal of the grassy vegetation from tailings dams and sand dumps or the crust surfaces, which provide moderate resistance to wind and a reduction in the frequency and severity of dust fallout (Liefferink M *et al*. 2014).

Proper rehabilitation and maintenance activities can reduce the risk of dust fallout to surrounding communities and the environment. It is therefore crucial that on-going monitoring is undertaken for rehabilitated areas to ensure appropriate vegetation establishment and sustainable use of the land post closure to avoid desertification of areas.

8.3 Radioactivity

The issue of radiation post closure of sites needs to be assessed as the level of radiation will determine the potential end land use. As noted in section 7.2.1. it is suggested that a Radiation Assessment be conducted post reclamation of the old tailings facilities. The findings of the assessment will determine what the potential end land use would be and what remedial action will be required.

8.4 Site Access

It is crucial that areas that pose high risk to both humans and animals are fenced off and appropriate signage erected. In addition controlled access to certain areas may need to be implemented.

8.5 Latent Impacts

Latent impacts occur due to bioaccumulation and exposure to naturally occurring radioactive materials and the presence of elevated toxic metals in the environment that are made bioavailable due to mining (Liefferink M *et al*. 2014).

Historically in most of the reclamation operations, only gold were reclaimed leaving uranium and other toxic metals in the re-deposited tailings.

During the reclamation process the fallout of toxic and radioactive dust and water pollution are often exacerbated (van Tonder *et al*. 2008). (Liefferink M *et al*. 2014), which would have to be monitored over the long term, post closure to ensure that these levels do not exceed recommended standards or guidelines.

The failure to rehabilitate and remediate all areas would result in the creation of new contaminated sites, thus special care needs to be taken when rehabilitation is undertaken.

9 End Land Use

The West Rand and Far West Rand Goldfields are currently the subject of intensive economic interest, with a number of operating or planned mining activities. In recent years, mining has been limited to the extraction of gold on a relatively small scale from various residue deposits. While this has led to a small reduction in the volume of tailings, it has also led to the exposure of tailings piles to the elements with the related impacts on surface and groundwater due to the acceleration of AMD formation and air pollution by the generation of windblown dust (Council of Geoscience Reports).

Owing to the soil contamination and stability issues with tailings facilities, in particular contamination with radioactive materials and based on the geology of the area (sink hole formations) will determine what the end land use will be.

Furthermore, any developments proposed on old mining land will need to undergo extensive environmental and stability assessments before they can be permitted (Council of Geoscience Reports).

When considering the end land use for each component of the project and taking the above into account the selected land use needs to consider many factors.

The extent of gold and uranium mining, and heterogeneity of substrata and land uses, means that decision-making needs to be based on risk assessment at both the regional and site-specific scale.

Dwellings and agriculture, in particular irrigated agriculture, were identified as vulnerable end land uses for Mine Residue Deposits (MRD) footprints or areas within the zone of influence of MRDs. Thus, when determining land uses and setting closure objectives in metal mining regions, residual and latent impacts need to be considered, and the potential for these impacts beyond the immediate site. Through so doing, future harm and liabilities can be avoided. Towards this it is recommended that a restriction be placed on certain land uses on MRDs, footprints and polluted areas, and the implementation of buffer zones, pending quantitative environmental risk assessments.

The chosen end land use of these areas is of fundamental importance as goals can be set and monitoring of rehabilitation can be achieved. The rehabilitation plan is firmly directed at the end land use of the various areas. Should this change, the rehabilitation plan will need to be amended.

In these cases, it must be accepted that some areas will never be suitable for unrestricted development and that these areas will need to be demarcated as such and appropriate land-uses should be proposed and implemented. In many cases, however, new settlements have been developed on un-rehabilitated footprints of tailings dams (van Tonder *et al*. 2008) (Liefferink M *et al*. 2014).

With the curtailing of gold mining on the Witwatersrand, mining land is being redeveloped. However, inappropriate developments, such as houses or farms, on MRD footprints and other contaminated sites could result in liabilities for the public and the closing mines. Avoiding built developments altogether and vegetating MRDs and footprints with unsuitable plant species, such as those for pastures and playing fields, can also increase risk through the creation of `attractive nuisances'. These encourage use by potentially vulnerable receptors such as grazing livestock and children (Sutton and Weiresbye, 2008).

Regulation 56 of the MPRDA Regulations provides that mining sites should be rehabilitated as far as is practicable to its natural state – or to a predetermined and agreed standard or land use which conforms with the concept of sustainable development.

Following the retreatment of tailings and the subsequent rehabilitation of TSF sites, land will progressively become available for land uses other than mining. However, large portions of this land may be irreversibly transformed, meaning that the full restoration of this land will not be achievable. Nevertheless, it is consistent with legislation that alternative end-land uses are considered as part of mine closure planning. These could include land uses suitable for both interim and permanent end uses.

The following observations primarily relate to those aspects of alternative end-land uses that could be of significance in terms of economic benefits to, and the health and safety of, host communities.

The allocation of approved reclaimed land to local communities (through their respective municipalities), may provide them with new economic opportunities and financial gains if this land is used productively. Most of this land belongs to Sibanye Gold Limited (SGL) and other mining companies, and their involvement in the re-allocation of land will, therefore, be non-negotiable. However, the availability of reclaimed land will be contingent on the required mine closure permits, while the relevant municipalities cannot be made responsible for any remaining liabilities with regard to residual contamination impacts.

It is acknowledged that realising the above benefit will require considerable effort and careful planning. However, the consideration of land use alternatives is one of the cornerstones of community planning. The primary land use categories that encompass basic functions are residential, commercial, industrial, recreational, institutional and agricultural uses.

It is possible that reclaimed land will not be suitable for residential use and/or the production of food crops due to residual contamination levels and/or unstable soils. Some of this land may also not be suitable for livestock grazing. Options for alternative human end-uses may, therefore, be limited. Potential end-land uses may include industrial sites, renewable energy projects, landfills, graveyards, sewage disposal and some farming activities. However, the use of reclaimed land may be contingent on the release of this land by the NNR.

Decisions regarding end-land uses for reclaimed TSF sites would require a systematic and consultative decision-making process. It is important to note that where no suitable ***human*** land uses are identified, affected areas may still attract undesirable land uses at, or near, the reclaimed sites. These could include informal settlement, as well as illegal mining activities. Such practices may hold severe health and safety risks for those actors, and it is, therefore, essential that access to this land is access prohibited and prevented.

It is recognised that the above positive impact is to some extent offset by land acquisition for new project facilities (in particular the CPP and RTSF), as well as land lost to some pipelines and power line servitudes.

The following recommendations are made:

- Ensure that reclaimed land is made safe for both humans and animals. Ground- and surface water must be fit for approved future land uses;

- Comply with the requirements of MPRDA which provides that interested and affected parties must be involved in decision-making regarding future land uses;
- Implement the recommendations of the relevant specialist studies (in particular the Soil Study and Rehabilitation plan);
- Assess land end-land uses for each individual rehabilitated site. Rehabilitation must be consistent with the relevant end land-use objectives of closure plans;
- Reclaimed land areas not suitable for human settlement, crop cultivation or livestock production, must be clearly demarcated as such and illegal settlement on, and use of this land must be prohibited, monitored and controlled;
- If particular development opportunities on reclaimed land are approved, these should be discussed with local municipalities for possible integration into Integrated Development Plans (IDPs) and Spatial Development Frameworks (SDFs); and
- Investigate if, and how SGL could contribute to the development of reclaimed land for the benefit of local communities. This could take the form of partnerships with local authorities and other mining companies, and/or including such development projects in the SLP/Local Economic Development programme of the Project.

10 Monitoring

Long term monitoring is regarded to be extremely important, especially in the areas with water (rivers and wetlands) and an end land use of agriculture.

Metals such as manganese, cobalt, copper, zinc, the metalloid arsenic, lead, magnesium and long-lived cyanide metal complexes persist in unrehabilitated footprints of reclaimed tailings storage facilities (Liefferink M *et al*. 2014).

The rehabilitation plan 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.

Monitoring is crucial with respect to rehabilitation with particular emphasis for this project. Table 11-1 below provides monitoring activities that should be undertaken. Additional monitoring activities may be contained within some of the other specialist reports and thus these also must also be taken into consideration.

11 Monitoring and Maintenance Plan

Table 11-1: Monitoring and maintenance activities

Aspect	Timing	Aim	Actions
Radioactivity	Post reclamation prior to rehabilitation of the site	Assess incidence of radioactivity	During the reclamation process the fallout of toxic and radioactive dust and water pollution are often exacerbated (van Tonder *et al*. 2008). (Liefferlink, 2013) which would have to be monitored over the long term, post closure to ensure that these are returned to their natural levels. It is suggested that a Radiation and Radon Assessments be conducted for reclaimed sites.
Topography	Bi-annually	Assess 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.
	Bi-annually	Erosion repair	Erosion gullies identified on site should be checked and packed with stone from the surplus rock piles.
	Bi-annually	Subsidence repair	The subsidence issues which occur should be checked and remedied using soil from the subsidence soil pile.
Groundwater	Bi-annually	Monitor water	A hydrologist should assess groundwater levels and quality in boreholes sited in groundwater report. (**NB timing to be confirmed with to authority's requirements**).
Soil	Annually	Assess soil qualities	A specialist study should be undertaken on completion of rehabilitation work. **<u>Assessment should identify:</u>** • Rehabilitated soil thickness and soil characteristics;

Aspect	Timing	Aim	Actions
			• Erosion occurrences; • Soil acidity and salt pollution analyses (pH, electrical conductivity and sulphate) at 0 mm-250 mm soil depth every 10 ha; and • Fertility analysis (exchangeable cations K, Ca, Mg and Na and phosphorus) every 16 ha (400 mx400 m).
Surface water	Annually (after first summer rains and after any large storms)	Maintain good surface drainage	Surface water drainage should be assessed by a surface water specialist. Assessment of the functionality of the surface water drainage systems will ensure that the drainage of the recreated profile matches the rehabilitation plan. Additionally it ensures early detection of poorly functioning drainage structures. These can then be repaired or replaced before they cause significant damage.
Vegetation	Annually (end summer)	Monitor Vegetation	Vegetation assessments and surveys should be undertaken by external experts to establish the full range of plant species that have become established (during summer) and whether a successful species succession is taking place.
	Annually (5yrs)	Reseed areas of poor vegetation	Reseed with quantities recommended by the specialist. Maintain at least a 60% basal cover. Reseed bare areas greater than 2 m^2.
	Annually (5yrs)	Fertilizer application	Apply 300 kg/ha LAN (Nitrogen) once a year to all areas. As the areas are weak because of lack of topsoil, annual Nitrogen fertilization should be provided for at least 5 years. Depending on soils analysis results, additional fertiliser may be required to maintain phosphate and potassium levels.
	Annually	Clear Alien Vegetation	A specialist should undertake inspections of the project area on an annual basis to identify alien invasive and problem plants on site.

Aspect	Timing	Aim	Actions
	Quarterly	Heavy Metal presence in plants	Leaf samples should be taken quarterly and sent to a lab to test for the uptake of heavy metals and radionuclides.
Fauna	Annually	Identify species	A specialist should undertake an assessment of the project area on an annual basis to monitor the re-colonisation of fauna species through species assessment (Sherman and pitfall trapping).

12 Conclusion and Recommendation

12.1 Initial Rehabilitation - Primary Issues

The following concerns are noteworthy with regards to this project. Successful implementation of the rehabilitation plan should result in these concerns being limited.

- Dust fall out and erosion as a result of poor vegetation cover;
- Should rehabilitation not be successfully implemented wind erosion as a result of poor physical cover will have a negative effect on the surrounding areas. It is common that have grass covers are short-lived on gold TSF's. This should be avoided as best as possible;
- Access to site and potential exposure to radiation levels that exceed the recommended levels;
- Until the area is successfully remediated and the levels radiation been confirmed to be within the guidelines access to these areas needs to be controlled;
- It is essential that access is limited to the TSF, RTSF and Plant areas through the installation of fences and good security in order that people and animals are not harmed; and
- Ensure that monitoring is undertaken to ensure that rehabilitation efforts have been successful.

In conclusion the overall positive impacts of the proposed project and the additional phases that may outweigh the negative impacts associated with the project and the historical impacts that have occurred as a result of historical mining in the area. This project is crucial with respect to rectifying historical impacts and minimising future environmental disasters that could occur in the proposed project is not undertaken. The proposed project itself does have its own risk and impacts associated with post closure. If rehabilitation and post closure mitigation is adopted correctly minimisation of these impacts could be achieved through appropriate management and responsible care

13 References

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