Sasol Sigma Defunct Colliery Surface Mitigation Project: Proposed River Diversion and Flood Protection Berms

Rehabilitation Report

Project Number:

SAS5250

Prepared for:

Sasol Mining (Pty) Ltd

Date:

September 2018

Digby Wells and Associates (South Africa) (Pty) Ltd
Co. Reg. No. 2010/008577/07. Turnberry Office Park, 48 Grosvenor Road, Bryanston, 2191. Private Bag X10046, Randburg, 2125, South Africa
Tel: +27 11 789 9495, Fax: +27 11 069 6801, info@digbywells.com, www.digbywells.com

DIGBY WELLS
ENVIRONMENTAL

This document has been prepared by Digby Wells Environmental.

Report Type:	**Rehabilitation Report**
Project Name:	**Sasol Sigma Defunct Colliery Surface Mitigation Project: Proposed River Diversion and Flood Protection Berms**
Project Code:	**SAS5250**

Name	**Responsibility**	**Signature**	**Date**
Christine Reinecke	Report Writer		August 2018
Siphamandla Madikizela	1st Review		August 2018
Leon Ellis	2nd Review		August 2018
Brett Coutts	OpsCo Review		September 2018

DECLARATION OF INDEPENDENCE

Digby Wells and Associates (South Africa) (Pty) Ltd

Contact person: Christine Reinecke

Digby Wells House	Tel:	011 789 9495
48 Grosvenor Road	Fax:	011 069 6801
Turnberry Office Park, Bryanston	E-mail:	christine.reinecke@digbywells.com
2191		

I, Christine Reinecke 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 Sasol Mining (Pty) Ltd, other than fair remuneration for work performed, specifically in connection with the Sasol Sigma Defunct Colliery Surface Mitigation Project: Proposed River Diversion and Flood Protection Berms.

Full name:	Christine Reinecke
Title/ Position:	Assistant Rehabilitation Consultant
Qualification(s):	BSc (Hons.) Geography and Environmental Science
Experience (years):	1.5

EXECUTIVE SUMMARY

Digby Wells Environmental (hereafter Digby Wells) was appointed by Sasol Mining (Pty) Ltd (Sasol Mining) as the Independent Environmental Assessment Practitioner (EAP) to ensure compliance by undertaking the required environmental regulatory process required to implement the proposed surface mitigation measures at the Sigma Defunct Colliery (proposed project). This report details the rehabilitation (remediation) activities that need to be implemented at the various sections where diversion canals and flood protection berms will be constructed.

The proposed project is aimed at diverting the Leeuspruit and Rietspruit watercourses away from the areas where there is a significant probability of pillar failure resulting in subsidence thereby preventing ingress of surface water into the underground mine workings. This will be achieved by constructing diversion canals and flood protection berms to channel the Leeuspruit and Rietspruit away from these areas.

The main land uses in the area are underground mining and veld for grazing. Agricultural activities are taking place at other locations within the Sigma Defunct Colliery. Also, upmarket property development occurs along the Vaal River. The proposed diversion system is designed as a permanent measure forming part of the closure plan for Sigma Defunct Colliery.

The no-go alternative in this particular instance refers to a situation where the proposed surface mitigation measures are not implemented. In the event that the proposed surface mitigation measures are not implemented there is a high probability of pillar failure resulting in subsidence, subsequently leading to alterations of flow regimes and water quality in groundwater and surface water, loss of habitats and loss of connectivity between habitats. All these impacts can lead to alteration of surviving habitats and changes to the ecological function of communities. Species that depend on these terrestrial, aquatic, and semi-aquatic habitats can be particularly susceptible to these impacts.

The following recommendations are made to minimise the impacts:

- Strategic water management plans should be implemented to ensure that the effect on the environment in general and surface water in particular is minimised (Digby Wells Environmental (b), 2018). The plans should developed in consultation with stakeholders to ensure the sustainable development and management of the river diversion;
- Care must be taken to provide erosion and sedimentation control protection on the site such that construction runoff is directed away from the proposed flood protection berms locations in Leeuspruit Sections 2 to 4, and Rietspruit Section 1;
- To ensure efficiency of the system, protection berms and diversion canals have to be inspected for silting and blockages of inflows, pipelines for hydraulic integrity and the overall surface water flow performance monitored;

- Berms should be monitored for erosion monthly for the 1st year, quarterly for the 2nd year, and bi-annually for the 3rd year until sustainability is confirmed.;
- If any erosion occurs, corrective actions must be taken to minimise any further erosion from taking place;
- Ensure that sufficient secondary grassland and wetland vegetation is retained to maintain ecological processes through monthly monitoring for the 1st year, quarterly for the 2nd year, and bi-annually for the 3rd year until sustainability is confirmed;
- Minimise unnecessary removal of the natural vegetation cover;
- Plan excavations carefully and avoid moving of heavy machinery into sensitive areas unnecessarily;
- Newly constructed berms will have to be re-vegetated and stabilised as soon as construction has been completed;
- Wetlands and aquatics monitoring should take place monthly for the 1st year, quarterly for the 2nd year, and bi-annually for the 3rd year until sustainability is confirmed;
- The proposed activities associated with the alteration of the river banks must preferably take place during the drier period of the year and the associated disturbance within the river channel limited as far as possible, both spatially and temporally;
- Use of accredited contractors for removal of construction equipment must be ensured, this will reduce the risk of waste generation and accidental spillages;
- All erosion noted within the construction footprint should be remedied immediately and included as part of a monitoring should take place monthly for the 1st year, quarterly for the 2nd year, and bi-annually for the 3rd year until sustainability is confirmed; and
- Surface inspection on the fully rehabilitated areas must be undertaken to ensure a surface profile that allows good drainage. This will ensure improvement or increased catchment yield on to the surrounding water streams.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 Introduction

Digby Wells Environmental (Digby Wells) was appointed by Sasol Mining (Pty) Ltd (Sasol Mining) as the Independent Environmental Assessment Practitioner (EAP) to ensure compliance by undertaking the required environmental regulatory process required to implement the proposed surface mitigation measures at the Sigma Defunct Colliery (proposed project). This report details the rehabilitation (remediation) activities for various sections where diversion canals and flood protection berms will be constructed.

2 Background

Sasol Mining's Sigma Defunct Colliery now referred to as the Sigma Defunct Colliery occupies a mining area of approximately 11 643 ha. Mining activities at the Sigma Defunct Colliery was conducted under Mining Licences No. 1/2001 and 3/2001, granted by the Department of Mineral Resources (DMR).

Sigma Defunct Colliery commenced operations in 1952 with underground mining, holding mineral rights to several coal deposits in the Sasolburg district. Underground mining methods was the primary method of extracting these reserves and included mechanised board-and-pillar and rib pillar extraction and bottom coaling methods. Access to the underground operations was via several shafts, and the coal was then conveyed to a 'dry' coal handling plant at 3 Shaft where the coal was screened and fed to silos.

In 1992 the Wonderwater opencast mine was developed to extract coal from the north-eastern side of the reserves which occupied a mining area of approximately 385 ha. The Wonderwater opencast mine was mined utilising truck and shovel methods. The mining ceased in 2005 after which the opencast mine was backfilled and rehabilitated. The final voids were left as part of the water management of the underground workings.

The Mohlolo Operations, situated adjacent to the Wonderwater opencast mine commenced with its activities in 1999 and occupied a mining area or approximately 264 ha. The underground operations were accessed from the Wonderwater opencast mines highwalls in the north and the south and divided the operations into Moholo North and Mohlolo South. The underground mining was scaled down and ceased by 2005, the underground mine workings were left to be flooded.

Sigma Defunct Colliery applied for mine closure where a closure application and closure report was submitted to the DMR in 2009. Sigma Defunct Colliery began to implement the proposed mitigation measures as per the requirements of the closure plan and Environmental Management Programme (EMP) to address all the significant risks and rehabilitation measures which were required to obtain the needed closure certificate. Jones and Wagener (J&W) were appointed to assist Sasol Mining in the compilation of a Risk Assessment Report for mine closure process to identify all the significant latent risks which Sigma Defunct Colliery have and rate them in accordance with the Sasol Risk Assessment Methodology. This report further proposed mitigation measures to be implemented to reduce the significant rated risks to an acceptable residue risk level. The report was compiled in 2015 and has now been updated in 2018.

3 Project Description

As part of the Risk Assessment Report, mitigation measures have been proposed and grouped together as underground mitigation measures (ash backfilling) and surface mitigation measures (river diversions and berm constructions). Sasol Mining have allocated funds in accordance with the mines financial provision to provide for the implementation of the project.

The Underground Mitigation Measures which includes ash backfilling of certain areas with ash slurry is being dealt with as a separate project and under a separate environmental authorisation process.

The Surface Mitigation Measures proposed in the Risk Assessment Report requires environmental authorisation. Two rivers flow through the Sigma mining area namely the Rietspruit and the Leeuspruit. Beneath these water courses or floodplains a hazard of pillar failure exists which can result in subsidence. Subsidence is expected to have a significant impact on surface aspects should it occur and no mitigation measures are implemented. The risk of this occurring is considered to be significant. Therefore various mitigation measures have been proposed to reduce the significant risk areas to an acceptable residual risk (insignificant risk).

According to the J&W Design Report, 2018 a total of 37 potentially significant risks (associated with underground mined panels where a high potential of pillar failure has been identified) were identified of which 36 are located within the Leeuspruit and only one within the Rietspruit. J&W's Design Report, 2018 sub-divided the Leeuspruit into four sections numbered in the direction of stream flow (from south to north).

It should be noted that J&W have indicated that no upgrades to any existing culverts or bridge crossings are proposed as part of this project.

The surface mitigation measures that were considered include full stream diversions, partial stream diversion and ash backfilling of mined panels or various combinations thereof. A description of the various diversions types is provided below:

- Full stream diversion:
  - Typically consists of a diversion canal which follows along a completely new alignment from the original stream alignment. The stream flow is diverted along the new route and discharges back into the existing stream downstream of the affected area. A diversion canal mitigates the risk by moving the stream away from the significant risk area.
- Partial stream diversion:
  - A partial stream diversion entails confining the stream flow by means of either channelling the stream or flood protection berms or both in order for it not to cross

areas where a high chance of subsidence could occur. The purpose of flood protection berms is to prevent the existing stream flow from entering significant risk areas. Where possible, flood protection berms are used in isolation, however if the position of a berm obstructs the natural stream flow (i.e. crossing existing watercourse centreline), flood protection berms are used in combination with channelling the stream. This prevents unnecessary secondary issues, for example backwater or ponding upstream of the berm, and allows unimpeded flow of the stream past the problem areas.

- Backfilling:
  - Ash backfilling is predominantly used where a full stream diversion or partial stream diversion alone does not mitigate the risk or where a diversion canal cannot avoid crossing over a significant risk area. In the case where a full diversion or partial diversion is not possible, only backfilling is proposed.

It must be noted that although mentioned, ash backfilling is being dealt with as a separate project and is not considered to be incorporated as part of this environmental authorisation process.

The proposed project is aimed at diverting the Leeuspruit and Rietspruit watercourses away from the high probability of risk areas thereby preventing ingress of surface water into the mine workings. This will be achieved by constructing diversion canals and flood protection berms to channel the Leeuspruit and Rietspruit away from the undermined areas deemed areas of potentially significant risks as per the mine closure assessment report (van der Berg, et al., 2018).

3.1 Surface Mitigation Measures

As mentioned above the surface mitigation measures have been divided into 5 sections along the Leeuspruit with only one section in the Rietspruit. A description of each section is provided in Table 3-1 below:

Table 3-1: Infrastructure and Mitigation Measures

Significant Risk Area	Mitigation Measure Implemented	Description
Leeuspruit: Section 2	■ Flood protection berm to be constructed to avoid one area of significant risk.	■ The flood protection berm will comprise of suitable material, typically clayey sand or sandy clay material obtained from other necessary excavations.
Leeuspruit: Section 3	■ Combination of diversion canals, flood protection berms and ash backfilling.	■ The proposed design comprises of two flood protection berms to direct the flow of water away

Significant Risk Area	Mitigation Measure Implemented	Description
		from significant areas; ■ A formalised canal to divert the stream flow away from the natural stream flow path (Armorflex or a similar approved lining); and ■ Ash backfilling will be utilised were diversions are not possible. Ash Backfilling is considered to be a separate project and under a separate environmental authorisation process.
Leeuspruit: Section 4	■ Two Full stream diversion canals are proposed, namely the Southern diversion canal and Northern diversion canal; ■ Flood protection berms will also be utilised; and ■ Ash Backfilling will also be utilised.	■ This section is located immediately west of the Sasolburg residential area and comprises approximately 2.3km of the Leeuspruit, from the Afrikaans High Sasolburg up to the R59 provincial road; and ■ Ash backfilling will be utilised were diversions are not possible. Ash Backfilling is considered to be a separate project and under a separate environmental authorisation process.
Leeuspruit: Section 5	■ This section's design comprises mainly of backfilling polygons due to surface restrictions on either side of the stream.	■ Located on the south-western side of the area is private infrastructure and northeast is an operational sand mine; and ■ Some of these areas have already been backfilled. Ash Backfilling is considered to be a separate project and under a separate environmental authorisation process.
Rietspruit: Section 1	■ Only one significant risk area has been identified; and ■ A flood protection berm is	■ Small diameter pipes will also be installed at low points along the berm to allow the slow release of water accumulated behind the

Significant Risk Area	Mitigation Measure Implemented	Description
	proposed.	berms.

3.2 Study Area

The Sigma Defunct Colliery is situated adjacent to the town of Sasolburg, in the Free State Province and it is bordered to the north by the Vaal River. It comprises of the main Sigma underground colliery, the Wonderwater opencast mine and the Mohlolo underground colliery. The location of the proposed project is shown in Figure 3-1 and Figure 3-2.

The key infrastructure (Table 3-1) associated with the project includes various diversion canals and flood protection berms to channel the Leeuspruit and Rietspruit past areas with high probability of pillar failure resulting in subsidence identified through the mine closure risk assessment. The proposed diversion system is designed as a permanent measure forming part of the closure plan for Sigma Defunct Colliery.

No closure plan is therefore required upon construction of the river diversion as it will remain in place permanently. The proposed diversion infrastructure is depicted in Figure 3-3.

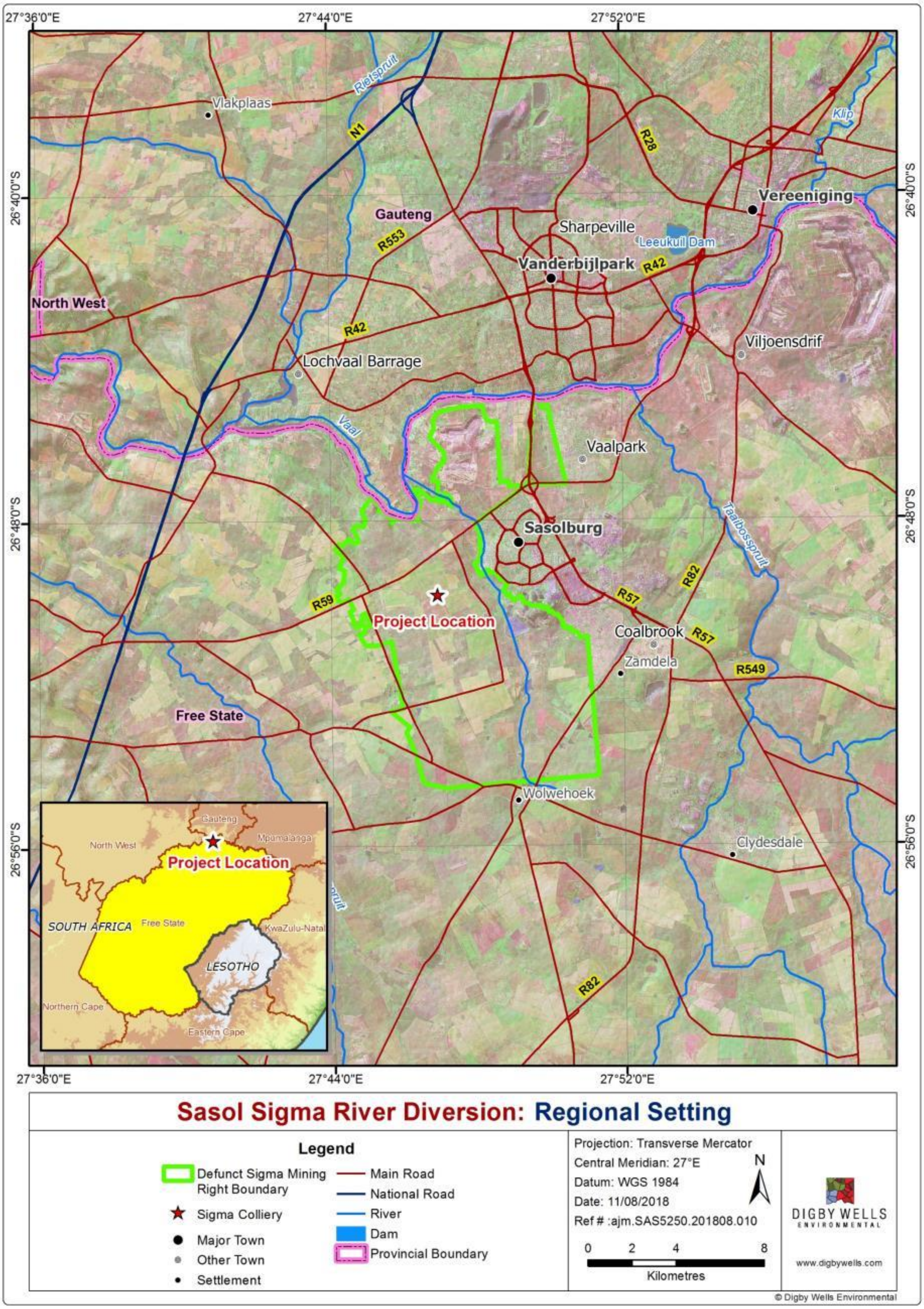

Figure 3-1: Regional Setting

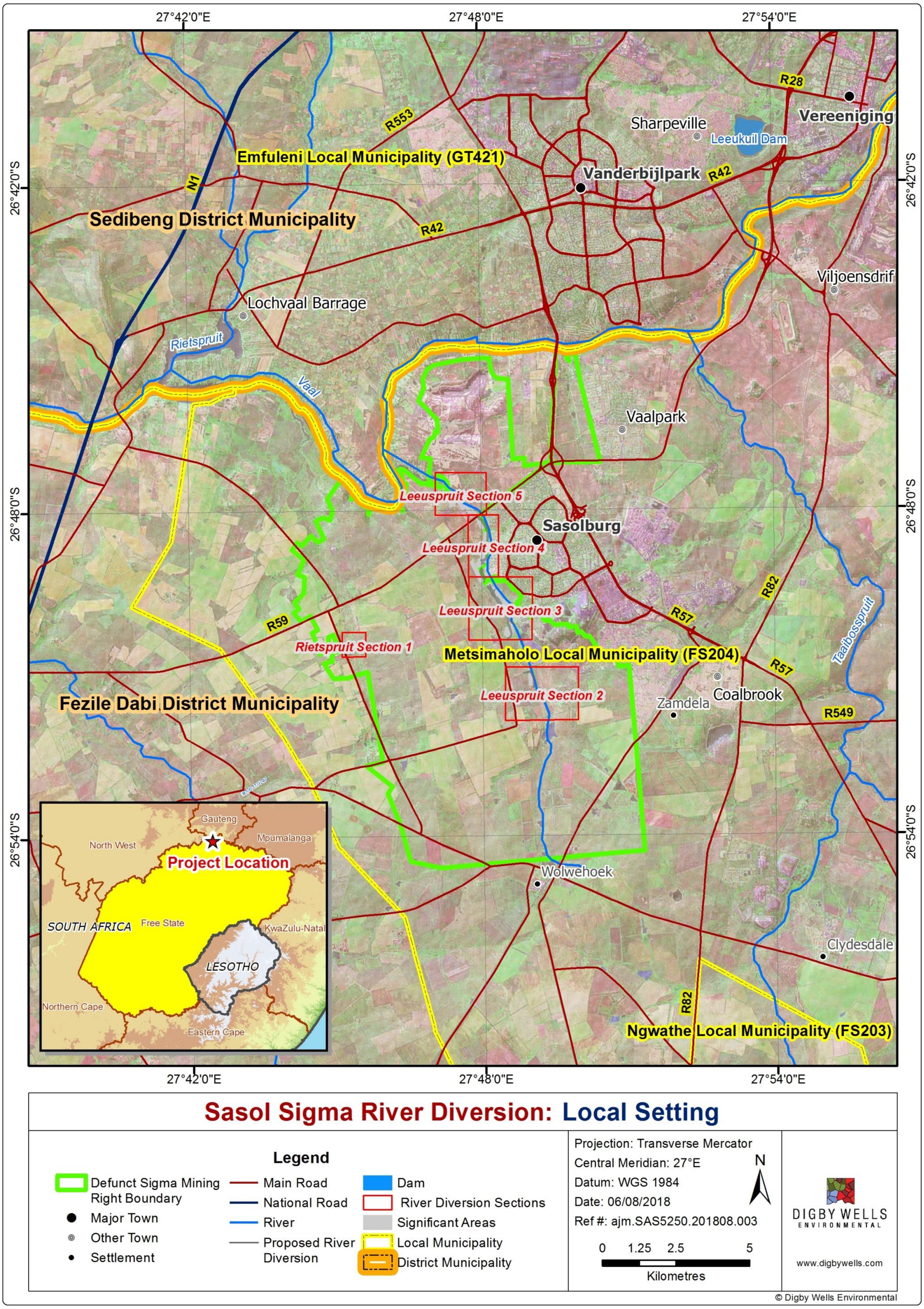

Figure 3-2: Local Setting

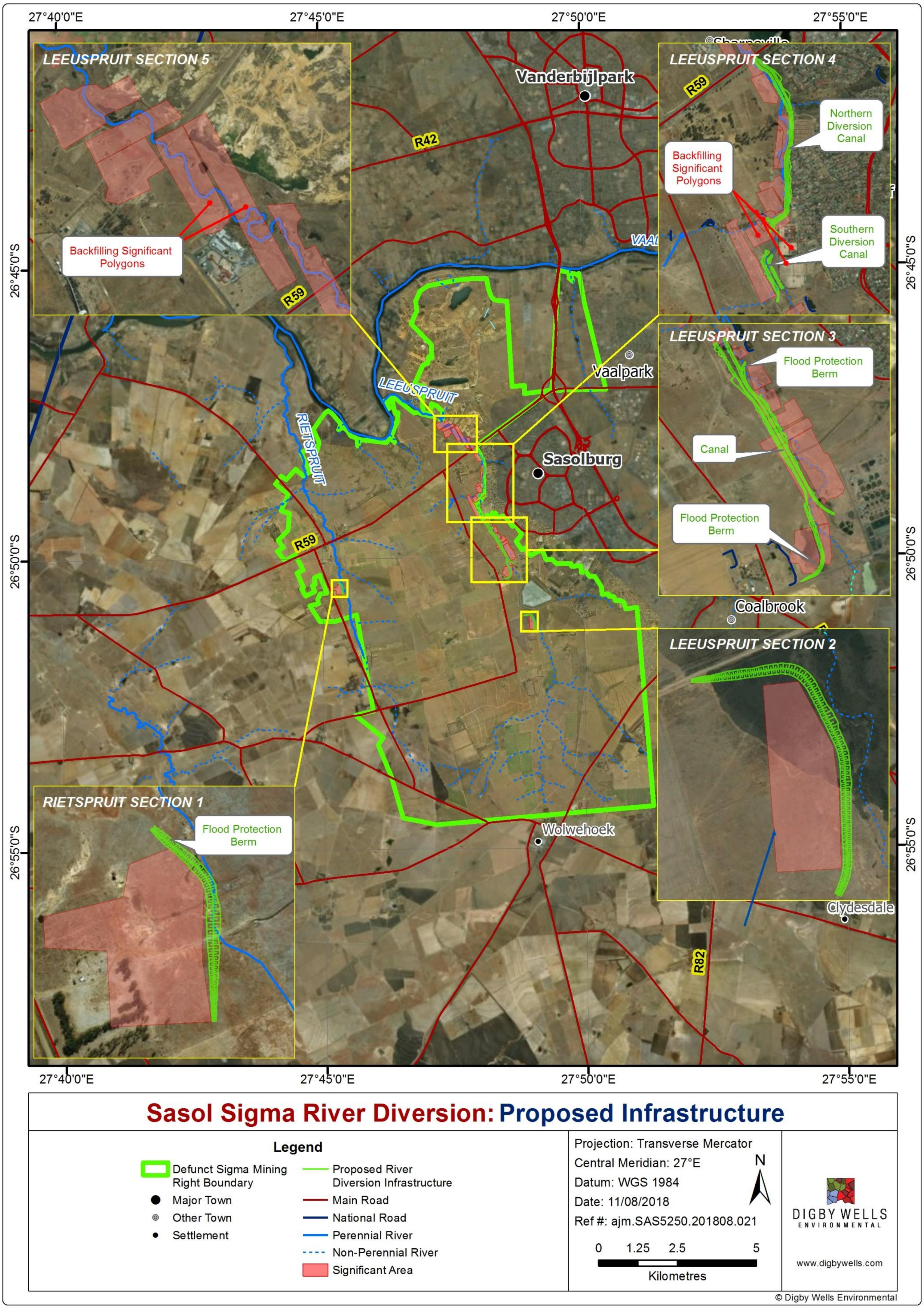

Figure 3-3: Site Infrastructure

4 Plan Structure

The remainder of the Rehabilitation Plan is structured as follows:

Section	Theme
Section 5	Details of Author(s).
Section 6	Terms of Reference
Section 7	Land Use Plan
Section 8	Cumulative Impacts
Section 9	No-Go Alternative
Section 10	Rehabilitation (Remediation) Actions
Section 11	Operation and Maintenance
Section 12	Recommendations and Conclusion
Section 13	References

5 Details of Author(s)

The following is a list of Digby Wells' staff who was involved in the compilation and review of this report for Sasol Defunct Colliery:

Christine Reinecke received a Bachelor of Social Science in Environmental Science and Management and completed her BSc (Hons) in Geography and Environmental Science, specialising in Mine Rehabilitation at Monash South Africa. She joined Digby Wells in March 2017 to form part of the Mine Closure and Rehabilitation Services Department and is an Assistant Rehabilitation Consultant. She has been involved in studies such as; Rehabilitation and Closure Plans, conducting Risk Assessments, compiling Annual Rehabilitation Plans and Rehabilitation Audits.

Siphamandla Madikizela is a Soil Scientist, completed his MSc in Soil Science at University of KwaZulu-Natal and is a Professional Natural Scientist (Registration no. 400154/17) in the Republic of South Africa. Prior to his employment at Digby Wells Environmental, Siphamandla worked as an Assistant Plantation Manager at EcoPlanet Bamboo SA. He is the part of the Closure, Rehab and Soils Department at Digby Wells Environmental. His role involves conducting soil surveys; soil, land capability and land use environmental impact assessments; soil and agricultural potential studies; soil contamination assessments; interpreting results of soil samples; soil management plans and writing detailed scientific reports in accordance to local legislation and IFC standards and World Bank Guidelines. Siphamandla has worked in projects in South Africa, Democratic Republic of the Congo, Malawi and Mali.

Leon Ellis is the Divisional Manager of the Mine Closure and Rehabilitation Services Division at Digby Wells. Leon completed his BSc. (Hons) in Geography and Environmental Management at the University of Johannesburg (UJ) in 2009. He joined Digby Wells in January 2013. He has eight years' experience in the environmental services sector with specialised focus on Environmental Liability Assessments, Mine Closure Plans, Performance Assessments and Risk Assessments, locally and internationally. He has also been involved in the undertaking of Environmental Impact Assessments (EIAs) and Environmental Management Programmes (EMPs). Leon also completed the Environmental Risk Assessment and Management course based on ISO 31000 at the Centre of Environmental Management (North West University) in 2016.

Brett Coutts is an Ecologist with a BSc Honours in Ecology, Environment and Conservation. Brett gained practical hands on experience as a project manager on environmental rehabilitation projects at Hydromulch and his roles and responsibilities include the compilation of Basic Assessment (BA) reports, Scoping & Environmental Impact Reports, compilation of Environmental Management Plans (EMP), GIS mapping and Biodiversity Action Plans linking to rehabilitation. Brett is currently the Divisional Manager for the Ecological and Atmospheric Sciences Division. Prior to his appointment, he gained experience as a junior project manager on environmental rehabilitation projects at Hydromulch and then was appointed by Terra Pacis as an Environmental Consultant where his roles and responsibilities included the compilation of Basic Assessment (BA) reports, Scoping & Environmental Impact Reports, compilation of Environmental Management Plans (EMP), GIS mapping and Biophysical Studies.

6 Terms of Reference

The overall objective of the rehabilitation plan will be to provide rehabilitation (remediation) actions associated with construction related activities, more specifically the flood protection berms and construction of the canals. The objectives that can be set for the project are summarised below:

- Implementation of surface mitigation measures to emulate natural flow through the system;
- The implementation of water management measures to ensure that the effect on the environment including surface water in particular is minimised;
- Leave a safe and stable environment for both humans and animals and make their condition sustainable;
- Reduce residual impacts as far as possible;
- Provide realistic and achievable rehabilitation goals that can be set and measurable over time; and
- Monitor and maintain areas that have been rehabilitated.

7 Land Use

The final Land Use Plan (LUP) is essentially the end land use to which Sasol Mining would like to return the land after the construction phase of the proposed project has been completed. The objectives set as part of the planning process aims to ensure that the final LUP is achieved and that the area is sustainable in the long term from an environmental and social point of view.

The main land uses in the area are mining and veld for grazing. Agricultural activities are taking place at other locations within the Sigma Defunct area. Also, upmarket property development occurs along the Vaal River Figure 7-1.

The diversion system is designed as a permanent measure forming part of the closure plan for Sigma Defunct Mine. Therefore no closure plan is required upon removal of the infrastructure as it will remain in operation on a permanent basis. For the proposed river diversion layout, refer to Figure 3-3.

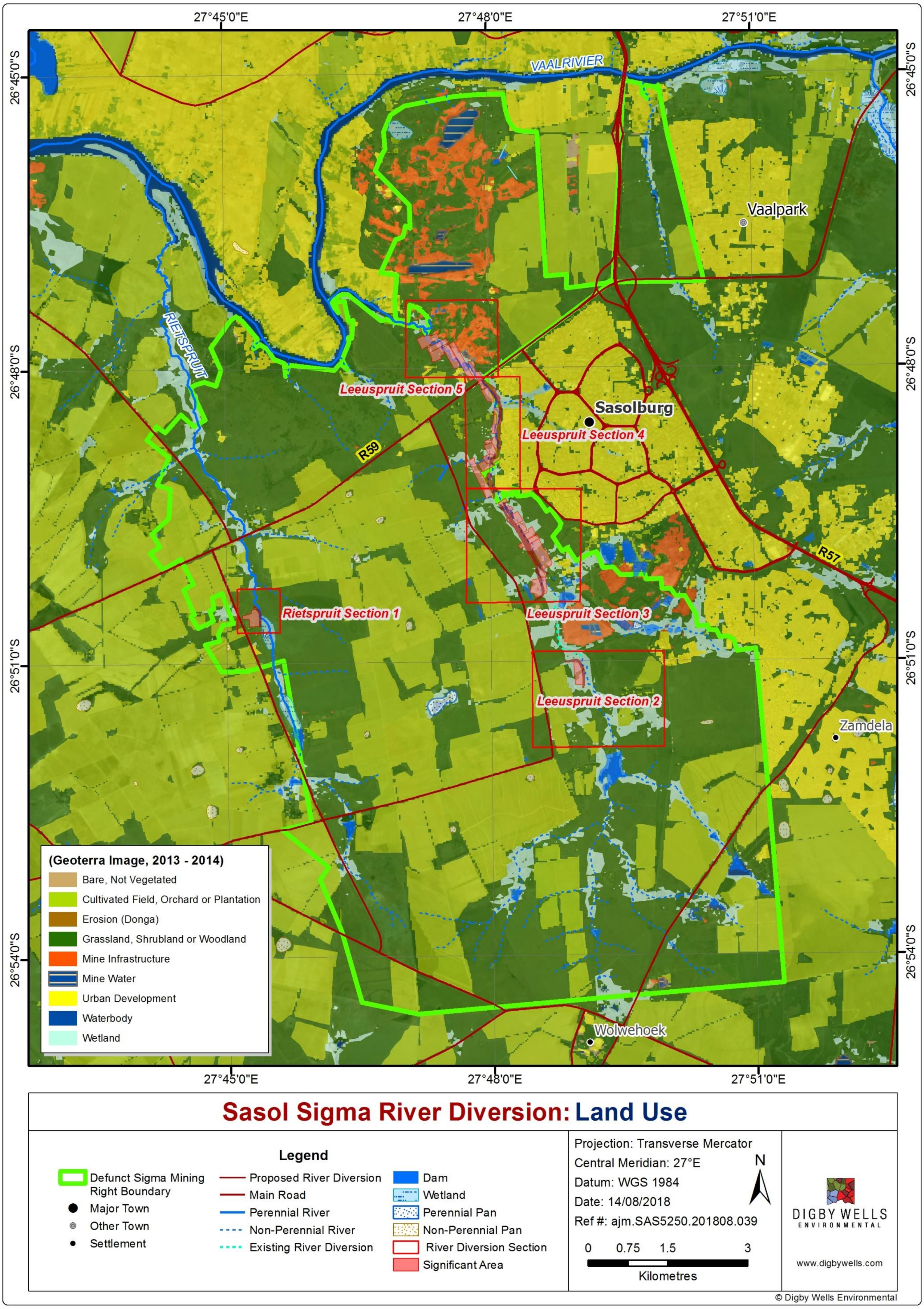

Figure 7-1: Current Land Use

8 Cumulative Impacts

Cumulative impacts are assessed by considering past, present and anticipated changes to the ecological environment. The only construction and subsequent removal of vegetation that will occur is within the footprint of the River Diversion (after mitigation). Impacts occurring from site clearing, soil disturbance and subsequent removal of vegetation pose noteworthy cumulative impacts to the general area.

9 No-Go Alternative

The no-go alternative in this particular instance refers to a situation where the proposed surface mitigations are not implemented. In the event that the proposed surface mitigation measures are not implemented there is a significant probability for pillar failure resulting in subsidence which could lead to the collapse of ground surfaces, subsequently leading to alterations of flow regimes and water quality in groundwater and surface water, loss of habitats and loss of connectivity between habitats. All these impacts can lead to alteration of surviving habitats and changes to the ecological function of communities. The river diversion is being proposed to protect species which depend on these terrestrial, aquatic, and semi-aquatic habitats.

10 Rehabilitation (Remediation) Actions

The potential risks identified in this section are a result of both the environment in which the project activities take place, as well as the actual activities. The potential risks are discussed per aspect, per River Section and per each phase of the project i.e. the Construction Phase. It is also noted that although the impacts for the Construction Phase of the various sections may be different the Operational Phase is predicted to be relatively similar for each section therefore only one operational phase for each aspect has been assessed. No decommissioning phase will be undertaken for this project as the surface mitigation measures are proposed to be permanent. These activities along with the rehabilitation (remediation) actions can be seen in Table 10-1 below.

Table 10-1: Rehabilitation (Remediation) Actions

Significant Risk Area	Phase	Project Activity	Rehabilitation (Remediation) Actions
Leeuspruit Section 2- 5 and Rietspruit Section 1	General Construction Activities	▪ Contractor Camp / Laydown Area Establishment	▪ Remove remaining waste in contractors area after moveable structures and equipment have been removed by contractors; ▪ Rip footprint areas to alleviate compaction; ▪ Reseed with unpalatable grasses and improve species diversity by planting species; ▪ Monitor and maintain vegetation establishment; and ▪ Remove alien invasive vegetation.
		▪ Site clearing, including the removal of topsoil and vegetation	▪ Special care must be taken to ensure that excessive loss of vegetation must is avoided by restricting construction activities to the project foot point area ▪ The removal of any, soils, fauna and flora from the site must be strictly prohibited unless unavoidable and essential for construction activities related to the project; ▪ During construction, the construction footprint must be kept to a minimum as far possible and as much of the natural vegetation must be retained where possible, to assist in preventing erosion.
		▪ Stockpiling of soil once excavated	▪ Use stockpiled soils and topsoil during the construction phase; ▪ Reseed with unpalatable grasses and improve species diversity; ▪ Monitoring of erosion; and ▪ Remove alien invasive vegetation.
		▪ Water Management	▪ Alteration of natural hydrology can be prevented by installing energy dissipaters at the discharge point to avoid erosion of the riverbed and banks. These could be in a form of gabions, silt trap, chutes spillway, etc. to ensure reduction of water velocity refer to (Jones & Wagener, 2018).
		▪ Construction activities within a water courses and wetlands	▪ Limit the footprint area of the construction activities to what is absolutely essential in order to minimise impacts as a result of vegetation clearing and compaction of soils (all areas but critically so in wetland areas); ▪ If it is absolutely unavoidable that any of the wetland areas present will be affected, disturbance must be minimised and suitably rehabilitated, e.g. a wetland offset strategy to compensate for the loss of wetland area due to the canals and berms construction. ▪ Ensure that no incision and canalisation of the wetland features present takes place refer to (Digby Wells Environmental (a), 2018); ▪ All erosion noted within the construction footprint should be remedied immediately and included as part of an ongoing rehabilitation plan; ▪ Active rehabilitation, re-sloping, and re-vegetation of disturbed areas immediately after construction; ▪ All soils compacted as a result of construction activities should be ripped/scarified (<300mm) and profiled (see Digby Wells Environmental (c), (2018) for more information); and ▪ A wetland offset strategy should be developed in order to compensate for the loss of wetland and instream areas due to the canals and berms. Ideally, the PES and EIS of wetlands and instream areas within Sasol's mining lease area should be improved.

Significant Risk Area	Phase	Project Activity	Rehabilitation (Remediation) Actions
		▪ Temporary storage of hazardous products, including waste and fuel	▪ Remove diesel tanks and associated infrastructure from site (it is assumed that all potential contamination is removed during operations); ▪ Dispose of contaminated material at a hazardous waste facility; ▪ Once the site has been cleared of all infrastructure and rubble and no contamination is present, the exposed area should be reshaped to create a gently sloping, free-draining topography; ▪ Reseed with unpalatable grasses and improve species diversity. Additionally, replant species that were relocated during construction phase; ▪ Monitor and maintain vegetation establishment; and ▪ Remove alien invasive vegetation.
		▪ Utilise existing roads to access the various river sections	▪ The footprint area should be ripped to alleviate compaction and to assist with vegetation establishment; ▪ Reseed with unpalatable grasses and improve species diversity. Additionally, replant species that were relocated during construction phase; ▪ Monitor and maintain vegetation establishment; and ▪ Remove alien invasive vegetation.
Leeuspruit Section 2	Construction Phase	▪ Construction of flood protection berm ▪ Vegetation of flood protection berm	▪ Will be constructed from clayey sand, or sandy clay material obtained from other necessary excavation, compacted to minimum 95% Proctor Density[1]; ▪ Side slopes should not be steeper than 1V:5H as per engineering design; ▪ Small ponding areas will be backfilled, whereas slow release outlet pipes will be installed within the berm at larger areas to allow water to discharge after the flood peak in the Leeuspruit has dissipated; ▪ These will typically comprise 600 mm to 900 mm diameter concrete pipe culverts installed within the berm at local low spots; ▪ Should be filled and naturally vegetated (topsoil capping grassed with indigenous grass); ▪ Should be designed with long radius curves (> 500 m) to be both aesthetically pleasing and to minimise flow disturbance in the stream; and ▪ The berm footprint should not encroach onto underground areas, unless the underground area is backfilled below the berm.
Leeuspruit Section 3 Leeuspruit Section 4	Construction Phase	▪ Construction of flood protection berm ▪ Vegetation of flood protection berm ▪ Construction of formalised canal	▪ The canal bottom width and side slopes vary along the canal length in order to remain below the natural ground level as the topography varies. The canal bottom width and side slopes are summarised below; ▪ Shall be constructed from clayey sand, or sandy clay material obtained from other necessary excavation, compacted to minimum 95% Proctor Density; ▪ Side slopes not steeper than 1V:5H as per engineer design for both the berm and the canal; ▪ The maximum velocities within the Southern and Northern diversion canals are well in excess of 2.0 m/s and will therefore require adequate erosion protection measures. It is proposed that Armorflex 180 (or similar materials), that can handle flow velocities of up to 5.5 m/s, be used to protect the flow area of the canal. ▪ The ArmorFlex should be filled and naturally vegetated (topsoil capping grassed with indigenous grass); ▪ should be designed with long radius curves (> 500 m) to be both aesthetically pleasing and to minimise flow disturbance in the stream; and ▪ The berm and canal footprint shall not encroach onto problematic underground area, unless the polygon is backfilled below the

[1] The Proctor compaction test is a laboratory method of experimentally deter construction the optimal moisture content at which a given soil type will become most dense and achieve its maximum dry density.

Significant Risk Area	Phase	Project Activity	Rehabilitation (Remediation) Actions
			berm.
Leeuspruit Section 5	Construction Phase	▪ Ash backfilling	▪ The backfilling of Leeuspruit Section 5 is planned and addressed in a separate report as part of a separate project (Digby Wells Environmental - Ash Backfilling, July 2018).
Rietspruit: Section 1	Construction Phase	▪ Construction of flood protection berm ▪ Vegetation of flood protection berm	▪ Shall be constructed from clayey sand, or sandy clay material obtained from other necessary excavation, compacted to minimum 95% Proctor Density; ▪ Side slopes not steeper than 1V:5H as per engineer design; ▪ Should be naturally vegetated (topsoil capping grassed with indigenous grass); ▪ Should be designed with long radius curves (> 500 m) to be both aesthetically pleasing and to minimise flow disturbance in the stream ▪ Drain below the berm spaced at 40 m intervals to facilitate seepage underneath the berm and to maintain wetlands downstream of the berm; and ▪ The berm footprint should not encroach onto problematic underground area, unless the polygon is backfilled below the berm.
Leeuspruit Section 2- 5 and Rietspruit Section 1	Operational Phase	▪ Removal of everything related to construction phase	▪ Remove all equipment and machinery from site; ▪ Rip footprint areas to alleviate compaction; ▪ Reseed with unpalatable grasses and improve species diversity. Additionally, replant species that were relocated during construction before the rainy season; ▪ Install temporary fencing to protect new vegetation on the berms from cattle and other animals; ▪ Monitor and maintain vegetation establishment; and ▪ Remove alien invasive vegetation.

10.1 Rehabilitation (Remediation) Strategy

The following section describes general rehabilitation (remediation) strategies to assist with the proposed river diversion rehabilitation (remediation).

10.1.1 Soil Management

Soil management for this project include the following:

- Topsoil and sub soil must be stored separately; and
- Soil must be stockpiled for construction of berms.

10.1.2 Soil Compaction Alleviation

In order to alleviate or reduce soil compaction the following should take place:

- Rip all disturbed footprints and heavily compacted areas to improve soil fertility; and
- Soils should be moved and/or replaced when they are dry to minimise compaction.

10.1.3 Soil Amelioration

Soil amelioration should be done as follows:

- Following de-compaction, an acceptable seed-bed should be produced through surface tillage; and
- Fertiliser should be applied (if vegetation does not establish) to raise the soil nutrient content to the desired levels and maintenance should continue.

10.1.4 Erosion Control

The following should be done as part of erosion control on rehabilitated land:

- Unnecessary disturbance and vegetation removal should be avoided and prevented;
- Construction of flood protection berms as per engineering designs to minimise erosion; and
- Rehabilitated areas should be fenced off for 1 year and monitored for erosion monthly for the 1st year, quarterly for the 2nd year and bi-annually for the third year until sustainability is confirmed.

10.1.5 Vegetation Establishment

The establishment of natural vegetation is a necessary component of the rehabilitation (remediation) phase. The overall objectives for the establishment of natural vegetation of reshaped areas are to:

- Avoid soil loss through proper management techniques (refer to (Digby Wells Environmental (c), 2018));

- Reduce sedimentation into aquatic ecosystems such as rivers, wetlands and streams;
- Re-establish eco-system processes (succession) to ensure that a sustainable land use can be established without requiring excessive fertiliser additions; and
- Restore the biodiversity of the area as far as possible. Care must be taken to avoid indiscriminate destruction of habitat; and where possible the rehabilitation of transformed areas and restoration of degraded secondary riparian vegetation units and grassland must take place in order to improve the ecological health of the floristic component on the affected habitat types

In order to ensure vegetation establishment, the following should be done:

- Rehabilitated areas should be properly prepared and fenced off to prevent cattle from destruction of newly established vegetation;
- Woody patch cavities should be in-filled with suitable growth medium; and
- Growth properties should be improved by the addition of organic matter and fertilizer, where required.

To ensure successful rehabilitation (remediation) at the proposed project area, it is important to note vegetation types so that these can be replaced to some extent once construction has been completed.

10.2 Alien Invasive Species Management

Alien invasive species tend to out-compete the indigenous vegetation; this is due to the fact that they are vigorous growers that are adaptable and able to invade a wide range of ecological niches (Bromilow, 2010). They are tough, can withstand unfavourable conditions and are easily spread which is detrimental to rehabilitation (remediation) of vegetation. Alien Invasive Plants (AIPs) directly compete with rehabilitating vegetation and could result in increasing costs of revegetation in the long term. In addition, various invasive species are required by law to be removed. Methods should be used that are appropriate for the species concerned, as well as to the ecosystem in which they occur. When performing the controlling methodology for weeds and invaders, damage to the environment must be limited to a minimum. One of the most cost-effective and sustainable options is to utilise biocontrol. Biocontrol makes use of a natural enemy of the AIP in its native country to help reduce the population in the country it invades (see the Agricultural Research Council website for more information on Biocontrol). If mechanical and chemical means need to be used, AIPs must be continually removed after rehabilitation (remediation) has occurred for at least three growing seasons to ensure the seed bank is depleted. Continual monitoring will be needed for seeds that are likely to be blown in from adjacent areas.

- There must be no planting of alien plants (e.g. *Argemone ochroleuca subsp. Ochroleuca, Amaranthus hybridus L, Berkheya rigida, Bidens pilosa- , Cirsium* *vulgare, Conyza canadensis (L.), Datura ferox, Eucalyptus camaldulensis, Flaveria bidentis, Gleditsia triacanthos, Pinus patula, etc.* (Digby Wells Environmental (c), 2018)) anywhere within the construction area;

- 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; and
- It is considered essential that appropriate veld management (particularly appropriate grazing levels and burning frequencies) should be applied to areas of secondary indigenous vegetation (e.g. secondary grassland of historically cultivated areas), and especially the grassland and wetland vegetation of untransformed habitats. Appropriate grazing levels and burning frequencies will not only ensure that good vegetation condition and biodiversity levels are maintained, but will also serve to control the spread and increase in cover of palatable alien species such as *Paspalum dilatatum*.

In order to manage alien invasive species the following should be done:

- Mechanical methods including tree felling, hand pulling & ring barking should be implemented;
- Chemical control methods including selective/ non-selective, contact/ systemic herbicides as per regulations should be implemented;
- Category 1(a), & 1(b) of the National Environmental Management: Biodiversity Act, 2004 (Act No. 10 of 2004) (NEMBA) listed species should be target for eradication;
- Preventative measures should be undertaken within the proposed project area where natural vegetation occurs to combat bush encroachment and invasion of alien species which may result in the deterioration of natural resources; and
- Regular vegetation monitoring of the site should take place.

10.3 Re-Vegetation

In selecting a seed mixture, one can use commercial available seeds, or harvesting can be done from surrounding areas (Redco, 2010). Revegetation is required in disturbed areas as well as for newly constructed berms and canals. Plant species to be selected for rehabilitation should be hardy, tolerant of drought, acidity, fire and harsh conditions (GDARD, 2009). Grasses such as *Hyparrhenia hirta* (Common Thatching Grass) and *Cynodon dactylon* (Couch Grass) are suitable for this. Further to this, unpalatable species should be planted and fenced off for the first year so cattle and other animals don’t eat the grass and thus stay away from the berms to prevent major erosion and damage. After vegetation establishment success has been confirmed, palatable grass species can be planted for grazing purposes.

Revegetation is required as part of the mitigation measures of the project. For the erosion berms and canal, plants that offer good ground cover for erosion control and that establish and spread easily are ideal. Hydromorphic species will need to be planted within the canal and these species must be able to withstand fast flow and frequent inundation Table 10-2 lists plant species suitable for revegetation of the canals and erosion berms. Species Group A and B are for the erosion berms and the edges of the canals, whilst Species Group C is for the permanent wetland area of the canal. It is advisable that hydromorphic plant species are planted as ‘plugs’ in a 1x1 m^2 grid in the gaps of the ArmorFlex. Species such as *Phragmites australis, Typha capensis and Imperata cylindrica* will naturally colonise and spread from the initial plantings

Table 10-2: Plant Species for Revegetation

	Erosion berms	Canal edges	Canal bed
Cynodon dactylon	X	X	
Hyparrhenia hirta	X		
Chloris gayana	X		
Digitaria erianthra	X	X	
Phragmites australis			X
Typha capensis			X
Imperata cylindrica			X
Schoenoplectus sp.			X

11 Operation and Maintenance

The ownership and responsibility for maintenance of the river diversion infrastructure would normally reside with the same party that constructs the works and in whose name the Water Use License is issued. In this case it is not clear how this will be addressed given that (some of) the infrastructure will be constructed on property owned by others. Furthermore, the ultimate purpose of implementing proposed risk mitigations is for Sasol to obtain a closure certificate (Jones & Wagener, 2018). This means that, the ultimate responsibility for ensuring the infrastructure remains functional will be transferred to the Government or the land owner, if closure is the final option.

Our understanding is that the land will be transferred or sold subject to sustainable long-term conditions, which should, amongst other, include the routing inspections and functional maintenance of the risk mitigation infrastructure.

11.1 Operation

The proposed diversion system is designed as a gravity flow system with no operational inputs required. The proposed diversion system is a fully passive, non-attenuating system and therefore requires no operational inputs. No diversion system is however completely free of maintenance and regular inspections and maintenance, for example removal of debris, erosion repair, etc. will be required monthly for the 1st year, quarterly for the 2nd year, and bi-annually for the 3rd year until sustainability is confirmed.

11.2 Inspections and maintenance

Routine inspections and maintenance is required to maintain the system in a good working condition. It is recommended that inspections be carried out monthly for the 1st year, quarterly for the 2nd year, and bi-annually for the 3rd year until sustainability is confirmed, at the start of the dry season. This allows maintenance activities to be carried out, as well as after major flood events (Jones & Wagener, 2018). Since no measuring stations are present within either of the two streams a major flood event is defined as any one of the following taken from Jones & Wagener (2018):

- Rain in excess of ± 70 mm over a 24-hour period (1:5-year storm), or;
- Flood event causing either of the two streams to overtop the R59 tar road, or; • Flood event causing the Leeuspruit to encroach into the town area past the fence erected in between the town and Section 4, or;
- Whenever any damage or excessive flooding is reported by the community.

The following inspection and maintenance activities (Table 11-1) need to be carried out during routine and post-flood inspections (Jones & Wagener, 2018):

Table 11-1: Required Routine Inspection and Maintenance Actions

Required Inspections	Maintenance Actions
Inspect all culverts for debris and siltation.	Remove debris or siltation.
Review condition of vegetation inside streams.	Remove excessive vegetation such as large shrubs and trees that may cause a flow obstruction. Remove loose vegetation (branches, driftwood, etc.). Revegetate ineffectively vegetated areas by hand-planting.
Inspect all structures, for example, berms, waterways, courses, and so forth for erosion and structural damage.	Inform responsible engineer to action appropriate repair work to re-establish structures.
Inspect entire stream for signs of subsidence, surface cracks, sinkholes or potholes.	Inform responsible engineer to action appropriate repair work.

Required Inspections	Maintenance Actions
Inspect fence in between Sasolburg Town and Leeuspruit Section 4.	Restore fence if damaged.
Inspect connections for damage to road or culvert / bridge structure.	Notify accountable authority to action correct repair work. In case of severe damage resulting in a road safety hazard notify traffic police and implement temporary warning signs.
Inspect the stream for any deviation to the normal design flow path (e.g. regular overtopping of banks, noteworthy deviation caused by silt deposition, etc.).	Notify accountable engineer to inspect and take appropriate action if required.

Note: The obligation and necessities for reviews and support should be reassessed if the framework is exchanged to another proprietor than Sasol, for instance upon definite conclusion of the mine. It is important that the framework be reviewed, and the support directed, by an appropriately qualified individual to guarantee it stays practical.

12 Recommendations and Conclusion

This report details the rehabilitation (remediation) activities that need to occur at the various sections where diversion canals and flood protection berms will be constructed. The feasibility design of the surface mitigation measures was covered in this report; however, the feasibility design of the ash backfilling component is still in progress (Digby Wells Environmental - Ash Backfilling, July 2018), pending the outcome of various studies currently underway.

The findings of specialist reports for this project indicate that most of the proposed activities pose a high probability of impacting the soils and wetlands over the longer term. Based on the findings of this report, the mitigation measures and the anticipated impacts of the diversion can be reduced from a high to moderate level of significance. The following recommendations are made to minimise the impacts:

- Strategic water management plans should be implemented to ensure that the effect on the environment in general and surface water in particular is minimised (Digby Wells Environmental (b), 2018). The plans should developed in consultation with stakeholders to ensure the sustainable development and management of the river diversion;
- Care must be taken to provide erosion and sedimentation control protection on the site such that construction runoff is directed away from the proposed flood protection berms locations in Leeuspruit Sections 2 to 4, and Rietspruit Section 1;
- To ensure efficiency of the system, protection berms and diversion canals have to be inspected for silting and blockages of inflows, pipelines for hydraulic integrity and the overall surface water flow performance monitored;

- Berms should be monitored for erosion monthly for the 1st year, quarterly for the 2nd year, and bi-annually for the 3rd year until sustainability is confirmed.;
- If any erosion occurs, corrective actions must be taken to minimise any further erosion from taking place;
- Ensure that sufficient secondary grassland and wetland vegetation is retained to maintain ecological processes through monthly monitoring for the 1st year, quarterly for the 2nd year, and bi-annually for the 3rd year until sustainability is confirmed.;
- Minimise unnecessary removal of the natural vegetation cover;
- Plan excavations carefully and avoid moving of heavy machinery into sensitive areas unnecessarily;
- Newly constructed berms will have to be re-vegetated and stabilised as soon as construction has been completed;
- Wetlands and aquatics monitoring should take place monthly for the 1st year, quarterly for the 2nd year, and bi-annually for the 3rd year until sustainability is confirmed;
- The proposed activities associated with the alteration of the river banks must preferably take place during the drier period of the year and the associated disturbance within the river channel limited as far as possible, both spatially and temporally;
- Use of accredited contractors for removal of construction equipment must be ensured, this will reduce the risk of waste generation and accidental spillages;
- All erosion noted within the construction footprint should be remedied immediately and included as part of a monitoring should take place monthly for the 1st year, quarterly for the 2nd year, and bi-annually for the 3rd year until sustainability is confirmed; and
- Surface inspection on the fully rehabilitated areas must be undertaken to ensure a surface profile that allows good drainage. This will ensure improvement or increased catchment yield on to the surrounding water streams.

13 References

Bromilow, C., 2010. *Problem Plants and Alien Weeds of South Africa.* 3rd ed. Pretoria(Gauteng): Briza Publications.

Department of Water Affairs and Forestry, 1999. *Determining the Ecological Importance and Sensitivity (EIS) and Ecological Management Class (EMC). Version 1.0. 24 September 1999.,* s.l.: s.n.

Digby Wells Environmental - Ash Backfilling, July 2018. *Basic Assessment Report and Environmental Management Programme Report for the Sasol Sigma Ash backfilling Project - BAR and EMP Report,* Bryanston: s.n.

Digby Wells Environmental (a), 2018. *Basic Assessment Process to Obtain Environmental Authorisation for the Surface Mitigation Measures Proposed at the Sasol Sigma Colliery, Sasolburg - Aquatic and Wetland Assessment,* Bryanston: s.n.

Digby Wells Environmental (b), 2018. *Basic Assessment Process to Obtain Environmental Authorisation for the Surface Mitigation Measures Proposed at the Sasol Sigma Colliery, Sasolburg - Surface Water Assessment,* Bryanston: s.n.

Digby Wells Environmental (c), 2018. *Basic Assessment Process - Environmental Authorisation for the Surface Mitigation Measures Proposed at the Sigma Defunct Colliery, Sasolburg - Soils and Land Capability Assessment Report,* Bryanston: s.n.

Digby Wells Environmental, 2014. *Ecological Assessment of the Wetlands associated with the Mooikraal Mining Right Area,* Johannesburg: s.n.

Jones & Wagener, 2018. *Sigma Defunct Mine Closure Leeuspruit and Rietspruit Ingress Mitigations Feasibility Design Report,* Johannesburg: Jones & Wagener Engineering & Environmental Consultants.

Kleynhans, C. J., 1999. *A procedure for the determination of the ecological reserve for the purposes of the national water balance model for South African River. Institue of Water Quality Studies,* Pretoria: Department of Water Affairs & Forestry.

Mucina, L. & Rutherford, M. C., 2007. *The vegetation of South Africa, Lesotho and Swaziland.* Pretoria: South African National Biodiversity Institute.

Redco, 2010. *Sasol - Wonderwater Rehabilitation Plan,* Potchefstroom: Redco Rehabilitation Design & Construction Services.

van der Berg, J. P., le Roux, T. G. & Hoffman, F. A., 2018. *Sigma Defunct Mine Closure Leeuspruit and Rietspruit Ingress Mitigations Feasibility Design Report,* s.l.: Jones & Wagener: Engineering & Environmental Consultants.

Van Tonder, D. J. & Scheppel, C. J., 2000. *Environmental Management Programe Report for Sigma Colliery,* s.l.: Sasol Coal.

Worldwide Fund for Nature - South Africa, 2016. *Water: Facts and Futures - Rethinking South Africa's Water Future,* Cape Town: WWF-SA.