

Appendix G

SPECIALIST REPORTS



Appendix G.1

GEOTECHNICAL SCOPING REPORT





Sasol South Africa Limited

THE PROPOSED SASOL SECUNDA GAS TO POWER FACILITY

Geotechnical Site Sensitivity Verification Report





Sasol South Africa Limited

THE PROPOSED SASOL SECUNDA GAS TO POWER FACILITY

Geotechnical Site Sensitivity Verification Report

REPORT (REV0) CONFIDENTIAL

PROJECT NO. ZA0068671.2768

DATE: AUGUST 2026



Sasol South Africa Limited

THE PROPOSED SASOL SECUNDA GAS TO POWER FACILITY

Geotechnical Site Sensitivity Verification Report

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1 INTRODUCTION

WSP Group Africa (Pty) Ltd (WSP) has been appointed by Sasol South Africa Limited to undertake a geotechnical impact assessment desktop study for the proposed Sasol Gas to Power Facility, which aims to supply electricity to the national grid. The proposed project includes the external infrastructure and project footprint, the utilities required to support the Secunda Gas to Power Project, and integration with the Secunda facility, including the installation of transmission lines and the routing of high-voltage cables within existing servitudes.

The objective of the desktop study is to perform a high-level assessment of the impacts of the proposed facility on the geotechnical conditions on and around the site. The geotechnical assessment is required to inform the Environmental Authorisation (EA) process.

This Site Sensitivity Verification Report (SSVR) presents the findings of the geotechnical site sensitivity verification undertaken for the geotechnical desktop assessment for the Sasol Gas to Power Facility. The report further provides a scoping-level assessment of potential geotechnical impacts associated with the proposed project.

1.1 PROJECT DETAILS

The Secunda Gas to Power project aims to generate electricity through Liquefied Natural Gas (LNG) (methane rich gas being considered as back-up feed), with the objective to provide power to the national grid, supporting South Africa's growing energy needs.

The Inside Battery Limit (IBL) scope includes the main equipment for generating electricity, which will be proposed by the vendor. The Outside Battery Limit (OBL) scope will focus on the external infrastructure and utilities required to support the Secunda Gas to Power project (integration into the Secunda Facility). The electrical scope will cover the reconfiguration of the electrical network. The installation of transmission lines, along with the routing of high-voltage cables through existing servitudes, will also be considered.

In addition to the electrical work, the OBL scope will involve the installation and routing of various pipelines. These will include pipelines for LNG, Methane Rich Gas (MRG) and any required utilities such as cooling water, raw water, firewater, instrument air, and any effluent. Depending on the IBL requirements, raw water treatment will also be included to achieve the necessary water quality specifications.

Figure 1-1 shows the locality of the site and illustrates the possible pipe routings of the LNG from the pressure protection station to the brownfield plot as proposed by the gas infrastructure team. There are two routings being considered, one through the primary area and the other in the secondary area around the south eastern side of the factory. The final pipe routing will be selected as the project develops.

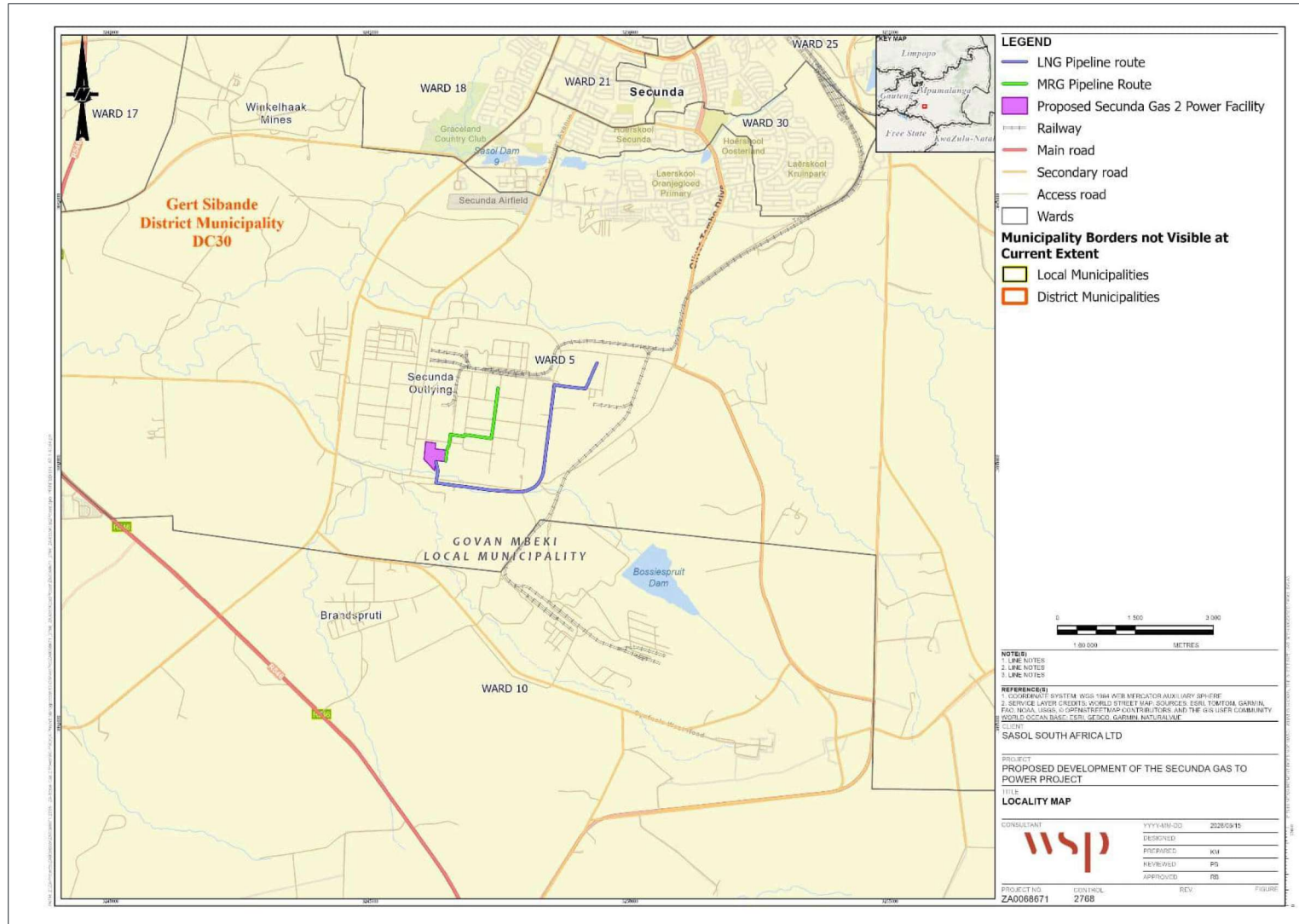


Figure 1-1 - Locality Map

1.2 SPECIALIST CREDENTIALS

The geotechnical SSVR was undertaken by an experienced professionally registered engineering geologist, and the work was overseen by a professionally registered senior geotechnical engineer. The CV's for Khuthadzo Bulala and Heather Davis are included in Appendix A.

Khuthadzo Bulala is an engineering geologist with a Bachelor of Science Honors Degree from the University of Limpopo. She is registered as a Professional Scientist (Pr.Sci.Nat 116482). Khuthadzo has ten years of experience in engineering geology, geotechnical engineering, environmental geology, and soil surveys.

She has extensive experience in conducting geotechnical assessments and detailed geotechnical investigations.

The SSVR was reviewed and authorized by Heather Davis. Heather is a qualified Professional Engineer (Pr.Eng 960229) with over 40 years of experience. She obtained a BSc Honours degree in Engineering Geology and Geotechnics from the University of Portsmouth (UK) in 1982. A post graduate diploma was obtained from the University of the Witwatersrand in 1993 which focused on geotechnical engineering and rock mechanics.

She is currently the geotechnical team lead at WSP. She has accumulated extensive experience in Sub Saharan Africa which has included work on power plants and renewable energy projects in South Africa.

2 SITE DESCRIPTION

The proposed Sasol Gas to Power Facility is located within the Sasol Secunda Operations (SSO). The SSO site is located approximately 5 km south of the town of Secunda in the Govan Mbeki Local Municipality within the Gert Sibande District Municipality, in the Mpumalanga Province. The layout of the site is provided in Figure 2-1.

The Secunda area has a subtropical Highland climate characterised by dry winters and warm temperate summers. The area receives an average annual rainfall of about 817mm with the highest rainfall occurring in December. The hottest months are September to February with an average maximum temperature of 25°C. The coldest months are between June and July with an average minimum temperature of 3°C.

2.1 DRAINAGE AND TOPOGRAPHY

SSO is part of the Vaal Water Management Area (WMA) 5 and quaternary sub-catchment C12D of the Vaal primary drainage region. It can be observed that Klipspruit, Trichardspruit, Bossiespruit, Groot Bossiespruit, Brandspruit and the Kleinspruit, including their respective tributaries and associated wetlands, are watercourses which drain east to west through SSO to the Grootspuit, which finally drains into the Waterval River.

The proposed facility lies at an elevation that ranges between approximately 1595m and 1598m. The pipelines lie at an elevation that range between 1580m and 1610m. The highest point is in the north of the site and the lowest point in the south.

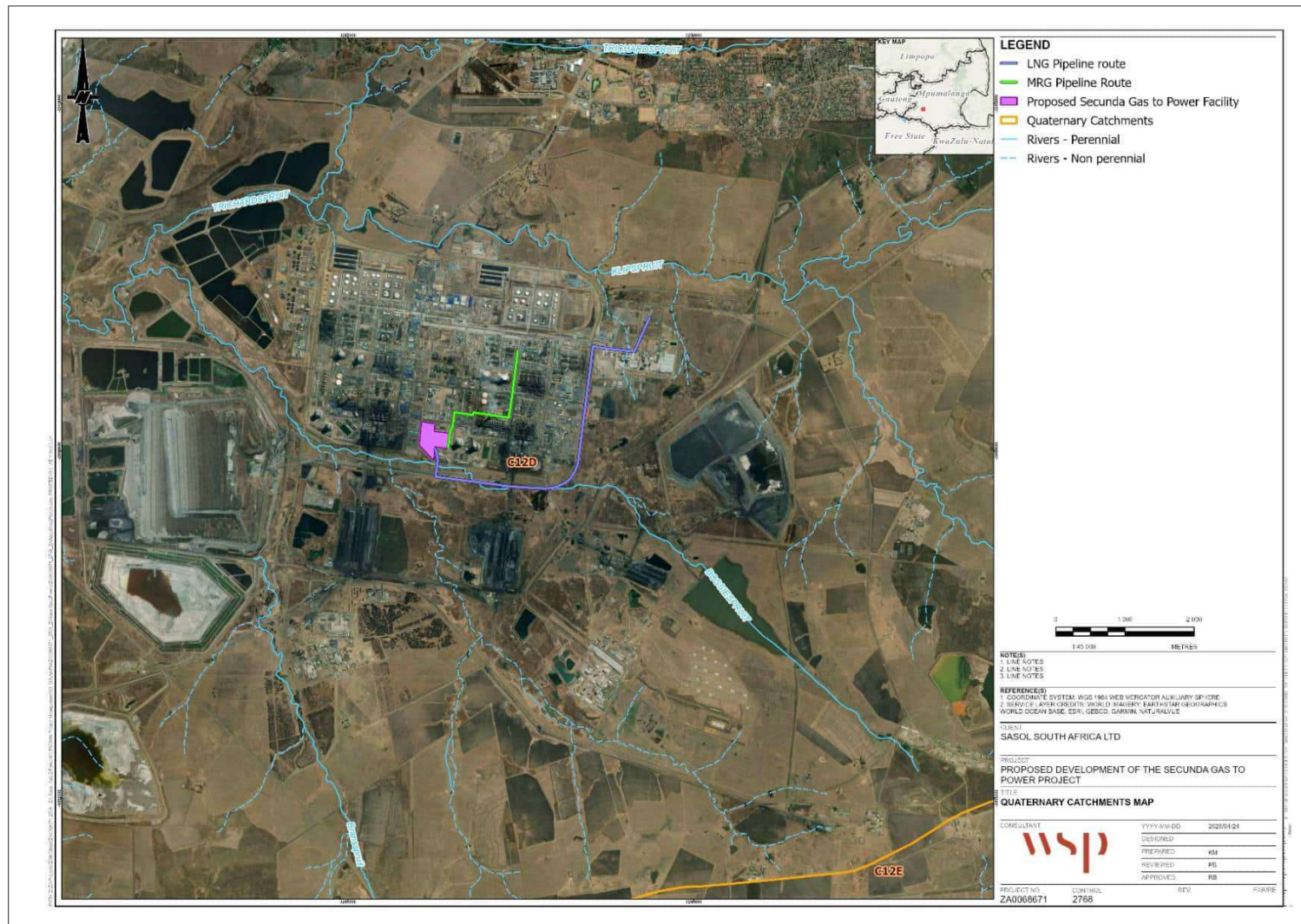


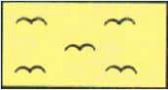
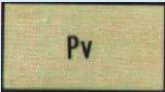
Figure 2-1 – Site Layout Map

3 GEOLOGY

According to the published 1: 250 000 geological map, Sheet 2628 East Rand, the study area is underlain by rocks of the Vryheid Formation (Pv), Ecga Group of the Karoo Supergroup. This Vryheid Formation comprises sandstone, shale and coal beds. The Vryheid Formation has been extensively intruded by Jurassic age dolerite (Jd). The dolerites occur both as sills and linear dyke structures that may extend over tens of kilometres. It can be seen that much of the project area is directly underlain by Vryheid Formation.

An excerpt of the published geological map showing the site is presented on Figure 3-1 and the lithostratigraphy is indicated in Table 3-1.

Table 3-1 – Lithostratigraphy of the Area

Supergroup	Group	Formation	Description	Map Symbol
Quaternary Deposits			Alluvium	
Intrusive			Dolerite	
Karoo	Ecga	Vryheid	Sandstone, shale, coal beds	

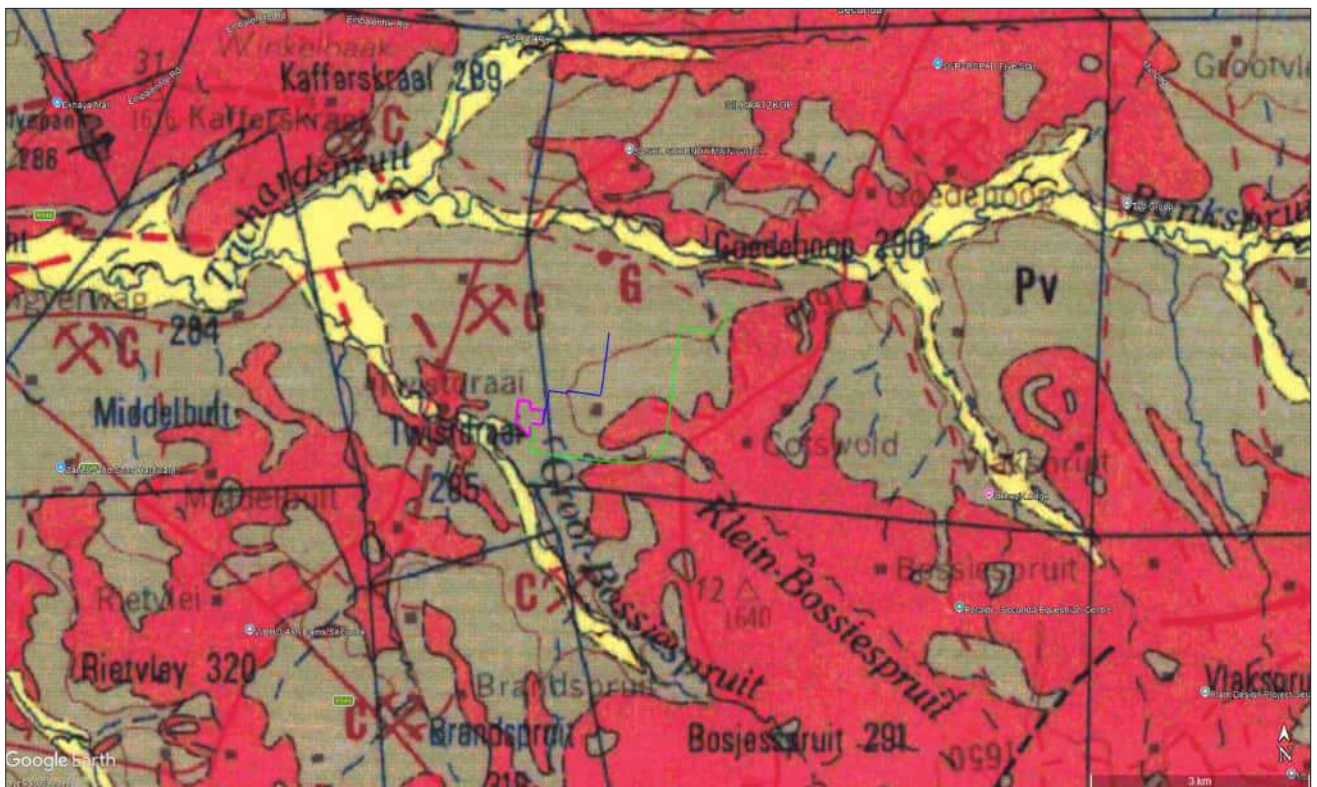


Figure 3-1 - Regional Geology of the Area

4 EXPECTED GROUND CONDITIONS

4.1 VRYHEID FORMATION

Sandstone

Vryheid Formation sandstone generally weathers into sandy residual soils (Brink, 1983). Generally, these soils are thinly developed with bedrock being encountered relatively close to surface.

Sandstone does not weather uniformly, leading to dense layers being underlain by less competent layers of the same soil. The sandy profile will exhibit short term or elastic settlement with, generally, no long-term settlement characteristics.

In some cases, the residual sandstone may develop a potentially collapsible grain structure. Collapsible soils exhibit additional settlement upon wetting without any change in the load. This can occur many years after construction as a result of any inundation. If recognised at investigation stage, these collapsible materials can be easily dealt with during construction with some remediation being required. Usually, sandstone presents a competent founding medium for relatively heavily loaded structures.

Where material is required for construction, natural sandstone gravel or crushed sandstone bedrock can potentially be a suitable source. Consideration must be given to the potential presence of excessive pyrite and muscovite which can cause problems where sandstone is used as basecourse (road construction). The material quality will have to be assessed during the geotechnical investigation.

Shale

Vryheid Formation shale generally weathers to a clayey residual soil which is often compressible and potentially expansive (Brink, 1983). Expansive soils are those materials that exhibit volume change with a change in moisture content. These materials “shrink” when the moisture content decreases, and “heave” or “expand” when the moisture content increases.

Where the residual clay profile is thinly developed, it is recommended that the material should be stripped. Where thickly developed, the structural design needs to take cognizance of the potential expansiveness and compressibility of this material.

Shale rock and excavated shale, which presents as a gravel, often deteriorates on exposure. Although shale material can be considered for use in construction, the potential for deterioration needs to be pre-determined in the laboratory. If suitable, the gravel can be used in selected layers in road construction, but seldom as base course. Gravelly shales are occasionally used in the wearing course of gravel roads, but not all types are suitable.

Slope instability may occur when sliding occurs on bedding planes within the rock mass which are inclined sufficiently. Ingress of water into layers and the resulting high pore-water pressure plays a key role in sliding failures. This is considered highly unlikely as the strata are mostly horizontally disposed in the area.

Coal beds

Coal seams are present within the Vryheid Formation with a thickness ranging from centimetres to 10m but are not generally encountered at surface. A number of mines are present in the area and are discussed in Section 6.5.

4.2 DOLERITE

Generally, residual doleritic soil is relatively thickly developed above dolerite rock with the profile becoming coarser with depth. Cobbles and boulders are often present above the rock grading upwards into gravel, sand and finally residual clay at the top of the profile. Cobbles and boulders of dolerite, however, can be present throughout the entire residual profile.

Residual doleritic clay is generally compressible and potentially expansive in the “medium to high” range. Where a structure straddles residual dolerite and a different soil type, the structure should be moved to avoid differential settlement or designed accordingly.

Dolerite rock, cobbles, boulders, gravel and sand are generally durable and are suitable for a variety of purposes. Dolerite rock is commonly quarried and used as a construction material such as for concrete aggregate and road construction materials.

5 EXISTING GEOTECHNICAL WORK

Numerous geotechnical investigations have been undertaken at the SSO. WSP has previously acquired some of the reports from the Sasol library. A seepage study was conducted along the southern boundary of the SSO in 2008 by Jones & Wagener:

Title *Seepage Study Extension. Coal Supply and Secondary Area South of Plant.*

Reference *JW59/07/A839*

Report date *March 2008*

The report is attached in Appendix B. The positions are indicated on Figure 5-1 and the profile is summarized in Table 5-1.

Eleven auger holes were bored along the southern boundary, bordering the proposed facility footprint, A01 to A11. Auger profiles were not supplied for A02, A04, A05, A08 and A11 in the report. Index properties and the permeability were not determined during the investigation.

The profile comprises: -

- Fill and Topsoil – encountered from surface in the auger holes with the exception of A03. The thickness of the layer ranged from 0.20m to 2.50m and generally comprised loose to dense silty sand or soft sandy silt. Medium dense silty sand topsoil was only encountered in A03 to 0.3m.
- Transported material – encountered below the topsoil in A03 and was described as sandy clay with scattered gravel. The layer was present to depths ranging from 0.30m to 1.20m
- Alluvium – generally, encountered below the fill or transported material. The alluvium generally comprised soft to firm sandy clay. The layer extends to a depth of 2.3m to 4.7m.
- Residual Siltstone – encountered in A01. The material was generally described as silty clayey sand to sandy clayey silt. The residual material extends from a depth of 3.1m to a depth of 4.0m.
- Siltstone Rock – Siltstone was profiled at the base of four auger holes A01, A03, A06 and A10. Where intersected, siltstone was profiled as very soft to medium hard strength.
- Groundwater – Slight to strong seepage was observed in all the auger holes at depths ranging between 2.00m and 5.00m.

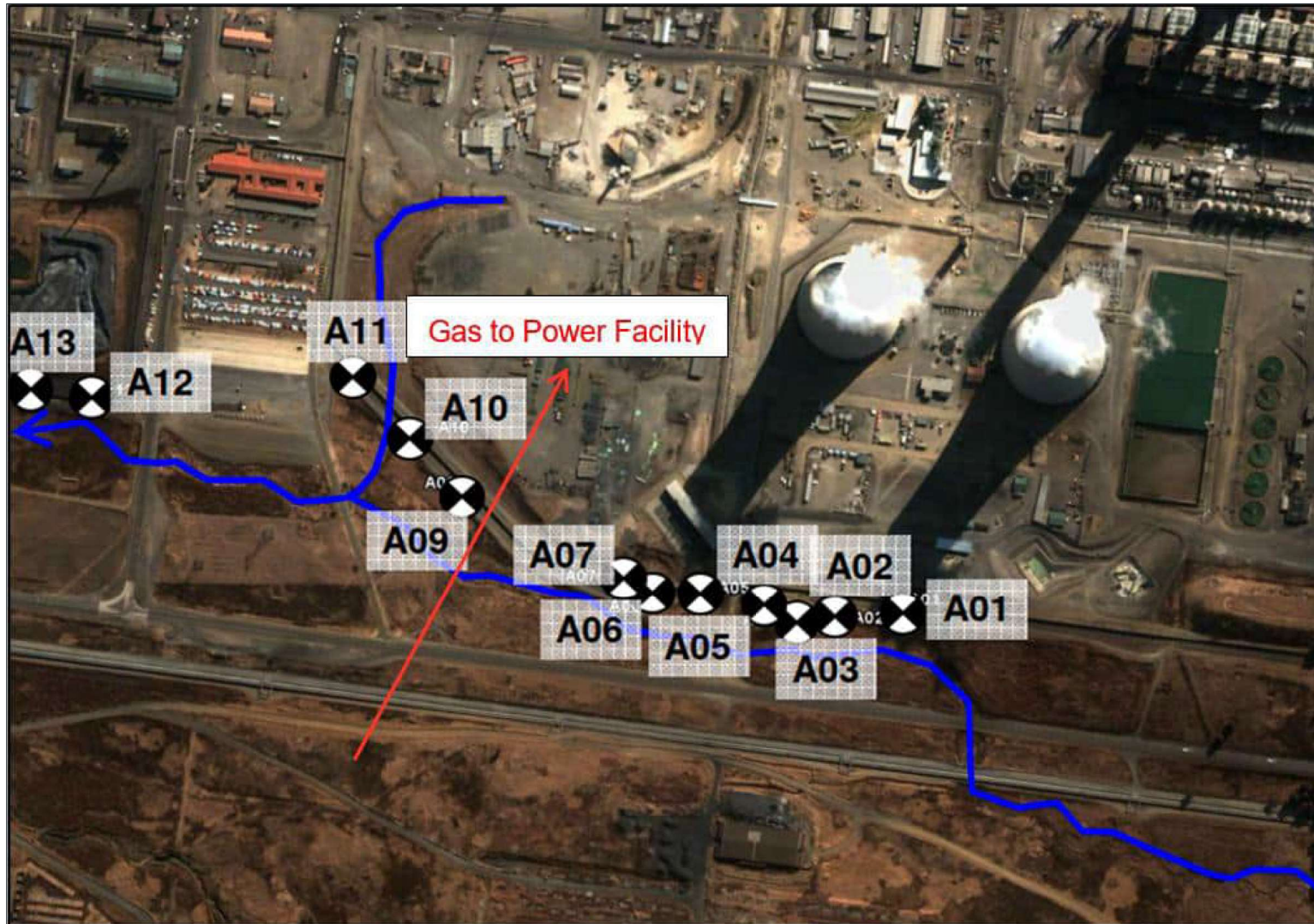


Figure 5-1 - Position of auger holes along the southern boundary

Table 5-1 – Summary of the profile as encountered in the 2008 auger holes

Data Point	Fill		Topsoil	Transported	Alluvium	Residual Siltstone	Siltstone Bedrock		Groundwater	Comment
	Silty Sand	Sandy Silt	Silty Sand	Sandy Clay	Sandy Clay	Sandy Clay- Clayey Silt	Depth (m)	Rock hardness		
A01	0.0 – 0.2 L	0.2 – 1.0 S			1.0 – 3.1 F	3.1 – 4.0 SCSi F	4.0	MHR	Moderate seepage at 2.5m	Auger refusal on MHR
A03			0.0 – 0.3 MD	0.3 – 1.2 F	1.2 – 2.5 F		2.5	SR – MHR	Slight seepage between alluvium and siltstone	Auger refusal on SR - MHR
A06					0.0 – 2.3 S-F 2.3 – 4.2 F		4.2	MHR	Slight to moderate seepage at 2.3m	Auger refusal on MHR
A07	0.0 – 1.8 MD				1.8 – 3.0 S				Strong seepage at 2.0m	Sidewall collapse at 3.0m
A09	0.0 – 2.5 MD-D				2.5 – 3.5 F				Very strong general seepage	Sidewall collapse from 1.0m to 2.50m
A10	0.0 – 2.0 MD-D				2.0 – 4.7 F-S		4.7	SR	Slight seepage at 4.7m	Auger refusal on rock at 4.7m

6 GEOTECHNICAL EVALUATION

6.1 PRELIMINARY FOUNDATION CONDITIONS

Where structures are underlain by sandstone, rock is expected at a depth of, generally, less than 3m. Therefore, founding in rock should be possible. Where structures are underlain by shale, siltstone or dolerite the residual profile may be more thickly developed with rock expected at a depth of, generally, more than 3m but less than 6m. As evidenced by the auger holes on the southern boundary of the site. Dolerite boulders in the profile must not be mistaken for solid dolerite rock.

A detailed geotechnical site investigation must be conducted to ascertain the foundation conditions.

6.2 WATER PRECAUTIONS

Flooding affects flat lying areas; areas confined to drained channels and flood plains. The Gas to Power facility is located on a relatively flat gradient where water ponding is a possibility during wet periods especially with clay being present (J&W, 2008). Therefore, stormwater management is recommended in all flat areas to facilitate water run-off and to alleviate the possibility of standing water at the foundation positions.

6.3 SLOPE STABILITY

Where excavations are required, up to a depth of 3m, excavations should be excavated at a batter of 1:1.5 in soil where no water or seepage is evident and to 1:2, or flatter, where water is encountered. Rock can be excavated at a batter of 1:0.5 or vertically in the temporary case up to a depth of 3m. Should permanent excavations or deep excavations be proposed for the site, a slope assessment will be required.

6.4 EXCAVATABILITY

The expected excavation characteristics of the soil horizons have been evaluated according to the South African Bureau of Standards standardized excavation classification for earthworks (SABS – 1200D).

The definition of the excavation classes is indicated in Table 6-1 and the assessment of the in-situ profile in Table 6-2. The ease of excavation is a critical financial factor for any development.

Table 6-1 – SABS 1200D Excavation Classes

Class of Excavation	General Definition
Soft	<p>Excavation in material which can be efficiently removed or loaded by any of the following plant without prior ripping:</p> <p>A bulldozer with a mass of at least 22 tons (which includes the mass of the ripper, if fitted) and an engine developing approximately 145kW at the flywheel. Or</p> <p>A tractor-scraper unit with a mass of at least 28 tons and an engine developing approximately 245kW at the flywheel, pushed during loading by a bulldozer as specified for intermediate excavation. Or</p> <p>A track type front end loader with a mass of at least 22 tons and an engine developing approximately 140kW at the flywheel</p>

Class of Excavation	General Definition
Intermediate	Excavation (excluding soft excavation) in material which can be efficiently ripped by a bulldozer with a mass of at least 35 tons when fitted with a single tine ripper and an engine developing approximately 220kW at the flywheel.
Hard	Excavation (excluding boulder excavation) in material which cannot be efficiently ripped by a bulldozer with properties equivalent to those described for intermediate excavation. This type of excavation generally includes excavation in material such as formations of unweathered rock, which can be removed only after blasting.
Boulder Class A	Excavation in material containing in excess of 40% by volume of boulders between 0.03m ³ and 20m ³ in size, in a matrix of softer material or smaller boulders. Excavation of fissured or fractured rock shall not be classed as boulder excavation but as hard or intermediate excavation according to the nature of the material.
Boulder Class B	Where material contains 40% or less by volume of boulders in a matrix or soft material or smaller boulders.

Table 6-2 – Expected Excavatability on site

Material	Excavation Class
Dolerite	Soft excavation in residual clay, sand and gravel. Boulder Class A and Boulder Class B where boulders are encountered. Hard excavation in dolerite rock
Vryheid shale and residual shale	Soft excavation in residual shale and very soft to soft rock shale. Intermediate to hard excavation in medium hard and harder rock shale.
Vryheid Sandstone and residual sandstone	Soft excavation in residual sandstone and very soft to soft rock sandstone. Intermediate to hard excavation in medium hard and harder rock sandstone.

6.5 UNDERMINING AND SUBSIDENCE

Subsidence at surface in undermined areas is caused by the collapse and failure of the underground mining voids relatively close to the surface (Heath and Engelbrecht, 2011). Mpumalanga contains some of the most extensive coal seams in South Africa and is characterised by both historical and active opencast and underground mining operations.

The following underground mines (Figure 6-1) supply feedstock to Secunda Synfuels Operations and they are located on the southern side within a 6km radius:

- Bosjesspruit Colliery 6km
- Brandspruit Colliery
- Twistdraai Colliery

All of these mines have underground workings and could potentially pose undermining problems for the proposed site.

Some portions of the proposed site are expected to be underlain by mudrock, shale, siltstone and possibly sandstone. Areas with roof strata composed of shale are more susceptible to gradual movements. Roof strata composed of competent sandstone are less susceptible to deformation. Gradual subsidence and sudden collapse are accompanied by surface deformation including fractures, crevices, faults, step folds and slides. The extent of any undermining below the site should be assessed, in detail, prior to development.

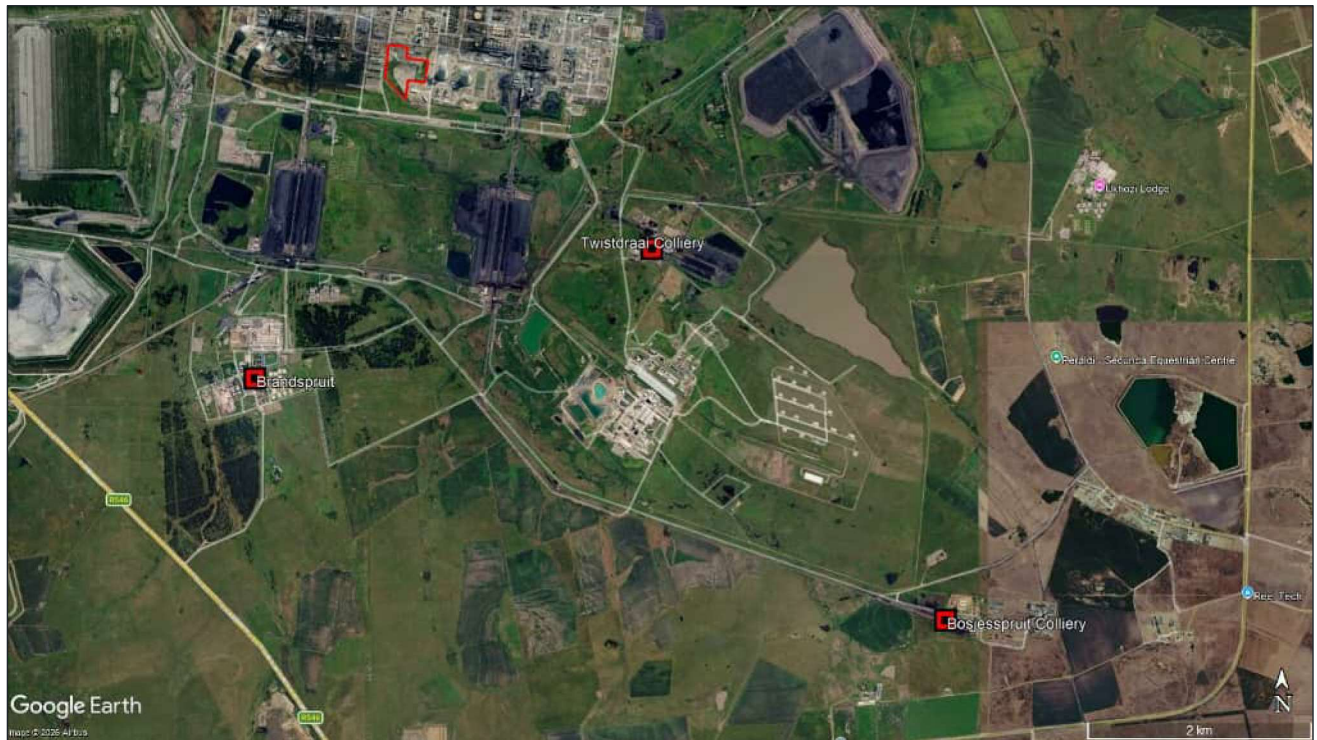


Figure 6-1 - Location of underground operations south of the proposed facility

6.6 SEISMIC HAZARD

The southern African region is characterised by natural and mining-induced seismic activity. Data that was produced by Council for Geoscience placed the site within the zone where the minimum seismic event, with a 10% probability of being exceeded in a 50-year period, is between 0.0201 – 0.0293g as illustrated in Figure 6-2. This basically suggests that the area is expected to have medium levels of seismic hazard. Most of these earthquakes will be mining induced.

There are two seismic activity zones according to SANS 10160-4 (2011):

- Zone I – Regions of natural seismic activity
- Zone II – Regions of mining-induced and natural seismic activity

In accordance with the seismic zones contained in SANS 10160-4, the site falls within zone II (Figure 6-3).

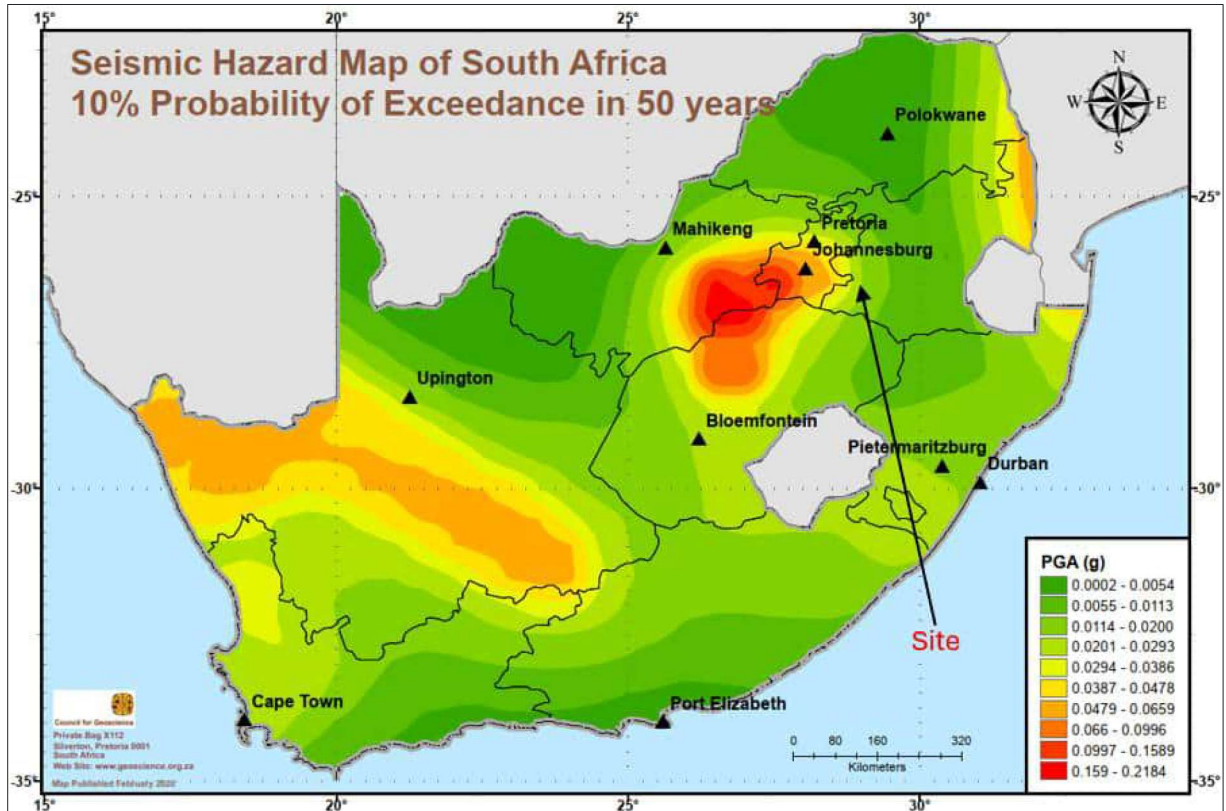


Figure 6-2 - Probabilistic Seismic Hazard Map of South Africa

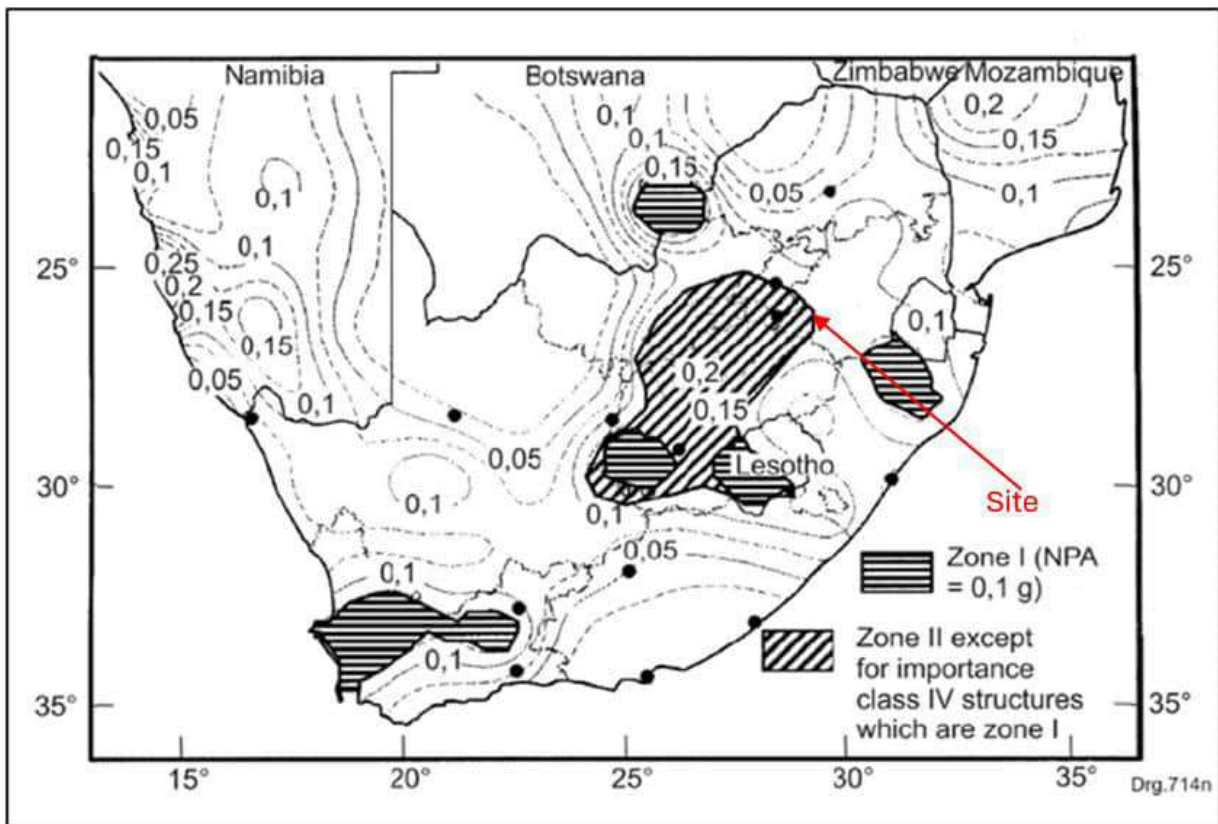


Figure 6-3 - Seismic Zones of South Africa

7 GEOTECHNICAL IMPACT SCREENING

A high-level screening of impacts and mitigation for geotechnical impacts of the proposed Sasol Gas to Power Facility was performed.

Geotechnical impacts need to be considered as part of the development. The identified risks can typically be mitigated by the implementation of an appropriate and effective environmental management plan. Mitigation measures must be implemented to avoid or reduce negative impacts during construction, operation and decommissioning phases.

The potential geotechnical impacts of the development and the sensitivity screening in the pre-mitigation situation are presented in Table 7-1. The methodology and rating for the assessment is attached in Appendix C.

Based on the high-level screening of impacts assessment matrix undertaken for this project, geotechnical impacts of the Sasol Gas to Power Facility were verified to be “Negative Very Low to Negative Low”. The anticipated impacts will have negative effects and will require mitigation.

Table 7-1 - Geotechnical Impacts

Aspect	Impact	Mitigation Measures	Status	Consequence	Probability	Sensity Screening
Construction and Operation						
Soil erosion	<ul style="list-style-type: none"> ■ Increase stormwater velocity. ■ Increase in soil and wind erosion due to cleared vegetation. ■ Creation of drainage paths along access tracks and side slopes. ■ Sedimentation of non-perennial features and excessive dust. 	<ul style="list-style-type: none"> ■ Rehabilitation of affected areas (minor areas within SSO with vegetation). ■ Construction of temporary berms and drainage channels to divert surface water. ■ Minimize earthworks and fills. ■ Correct engineering design and construction of gravel roads and water crossings. ■ Control stormwater flow. ■ Dust suppression measures for wind erosion. 	Negative	Moderately severe	Probable	Low
Potential hydrocarbon (incl. oil, fuels, chemicals) spillages	<ul style="list-style-type: none"> ■ Potential groundwater and drainage feature contamination. 	<ul style="list-style-type: none"> ■ Vehicle and construction machinery repairs to be undertaken in designated areas with proper soil protection (i.e. on impermeable surfaces or with the use of drip trays). ■ Spill kit to be maintained on site, spills and contaminated soils to be collected and disposed appropriately. 	Negative	Moderately severe	Probable	Low
Disturbance of fauna and flora	<ul style="list-style-type: none"> ■ The displacement of natural earth material and overlying vegetation leading to erosion and displacement of natural ecosystems. 	<ul style="list-style-type: none"> ■ Limit excavations to developmental areas. 	Negative	Moderately severe	Probable	Low
Slope stability	<ul style="list-style-type: none"> ■ Slope instability around structures. ■ Steeply dipping joints in rock or boulders in soil mass may prove treacherous in cuttings and deep foundation 	<ul style="list-style-type: none"> ■ Avoid steep slopes areas, as far as practicably possible. ■ Design cut slopes according to detailed geotechnical analysis and adopt appropriate support mechanisms. 	Negative	Moderately severe	Probable	Low

Aspect	Impact	Mitigation Measures	Status	Consequence	Probability	Sensity Screening
	excavation leading to collapse of sidewalls.					
Seismic activity	<ul style="list-style-type: none"> Damage of proposed development. 	<ul style="list-style-type: none"> Design according to expected peak ground acceleration. 	Negative	Severe	Improbable	Low
Decommissioning						
Soil erosion	<ul style="list-style-type: none"> Increase in soil and wind erosion due to clearance of structures. Displacement of soil and damage to vegetation by vehicles 	<ul style="list-style-type: none"> Use existing road network and access tracks. Use of temporary berms and drainage channels to divert surface water. Minimize earthworks and demolishing footprints. Rehabilitation of affected areas (such as revegetation). Reinstate channelized drainage features. Strip, stockpile and re-spread topsoil. Dust suppression measures for wind erosion. 	Negative	Moderately severe	Probable	Low
Hydrocarbon (incl. oil, fuels, chemicals) spillages from heavy plant	<ul style="list-style-type: none"> Potential hydrocarbon spillages in machinery due to clearance of structures. 	<ul style="list-style-type: none"> Vehicle and construction machinery repairs to be undertaken in designated areas with proper soil protection (i.e. on impermeable surfaces or with the use of drip trays). Spill kit to be maintained on site, spills and contaminated soils to be collected and disposed appropriately. Frequent checks and conditional monitoring 	Negative	Moderately severe	Probable	Low
Disturbance of fauna and flora	<ul style="list-style-type: none"> The displacement of natural earth material and overlying vegetation leading to erosion and displacement of natural ecosystems. 	<ul style="list-style-type: none"> Limit excavations to decommissioning areas. 	Negative	Moderately severe	Probable	Low
Slope stability	<ul style="list-style-type: none"> Slope instability around structures. 	<ul style="list-style-type: none"> Design cut slopes according to detailed geotechnical analysis and adopt appropriate support mechanisms. 	Negative	Negligible	Improbable	Very Low

Aspect	Impact	Mitigation Measures	Status	Consequence	Probability	Sensity Screening
		<ul style="list-style-type: none"> Adopt appropriate support mechanisms in excavation. 				
Cumulative						
Soil erosion	The displacement of natural earth material and overlying vegetation leading to: <ul style="list-style-type: none"> Exposure of upper soil layer. Increase in stormwater velocity. Soil washed downslope into drainage channels leading to sedimentation. Erosion will be exacerbated during periods of heavy rainfall. 	<ul style="list-style-type: none"> Use existing road network and access tracks. Use temporary berms and drainage channels to divert surface water. Minimize earthworks and demolishing footprints. Rehabilitation of affected areas (such as revegetation). Control stormwater flow. 	Negative	Moderately severe	Probable	Low
Potential oil spillages	<ul style="list-style-type: none"> Contamination of ground and surface water from heavy plant and service vehicles. 	<ul style="list-style-type: none"> Service vehicle and construction machinery repairs to be undertaken in designated areas with proper soil protection. Frequent checks and conditional monitoring. 	Negative	Moderately severe	Probable	Low
Disturbance of fauna and flora	<ul style="list-style-type: none"> The displacement of natural earth material and overlying vegetation leading to erosion and displacement of natural ecosystems. 	<ul style="list-style-type: none"> Limit excavations developmental/ decommissioning areas. 	Negative	Moderately severe	Probable	Low
Seismic activity	<ul style="list-style-type: none"> Damage of proposed development. 	<ul style="list-style-type: none"> Design according to expected peak ground acceleration. Frequent monitoring of functionality and servicing of seismic dampening measures. 	Negative	Moderately severe	Probable	Low

8 SITE SENSITIVITY VERIFICATION REPORT

There are currently no sensitivity layers/sensitivity ratings in the Department of Forestry, Fisheries and the Environment (DFFE) Screening Tool Report for geotechnical features.

A site sensitivity verification, based off the desktop study is provided below.

The geotechnical sensitivity rating of Gas to Power facility was verified to be “Low” as presented in Table 8-1. The rating is due to the absence of any geohazards in the area.

Table 8-1 – Sasol Gas to Power Site Sensitivity Verification

Sensitivity Rating of Entire Site in DFFE Screening Tool Report	Specialist’s Verified Sensitivity Rating
N/A	Low

9 FURTHER GEOTECHNICAL INVESTIGATION

Should the proposed project be authorised, a detailed intrusive site investigation is recommended. This should be carried out post environmental authorisation, to further characterize site conditions, to better understand the key geotechnical risks characteristics and to optimise the design.

The primary objectives of the proposed intrusive investigation must include

- Determination of the founding conditions for all structures. The scope of the intrusive investigation should comprise the excavation of test pits with an excavator to reach 5.00m.
- Laboratory testing to determine the behavioural characteristics of the in-situ materials.
- Investigation of materials to be used during construction.
- Assessment of the extent of the undermining.

10 CONCLUSIONS AND LIMITATIONS

Based on WSP’s SSVR geotechnical desktop study, the proposed Sasol Gas to Power Facility site is suitable for the development of the proposed development. No geological sensitive areas are present within or around the site. No fatal flaws were identified during the site sensitivity verification reporting. A verified “*Negative Very Low to Negative Low*” impact was assessed, from a geotechnical perspective, for the pre-mitigation situation for the proposed facility. It is recommended that a detailed intrusive geotechnical investigation must be undertaken before construction to ascertain the subsurface horizons and the subsoil properties.

Your attention is drawn to Appendix D: Document Limitations.

The statements presented in this document are intended to advise you of what your realistic expectations of this report should be, and to present you with recommendations on how to minimize

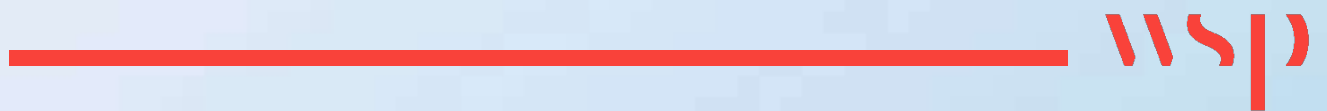
the risks associated with the groundworks for this project. The document is not intended to reduce the level of responsibility accepted by WSP, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in so doing.

11 REFERENCES

- 1:250 000 Geological Map Series (2628 East Rand). Published by the Council for Geoscience.
- Brink. A.B.A (1983). Engineering Geology of Southern Africa: The Karoo Sequence. Volume 3. Building Publications: Pretoria.
- Council for Geoscience. Report No. 2003-0053. (2003). Probabilistic Peak Ground Acceleration and Spectral Seismic Hazard Maps for South Africa. Kijko A., Graham G., Bejaichund M., Roblin D, Brand M.B.C.,
- Heath G. and Engelbrecht J. (2011). Deformation due to Mining Activities. Council for Geoscience. Report Number 2011-065.
- Johnson, M.R., Anhaessler, C.R. and Thomas, R.J. (2006). The Geology of South Africa. Geological Society of South Africa, Johannesburg/Council for Geoscience, Pretoria.
- SANS 1200D: "Standardized specification for civil engineering construction - Part D: "Earthworks" South African National Bureau of Standards, ISBN 0-626-08060-6, pg.6, 1990.
- South African National Standard SANS 10160-4: 2017. Seismic action and general requirement for buildings.

Appendix A

CURRICULUM VITAE





Heather Davis

Earth & Environment, Mine Waste, Geotechnical & Material Services – Geotechnical Team Lead

CAREER SUMMARY

Over forty years of experience within the fields of geotechnical engineering and engineering geology. Most of the work has been gained in Sub Saharan Africa including South Africa, Swaziland, Botswana, Malawi, and Angola. A wide range of projects have been handled ranging from investigations for large projects such as coal fired power stations, hydroelectric power schemes, mine processing plants, major freeways and major pipelines to smaller scale projects for commercial developments and residential buildings. Forensic investigations have, also, been completed for failed tailings facilities, structures and slopes.

Responsibility has been taken for all facets of the geotechnical investigation including the site investigation planning, procurement, drilling supervision, fieldwork, in situ testing, analysis, reporting and supervision during construction. Contract documentation and administration for geotechnical investigations has, also, been handled.

Extensive experience in dolomitic terrain and was involved in the re-drafting of SANS 1936 Parts 1 and 2 and subsequent revisions to the standard. Also, involved in the ECSA feasibility study to have a specified category of registration for D4 level dolomite geo-professionals. Dolomite assessments for large facilities such as the Telkom site in Centurion, the Mispah tailings facility as well as for residential complexes and individual units have been carried out. Linear dolomitic assessments for roads and pipelines have been completed.

Heather is a registered professional engineer, a fellow of the South African Institution of Civil Engineers and served as Treasurer of the Geotechnical Division from 2006 to 2020.

2 years with WSP

40 years of experience

Area of expertise

Site Investigations
Forensic Assessments
Dolomitic Terrain Assessments
Problem Soil Assessments

Language

English – Fluent

EDUCATION

Graduate Diploma in Civil Engineering in the field of Geotechnical Engineering, University of the Witwatersrand SA	1993
BSc (Honours) Engineering Geology and Geotechnics, Portsmouth University, England	1982

PROFESSIONAL MEMBERSHIPS

ECSA – Professional Engineer, Engineering Council of South Africa – Member No. 960229	1996
SAICE - Fellow of the South African Institution of Civil Engineering	1998

PROFESSIONAL HISTORY

WSP Group Africa (Pty) Ltd	April 2022 – present
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Heather Davis

Earth & Environment, Mine Waste, Geotechnical & Material Services – Geotechnical Team Lead

Jones & Wagener (Pty) Ltd (following the merger with Verdi Consulting)	January 2018 – March 2022
Verdi Consulting Engineers (Pty) Ltd	March 2014 – December 2017
AECOM SA (Pty) Ltd (formerly BKS (Pty) Ltd.	February 2007 – February 2014
ARQ (Pty) Ltd	January 2003 – January 2007
Knight Hall Hendry (Pty) Ltd	January 2001 – December 2003
VKE Engineers (Pty) Ltd	November 1987 – December 2000
National Building Research Institute of the CSIR	November 1985 – October 1987
Geological Survey of South Africa	November 1982 – October 1985

PROFESSIONAL EXPERIENCE

Western Range Iron Ore Mine Development, Liberia 2022 - 2023

Lead Geotechnical Engineer: South Africa Team

Design level geotechnical investigations for the Processing Plant, Quarries and several Tailings Residual Facilities were undertaken. The investigations included rotary core drilling, Cone Penetration testing and test pitting. All the data was analysed and assessed with recommendations provided for founding and required remedial measures. A challenging project due to the shallow water table which reaches the surface during the wet season.

Wessels and Mamotwan Mine Geotechnical Investigations, Hotazel, South Africa 2022 – 2024

Lead Geotechnical Engineer.

Geotechnical investigations carried out to allow the Mine to comply with International Standards with regard to information pertaining to the Tailings Residue Facilities (TSF). In addition, rail lines are to be constructed across the TSFs in places. Investigations including rotary core drilling, Cone Penetration Testing, test pitting and sampling of the tailings streams were undertaken. Comprehensive reports issued.

SANRAL, N1 Sections 20 and 21 Geotechnical Investigation, Brakfontein, South Africa 2008 to 2012

Lead Geotechnical Engineer

Upgrade, extensions and additions to the N1 Ben Schoeman Freeway, Sections 20 and 21, between the Brakfontein and Allandale Interchanges as part of the Gauteng Freeway Improvement Project (GFIP) carried out for South African National Roads Agency SOC Ltd (SANRAL). Contract documentation for the subsurface investigation was drafted and all components of the project management of the SANRAL contract were handled. The site investigation included extensive rotary core drilling, percussion drilling and test pitting. Work included the analysis, assessment and provision of founding recommendations for the 22km of dual carriageway. Design components included culverts, retaining walls, cut slopes, embankments and bridges founded on ancient granite, sedimentary rocks of the Pretoria Group along with dolomite and dolomitic residuum. Both conventional and piled foundations were used for the various bridge structures and elements.

SANRAL, N11 Section 9, Hendrina, South Africa 2015 to 2016

Lead Geotechnical Engineer

Upgrade of National route N11 Section 9 between Hendrina and Hendrina Power Station. Planning and supervision of the linear investigation, by means of rotary drilling and test pitting, of 18.56km of roadway including two river bridges, cuts, fills and culverts. Full report compiled including recommendations for all



Heather Davis

Earth & Environment, Mine Waste, Geotechnical & Material Services – Geotechnical Team Lead

facets of the project. All work carried out as per the current SANRAL requirements and all contract administration for the drilling investigation handled.

SANRAL, National Route N5, between Harrismith and Kestell, Harrismith and Kestell, Orange Free State, South Africa 2011 to 2013

Lead Geotechnical Engineer

Carried out for SANRAL, which included drafting the contract documentation for the subsurface investigation which included extensive rotary core drilling and test pitting. The project includes the rehabilitation of the National Route 5 involving extending existing bridges, design and construction of new bridges and design of significant culvert structures. The bridge structures included river bridges, road over rail and road over road structures. Work carried out included supervision of the site investigation, analysis and provision of founding recommendations for all structures, contract administration and arbitration of claims.

Anglo Platinum. Mogalakwena Platinum Mine, New Northern Concentrator, Limpopo, South Africa. 2020 to 2021

Lead Geotechnical Engineer

Pre-feasibility and feasibility level investigations for the New Northern Concentrator. Supervision of all field work and provision of recommendations for all the structural elements. Additional design level investigation carried out for the M3C BOS Low Grade Stockpile.

NMPP/ Transnet, Multi Products Pipeline, Geotechnical Investigation, Johannesburg. South Africa 2008 to 2009

Section Lead Geotechnical Engineer

Geotechnical input for pipeline section running from Kendal to Waltloo and Jameson Park to Langlaagte in Johannesburg. Investigations have included test pitting; in situ testing and borehole have included test pitting, in situ testing and borehole drilling. The assessment of the route underlain by dolomite and dolomitic residuum was, also undertaken.

TCTA, Vaal River Eastern Sub-System Augmentation, Vaal, South Africa 2006 to 2008

Lead Geotechnical Investigation

Geotechnical investigation for TCTA for a pipeline to carry water from the Vaal Dam to Secunda for use by SASOL and ESKOM. Planning and preparation of contract documentation for drilling, trenching programmes, laboratory and in situ testing. Extensive field work was completed, and recommendations provided for trench sidewall stability, excavatability, construction through problem areas and recommendations for design and construction of the surge tanks, pipe bridges, abstraction works, de-silting works and access roads.

Aquarius Mining. Marikana, Mine Processing Plant, Rustenburg, South Africa 2001 to 2002

Geotechnical Engineer – Plant side

Several candidate sites and the detailed Geotechnical investigation of the final site for the processing plant for new platinum mine. Foundation recommendations for all plant elements were provided including those for silos, mills, crushers and conveyor trestles. Foundation design for large vibratory plant elements. Ongoing foundation inspections and providing geotechnical advice and recommendations to the client throughout construction.

Eskom, Medupi and Kusile Power Stations, Investigations and Foundation Assessments, Limpopo, South Africa 2008 to 2014

Lead Geotechnical engineer for AECOM

Assessment carried out for Hitachi/Eskom of existing information regarding the founding conditions. Provision of structure specific foundation recommendations which included settlement analysis, assessment of bearing capacity and determination of parameters for dynamic design. Site inspections and assessment of ground



Heather Davis

Earth & Environment, Mine Waste, Geotechnical & Material Services – Geotechnical Team Lead

conditions during construction for both Kusile and Medupi. Also, project manager for an additional geotechnical investigation carried out at Medupi Power Station due to unforeseen ground conditions. Investigation included percussion drilling with the Jean Lutz computerised system along with triple tube rotary drilling. Analysis of data allowing optimisation of the power station design.

Harmony Goldfields, Mispah, Tailings Storage Facility, Far West Rand 2017 to 2018

Geotechnical Team Lead

Failure of a section of the Mispah Tailings Storage Facility (TSF) which is underlain by dolomite, dolomitic residuum and rocks of the Karoo Supergroup. The initial assessment lead to the entire facility being re-assessed and candidate sites for new facilities being investigated. Of specific note was the liaison with several other geotechnical/engineering geological consulting firms regarding the failure.

Irene Village, Mall Extensions, Centurion, South Africa 2015 to 2018

Dolomite Specialist

In depth assessment of existing information applicable to the Irene Village Mall retail development in Irene. Dolomite stability assessments for extensions to the existing shopping mall including the addition of a multi-level parkade and additional retail space. Provision of founding recommendations for all facets of the development including earthworks, roadways and foundations.

Gautrans. Gautrain Project, Centurion, South Africa 2007 to 2014

Geotechnical Engineer

Input and comment on aspects of the route underlain by dolomite including the Centurion Gautrain Station were provided. Assessment of the efficacy of the remedial measures utilised at the station including an extensive programme of grouting. Also, investigation of dolomite related subsidence and a sinkhole adjacent to the Gautrain route and below a raised section of the train line in the Centurion area. Subsequent design of the remedial measures for the sinkhole, drainage measures and long-term monitoring of the area.

Africa Kingdom Holdings. Serengeti Golf and Wildlife Estate, Estate Developments, Kempton Park, South Africa 2016 to 2022

Dolomite Specialist

Dolomite stability assessments, coupled with near surface investigations, of parcels of land throughout the Serengeti Golf and Wildlife Estate. Developments have included single, double and triple storey residential units, Hotel, Club House and artificial lake. All reports have been submitted to the Council for Geoscience (CGS) and have included IHC to IHC7 conditions with Dolomite Area Designations of D2 to D4 being represented. NHBRC applications have been made for all the residential developments.

Aerosud, Manufacturing Facility, Pierre van Ryneveld Park, Centurion . South Africa 2016 to 2018

Dolomite Specialist

Various dolomite stability investigations and reviews have been undertaken for warehouses, ablution blocks, workshops, parking areas and other infrastructure elements across the Aerosud manufacturing facility. All work has, and is, being carried out according to SANS 1936 Parts 1 to 4 of 2012. A Dolomite Risk Management Plan was drafted for the Aerosud Facility and is updated on a regular basis. The site manly classifies as IHC4 to IHC7 with Dolomite Area Designation D2 and D3 being applicable to most of the site.



Khuthadzo Bulala

Earth & Environment, Mine Waste, Geotechnical & Engineering Services –
Senior Consultant

CAREER SUMMARY

Khuthadzo Bulala is an Engineering Geologist with 8 years' experience in geotechnical investigations. Her experience and technical skills include:

- Compilation of geotechnical investigation reports
- Geotechnical core logging
- Core orientation for inclines boreholes
- Planning, managing, and executing in-situ testing (test-pitting, geotechnical drilling operations, DCP testing and piezometer installations) for geotechnical investigations
- Laboratory testing selection and liaison with laboratories
- Analysis and interpretation of laboratory and in-situ test data
- Geological mapping and sourcing of construction materials and aggregates
- Sourcing, testing and specification of construction materials and aggregates
- Health and safety documentation for fieldwork projects
- Project management including resource management and client liaison

3 years with WSP

Area of expertise

Geotechnical Investigations
Geotechnical Core Logging
Geotechnical Report Writing
Laboratory Sampling Selection
Geological Mapping
H&S Documentation
Project Management

8 years of experience

Language

English – Fluent
Tshivenda – Fluent

EDUCATION

BSc. (Honours) in Geological Sciences, University of Limpopo South Africa	2013
BSc. Degree in Geological Sciences, University of Johannesburg (Auckland Park Campus)	2011

ADDITIONAL TRAINING

Civil Engineering and Renewable Energy, Geopile Africa	2020
Geotubes and Dewatering, Kaytech	2019
Site Monitoring Workshop, JG Afrika	2019



Khuthadzo Bulala

Earth & Environment, Mine Waste, Geotechnical & Engineering Services –
Senior Consultant

ArcGIS1, Introduction to Geographic Information System, JG Africa

2018

PROFESSIONAL MEMBERSHIPS

South African Council for Natural Professions – Pr. Sci Nat Member No. 116482

2021

PROFESSIONAL HISTORY

WSP Group Africa (Pty) Ltd

September 2021 – present

JG Afrika (Pty) Ltd

September 2016 – September 2021

Lesotho Highlands Development Agency (LHDA)

March 2016 – August 2016

PROFESSIONAL EXPERIENCE

Geotechnical Investigations

Ib vogt (Pty) Ltd, Ngonyama Solar Energy Facility Detailed Geotechnical Investigation, Bloemfontein, Free State, South Africa

March 2023 – ongoing

Engineering Geologist

Field investigation including test pitting, DCP and sampling and report writing.

South32 Mamatwan Mine, Tailings Storage Facility Geotechnical Investigation, Hotazel, Northern Cape, South Africa

January 2023 – ongoing

Engineering Geologist

Field investigation including test pitting, sampling and report writing.

Sasol Secunda Operations, Inside Ash Geotechnical Inside Ash Seepage Analysis, Secunda, Mpumalanga, South Africa

October 2022 – Ongoing

Geotechnical Desktop Study

Gap analysis and additional investigation executions plans for Inside Ash Seepage Analysis.

Enertrag South Africa (Pty) Ltd, Impumelelo Wind Energy Facility Geotechnical Desktop Study, Secunda, Mpumalanga, South Africa

October 2022 – January 2023

Field Engineering Geologist

Field investigation including test pitting, DCP and sampling. Report writing and foundation recommendation.

Enertrag South Africa (Pty) Ltd, Mukondeleli Wind Energy Facility Geotechnical Desktop Study, Secunda, Mpumalanga, South Africa

October 2022 – December 2022

Field Engineering Geologist

Field investigation including test pitting, DCP and sampling. Report writing and foundation recommendation.

Enertrag South Africa (Pty) Ltd, Vhuvhili Solar Energy Facility Geotechnical Desktop Study, Secunda, Mpumalanga, South Africa

June – August 2022

Project Management and Client Liaison



Khuthadzo Bulala

**Earth & Environment, Mine Waste, Geotechnical & Engineering Services –
Senior Consultant**

Geotechnical desktop study for the Vhuvhili Solar Energy Facility and the associated structures to supplement a project Environmental Impact Assessment.

**Enertrag South Africa (Pty) Ltd, Vhuvhili Solar Energy Facility Detailed Geotechnical Investigation, Secunda, Mpumalanga, South Africa
October 2020 – July 2021**

Field Engineering Geologist

Field investigation including test pitting, DCP and sampling. Report writing and foundation recommendation.

Scaw South Africa (Pty) Ltd, Union Junction Hill Borrow Pit Geotechnical Investigation, Johannesburg, South Africa

February 2022 – May 2022

Project Management and Client Liaison

Geotechnical investigation for clay lining material that is needed for the development of the landfill site for their operations and

ArcelorMittal Mine Extensions, Geotechnical Investigation, Tokadeh, Liberia

January 2022

Geotechnical Report Writing

For the ArcelorMittal facilities; Tokadeh pit, Tokadeh infrastructure, Gangra Pit, Water Storage Dam, Tailings Management Facility, and Bucanan Port.

Debswana Diamond Company, Debswana Mine Facilities, Central District, Botswana

November 2021

Geotechnical Desktop Study

Gap analysis and additional investigation executions plans for Damtshaa, Orapa and Letlhakane mine facilities.

Lesotho Highlands Development Agency (LHDA), Polihali Dam, the Diversion Tunnel and the Transfer Tunnel, Tlokeng, Lesotho

March 2016 – December 2017

Site Supervision

Drilling, water pressure tests, installation of piezometers, rotary core logging for the dam site, the saddle dam, the coffer dam, the diversion tunnel, the Katse Dam transfer tunnel and the proposed borrow pits.

Calvus Properties (Pty) Ltd, Rietfontein Dam, Eastern Cape, South Africa

May 2019 – September 2021

Project Manager

Trial pitting for the dam foundation, spillway construction and the construction material at the site. Evaluation of engineering properties of subsurface material. Geotechnical reporting for dam design purposes. Geotechnical investigation and reporting for construction material borrow pits.

Umgeni Water, Darvil Dam, Pietermaritzburg, Kwa-Zulu Natal, South Africa

August 2018 – December 2018

In-Situ Investigation

Including test pitting for geotechnical soil profiles of the proposed dam site to determine the dam foundation depth. Project management and selection of laboratory tests for study objectives subsequent to the fieldwork. Compilation of a geotechnical report for the dam design and for the construction material.

Sivest SA (Pty) Ltd, Gluckstadt Water Supply Scheme, Tugela Ferry, Kwa-Zulu Natal, South Africa

November 2019 – March 2020

Field Geologist



Khuthadzo Bulala

**Earth & Environment, Mine Waste, Geotechnical & Engineering Services –
Senior Consultant**

Evaluation along the proposed water supply pipeline, at the proposed borehole structures and at the proposed reservoir. Assessment of geotechnical properties of potential bedding material for construction. Ntabamhlophe Tank –Responsible for the field investigation and the report writing for the proposed tank.

**JG Afrika Water Division, Ntabamhlophe Tank, Wembezi, Kwa-Zulu Natal, South Africa
January – April 2021**

Project Manager and Client Liaison

Field investigation including test pitting and sampling. Report writing and foundation recommendation. Foundation assessment during construction.

**Scatec Solar South Africa, Kenhardt Solar Farm, Kenhardt, Northern Cape, South Africa
October 2020 - July 2021**

Project and Subcontract Management

Drilling supervision, in-situ investigation for site characterization. Management and selection of laboratory tests for study objectives. Client liaison and geotechnical report for pylon foundations, substation foundation and access road construction.

**Enertrag SA (Pty) Ltd, Dalmanutha Wind Energy Facility, Belfast, Mpumalanga, South Africa
December 2021 – May 2022**

Project Manager and Client Liaison

Geotechnical desktop study for three wind energy facilities and their associated structures to supplement a project Environmental Impact Assessment.

**G7 Renewable Energies (Pty) Ltd, Oya and Yemaya Solar and Wind Energy Facility, Maitjiesfontein, Western Cape, South Africa
August 2019 – July 2020**

Geotechnical Desktop Study Reports

For the two sites for the two solar sites. Test pitting and sample selection for required tests for the Oya site. Analysing and interpreting fieldwork data and laboratory results.

**Sivest SA (Pty) Ltd, Client, Koup 1 and Koup 2 Wind Energy Facility, Leeu Gamka, Western Cape, South Africa
February 201 – July 2021**

Project Manager and Client Liaison

Geotechnical desktop study for two wind energy facilities and their associated structures to supplement a project Environmental Impact Assessment.

**WSP Africa, Client, Three Wind Energy Facilities, Northern and Western Cape, South Africa
May – September 2021**

Project Manager and Client Liaison

Project management and client liaison. Geotechnical desktop studies for the proposed Brandvalley, Karreebosch and Rietkloof wind farm energy facilities and three 33kV powerlines and their associated structures.

**WSP Africa Group, Uvuvuselela Railway Line Extensions, South Africa
October 201 – December 2021**

Project Manager and Client Liaison

Geotechnical desktop studies for the proposed Transnet Railway Loop extensions, Port Elizabeth Port extensions and loading yards in Gauteng.

**South African National Road Agency Limited, N2 Pongola to Kangela, Kwa-Zulu Natal, South Africa
2017 – 2021**

Field Geologist



Khuthadzo Bulala

**Earth & Environment, Mine Waste, Geotechnical & Engineering Services –
Senior Consultant**

Responsible for trial pitting, logging, and sample collection for laboratory analysis for the N2 construction borrow pits. Collation of field data and laboratory data.

HHO Consulting Engineers, N3 Borrow Pits, Kwa-Zulu Natal, South Africa

November 2018 – April 2019

Field Engineering Geologist

Rotary core logging and percussion chips logging for the proposed borrow pits located between Durban and Pietermaritzburg for the N3 construction.

ZVK Holdings (Pty) Ltd Mfulamuni Access Road and Aggregates, Pomeroy, Kwa-Zulu Natal, South Africa

January – June 2022

Project Manager and Client Liaison

Fieldwork for the realignment and the re-gravelling of the Mfulamuni access road. Ensuring adequate laboratory testing for the road and the potential borrow pits. Report compilation for the road and the material investigation.

Naidu Consulting, P77 Culverts, Dududu, Kwa-Zulu Natal, South Africa

January – July 2020

Project Manager and Client Liaison

Responsible for trial pitting, logging and DPL testing to determine the subsurface characteristics for the proposed seven culverts. Compilation of an interpretive geotechnical report highlighting the foundation depths for each culvert and the geotechnical constraints thereof.

Royal HaskoningDHV, Kikwood to Addo Borrow Pit and Retaining Walls, Kirkwood, Eastern Cape, South Africa

April – December 2019

Project Manager and Client Liaison

Soil profiling and interpretation of the field profiles and laboratory results for the borrow pit and retaining walls. Material volume calculations for the borrow pits. Dynamic cone penetration and interpretation for the competent foundations for the retaining walls. Data assimilation and assessment for report writing.

High End Construction, Eastwood Pedestrian Bridge, Pietermaritzburg, Kwa-Zulu Natal, South Africa

February – May 2019

Project Manager and Client Liaison

Construction of a pedestrian bridge. Fieldwork including test pitting and DPL testing. Analysing and interpreting the field data to recommend foundation levels.

Eskom, Refurbishment of 9 Eskom Towers, Eastern Cape, South Africa

August 2019 – September 2019

Engineering Geologist

Test pitting for geotechnical ground profiles of each site. Management and selection of laboratory tests for study objectives. Foundation recommendations for each site. Geotechnical report for design purposes.

KZN Department of Public Works, Nkweletsheni Primary School, Richmond, Kwa-Zulu Natal, South Africa

January – March 2020

Project Manager and Client Liaison

School refurbishment. Test pitting, percolation testing and DPL testing for geotechnical ground profiles of the site. Management and selection of laboratory tests for study objectives. Geotechnical report for foundations, recommendations for the soak-away and for the multipurpose sports ground.

JG Afrika (Pty) Ltd Water Department, Zwelisha Moyeni Water Treatment Works, Bergville, Kwa-Zulu Natal, South Africa



Khuthadzo Bulala

**Earth & Environment, Mine Waste, Geotechnical & Engineering Services –
Senior Consultant**

January – March 2021

Project Manager and Client Liaison

Test pitting and DPL testing for geotechnical ground profiles of the site. Management and selection of laboratory tests for study objectives. Geotechnical report for foundations of treatment works structure founded at depth of 4-5m below NGL.

**JG Afrika (Pty) Ltd Water Department, Hammersdale Waste-Water Treatment Works,
Hammersdale, Kwa-Zulu Natal, South Africa**

May 2020 – March 2021

Engineering Geologist

Subsurface profiling and DPL testing for the extensions to the existing Hammersdale WWTW. Analysis of the profiles and selection of laboratory tests for study objectives. Data analysis and report compilation for structure foundations.

Sultex Holdings (Pty) Ltd, Proposed Giba Industrial Development, Pinetown, Kwa-Zulu Natal, South Africa

May 2019 – July 2019

Engineering Geologist

Test pitting for soil profiling, disturbed and undisturbed sampling, delineation of groundwater seepage areas. Management and selection of laboratory tests. Analysing and interpretation of laboratory test results. Compilation of geotechnical report for foundations and groundwater management recommendations.

Smec, Cornubia Fills, Cornubia, Kwa-Zulu Natal, South Africa

March 2020 – January 2021

Project Manager and Client Liaison

In-situ testing for geotechnical soil profiles of the site and general site characterization for fills for the proposed housing development. Engineering geological report for the study for the fills. Reviewing the rotary drilling report for the client.

Mariswe (Pty) Ltd, Ward 7 Community Hall, Taylors Halt, Kwa-Zulu Natal, South Africa

January 2020 – March 2020

Project Manager and Client Liaison

Conducting the geotechnical investigation that included trial pitting, laboratory testing and percolation testing. Fieldwork and laboratory data processing for geotechnical report compilation.

**Dartingo Consulting Engineers (Pty) Ltd, Mandalathi Community Hall, Kwa-Zulu Natal, South Africa
2020**

Project Manager and Client Liaison

Conducting the geotechnical investigation that included trial pitting, laboratory testing and percolation testing. Fieldwork and laboratory data processing for geotechnical report compilation.

Ethekewini Municipality: Human Settlements and Infrastructure, Austerville Sites, Durban, Kwa-Zulu Natal, South Africa

February 2021 – June 2021

Project Manager and Client Liaison

In situ soil profiling and interpretation of the profiles. Consistency tests (DPL) and interpretation of the results evaluate the EASPB. Data compilation and report writing to determine the site's suitability for temporary housing development and recommending relevant foundation measures.

JG Afrika (Pty) Ltd Agricultural Engineering Division, Five ADA Rabbitry Sites, Kwa-Zulu Natal, South Africa

August 2019 – October 2019

Project Manager and Client Liaison

Khuthadzo Bulala

**Earth & Environment, Mine Waste, Geotechnical & Engineering Services –
Senior Consultant**

In situ soil profiling and interpretation of the profiles. Consistency tests (DPL) and interpretation of the results evaluate the EASPB and sample collection for laboratory analysis. Report compilation with foundation recommendations.

**Private Developers, Several Intaba Ridge Estate Houses Pietermaritzburg, Kwa-Zulu Natal, South Africa
2017 – 2020**

Project Manager and Client Liaison with Property Developers

In situ soil profiling, conducting in-situ consistency tests (DPL) and sampling for laboratory analysis. Report writing to determine the site's suitability for the house developments and recommending foundation depths and types as per NHBRC guidelines.

**Private Developer, Student Accommodation, Pietermaritzburg, Kwa-Zulu Natal, South Africa
April 2019 – July 2019**

Project Manager and Client Liaison

For the proposed three storey student accommodation development. In situ soil profiling, conducting in-situ consistency tests (DPL) and sampling for laboratory analysis. Report writing to determine the site's suitability for the housing development and recommending foundation depths and type as per NHBRC guidelines.

Green Door Environmental, 220 Murray Road Development, Pietermaritzburg, Kwa-Zulu Natal, South Africa

June 2019 – August 2019

Project Manager and Client Liaison

Report writing and field data analysis for the infill geotechnical investigation report for a multi-story development in Hayfields. The development includes a school, a shopping complex, a drive through, a petrol filling station and a residential area.

Marang Environmental and Associates (Pty) Ltd, Heidelberg Cemetery Extension, Heidelberg, Gauteng, South Africa

June 2020 – December 2020

Project Manager and Client Liaison

For the extension of the existing Heidelberg cemetery. Subsurface profiling and interpretation of the profiles. Field sampling for laboratory analysis. Geotechnical report writing and evaluating the site as per the South African Council for Geoscience Guidelines for Cemeteries.

Ziphelele Planning and Environmental Consultancy, Three Proposed Umhlathuze Cemeteries, Empangeni, Kwa-Zulu Natal, South Africa

May 2018 – February 2019

Project Manager and Client Liaison

For the development of three cemetery sites. Subsurface profiling, percolation testing and field sampling for laboratory analysis. Geotechnical report writing, evaluating and rating the sites as per the South African Council for Geoscience Guidelines for Cemetery Development.

Ziphele Planning and Environmental Consultancy, Alfred Duma Cemeteries, Ladysmith, Kwa-Zulu Natal, South Africa

June 2019 – October 2019

Project Manager and Client Liaison

For the development of cemetery sites in the municipality. Geotechnical desktop studies to evaluate and rate the proposed sites in Colenso, Ladysmith and Ezakheni. The desktop study reports were written as per the South African Council for Geoscience Guidelines for Cemeteries.

**Alfred Duma Municipality, Closure of Acaciavale Landfill Site, Ladysmith, Kwa-Zulu Natal, South Africa
2018 – 2020**

Engineering Geologist



Khuthadzo Bulala

**Earth & Environment, Mine Waste, Geotechnical & Engineering Services –
Senior Consultant**

Fieldwork including test pit profiling and interpretation from test pitting and sampling for study objectives. Data analysis and report compilation for the closure of the landfill site and recommendations on closure material.

**Alfred Duma Municipality, Danskraal Landfill Site, Ladysmith, Kwa-Zulu Natal, South Africa
2020**

Project Manager and Client Liaison

Including GIS work to identify and shortlist potential landfill sites. Fieldwork including test pit profiling and interpretation from test pitting for landfill site development investigation. Data analysis and report compilation.

**Department of Rural Development and Land Reform, UMgungundlovu Landfill Site, Pietermaritzburg,
Kwa-Zulu Natal, South Africa
March 2020**

Site Supervision

For the percussion drilling contract for the proposed new landfill site. Subcontractor management and client liaison. Percussion chip logging. Borehole water level and yield measurements. Hydrocensus and sampling existing boreholes in a 1km radius.

**Department of Rural Development and Land Reform, Agricultural Potential Assessment for the Ground
Truthing: New Irrigation Schemes Survey in Harry Gwala District, Umzimkhulu, Kwa-Zulu Natal, South
Africa**

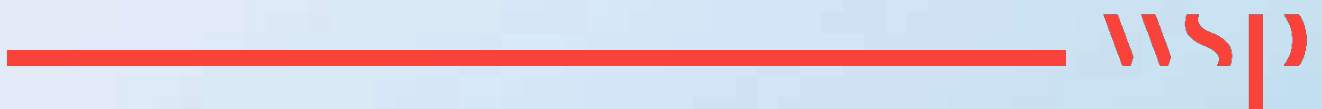
July 2017 – August 2019

Project Manager and Client Liaison

Agricultural soil survey and sampling. Data analysis and report compilation for the agricultural potential and the irrigation potential of 7500ha land in the district municipality. Presentation of the final findings to the client.

Appendix B

**JONES & WAGNER 2008: SEEPAGE
STUDY EXTENSION. COAL SUPPLY
& SECONDARY AREA SOUTH OF
PLANT**



SASOL TECHNOLOGY

**SEEPAGE STUDY EXTENSION
COAL SUPPLY AND SECONDARY AREA SOUTH OF PLANT**

Report No.: JW59/07/A839

March 2008



Jones & Wagener

Consulting Civil Engineers

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SYNOPSIS

This report describes a seepage study done to the south of the main Sasol Secunda plant, including mining and fertiliser areas. The study was done to add on to a previous seepage study done by Jones & Wagener on the western and northern Synfuels off-site facilities completed in May 2006.

A detailed description of the methodology followed in this study is given in Chapter 1 of the report. Firstly a desk study of the available information was conducted. This was followed by extensive in-stream measurements in the various receptor streams. An in depth study of the soil and groundwater in areas where potential seepage was identified followed. The final part of the study involved numerical modelling and collation of the information gathered.

This study area differs from the previous study in that contaminated runoff water contributes a large proportion of the contaminants reaching the streams. Due to the different mechanism of contaminant transport, catchment modelling of the various sources was included.

Based on the information gained during the study, remedial options were recommended. Remedial options are separated into four groups depending on whether the measure:

- is a legal requirement,
- is a significant contributor of contaminants,
- needs further monitoring or
- is an insignificant contributor of contaminants.

The recommended plan of action is as follows. Firstly the improvement of stream flow measurement accuracy is required and a set of process related decisions must be taken. Secondly, remediation of the areas that is required legally should be completed. Thirdly, remediation of the remaining significant sources should be addressed.

SASOL TECHNOLOGY**SEEPAGE STUDY EXTENSION****COAL SUPPLY AND SECONDARY AREA SOUTH OF PLANT****REPORT NO: JW59/07/A839**

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SASOL TECHNOLOGY

SEEPAGE STUDY EXTENSION

COAL SUPPLY AND SECONDARY AREA SOUTH OF PLANT

REPORT NO: JW59/07/A839

1. INTRODUCTION

1.1 Background

In 2005-2006 a seepage study was undertaken by Jones & Wagener (J&W) in the secondary areas to the West and North of the plant. This seepage study indicated that a significant contribution to salt load originated from the Bossiespruit south of the plant. Following these findings, Sastech requested J&W to carry out a second seepage study. The second seepage study concentrated on the coal supply and secondary area south of plant. The following areas were incorporated the study:

- Twistdraai Export mine,
- Sasol Coal Supply West (SCSW),
- Sasol Coal Supply East (SCSE) and
- Sasol secondary area south and south-east of the plant.

As the study progressed other potential pollution areas were identified and included in the study. These include:

- the fertiliser area and
- the area southwest of the explosives magazine, SMX.

Figure 1 shows the old as well as the new study area. The extension to the new study area is also shown. A fundamental difference between the previous study area and the new study area is that contaminated surface runoff contributes a large percentage of the pollutants in the new study area. In the old study area, pollutants reaching the stream were mostly from seepage sources. This theory was based on the monitoring results during rainfall events. Surface water modelling was therefore included in the new study.

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Figure 1 Study areas covered during this and the previous seepage study

1.2 Methodology

The investigation was carried out in six phases. Regular feedback sessions were held to discuss progress and plan for the following phases of the project. The six phases were as follows:

Phase 1: Desk study, low flow stream survey and weir depth measurement check

This phase included collection of the available literature on the study area. This included reports from Sastech, J&W, JMA, IGS and WMB. Monitoring data, recorded by Sasol Synfuels was also analysed.

A stream survey was carried out over a one-week period. The survey was carried out during a low rainfall period to establish the influence of seepage on the water quality in the Bossiespruit and Groot Bossiespruit rivers. A large number of in-stream measurements were made at regular intervals along the two rivers. Areas of abrupt changes in conductivity were identified and an effort was made to identify the source of contamination. Appropriate samples of the stream water as well as potential pollution sources were taken for detailed laboratory analysis.

Phase2: TLB testpit investigation

A test pit investigation was carried out over a period of ten days. Test pits were located adjacent to potential pollutant sources at regular intervals ($\pm 250\text{m}$). Spacing however was adjusted as pollution plumes were identified. A Tractor Loader Backactor (TLB) rig was used to excavate test pits to a maximum depth of 3m. Excavation of a test pit was stopped either when bedrock was reached or when the TLB was at the end of its reach. These holes were then inspected from the surface to detect any signs of seepage. In the event of seepage, an

estimate of the rate of seepage was made. A sampling device was lowered into the hole to sample the seepage for laboratory and on site analysis. Soil samples were taken of the strata where seepage occurred also for laboratory analysis.

Phase3: Auger hole investigation and high flow stream survey

Auger trial holes were drilled where TLB test pits were unable to penetrate sufficiently deep or where additional information was required. The auger rig investigation was completed over a period of two weeks with a Williams LDH type digger. Holes were usually stopped once the digger could no longer penetrate the bedrock, occasionally at the end of the machine reach.

These holes were then inspected from the surface to detect any signs of seepage as well as estimate the rate of seepage. A sampling device was lowered down the hole to collect the seepage for laboratory and on site analysis. Soil samples were also taken from the spoil for geotechnical classification tests.

A second detailed stream survey was conducted. This stream survey was named the high flow survey as it was conducted during the rainy season. The influence of both seepage and runoff was to be measured in this survey.

Phase 4: Borehole investigation

Boreholes were installed in contaminated areas identified in the study as well as areas where seepage in the deep aquifer was to be investigated. Construction of the boreholes was designed specifically to isolate the deep and shallow aquifers. Pump testing and water sampling was carried out on the boreholes in order to quantify the water and contaminant flow in the separate aquifers.

Phase 5: Numerical modelling

Rison Groundwater Consulting undertook the modelling of the groundwater pollution plumes from the key areas identified in the study. Surface water modelling was done using the surface topography information available.

Phase 6: Conceptual design of remedial measures and report generation

Several possible measures to control or limit seepage contamination were identified. The above-mentioned numerical models were then modified to simulate the different remedial measures proposed. The results as well as a cost estimate were then employed to evaluate the effectiveness of each alternative and a recommendation of the preferred solution was made. The results from the previous seepage study were combined with the new results to produce a global picture of contribution to seepage from the respective sources.

1.3 Objectives

The objectives of the investigation as a whole were as follows:

- Identify sources of pollutants and high risk or “hot spot” areas.
- Determine the nature of the pollutants.
- Identify seepage paths where possible, i.e. whether pollutants are entering the local streams from surface water and/or groundwater flow in shallow or deep aquifers.
- Estimate seepage and runoff rates and volumes.

- Provide a preliminary indication of the measures that can be implemented to limit the impact of the different contamination zones as well as the likely improvement these would have on the surface stream quality.

The objectives of the separate phases were as follows.

Phase 1: Desk study, stream survey and weir depth measurement check

The objective of the literature review was to collate, study and summarise data available relating to the study area.

The objectives of the stream survey were as follows:

- Measure conductivities along the Bossiespruit and Groot Bossiespruit rivers.
- Identify abrupt changes in conductivity along the rivers and attempt to determine the cause of this change in conductivity.
- Delineate highly contaminated seepage zones.
- Sample the potential pollution sources for laboratory analysis.
- Data recorded at the RESM stations were analysed with a critical view to verification.

The objective of the weir depth check was to verify the electronic measurement of water depth over the crest of the weir so as to verify the measurement of flow.

Phase2: TLB testpit investigation

The objectives of the test pits were to:

- Investigate and sample below the ground surface any seepage found, in potential seepage areas identified during the stream survey as well as areas suspected of seepage but not identified during the stream survey.
- Investigate the local geology to obtain an understanding of the mechanism of seepage. This included laboratory analysis of the soil samples collected during this phase.

Phase3: Auger hole investigation

The objectives of the auger hole investigation were the following:

- An investigation of the deeper geology and seepage.
- An investigation of the seepage in areas where there was not enough space for the construction of the TLB test pit.
- Further water and soil sampling for laboratory analysis.

Phase 4: Borehole investigation

The objectives of the borehole investigation were as follows:

- Installation of boreholes that would effectively isolate the shallow and deep aquifers for separate sampling and pump testing purposes.

- Installation of permanent top structures for long term monitoring to assess the effectiveness of mitigation measures implemented.
- Investigation of deep aquifers.

Phase 5: Numerical modelling

The objectives of the numerical modelling were to:

- Provide a quantitative estimate of the seepage and runoff in the identified contaminated area.
- Provide an estimate of the extent of pollution plumes.
- Model the effectiveness of proposed remedial measures.

Phase 6: Conceptual design of remedial measures and report generation

The objectives of the conceptual design were:

- To suggest and describe mitigation measures in the identified contaminated areas.
- To provide an action plan for optimal implementation of these measures.
- Produce a report that combines all the information gained during the investigation as well as the proposed remedial measures.

1.4 Definitions and Abbreviations

Commercial

J&W	J ones and W agener
JMA	J asper M uller and A ssociates
WMB	W ates M eiring and B arnard (Now Golder Associates Africa)
IGS	I nstitute of G roundwater S tudies
MGC	M cknight G eotechnical C onsulting
WMS	W MS Leshika Consulting
SCS (W)	S asol C oal S tockyard (W est)
SCS (E)	S asol C oal S tockyard (E ast)

Technical

IWMP	I ntegrated W ater M anagement P lan
EC	E lectrical C onductivity – units of $\mu\text{S}/\text{cm}$ in this report
PC	P ollution C ontrol

1.5 Format of report

Tables, figures and photographs have been included in the main body of the report. Drawings, geological profiles, laboratory results, other reports, cost calculations and field test data have been included in the appendices.

2. INFORMATION SUPPLIED AND REFERENCE DOCUMENTS

2.1 Information Supplied

The following reports have been reviewed:

- J&W reports:
 - G24/94/4816 (1994)
“Groot Bossiespruit in the vicinity of the fertiliser factory – Pollution control study”
 - JW61/06/9891 (2001)
“Seepage study – Synfuels off site facilities”
- JMA reports:
 - 10111 (1997)
“Extension of ground water monitoring system – Discard dump at Twistdraai Export plant export project”
 - 20007 (2003)
“Ground water quality monitoring at Sasol Synfuels – Secunda”
- WMB reports:
 - 3398/1262/1/E (1996)
“Twistdraai Export plant export project – Environmental impact of the beneficiation plant”
- IGS reports:
 - 2004/02/PDV (2004)
“Groundwater quality monitoring at Sasol Synfuels, Secunda (Synoptic report)”
 - 2005/04/UV (2005)
“Groundwater investigation at Twistdraai Export plant coal export plant, Secunda”
 - 2006/19/PDV (2006)
“Groundwater investigation at Polymers plant, Secunda”
 - 2007/02/PDV (2007)
“Groundwater quality monitoring at Sasol Synfuels, Secunda”

2.2 Reference Documents

- 1:50 000 Topographical Map covering the area 2629AC Evander (1st Edition 1963, 2nd Edition 1984 and 3rd Edition 1995) published by the Chief Directorate Surveys and Mapping, Mowbray.
- 1:250 000 Geological Map, 2628 East Rand (1986), published jointly by the Department of Mines and Geological Survey, Pretoria.

3. **REVIEW OF INFORMATION SUPPLIED**

A literature review was carried out to collect relevant seepage and surface run-off information related to the southern mining areas. In this section the information reviewed is briefly discussed.

3.1 **Water Quality Data**

Water quality data from the REGM stations was given in the IGS report 2007/02/PDV (produced in January 2007). The relevant sections from that report to this study are summarised:

SMX

Elevated levels of Ammonia were recorded in REGM 103, directly north of the SMX plant. The effect on the Bossiespruit and Groot Bossiespruit could not be established.

Fertiliser dams

Of the 11 boreholes sampled around this facility, 10 showed major pollution problems. There was a marked increase in conductivity, and specifically in nitrate value, in the Groot Bossiespruit adjacent to the fertiliser dams.

Western stockpile (SCS (W))

No major pollution problems were encountered.

Eastern Stockpile (SCS (E))

REGM 64 showed pollution, however this was ascribed to migration from the fertiliser dams. The quality of the Groot Bossiespruit over this distance improves significantly.

Sulphur plants inside the primary area

Although the boreholes have been destroyed, historical data indicates severe ground water pollution in the vicinity of the sulphur plants. The sulphur plants seem to be on the Bossiespruit side of the watershed between the Bossie- and Klipspruit.

Twistdraai Export plant coal export and polymers plant

Groundwater samples show that the polymer plant contributes very little to groundwater pollution, a conclusion from the IGS report, 2006 (ref. no. 2006/19/PDV). In contrast both the discard dump as well as the Twistdraai Export plant is impacting severely on the adjacent streams. The discard dump induces seepage towards the Bossiespruit and 'Wollie se gat', whereas the Twistdraai Export plant induces seepage towards the Bossiespruit.

3.2 **Seismic and Geophysical Data**

J&W carried out an electromagnetic survey of the area downstream of RESM 14 (ref. no. G24/94/4816). DC resistivity gives an indication of groundwater conductivity. High measurements were recorded in the fertilizer pollution control dams cut-off trench, old SMX quarries and below the SCS (E) return water dam (J&W, 1994).

3.3 Integrated Water Management Plan

The Integrated Water Management Plan compiled by WMB (IWMP, November 1999) has been reviewed. This report contains a good bibliography of relevant reports as well as a description of every potential pollution source in terms of volumes, surface areas, water qualities, function, geology, geohydrology and existing baseline information. Issues of concern are noted for every potential pollution source. Information from the IWMP has been used in the discussion of facilities later in this report.

3.4 Previous Seepage Investigations

Seepage and surface run-off to the Groot Bossiespruit

A pollution control study was carried out by J&W in 1994 (G24/94/4816) to assess the influence of the Fertilizer site, SMX and the Sasol Coal Stockyards (SCS) on the water quality of the Groot Bossiespruit. The study was confined to the area downstream of RESM 14.

Both run-off and seepage problems were experienced in this area since Fertiliser Dam 8 historically spilled into the Groot Bossiespruit and seepage occurred in the Dolerite and the interface between the Dolerite and the Sandstone. A significant amount of seepage was collected in a seepage collection trench, however not all the seepage was intercepted. Due to the high concentration of contaminants in the seepage, contamination of the Groot Bossiespruit was severe. Seepage was also detected in most of the test pits surrounding the fertilizer area. Little or no insects could be found in the Groot Bossiespruit below the fertilizer area and damage to vegetation was noted. In order to mitigate the problem, the seepage cut-off trench was extended on the western side and deepened on the southern side of Fertiliser Dam 7. Collected seepage was routed to Fertiliser Dam 8. It was also reported that "Bossiespruit dams occasionally spilled during high rainfall events".

An annual report by JMA for 2002/3 noted that all of the pollution control dams of the Fertilizer plant contributed to contamination of the Groot Bossiespruit. This contamination was monitored at RESM 14 and hydro chemically correlated with the fertilizer plant. Additionally it also impacted the aquifers below SCS (E). The seepage volume reduced in the affected areas when Dams 5 to 7 of the Fertilizer plant dried out. The water table lowered by 0.65m and an improvement in the seepage quality during this period was also noted.

The follow-up annual report by IGS (2004) noted that Fertiliser Dams 5 to 7 were filled once again. Higher concentrations of nitrate and ammonium were noted in the river. It was concluded that the cut-off trenches were too shallow to intercept the seepage to the Groot Bossiespruit effectively. Seepage was detected below the SCS(E) return water dam. In some cases the Dolerite was as shallow as 0.5m below ground level. Ground water modelling carried out by JMA (2002/3) indicated limited ground water pollution from SCS(E) to the Groot Bossiespruit.

The SMX area is located on a Dolerite sill. Backfilled borrow pits were identified as potential sources of seepage (JMA, 2002/3). A vehicle washing area is located in the south-western corner of the site. Contaminated water from the washing area drains towards the 'Stinkdam' (IGS, 2004). High levels of nitrogen and ammonium were recorded. The groundwater did not influence the surface water at that point in time.

Seepage and surface run-off to the Bossiespruit

The Bossiespruit dam is located upstream of the river and is supplemented by the Grootdraai dam (water originally from the Vaal river). Consequently water in the Bossiespruit dam is

influenced by that of the Grootdraai dam. Deterioration in the quality of the water in the Bossiespruit dam was noted (high concentrations of Ca, Mg, Na, Cl, SO₄, and COD). This in turn influences the water quality of the Bossiespruit. Data from these reports were not sufficiently detailed to establish the effect of this deterioration at RESM 1, however it seemed that this effect was of little significance.

The Twistdraai Export plant export site drains towards the Bossiespruit river (WMB, 1996). The general geology of the site consists of black clay (1m), Dolerite (9m), Sandstone (3m) and siltstone (17m). The area was described as 'partially saturated' (JMA, 2003). The water table is located approximately 5.2m below ground level, allowing water to drain from high lying areas such as the discard and slurry ponds, to the Bossiespruit river.

It was also reported by IGS (2004) that water from the southern plant area drains towards the Bossiespruit, causing major contamination problems. IGS also point out that it will be "absolutely essential to drill boreholes at the southern side of the greater plant area along the Groot Bossiespruit". This is due to the fact that the topographic gradient and thus the subsequent movement of groundwater from the plant area is both towards the north and south.

3.5 Data Analysis

The positions of the RESM stations are indicated in Figure 2. The 15 minute database from 1 January 2002 to 4 September 2006 from the relevant RESM stations was analysed. In an attempt to reduce the data, daily and monthly (31 day) averages were calculated and a second database was produced.

Only five RESM stations with electronic logging systems are applicable to this study. These are shown in Figure 2 and may be summarised as follows:

- RESM 13 Bossiespruit before confluence with the Groot Bossiespruit
- RESM 12 Groot Bossiespruit before confluence with the Bossiespruit
- RESM 3 & 10 Bossiespruit after confluence with the Groot Bossiespruit
- RESM 1 Kleinspruit (after confluence of Bossiespruit & Trichardspruit)



Figure 2 Relevant RESM stations in and around the study area

Flow Measurement Data

Measurement of the flow of water in the various rivers is made by converting measurement of the depth of water flowing over a weir to a flow value, using the appropriate calibration curve (or table). Figure 3 is an example of such a calibration curve. It is important to note that a small error in depth measurement yields a large error in flow measurement due to the fact that the relationship between depth and flow is highly non-linear.

A flow balance was attempted in the previous seepage study carried out by J&W (2006). It was found that flows from the various RESM stations did not balance (i.e. the sum of the inflows does not correlate to the total outflow). The weirs were then re-calibrated to verify their existing calibrations. The existing calibrations were found to be in order. It was postulated that depth measurement on one or more of the RESM stations could be faulty. Consequently verification of the depth measurements at the respective RESM stations was attempted as a part of this study.

Depth measurements are made by means of pressure transducers and logged electronically. An electronic display of the transducer output has been installed at the RESM stations as shown in Figure 4. These transducers are installed at a fixed depth below the weir and hence an offset specific to each weir, is used. Depth measurements can also be made manually using the gauge plate installed at each RESM station as shown in Figure 4.

Sasol Secunda has a system whereby depth readings on the gauge plates and electronic display are taken on a weekly basis. The historic weekly data of the gauge plate and electronic readout from mid 2003 to October 2006 was studied. Figure 5 to Figure 8 show flow data calculated based on the data both from the gauge plate reading and the electronic display for RESM's 1, 5, 7 and 10. It is clear from these figures that RESM stations 1, 5 and 7 were

originally set-up correctly. A very clear point in time can be noted for each of the RESM stations where the set-up changed fundamentally and the electronic depth readings became inaccurate. Failure of the pressure transducer is the most likely cause of such an abrupt change in the system. RESM 10 seems mostly to overestimate flow over the weir. This station does not seem to have been set up correctly since mid 2003.

The flow gauging structure installed at RESM 12 has not been built to standard and can therefore not be calibrated for flow measurement. The only applicable and reliable flow data relevant to this study is therefore that of RESM 1 before November 2005 (assuming that data from before October 2003 was accurate).

Table 1 summarises the dates on which the flow readings are deemed to be accurate. Figure 9 shows the data from RESM 1 believed to be accurate. A base flow value of $0.2 \text{ m}^3/\text{s}$ was measured over the period.

Table 1 Dates on which the flow data from RESM stations are accurate

RESM no.	Accurate reading period
1	Oct 2003 to Nov 2005
5	Oct 2003 to April 2004
7	Oct 2003 to June 2005
10	Setup inaccurate
12	Sub standard construction

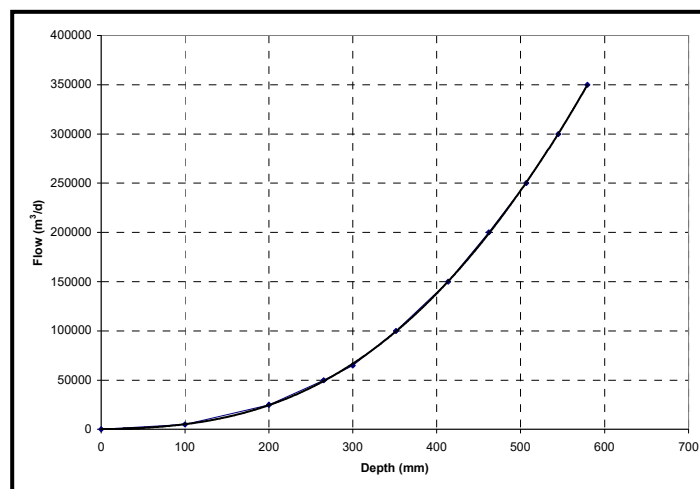


Figure 3 Sample calibration curve



Figure 4 Weir gauge plate as well as the electronic display for depth and conductivity

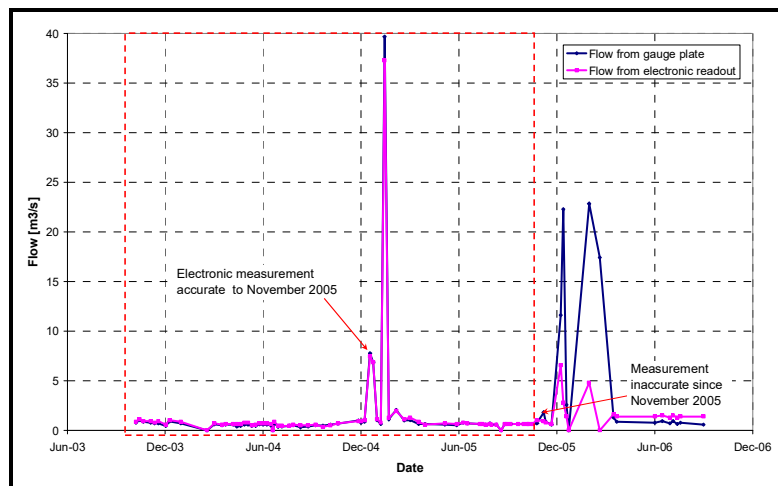


Figure 5 Manual data recorded weekly for RESM 1

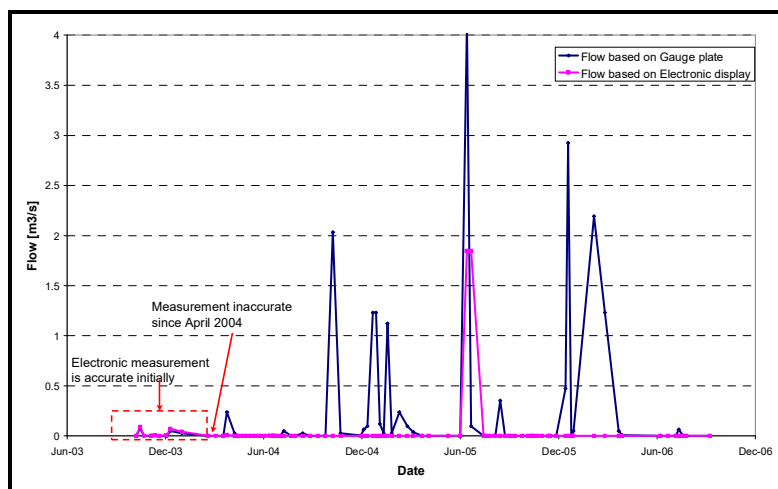


Figure 6 Manual data recorded weekly for RESM 5

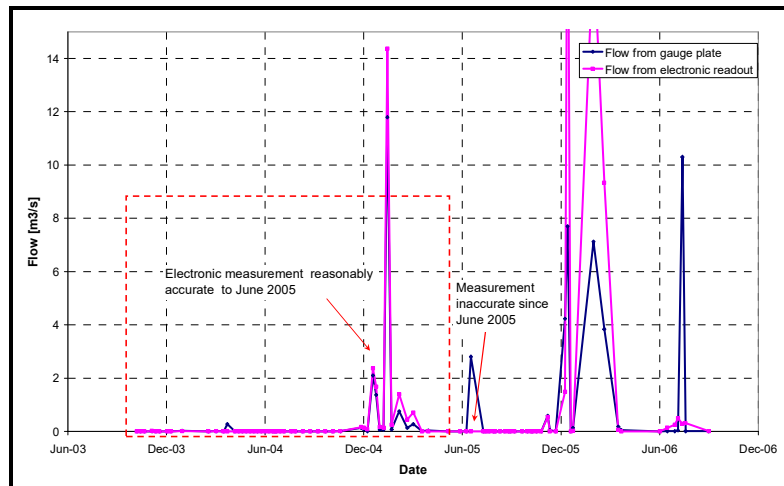


Figure 7 Manual data recorded weekly for RESM 7

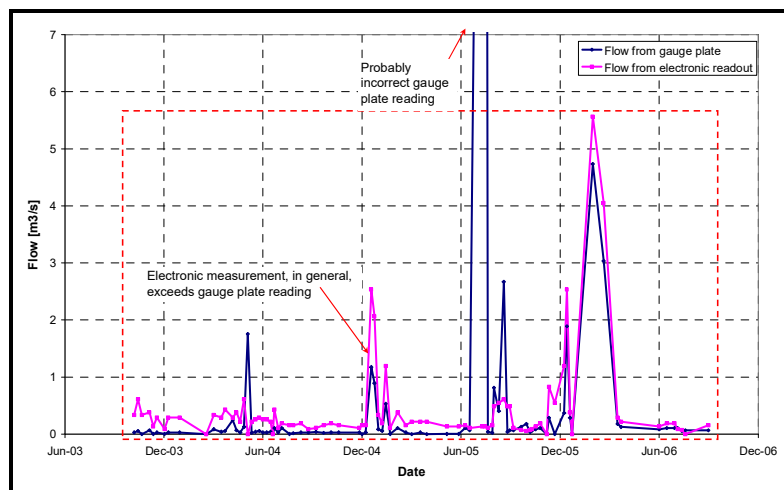


Figure 8 Manual data recorded weekly for RESM 10

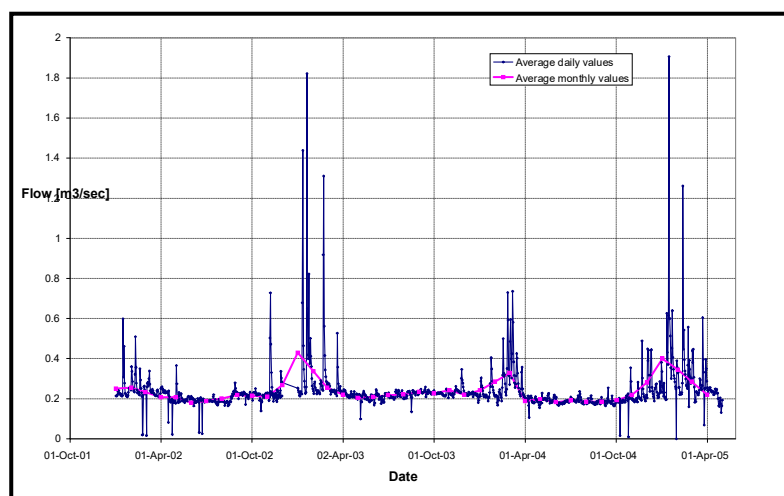


Figure 9 Accurate flow data recorded at RESM 1

Conductivity Measurement Data

RESM1

Figure 10 shows both the daily and monthly conductivity data recorded at RESM 1. Occasionally the conductivity reduces to zero, indicating a possible intermittent fault in the logging system.

Of interest is the trend of increasing peak values, usually in late March to early April, where daily average conductivity values exceed $800 \mu\text{S/cm}$. Figure 10 indicates that the higher summer flows revert to the lower winter base flow at about this time of the year. It is not entirely clear why this pattern has established. A possible explanation may be that water storage facilities are reasonably full at the end of the rainy season and a small amount of rainfall can cause spillage from these facilities to occur. This is illustrated in Figure 10, where the monthly average flow data has been added to the conductivity graph. It is not clear why the frequency of high conductivity values is on the increase. Although the linear regression shows a poor fit to the data set, it also indicates an increasing trend of conductivity values for this data set.

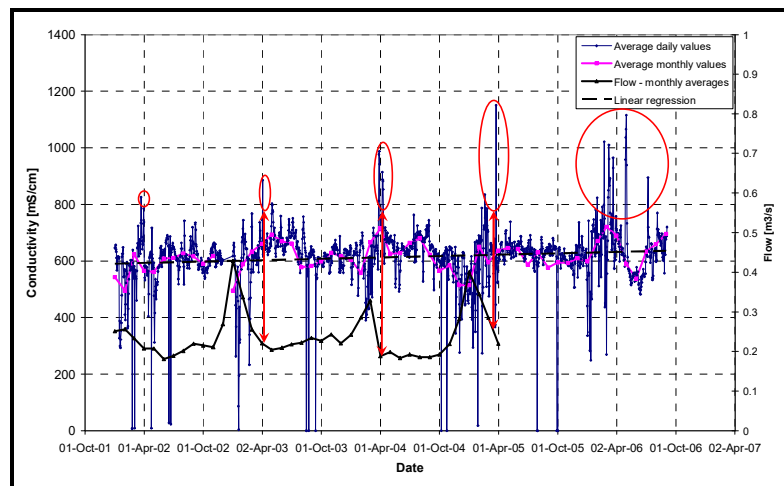


Figure 10 Conductivity and flow values recorded at RESM 1

RESM's 3, 10 and 12

Figure 11, Figure 12 and Figure 13 show the conductivity values recorded at RESM's 3, 10 and 12 respectively. High peak values have been highlighted as they were for RESM 1. Note that the scales on the graphs have not been kept constant. The range of conductivity values increase from RESM 3 to RESM 10 and increase significantly from RESM 10 to RESM 12.

A significant number of peak conductivity values were recorded in all cases (including RESM 1) around March 06 to May 06. Figure 14 contains the daily average data for the four RESM stations for the period of March 06 to May 06. A large number of important observations regarding the study area may be made using this graph (keeping in mind that the order of the RESM stations are 12, 10, 3 and 1 as listed from upstream to downstream as shown in Figure 2):

- High peak values in RESM 12 usually cause high peak values to follow in all the other RESM stations as shown by the black arrows. On every occasion where the daily average at RESM 1 exceeded $750 \mu\text{S/cm}$, a high peak at RESM 12 was measured.

- During this data set, no peaks have been measured in any of the RESM stations that could not be traced back to high readings in RESM 12. This would indicate that all the peak conductivity values originate upstream of RESM 12.
- Conductivity values measured at RESM 3 are very similar to those measured in RESM 10, indicating that most of the contaminants entering the Bossiespruit do so upstream of RESM 10.
- The conductivity at RESM 10 is, in general, significantly lower than conductivity measured at RESM 12.
- Low conductivity values at RESM 12 do not lower conductivity values at RESM 1. This indicates that RESM 12 is a high concentration, low flow source (i.e. cleaning up all the sources contributing to RESM 12 will significantly reduce high peak values at RESM 1, but will not reduce the average reading recorded at RESM 1).
- Note that the very high peak values at RESM 1 at the end of April, including four days in excess of 1,000 $\mu\text{S}/\text{cm}$, is more severe than the other peak values at RESM 1. This high peak is believed to be due to the fact that the end of the rainy season was reached and less clean runoff water was available to dilute the high conductivity water flowing through RESM 12. This phenomenon was noted for the four years preceding 2006 as well as shown in Figure 11.

The final graph of conductivity data, Figure 15, shows the conductivity measurements in all four relevant RESM stations during the dry (winter) season. The graph has been plotted to the same scale as Figure 14. The following observations may be made from this graph:

- The conductivity at RESM 12 increases gradually over the winter. This is believed to be due to the very low flow associated with this stream in winter causing the pool at RESM 12 to become stagnant. Evaporation from this pool then causes an increase in the concentration of salts in this pool. At some point the pool level drops below the transducer level, explaining why the measured conductivity reduces to zero.
- Conductivity values in the other RESM stations remain almost constant, with RESM 1 oscillating between 560 $\mu\text{S}/\text{cm}$ and 680 $\mu\text{S}/\text{cm}$.
- This graph seen in conjunction with Figure 14 clearly illustrates that peak values at RESM 1 only occur during the rainy season.

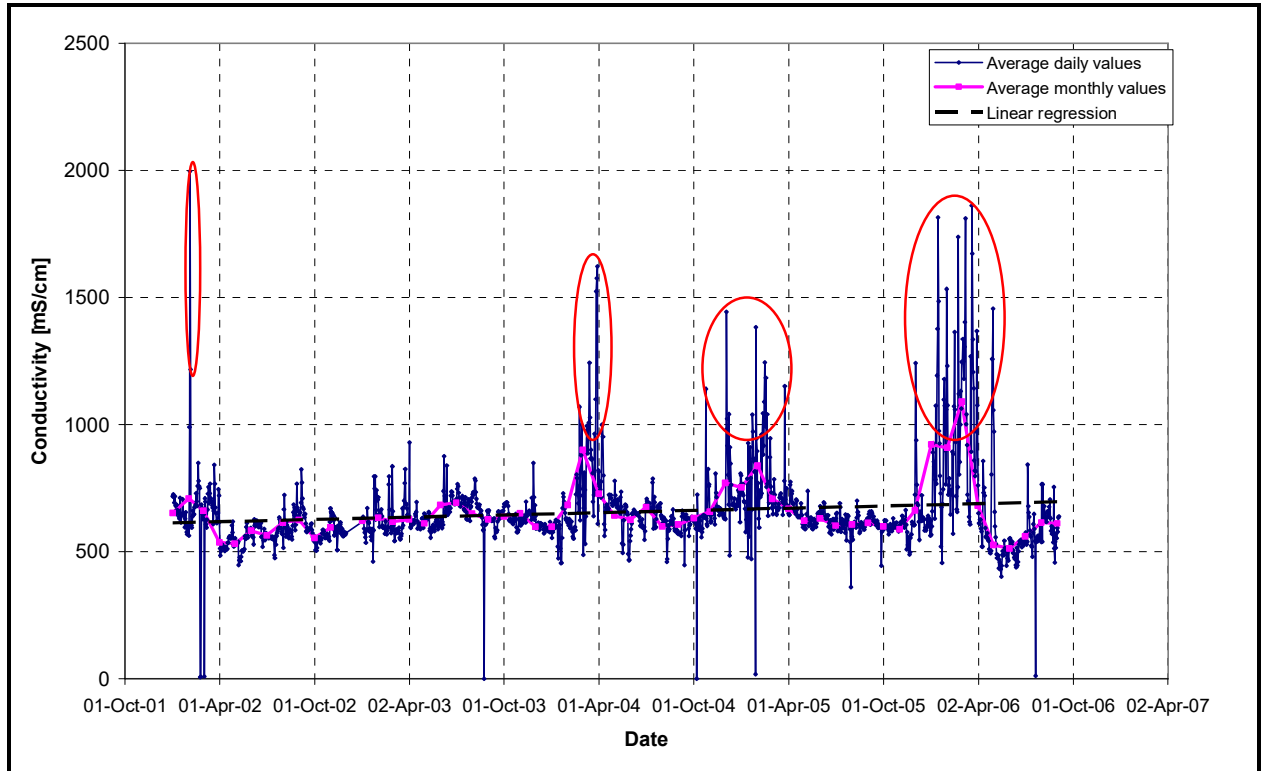


Figure 11 Conductivity values from RESM 3

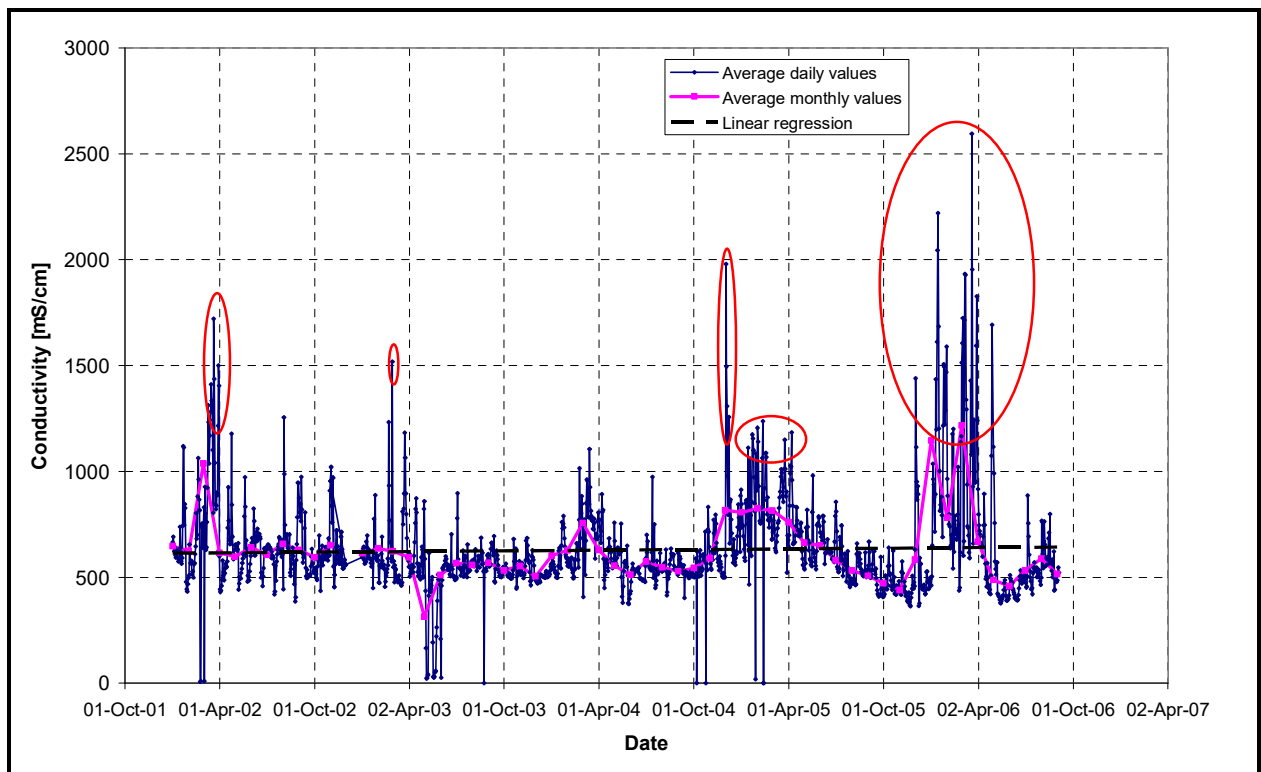


Figure 12 Conductivity values from RESM 10

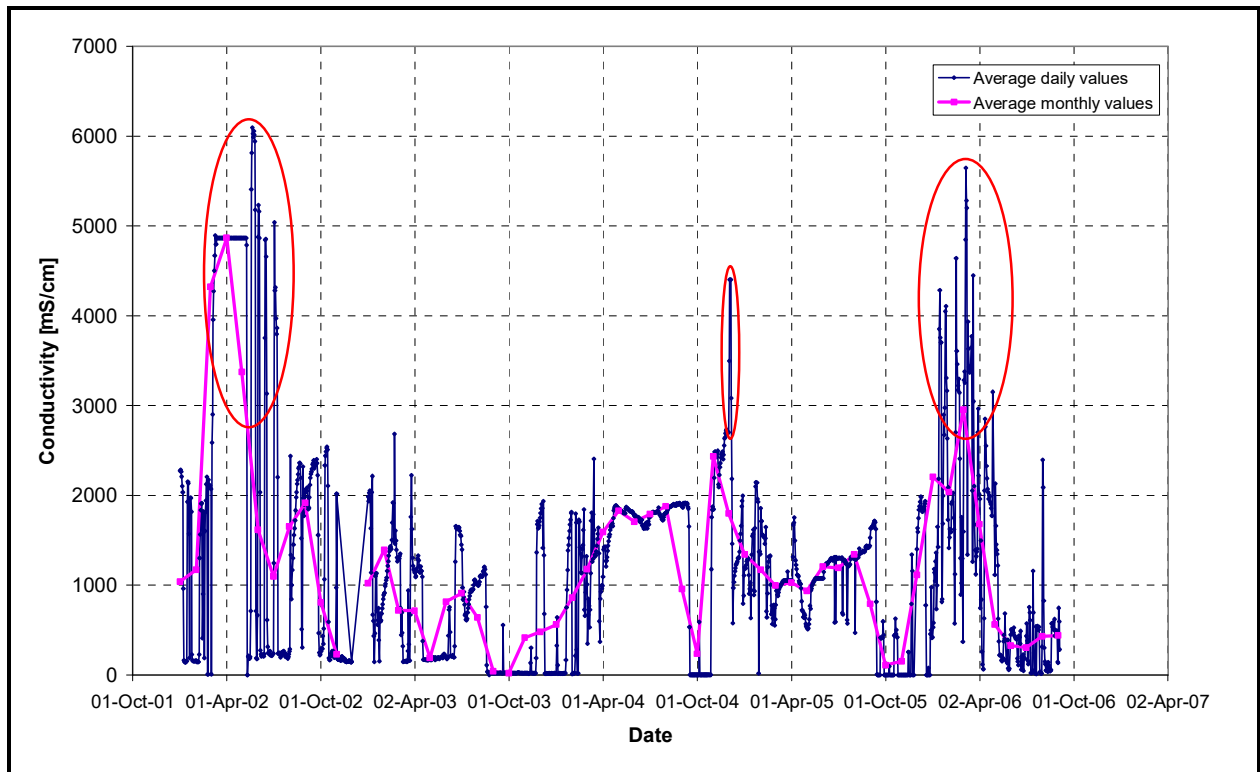


Figure 13 Conductivity values from RESM 12

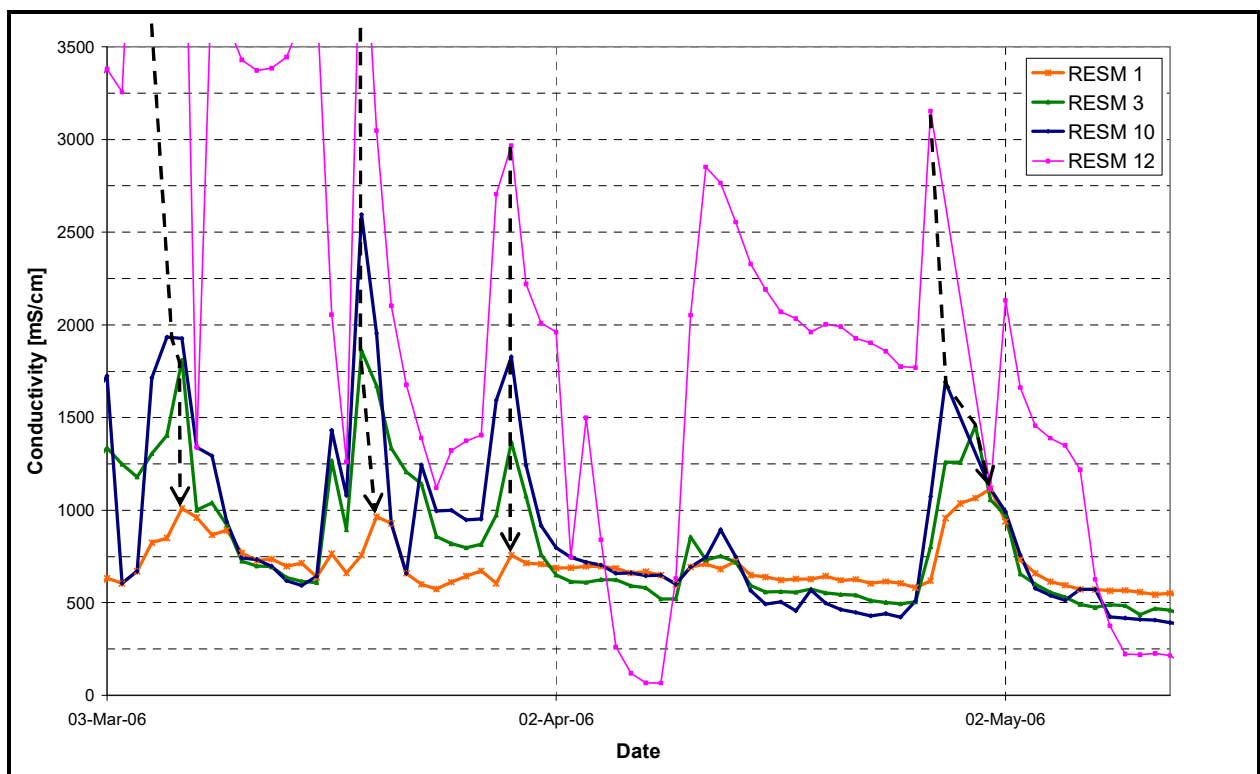


Figure 14 Conductivity values from relevant RESM's from March 2006 to May 2006, towards the end of the rainy season

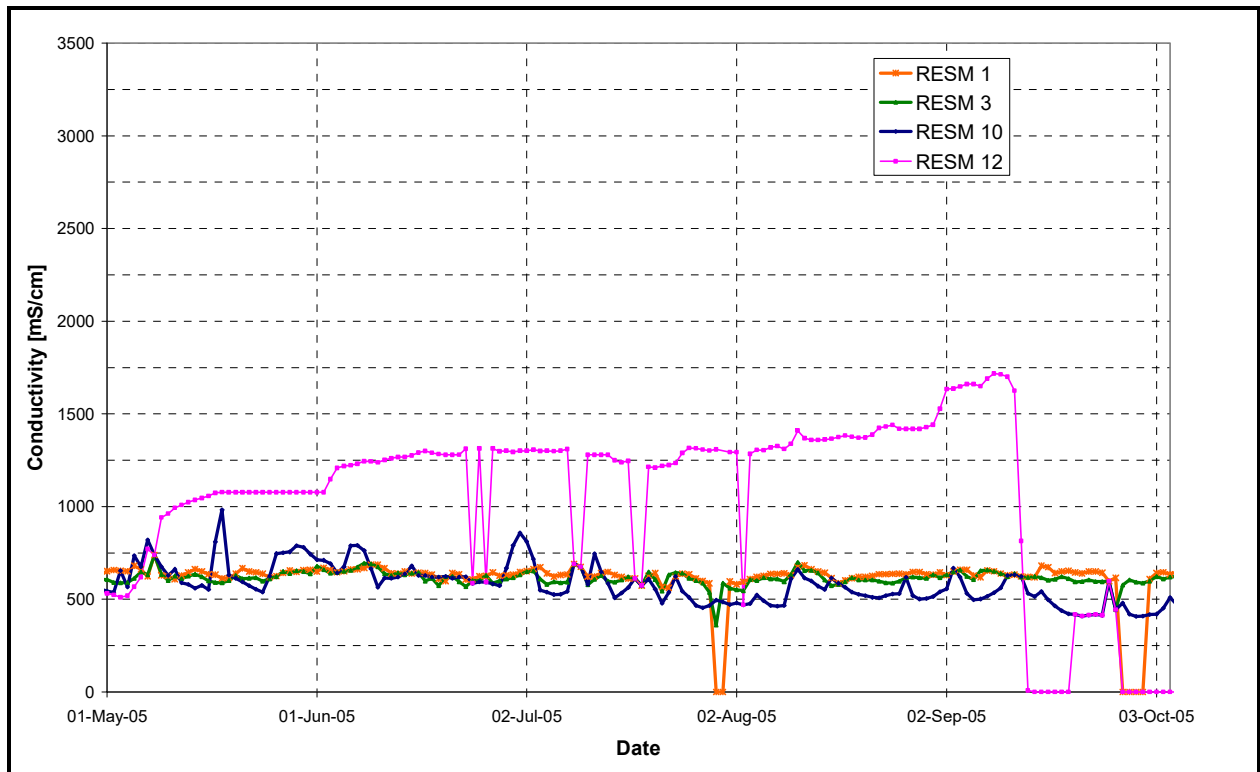


Figure 15 Conductivity values from relevant RESM's from May 2005 to Oct 2005, the dry season

3.6 Log of events at RESM 1

A log of events at RESM 1 was supplied by Mr J Linde to J&W. This log records information of instances at RESM 1 when a sudden increase in conductivity is measured. The event in Table 2 is an example of such an event. Note that this data indicates the same pattern as was observed in Figure 14, i.e. that the source of the plume could be traced to RESM 10. Several such events were recorded in the log, and although not all of the events were traced to RESM 10 the majority were.

This log also indicates information on the change in chemistry at RESM 1, and the presence of high nitrate concentrations generally coincides with the plumes that could be traced to RESM 10. This measurement indicates that the Fertiliser plant is the most likely source of the pollution plume.

Table 2 Sample from log of events at RESM 1

Date	Trigger	Monitoring point	Exceedance of permit requirements @ RESM 1	Nature of event	Detail information regarding release
2006/02/21	Sudden increase in conductivity	RESM 1	Yes	Rain storm	An average of 35.1 mm of rain was recorded at the complex. 69.8 mm rain was recorded at the Bossiespruit station. Elevated levels of nitrates were detected at RESM 10 during this month. A peak value were recorded on the 2006/02/22 (186 mg/l N), which would indicate that the fertilizer water alone could not have caused the peak on the 2006/02/21.

4. GEOLOGY OF THE AREA

The deduced geology is based on the information available and work carried out by J&W. The site is underlain by intrusive Dolerite dykes and sills, Vryheid Formation Sandstone, Shale and coal seams from the Karoo Sequence. Alluvial clayey deposits line the stream gullies, often frequented by slickensides. Pass over zones of both Dolerite and Sandstone/shale sub-outcrops occur in places.

The geology of the Karoo Sequence was dominated by the sub-aqueous deposition of sediments in a shallow lake environment, roughly 150 to 300 million years ago. These sediments were deposited over the older Vaalian igneous rock landscape. The Vryheid Formation was laid down as part of the Eccu Group in their Permian age 270 million years ago. At the end of the Permian age and during the Jurassic age, volcanic rocks in the form of Dolerite intruded through zones of weakness in the sediments (faults, joints and bedding planes) to form a series of sills and dykes. The well-known B4-dolerite sill forms an extensive capping over large areas in the coalfields of Mpumalanga. We are also aware of a graben structure and associated fault zones that strike in an east-west direction through the site.

Depending on the degree and mode of weathering, the dolerites can break down to a low permeable clayey residual soil or alternatively to a more permeable granular residual "sugar" dolerite. In general, the shales and sandstone weather to clayey soils with relatively low permeability, although sandy material is occasionally encountered. The depth across the site varies considerably.

5. STREAM SURVEY

The study has been separated into two sections namely the Groot Bossiespruit and Bossiespruit. The Groot Bossiespruit and Bossiespruit converge south of the plant to form the Bossiespruit. Other tributaries feed into these receiving water bodies.

The stream surveys were designed to assess the impact of the potential pollution sources on these water bodies. Measurements of conductivity, pH and temperature of the streams were taken at approximately 300m intervals. Once a significant change between two measurements was noted, an additional measurement would be made between these two. This procedure would continue until the source of the change in conductivity was identified. Water samples of the stream water and source water (dams) were then taken for detailed laboratory analysis.

Two separate stream surveys were conducted for the entire study area. The first survey was done at the end of August during the dry season to represent a “low” flow survey. The second survey was done in mid February during the rainy season (“high” flow survey).

Figure 16 shows the positions of all the water quality measurement points. In order to identify potential contamination, the rate of change in conductivity between two points of measurement was determined (i.e. $\mu\text{S}/\text{cm}/\text{m}$). A decrease in EC over a distance signified an improvement in the water quality while an increase signifies deteriorating water quality. Colours were then assigned to predefined changes in the EC (shown in Table 3). The solid symbols indicate measurements taken during the high flow while the outlined symbols represent the low flow stream survey.

Refer to Appendix D for raw data gathered during the stream survey as well as drawings A839-00-001 and A839-00-002 showing the high flow and low flow data points respectively.

Table 3 Symbols used to illustrate the rate of change in conductivity in the streams (all units $\mu\text{S}/\text{cm}/\text{m}$)

Decrease in EC	
Increase in EC of 0 to 0.5	
Increase in EC of .5 to 1.0	
Increase in EC of 1.0 to 1.5	
Increase in EC of 1.5 to 3.0	
Increase in EC of 3.0 to 40	

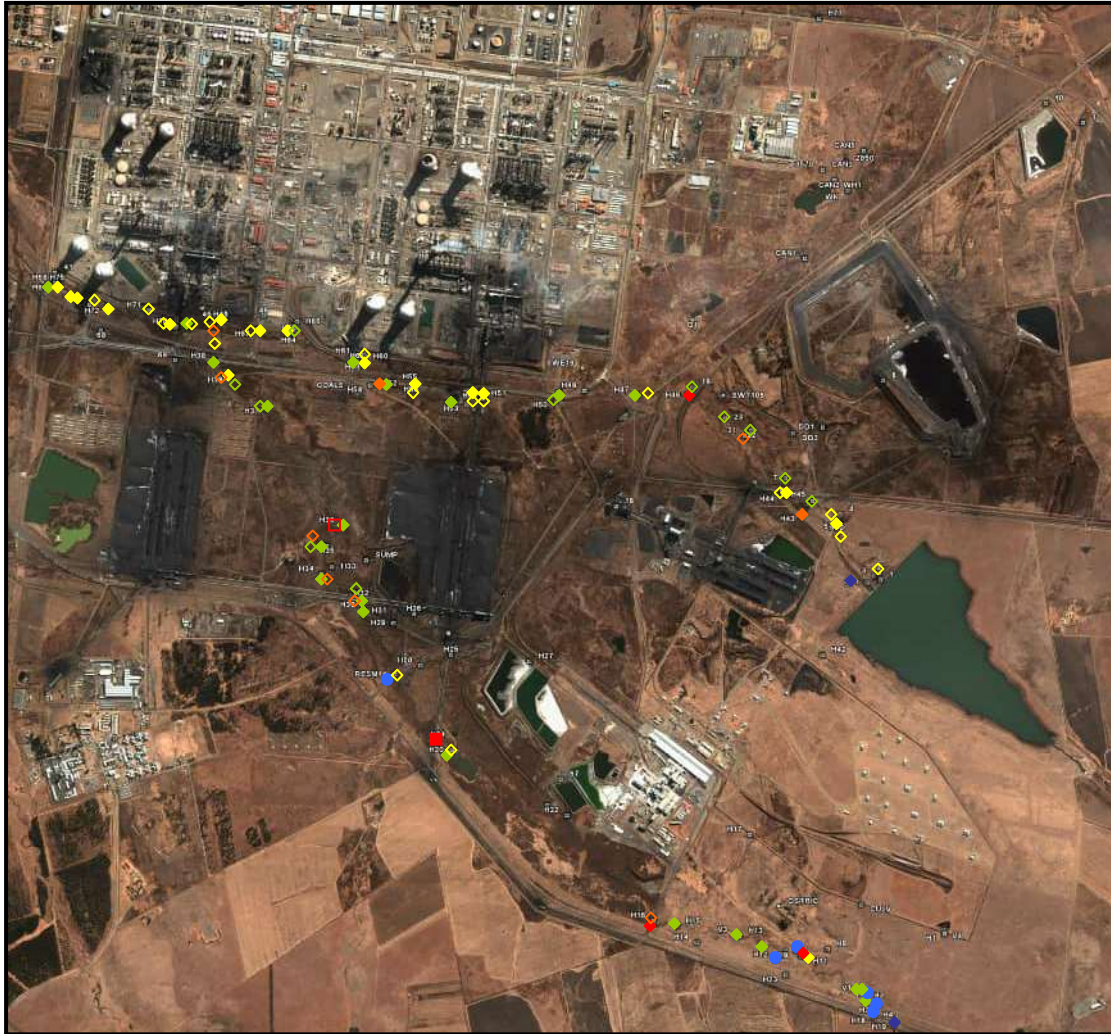


Figure 16 Low and high stream survey measurement locations and change in conductivity with distance

5.1 Water Quality of the Potential Pollution Sources

Water from potential pollution sources were sampled and sent for detailed laboratory analysis. Figure 17 shows the location of the potential pollution sources, and Table 4 is a summary of the laboratory test results of the potential pollution sources. The detailed laboratory results are attached in Appendix B.

The range of conductivity values in the potential pollution sources varies considerably. The Fertiliser pollution control Dam 3 shows extremely high conductivity values (60,100 $\mu\text{S}/\text{cm}$). Other facilities with notably high conductivity values include SCS(E) pollution control dam and the discard dump pollution control dam. These facilities are the only facilities with conductivities in excess of 10,000 $\mu\text{S}/\text{cm}$. Also note the very high concentration of Potassium in Fertiliser dam 3.

The pH of the potential pollution sources ranged between 5.7 and 8.7. pH was therefore not a useful indicator for the purpose of this study.

Table 4 Summary of water quality of potential pollution sources

Potential pollution source	Sample no.	Conductivity [$\mu\text{S}/\text{cm}$]	pH
Bossiespruit dam	B1	211	8.0
Twistdraai Export plant conveyor PC dam	B2	7,040	7.9
Twistdraai Export plant stockpile PC dam	B3	7,160	8.4
Twistdraai Export plant bin PC dam	B4	713	8.7
SCS(E) PC dam	G4	12,410	7.5
Fertiliser Dam 3	G6	60,100	5.3
Fertiliser Dam 7	H27W	54,400	5.5
Canal from SCS(W) passing under conveyor	G8	6,220	7.7
SCS(W) PC dam	G9	8,550	7.6
Discard dump return water dam	Disc 1	10,200	7.8
Canal from plant to Bossiespruit	P1	724	7.2
Ostrich Dam	OSTR	470	8.0
Wollie se gat	WO	2,950	8.0

Potential pollution source	Fluoride [mg/l]	Potassium [mg/l]	Sodium [mg/l]	Sulphate [mg/l]	Nitrates [mg/l]	Chloride [mg/l]
Bossiespruit dam	0.2	3.7	13	32	1.6	14
Twistdraai Export plant conveyor PC dam	2.1	18.0	1,427	3,242	3.6	288
Twistdraai Export plant stockpile PC dam	2.1	17.0	1,210	3,448	3.8	278
Twistdraai Export plant bin PC dam	2.1	15.0	1,379	3,326	5	278
SCS(E) PC dam	1.5	32	984	2,655	1,288	377
Fertiliser Dam 3	18	1,656	244	1,317	6,892	1,856
Fertiliser Dam 7	14	267	214	1,431	15	12,239
Canal from SCS(W) passing under conveyor	1.0	26	670	3,275	5.8	437
SCS(W) PC dam	7.3	29	1,275	3,490	337	278
Discard dump return water dam	1.8	37	1,933	5,797	0.2	437
Canal from plant to Bossiespruit	5.2	13	58	248	0.3	50
Ostrich Dam	1.0	6.9	24	61	<0.2	5
Wollie se gat	<0.2	8.3	126	1,425	0.5	126



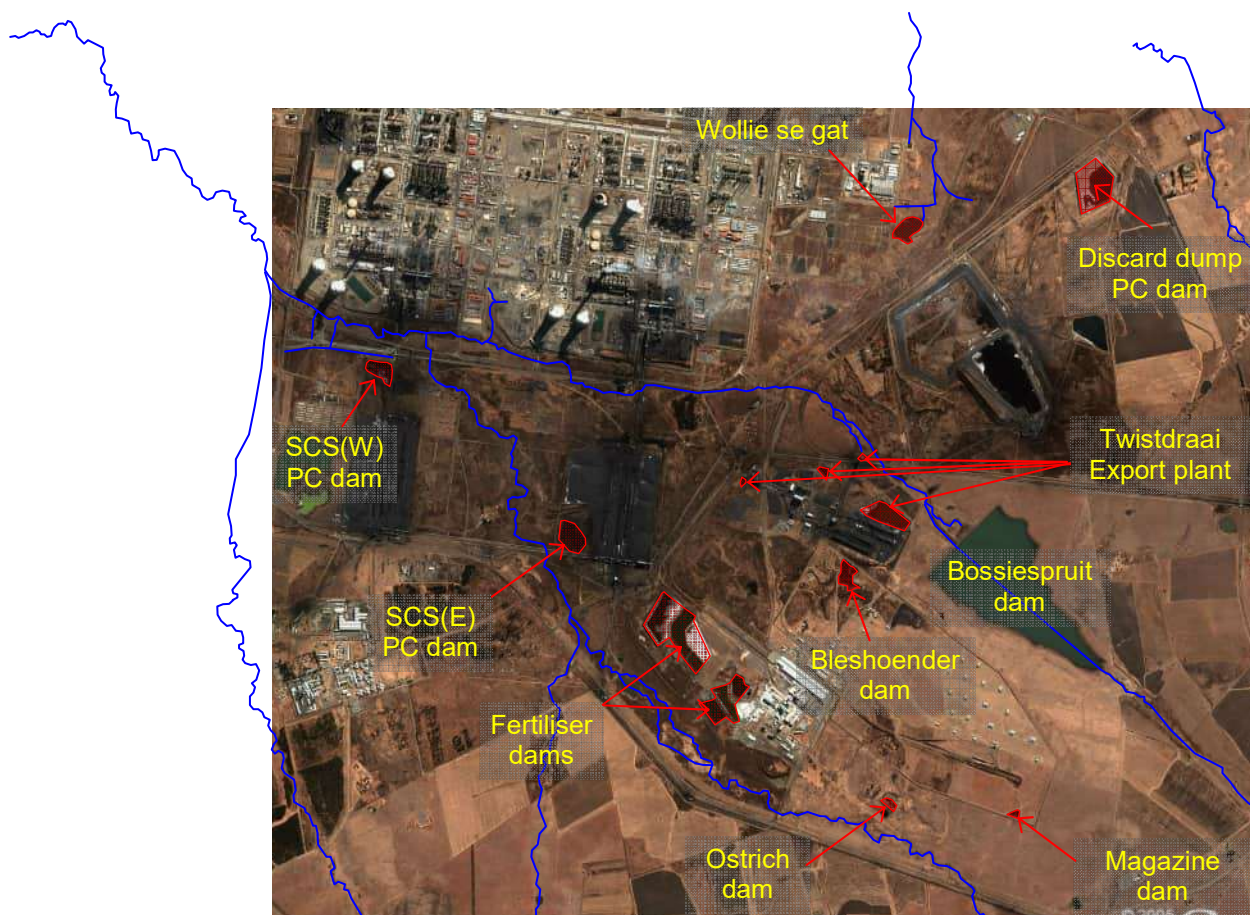


Figure 17 Potential pollution sources in the study area

5.2 Groot Bossiespruit

Low flow stream survey

The results of the low flow stream survey of the Groot Bossiespruit in terms of conductivity and rate of change in conductivity are summarised in Figure 18, Figure 19 and Figure 20. The coloured markers represent the rate of change in conductivity between two points as described in Table 3. Electrical conductivity measurements along the river vary from 310 $\mu\text{S}/\text{cm}$ to 2,830 $\mu\text{S}/\text{cm}$. The volume of water in the river was very low, the upper sections of the stream seemingly stagnant.

As mentioned previously, the original scope of work was restricted to the area downstream of RESM 15 (solid line in Figure 18) as the upstream area was also investigated previously. The stream survey revealed that the conductivity of the Groot Bossiespruit entering the study area was already relatively high (2,145 $\mu\text{S}/\text{cm}$). Further investigation was thus required upstream of RESM 15 and consequently, the scope of work was revised to include this area as shown on Figure 20. An additional survey was carried out six weeks later (broken line in Figure 18). Due to some rainfall in the interim period, the conductivity measurements were slightly less than before, resulting in a slight discontinuity of measurements at RESM 15.

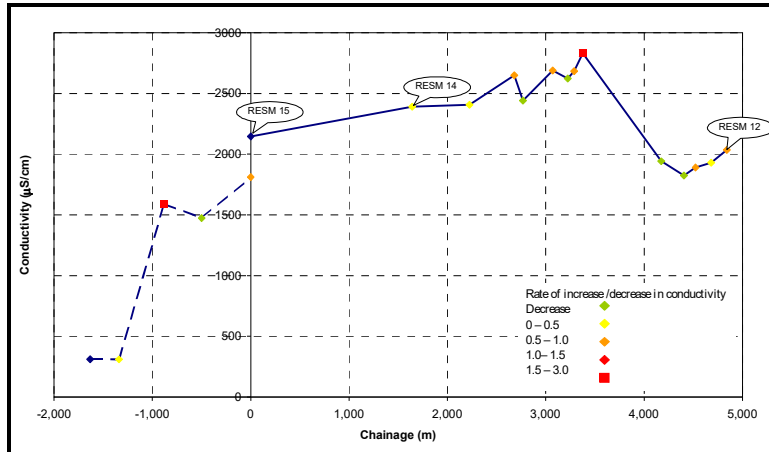


Figure 18 Graph of conductivity in the Groot Bossiespruit measured during the low flow stream survey



Figure 19 Locations of steam survey points during the low flow survey of the Groot Bossiespruit



Figure 20 Additional area upstream of RESM 15

High flow stream survey

The results of the high flow stream survey of the Groot Bossiespruit in terms of conductivity and rate of change in conductivity are represented in Figure 21 and Figure 22. The coloured markers represent the rate of change in conductivity between two points as described in Table 3. Variation of conductivity in the river during the high flow survey ($281 \mu\text{S/cm}$ to $4,600 \mu\text{S/cm}$) was more pronounced than during the low flow survey ($310 \mu\text{S/cm}$ to $2,830 \mu\text{S/cm}$). Significantly greater flow was observed in the stream with no section of the stream stagnant. A very clear peak value was identified which will be discussed in the next section.

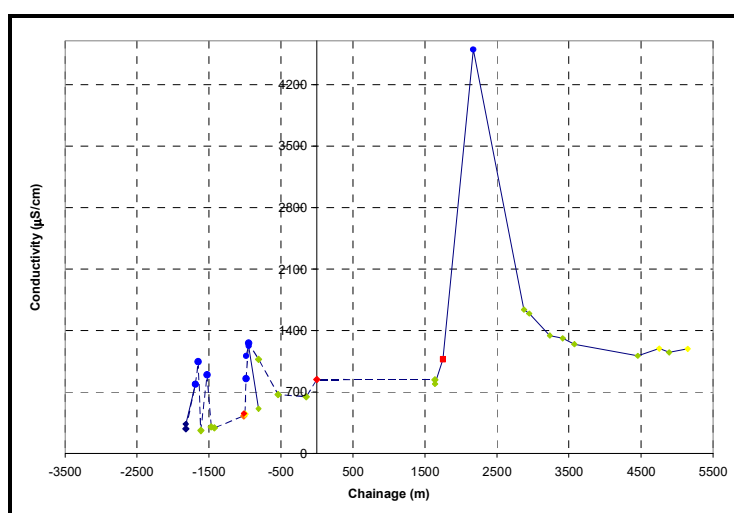


Figure 21 Electrical conductivity in the Groot Bossiespruit measured in high flow stream survey

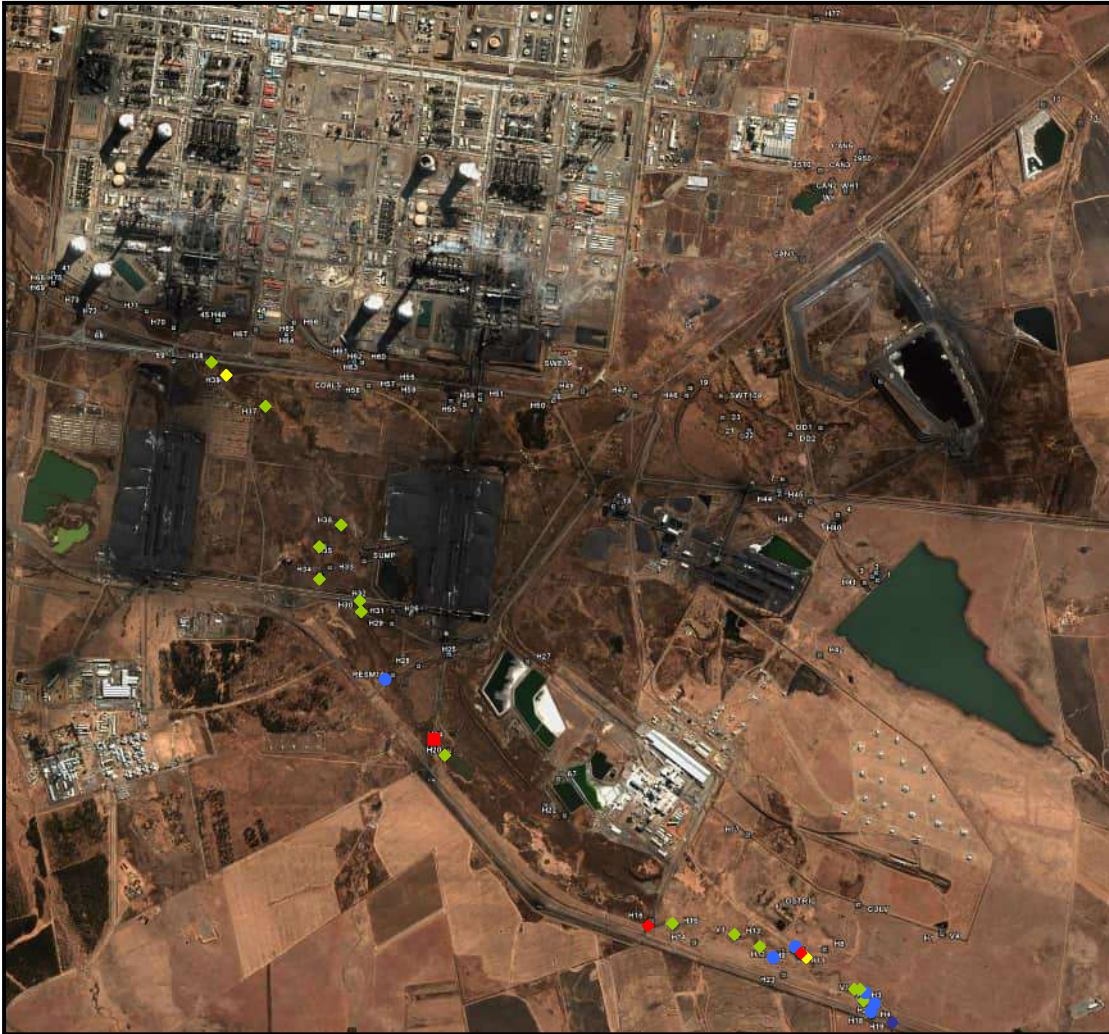


Figure 22 Location of steam survey points during the high flow survey of the Groot Bossiespruit

Areas of concern noted in the stream survey of the Groot Bossiespruit

Area to the South of SMX (Ostrich area)

Note from Figure 18, the low flow survey, that the measurement of conductivity is the same for both sides of the road leading to the Bossiespruit mine (i.e. the first two data points on the graph). A sharp increase in conductivity ($1,590 \mu\text{S/cm}$) was noted after confluence with the small stream originating from the Magazine dam in the south-eastern corner of SMX. The conductivity of the water collected below this dam was $2,077 \mu\text{S/cm}$. The Ostrich and Magazine dams were however both found to be reasonably clean and could not be the cause of an increase in conductivity in this area. No clear reason for the increase in conductivity over this section could be found. It was postulated that farmers to the south of this area may be using products from the fertiliser dam which makes its way to the Groot Bossiespruit in this area.

It can be seen from Figure 21, the high flow survey that the water quality of the Groot Bossiespruit deteriorates once it enters the area to the south of SMX (i.e. conductivity increased from $228 \mu\text{S/cm}$ to $841 \mu\text{S/cm}$). The conductivity of ponded water adjacent to the river was relatively high (i.e. in the order of $1,100 \mu\text{S/cm}$). Despite these measurements, the pollution source(s) could not be found.

In the vicinity the Fertiliser plant

During the low flow survey a gradual increase in conductivity in the stream was measured in this area. However, during the high flow survey a very sharp increase was measured in the stream. Contamination from this area is therefore mostly due to contaminated runoff. This area was thus not investigated for seepage (underground), but the catchment characteristics were investigated.

A very pronounced peak in conductivity in the Groot Bossiespruit was found during the high flow stream survey. The cause of this very high peak was found to be seepage from Fertiliser Dam 7 as shown in Figure 23. The seepage from this source does not report to the Groot Bossiespruit in winter due to evaporation along the flow path once the seepage daylight. This evaporation however serves to concentrate contaminants; which during a rainfall event causes highly concentrated dirty runoff to the Groot Bossiespruit.

In the vicinity of SCS(E)

The water quality of the Groot Bossiespruit in the vicinity of SCS(E) was influenced by various factors. Coal discard could be found in the river bed and below the conveyor belt (Figure 24a and b). A large canal intercepts dirty runoff from the coal dump and transports it to the return water dam (Figure 24c). In some area the canal seems to be constructed from coal discard (Figure 24d) which may lead to some contaminated runoff water getting to the Groot Bossiespruit. The peak in conductivity during the low flow survey (2,830 $\mu\text{S}/\text{cm}$) was measured between the SCS(E) return water dam and the coal stockpiles. An aerial photograph (Figure 24) shows salts precipitated on the ground surface in this vicinity.

During the high flow survey seepage from this area was masked by the very high conductivity in the stream upstream of this area. This area therefore seems to be a year round source of low volume seepage and was therefore further investigated by testpits.

In the vicinity of SCS(W)

SCS(W) manage their dirty water from the coal stockyard via a network of canals as shown in Figure 25. Dirty runoff from the stockyard is routed via the network of canals to the return water dam located north of the stockyard. A water course / canal on the eastern side of the stockyard was also mapped. It runs parallel to the road that leads up to the stockyards as shown in Figure 25. Water from a dirty loading area drains into this canal. The outlet of this canal is a concrete pipe that discharges into river as shown in Figure 27c and d.



Figure 23 Conductivity measurements in the vicinity of Fertiliser Dam 7



(a)



(b)



(c)



(d)



(e)

Groot Bossiespruit
river

Precipitated
salts

Return water
dam

Figure 24 Stream survey photographs from SCS(E) area

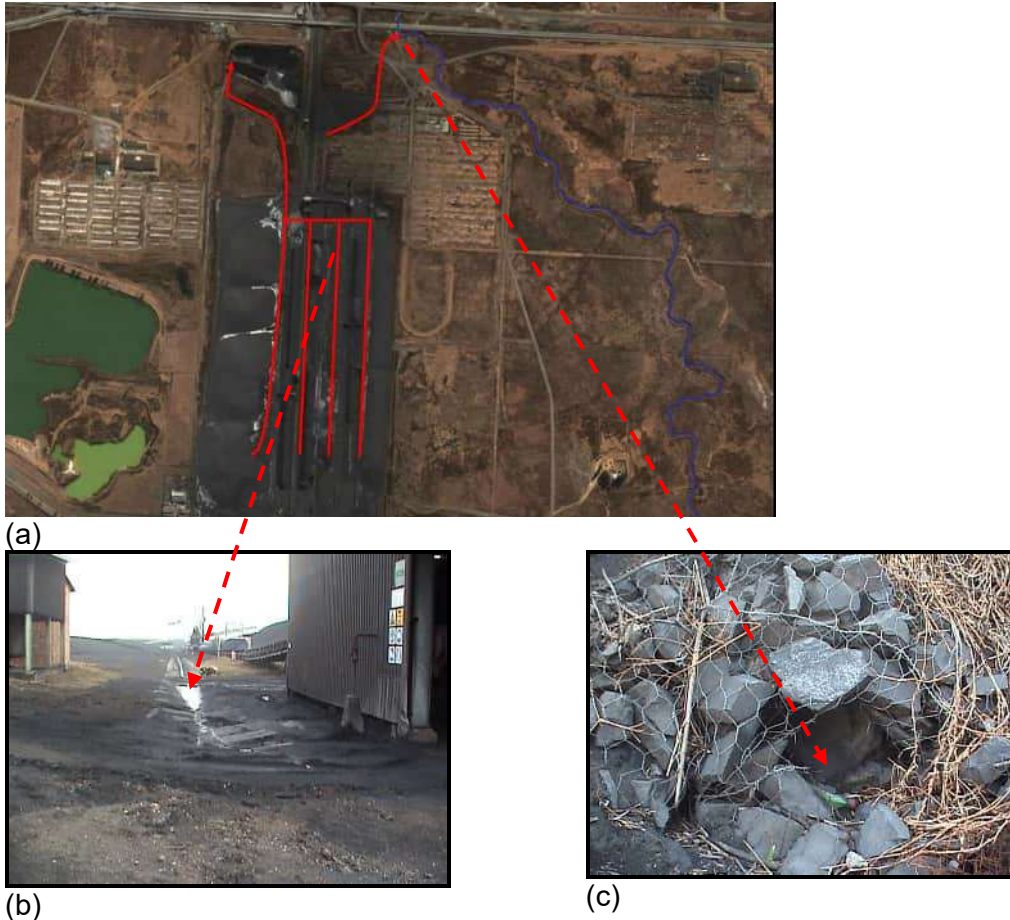


Figure 25 Stream survey photographs from SCS(W) area

5.3 Bossiespruit

Low flow stream survey

Although it was assumed that low flow conditions would prevail in the rivers, the Bossiespruit dam was overflowing at the time of the survey. The additional clean water in the Bossiespruit will have diluted seepage from potential pollution sources, thus making them more difficult to detect. Note that because of the additional volume of water in the river, the same magnitude of change in conductivity in the Bossiespruit implicated a far greater addition of contaminants than was the case for the Groot Bossiespruit. It was calculated that 96% of the combined flow originated from the Bossiespruit and 85% of the combined salt load at the time of the low flow survey.

The results of the low flow stream survey of the Bossiespruit in terms of conductivity and rate of change in conductivity are summarised in Figure 26 and Figure 27. The coloured markers represent the rate of change in conductivity between two points as described in Table 3. Electrical conductivity measurements along the river vary from 209 $\mu\text{S}/\text{cm}$ to 512 $\mu\text{S}/\text{cm}$. Note the almost constant increase in conductivity in this stream. Both the magnitude and the magnitude of variation in conductivity over the length of the river is thus considerably less than that of the Groot Bossiespruit.

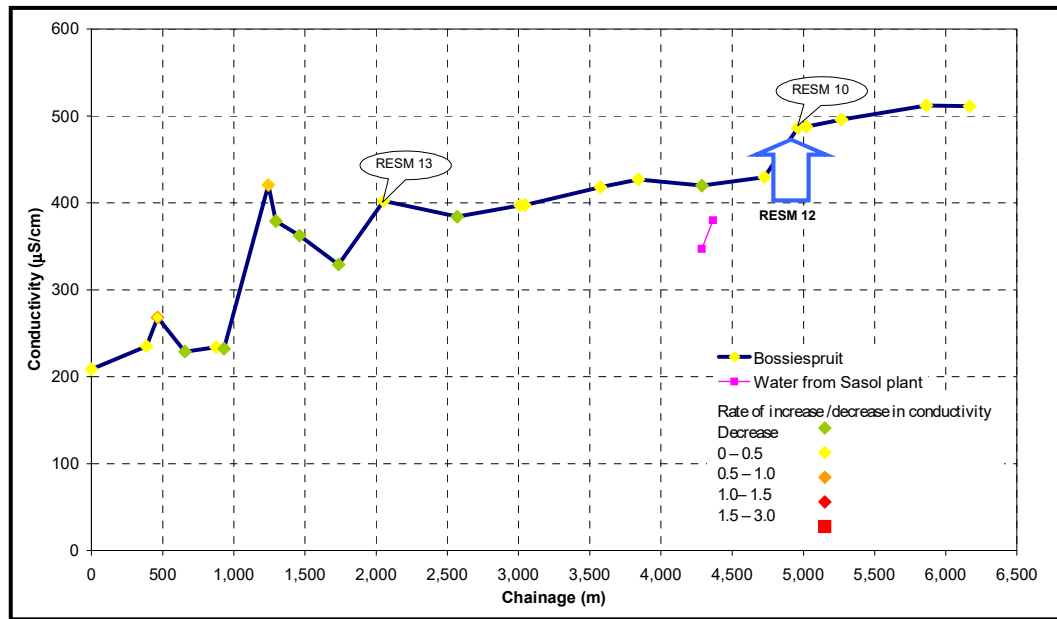


Figure 26 Conductivity in the Bossiespruit as measured in low flow stream survey



Figure 27 Conductivity in the Bossiespruit as measured in low flow stream survey

High flow stream survey

Figure 28 shows the variation in conductivity with distance in the Bossiespruit. The variation in the conductivity was greater during the high flow survey (420 $\mu\text{S}/\text{cm}$ to 1 525 $\mu\text{S}/\text{cm}$) than during the low flow survey (209 $\mu\text{S}/\text{cm}$ to 512 $\mu\text{S}/\text{cm}$). This was not anticipated, and is believed to be as a result of the Bossiespruit dam overflowing during the low flow survey.

Note that blow down water was released at the time of the high flow survey, the effect of which can be seen clearly in Figure 28.

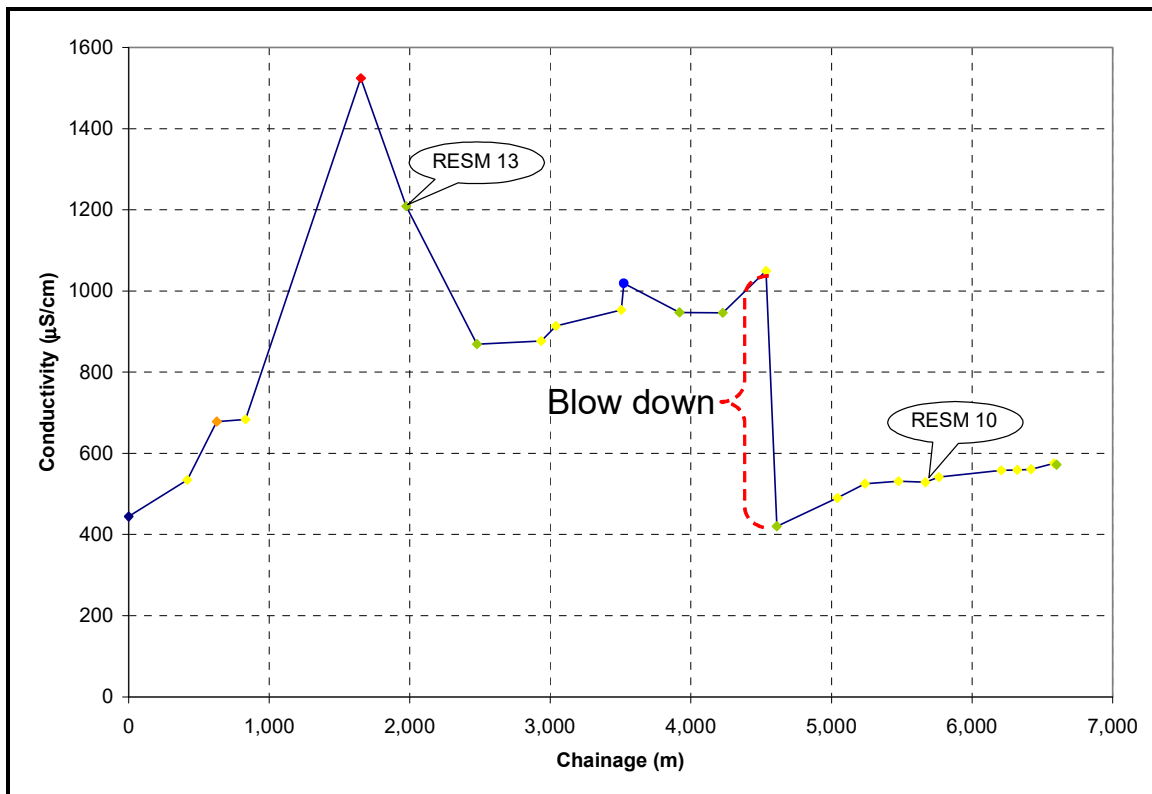


Figure 28 Conductivity in the Bossiespruit measured in high flow stream survey



Figure 29 Conductivity in the Bossiespruit measured in high flow stream survey

Areas of concern noted in the stream survey of the Bossiespruit

Area adjacent to the Twistdraai Export plant and discard dump

In both stream surveys an increase in conductivity of the Bossiespruit was noted from directly downstream of the Bossiespruit dam to the north-western corner of the railway loop. The upper section of this area, upstream of the railway loop, shows a gradual increase in conductivity. This may be attributed to seepage from the Twistdraai Export plant PC dam on the western side of the Twistdraai Export plant as well as to contamination from coal that has fallen from the conveyor belts crossing the Bossiespruit. The Twistdraai Export plant PC dam was further investigated by testpitting.

The lower section of the area, inside the railway loop, shows a more pronounced increase in conductivity especially in the high flow survey. Detail of the exact location of the increase during the high flow survey could not be gained due to the very thick bed of vegetation prohibiting access to the stream. Two possible sources were identified, the load-out silo and the discard dump.

Water from coal stored in the load-out silo flows freely to the wetland that has established itself on route to the Bossiespruit. A pollution control dam has been built between the silo and river to retain this contaminated water as shown in Figure 30a. The water collection system to route the water to this pollution control dam is not functioning, resulting in the flow of water past the pollution control dam as shown in Figure 30b. The general arrangement of the area is shown in Figure 30c.

The discard dump, located to the north of the Bossiespruit, has been built on complex geological features including dolerite sills and dykes. Contamination of various aquifers inevitably occurs. Although the stream survey could not differentiate between contamination from the discard dump and the silo, it is believed that both contribute to the increase in contaminants noted over this section. A leaking valve was noted on the Bossiespruit side of the discard dump, shown in Figure 31. The conductivity of the water leaking from the valve was 5,400 $\mu\text{S}/\text{cm}$. Fixing this type of housekeeping measure would reduce, but unfortunately not eliminate, contamination of the Bossiespruit from the discard dump.

Area between SCS(E) and the Sasol plant

Directly after the railway loop the conductivity in the stream reduces. This is believed to be as a result of clean catchments either side of the Bossiespruit in this section. After this section the water quality in the river deteriorated gradually in both surveys. This is to be expected as this section is bounded by dirty areas on either side. Two distinct sources of contamination were identified in the river section between SCS(E) and the plant, although these will probably not be the only sources of seepage along this section.

The first is water ponding below the conveyor belt which transports coal from SCS(E) to the primary plant. The conductivity of the pooled water was measured to be 10,730 $\mu\text{S}/\text{cm}$. A trickle of water from this pool to the Bossiespruit was noted during the high stream survey.

The second is water from a coal stockpile area to the north-west of SCS(E). This area has no water management system in place and all runoff will report directly to the Bossiespruit.

Area between SCS(W) and the Sasol plant

Conductivity measured in this section also increases gradually as expected as both sides of the river are bounded by dirty areas. A very important difference is the fact that blow down water was being released into the stream in the high flow stream survey upstream of this area as shown in Figure 28. Even though the blow down water increased the flow in the river approximately 10 fold, the rate of rise in conductivity was similar to what it had been before (in the previous section). This implies that a far greater amount of contaminants were entering the stream in this section. Three distinct sources were identified in this area, but again these will not be the only sources of contaminants in this section.

The first source identified was runoff water from the drive house and coal handling facility supplying coal to the Synfuels plant from SCS(W), shown in Figure 32b. This area was found to be wet all year round, indicating that process water was seeping out of the area, and that furthermore, no obvious dirty water management (containment) system could be identified to intercept runoff from this area.

The second source identified in this area is a canal that was originally built to divert clean water around the ash conveyor in the vicinity of SCS(W) as shown in Figure 33. Water in this stream was however found to be highly contaminated with a conductivity of 6,200 $\mu\text{S}/\text{cm}$ during the low flow survey.

The third possible source identified was seepage from the SCS(W) PC dam. This was further investigated in the following phases.



(a)



(b)



(c)

Figure 30 Load-out silo at Twistdraai Export plant showing a pollution control dam (a), flow of contaminated water towards river past dam (b) and a general layout of the area (c)



Figure 31 Photograph of leaking valve below Twistdraai Export plant discard dump



(a)



(b)

Figure 32 General layout of (a) and water ponding adjacent to (b) SCS(W) coal handling facility



(a)



(b)



(c)



(d)

Figure 33 Water canal north west of SCS(W) showing (a) layout of canal, (b) canal next to conveyor belt, (c) canal crosses conveyor via pipe and (d) canal between conveyor belt and Bossiespruit

5.4 Other areas of concern

“Wollie se gat” is an old Dolerite quarry to the north-west of the Twistdraai Export plant discard dump. During both the high flow and the low flow survey the quarry was overflowing and appeared to have done so for some time as a wetland had formed downstream. The conductivity of the overflow was $2,873 \mu\text{S}/\text{cm}$; which flowed towards the Klipspruit as shown in Figure 34. The flow volume was assessed during the low flow survey to be approximately 2 l/s. Wollie se gat was clearly being fed by a non-seasonal and reasonably constant source. A wet area to the west of the discard dump (shown on Figure 34 as a red oval) indicated that seepage from the Twistdraai Export plant discard dump was flowing towards Wollie se gat. As Wollie se gat is located on a Dolerite dyke, it seems likely that it is being fed by seepage from the discard dump through the dolerite aquifer. The IGS report on this area (ref no: 2006/19/PDV) reports on a detailed study of the area.

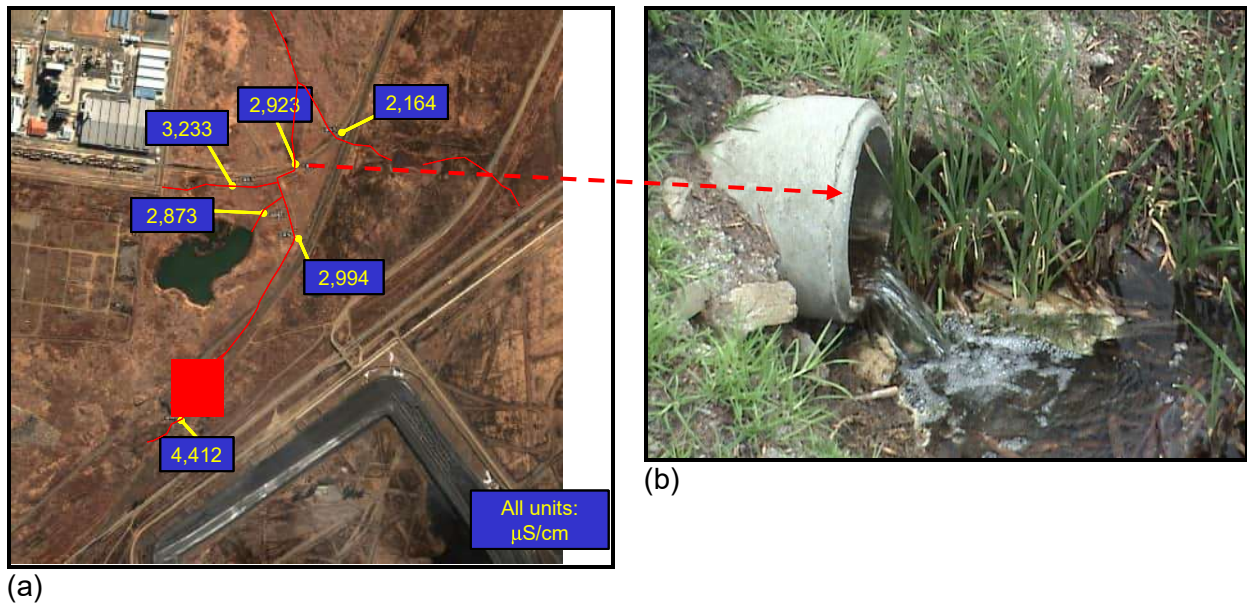


Figure 34 Conductivity measurements in the vicinity of Wollie se gat (a) and water overflowing from Wollie se gat passing through a pipe culvert (b)

6. INVESTIGATION OF AREAS OF CONCERN

Areas of concern were identified during the desk study, stream survey and walk over phase of this investigation. Depending on whether nature of the concern was identified as seepage or runoff, the method of detailed investigation was altered to suit. In this section the detailed investigation surrounding these areas will be discussed. The areas of concern listed in Table 5 and indicated on Figure 35 were identified and investigated.

In areas where seepage was identified as the method of contaminant transport, the area was investigated by testpits and/or auger holes. These were profiled with the specific aim of determining the extent, intensity and concentration of seepage. A scale of seepage intensity was developed in the previous J&W seepage study as shown in Table 6. This scale was again made use of. In areas where it was deemed necessary boreholes were constructed to measure aquifer parameters, followed by numerical modelling of the contaminant transport.

In areas where runoff was identified as the method of contaminant transport, the surface drainage characteristics in the area were investigated.

Table 5 Areas of concern identified and investigated

Area of concern	Description of concern	Receiving clean water body
Ostrich area	Source unclear	Groot Bossiespruit
Fertiliser dam 8	Runoff	Groot Bossiespruit
Fertiliser dam 7	Seepage and Runoff	Groot Bossiespruit
SCS(E) PC dam	Seepage	Groot Bossiespruit
Canal near SCS(W)	Runoff	Groot Bossiespruit
Twistdraai Export plant PC dam	Seepage	Bossiespruit
Load-out silo at Twistdraai Export plant	Non containment of process water	Bossiespruit
Twistdraai Export plant discard dump towards railway loop	Seepage, runoff and non containment of process water	Bossiespruit
SCS(E) conveyor and coal stockpile area	Runoff and non containment of process water	Bossiespruit
SCS(W) to Synfuels coal handling	Runoff and non containment of process water	Bossiespruit
SCS(W) PC dam	Seepage	Bossiespruit
Ash conveyor canal near SCS(W)	Runoff	Bossiespruit
Twistdraai Export plant discard dump towards Wollie se gat	Seepage	Klipspruit

Table 6 Scale for classification of observed seepage

Seepage description	Scale value
No seepage	0
Light seepage	1
Light to moderate seepage	2
Moderate seepage	3

Moderate to strong seepage	4
Strong seepage	5

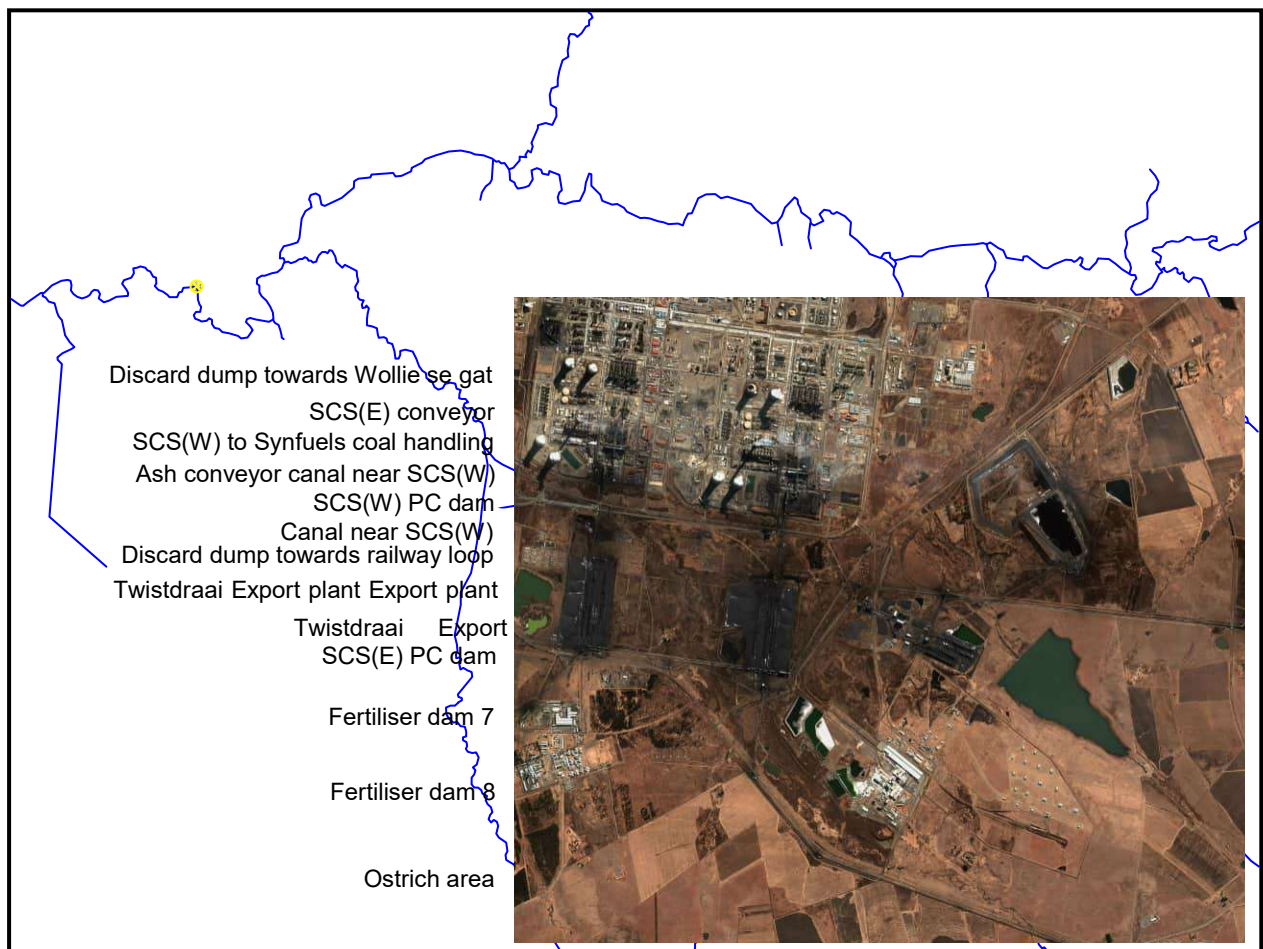


Figure 35 Potential seepage areas investigated in detail

6.1 Ostrich area

This area is associated with the high conductivity measured in the Groot Bossiespruit at RESM 14. Conductivity measurements vary greatly along this length of stream.

Walkover survey and desk study

Precipitated salts were noted occasionally along the banks of the Groot Bossiespruit. Both the Ostrich and Magazine dams were investigated and found not to be sources of contaminants as measurements indicated that the conductivity in both dams were relatively low.

Testpit and auger hole investigation

A network of testpits was constructed across the Ostrich area. These were numbered TP115 to TP122 as shown in Figure 36a. Additionally auger holes were drilled below the Magazine dam numbered F01 to F05 as shown in Figure 36b. The detailed profiles of these may be found in Appendix C.

In general the profile consists of alluvium underlain by residual dolerite becoming soft rock Dolerite between 1.3m to 3.1m. Occasionally a layer of fill overlies the alluvium up to 2.2m thick. Table 3 summarises the seepage results of the testpits and auger holes.

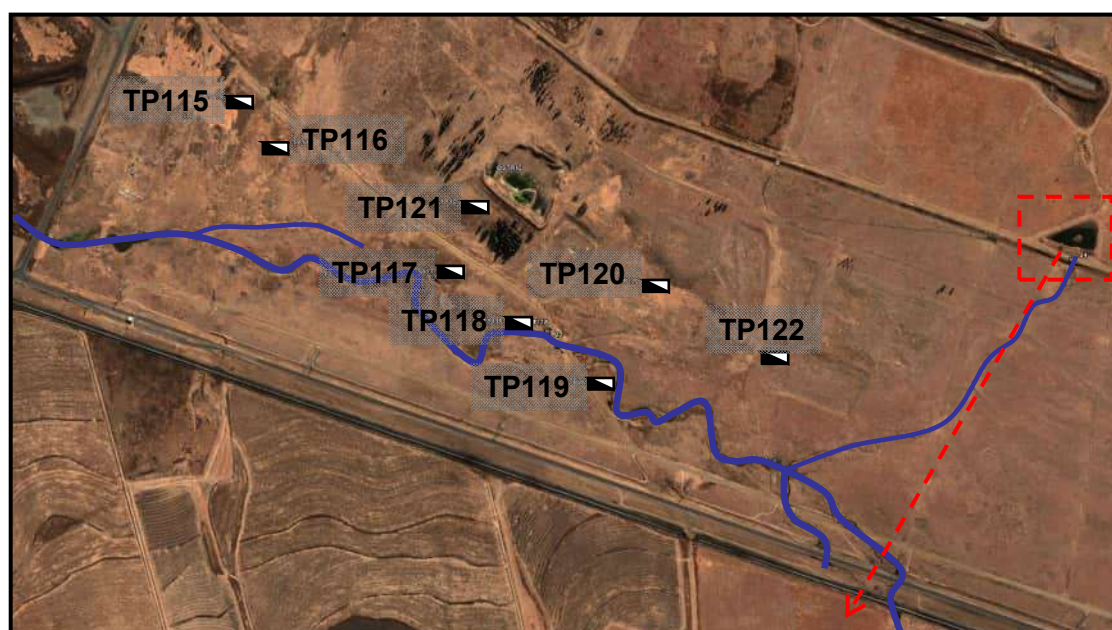
The strength of the seepage is slight with the exception of TP119 which is slight to moderate. TP119 is located on the opposite site of the Groot Bossiespruit than the rest of the testpits. The conductivity increases towards TP120 (eastwards). Auger refusal directly below Magazine dam was shallow (0.8m to 1.3m) with no seepage detected.

Conclusions

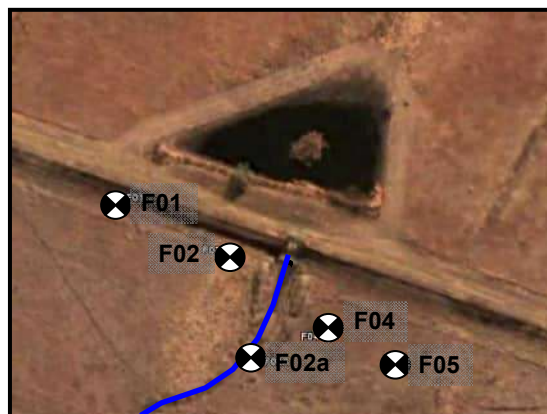
The source of seepage remains unknown. As the stream was either stagnant or flowing very slowly, large variations in conductivity will be induced by small quantities of contaminants. One possibility, mentioned at an interim feedback session with Sasol, is the use of products by neighbouring farmers produced by fertiliser finding its way to this area. This area is not believed to be a major contributor of contaminants to the system.

Table 3: Testpits and Auger holes in the seepage area SMX and Bossiespruit mine

Testpit or Auger hole [no]	Strength of seepage [no]	Conductivity [$\mu\text{S}/\text{cm}$]
TP115	0	<i>n.a.</i>
TP116	1	1,094
TP117	0	<i>n.a.</i>
TP118	1	1,361
TP119	2	1,397
TP120	1	1,765
TP121	0	<i>n.a.</i>
TP122	0	<i>n.a.</i>
F01	0	<i>n.a.</i>
F02	0	<i>n.a.</i>
F02A	0	<i>n.a.</i>
F04	0	<i>n.a.</i>
F05	0	<i>n.a.</i>



(a)



(b)

Figure 36 Test pits (a) and auger holes (b) in the Ostrich area

6.2 Fertiliser dam 8

Walkover survey and desk study

Runoff from the Fertiliser area is collected in a canal and routed to a pollution control dam known as Fertiliser dam 8 shown in Figure 37. The volume of this dam was estimated to be 600m^3 (by approximating the surface area and depth of the dam). Conductivity in the Groot Bossiespruit increased from $792\text{ }\mu\text{S/cm}$ upstream to $1,072\text{ }\mu\text{S/cm}$ downstream of this area during the high flow survey. Furthermore, the conductivity of the small pond that had formed downstream of the dam spillway as shown in Figure 37, was found to be $4,750\text{ }\mu\text{S/cm}$.

Runoff model

Surface contours of the Fertiliser area were used to measure the catchment area of Dam 8 as shown in Figure 38. Recently constructed canals were added to the model. The catchment area of Dam 8 is presently $175,495\text{ m}^2$. Legally dam 8 should be able to accommodate the 1:50 yr, 24 hr storm. That storm in the Secunda area is 128 mm. If we assume a runoff coefficient of 40%, 51mm of runoff will be generated in the area. The volume of runoff in such a case will be $8,985\text{ m}^3$. With an estimated volume of 600 m^3 Dam 8 is clearly inadequate in size. The volume of runoff that Dam 8, if empty, can accommodate equates to an 8.5 mm storm event. On the highveld an event of this magnitude occurs regularly during the rainy season.

Conclusions

The spillway of Dam 8 is shown on Figure 37. Erosion downstream of the spillway bears evidence of overtopping of this facility. Although this facility probably has little influence on the stream quality during dry periods, it is clear that it will have a major effect on stream quality during rainfall events.



Figure 37 Erosion downstream of Fertiliser dam 8 due to overtopping

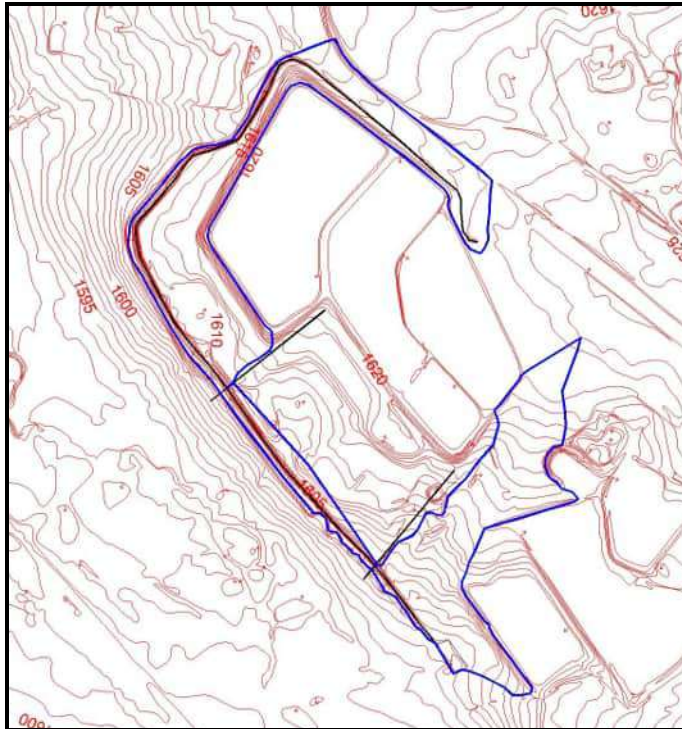


Figure 38 Catchment area of Fertiliser Dam 8

6.3 Fertiliser dam 7

Walkover survey and desk study

On recommendation of previous studies in the Fertiliser area, a canal was constructed around Fertiliser dam 7 to collect seepage. The polluted seepage was then routed to the Fertiliser dam 8 discussed above. The walkover survey indicated that this canal was not constructed deep enough to collect all seepage from the dams, although a significant amount of seepage is collected. Conductivity in this dam was measured to be 54,200 $\mu\text{S}/\text{cm}$.

Seepage bypassing the canal collected to the west of Dam 7 as indicated in Figure 23. An area has formed where no vegetation is growing and the soil is visibly moist. Puddles of seepage form in this area and conductivity in these was measured to be 35,500 $\mu\text{S}/\text{cm}$. During dry periods the seepage then evaporates from this area, concentrating the contaminants. During a rainfall event the seepage washes down via a canal to the Groot Bossiespruit. During the high flow survey this increased the conductivity in the Groot Bossiespruit from 1,072 $\mu\text{S}/\text{cm}$ to 4,600 $\mu\text{S}/\text{cm}$.

Conclusions

Even though this area only impacts on the stream quality during rainfall events, the source of the problem is seepage under the canal built to intercept seepage from Dam 7. A previous attempt to deepen the seepage cut-off trench was only partially successful as the rock at the base of the trench becomes too hard to excavate. The impact from this source is severe.

6.4 SCS(E) pollution control dam and stockyard

Walkover survey and desk study

An increase in conductivity was noted during the low flow survey in this area. Reeds were also growing in places below the pollution control dam as shown in Figure 39, indicating possible seepage. The conductivity in the pollution control dam was high (12,200 $\mu\text{S}/\text{cm}$). It was thus decided to investigate the entire area by testpitting.

Testpit and auger hole investigation

A row of testpits were constructed along the Groot Bossiespruit between the river and SCS(E). These were numbered TP126 to TP133A. A second row of testpits was made north of SCS(E) numbered TP123 to TP126. Table 7 contains a summary of the testpit results. The detailed profiles for these are given in Appendix C.

In general the profile consists of alluvium underlain by residual Siltstone becoming soft rock Siltstone between 2.5m to 2.7m. Occasionally a layer of fill overlies the alluvium up to 0.9 m thick.

Firstly note that north of testpit TP130, no seepage was found from SCS(E) towards the Groot Bossiespruit. Seepage to the Groot Bossiespruit was found adjacent to the SCS(E) pollution control dam. Seepage depth was between 2m and 2.5m in testpits TP131 and TP132 and 0.8m in TP133A. The seepage source is clearly the pollution control dam of SCS(E), however the last section of runoff collection canal flowing to the PC dam also seems to be causing some seepage and quite possibly spillage. High conductivity was recorded in this vicinity (TP131) and precipitated salts could be noted on the aerial photograph. Careful inspection of the aerial photograph seems to show a waterway from SCS(E) to TP131.

The results from TP125 will be discussed under the SCS(E) conveyor section.

Conclusions

Seepage has been identified in this area and the seepage area has been delineated with reasonable certainty. The mechanism of seepage has been investigated and found to be that of shallow seepage in the residual Siltstone layer. Spillage from the runoff collection canal seems to have taken place however this was not witnessed.

Table 7 Testpits in seepage area next to SCS(E)

Testpit [no]	Strength of seepage [no]	Conductivity [μS/cm]
TP123	0	<i>n.a.</i>
TP124	0	<i>n.a.</i>
TP125	3	2,238
TP126	0	<i>n.a.</i>
TP127	0	<i>n.a.</i>
TP128	0	<i>n.a.</i>
TP129	0	<i>n.a.</i>
TP130	0	<i>n.a.</i>
TP131	3	4043
TP132	2	1,600 to 3,000
TP133A	3	1,050

**Figure 39 Reeds SCS(E) PC dam wall**



Figure 40 Testpits around SCS(E)

6.5 Canal on the eastern side of SCS(W)

Walkover survey and desk study

A canal has been constructed on the north-eastern side of SCS(W) as shown in Figure 25a. The canal was intended to be a clean water canal. A coal handling area has subsequently been created next to this canal. Runoff from this dirty area drains to the canal and subsequently to the Groot Bossiespruit.

Runoff model

The surface area of the coal handling area is approximately 10,000 m². Assuming a runoff coefficient of 40%, this area will generate approximately 4 kl of contaminated water for every 1 mm of rain.

Conclusions

A coal handling area has been created without any dirty water management system. This is impacting on water quality in the Groot Bossiespruit.

6.6 Twistdraai Export plant pollution control dam

Walkover survey and desk study

This area is associated with the slight increase in conductivity in the Bossiespruit downstream of the Bossiespruit dam. Green patches could be noted below the pollution control dam, an

indication that seepage might occur from the dam. The conductivity in this dam measured during the low stream survey was found to be 7,090 $\mu\text{S}/\text{cm}$. It was decided to investigate this area further by testpitting.

Testpit investigation

The topography in this area was such that water would drain in a northern direction towards the Bossiespruit. Consequently a row of testpits were constructed along the northern perimeter of the pollution control dam. These were numbered TP104 to TP106 and located as shown on Figure 41. The detailed profiles are given in Appendix C.

Generally the soil profile consists of alluvium underlain by residual Dolerite becoming soft rock Dolerite at 1.5m. The profile of testpit TP104 differed from the rest in that it consisted of a layer of fill, on top of alluvium, underlain by residual Sandstone. TLB refusal was on very soft rock Sandstone. Table 8 summarises the seepage results of the testpits.

Slight seepage was noted in testpits TP104 and TP105. General seepage in TP105 occurred on the interface between the residual Dolerite and very soft rock Dolerite (2.2m) while that in TP104 was point seepage at various depths along the residual Sandstone layer. The seepage in testpit TP105 was too slight to measure its conductivity. The location of the increase in conductivity noted in the low flow stream survey corresponds to TP104.

Conclusions

Seepage has been identified in this area and the seepage area has been delineated with reasonable certainty. The mechanism of seepage has been investigated and found to be that of seepage in the residual Sandstone and residual Dolerite layer. The strength of seepage detected was very low and this area is therefore not considered a large contributor to the contaminants in the Bossiespruit.

Table 8 Testpits in seepage area Twistdraai Export plant PC dam

Testpit [no]	Strength of seepage [no]	Conductivity [$\mu\text{S}/\text{cm}$]
TP104	1	1,069
TP105	1	<i>n.a.</i>
TP106	0	<i>n.a.</i>

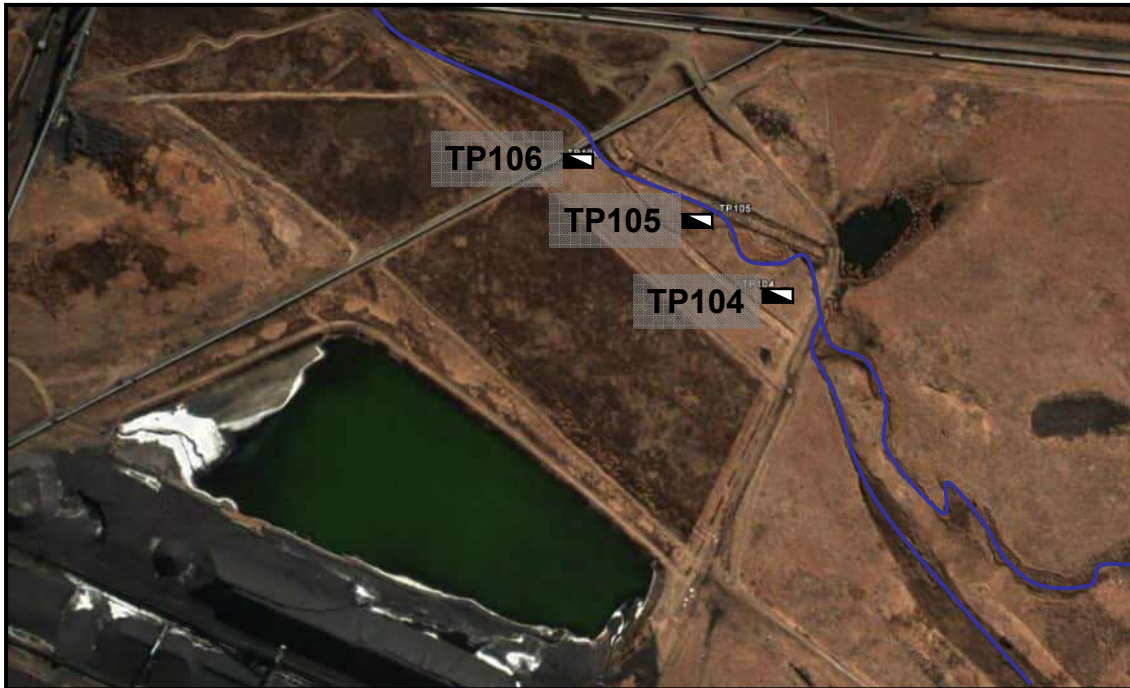


Figure 41 Testpits around Twistdraai Export plant PC dam

6.7 Twistdraai Export facility, Load out Silo

Walkover survey and desk study

This area is associated with the highest recorded conductivity during the low stream survey in the Bossiespruit. Water is freely draining from the load out silo towards the Bossiespruit. The pollution control dam built for retaining this water is no longer in use. A wetland has formed between the silo and the Bossiespruit. The location of the wetland coincided with the location where high conductivity was measured during the low stream survey.

Testpit investigation

Two separate rows of testpits were constructed along both sides of the Bossiespruit to distinguish between contaminants from the north and the south of the stream (TP101 to TP103 and TP107 to TP113 and TP134). The detailed profiles are given in Appendix C. The testpits north of the Bossiespruit will be discussed in the section regarding seepage from Twistdraai Export plant discard dump towards the railway loop.

Soil profiles consist of alluvium that is underlain by either residual Siltstone, residual Sandstone or residual Dolerite. Soft rock (i.e. Sandstone, Siltstone or Dolerite) was noted at depths varying between 1m to 2.2m. Table 9 summarises the seepage results of the testpits.

Strong seepage was observed in testpits TP101 and TP103. General seepage in these layers occurred at approximately 1.4m depth, in the alluvium. The measured conductivities in these testpits were also relatively high. A maximum conductivity in the seepage of the testpits in this area was recorded in TP101, 3,585 $\mu\text{S}/\text{cm}$. This testpit was situated directly downstream of the load out silo. It also corresponds to the point in the Bossiespruit where the highest conductivity was recorded during the low stream survey. Contaminants from this side of the river are clearly the result of polluted water from the silo.

Conclusions

Seepage has been identified in this area and the seepage area has been well delineated. The mechanism of seepage has been investigated and was found to be the non containment of process water at the load out silo.

Table 9 Testpits in seepage area Twistdraai Export plant Load out Silo

Testpit [no]	Strength of seepage [no]	Conductivity [$\mu\text{S}/\text{cm}$]
TP102	1	2,395
TP101	5	3,585
TP100	1	3,014
TP103	5	2,078

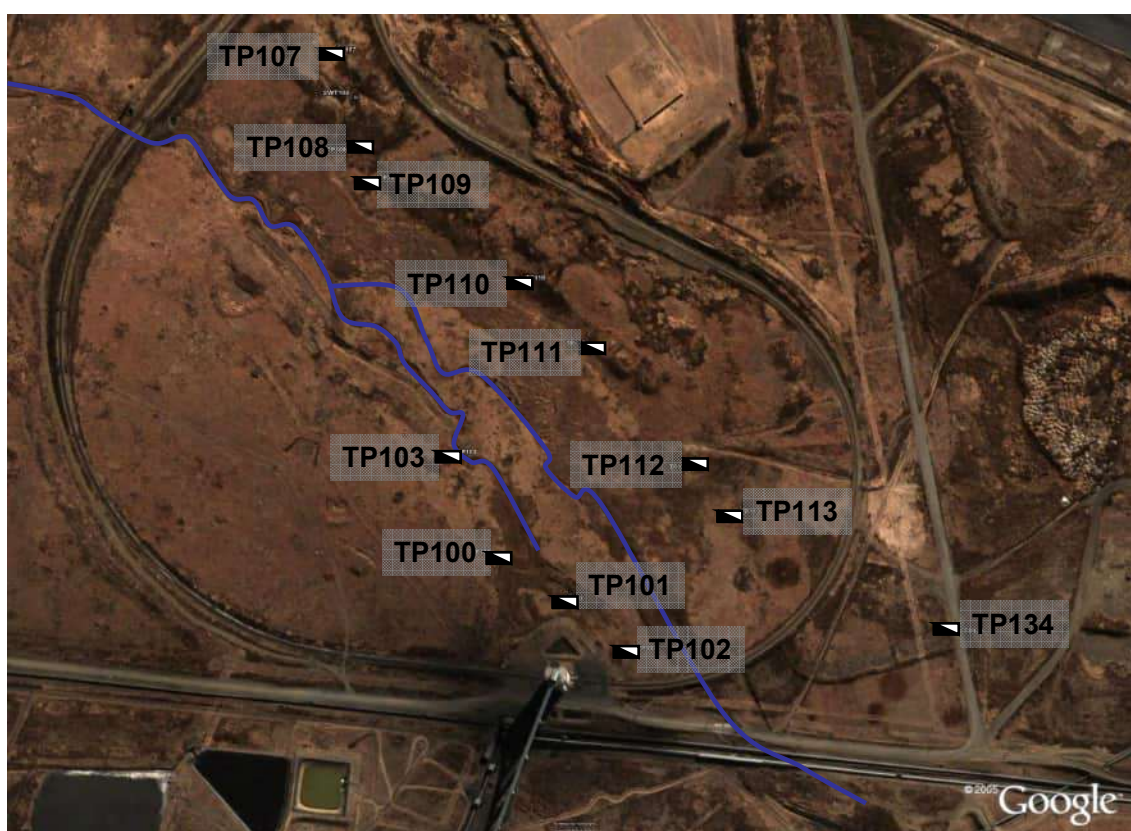


Figure 42 Testpits around Twistdraai Export plant Load out Silo and Discard dump

6.8 Twistdraai Export plant Discard Dump towards the railway loop

Walkover survey and desk study

The complex geology of this area makes it likely that seepage from the discard dump is reaching the Bossiespruit. Ponds on the northern side of the Bossiespruit have formed in a few locations. It was decided to investigate this area with both testpits and auger holes.

Testpit and auger hole investigation

The testpits north of the Bossiespruit in this area were excavated as shown on Figure 42. Residual Dolerite was encountered at the surface of TP107. An auger hole investigation was attempted to provide information on seepage in deeper horizons. The auger investigation was however unsuccessful as the auger could not penetrate the soft rock Dolerite on the site and refused at a shallow depth. Figure 43 indicates the positions where the auger holes were attempted. Table 10 summarises the seepage results of the testpits.

General seepage occurred in the residual Sandstone and residual Dolerite layers at depths varying between 1.4m to 2.2m. Point seepage however was noted in TP113 at 1.8m. The rate of seepage decreased from TP113 to TP110 and then increased again to TP108. The maximum conductivity was measured at TP112, 2,799 $\mu\text{S}/\text{cm}$. The conductivity of a pond situated between TP108 and TP109 closer to the railway line was measured as 1,983 $\mu\text{S}/\text{cm}$.

Conclusions

Due to the complex geology of this area it cannot be said that the seepage regime is sufficiently well understood in this area. The fact that contaminants are entering the stream from the opposite side of the Bossiespruit further complicates the picture.

Table 10 Testpits in seepage area Twistdraai Export plant Discard Dump towards the railway loop

Testpit [no]	Strength of seepage [no]	Conductivity [$\mu\text{S}/\text{cm}$]
TP102	1	2,395
TP101	5	3,585
TP100	1	3,014
TP103	5	2,078
TP113	4	2,474
TP112	3	2,799
TP110	1	n.a.
TP109	3	1,935
TP108	4	1,444



Figure 43 Auger holes around Twistdraai Export plant Load out Silo and Discard dump

6.9 SCS(E) conveyor and coal stockpile area

A gradual increase in conductivity was measured in the Bossiespruit along the south-eastern section of the Sasol plant. Two distinct sources were identified in this area, the conveyor transporting coal from SCS(E) to the primary plant and a coal storage area to the northwest of SCS(E).

Walkover survey and desk study

As noted in the stream survey, water was noted ponding below the conveyor belt of which the conductivity was 10,730 $\mu\text{S}/\text{cm}$. A trickle of this water was flowing from the pool to the Bossiespruit during the high stream survey.

The second source identified is runoff from a coal stockpile area to the northwest of SCS(E). This area has no water management system in place and all runoff will report to the Bossiespruit.

Testpit and investigation

The northern line of testpits indicated on Figure 40 are relevant to this area, i.e. TP123 to TP126. Of note is the moderate rate of seepage measured in TP125 at a conductivity of 2,238 $\mu\text{S}/\text{cm}$. This testpit was situated next to the conveyor belt, reasonably close to the area where water was seen ponding under the conveyor belt. The seepage was noted in the residual Siltstone layer.

Conclusions

Two sources of contaminants have been identified. Both of these will mainly impact on the Bossiespruit during runoff events. Some infiltration into the groundwater was detected which will cause a steady flow of contamination to the Bossiespruit.

In both of these areas there are little or no surface water management systems in place to manage dirty runoff. The necessity of storage of coal in the area described needs to be investigated.

6.10 SCS(W) - Primary plant coal handling area

Walkover survey and desk study

This area is associated with the gradual increase in conductivity along the Bossiespruit. As the Bossiespruit is however flowing strongly in this area the contaminant contribution of this area is believed to be high. The area below the conveyor belt next to RESM 12 was found to be very moist all year round as seen in Figure 32.

Testpit and auger hole investigation

A row of testpits and auger holes were excavated along the south western corner of the plant. Testpits were numbered F12A, E13, E8 to E1 and auger holes were numbered A12 to A19A. These are shown on Figure 44 a and b. The detailed profiles for these are given in Appendix C.

The soil profile generally consists of a layer of fill of varying thickness on top of alluvium. The alluvium in turn is underlain by residual Siltstone becoming soft rock Siltstone between 9m to 10m. Residual Dolerite was found in auger holes A19 and A19A. Brittle, red stained residual Siltstone was noted in A17. It appeared as though seepage occurred from this layer. Table 11 summarises the seepage results of the testpits and auger holes.

Note the peak in conductivity values measured in the testpits around the coal handling area, E13 and E8. The conductivity measured in these testpits was two to three times as much as other testpits in the vicinity. Also note the high rate of seepage measured in auger holes A12 and A13. There thus seem to be two areas where seepage is occurring in this area. As this corner of the plant is a topographical low point, water from the plant will naturally drain in this direction. The concentration of contaminants is however highest close to the conveyor. This area should thus be given priority for remediation.

Conclusions

The western coal handling area has been identified as a major source of contaminants to the Bossiespruit. The mechanism of contaminant transport has been investigated and found to be that of non containment of process water as well as dirty runoff water.

Table 11 Testpits and Auger holes in seepage area in the south western corner of the plant

Testpit or Auger hole [no]	Strength of seepage [no]	Conductivity [μ S/cm]
F12A	3	1008
E13	3	3129
E8	2	3130
E7	3	1648
E6	3	1469
E4	3	1405
E3	3	1782
E1	3	897
A12	4	1515
A13	5	1713
A14	3	2171
A16	1	<i>n.a.</i>
A17	0.5	<i>n.a.</i>
A18	1	<i>n.a.</i>
A19	1	<i>n.a.</i>
A19A	3	<i>n.a.</i>

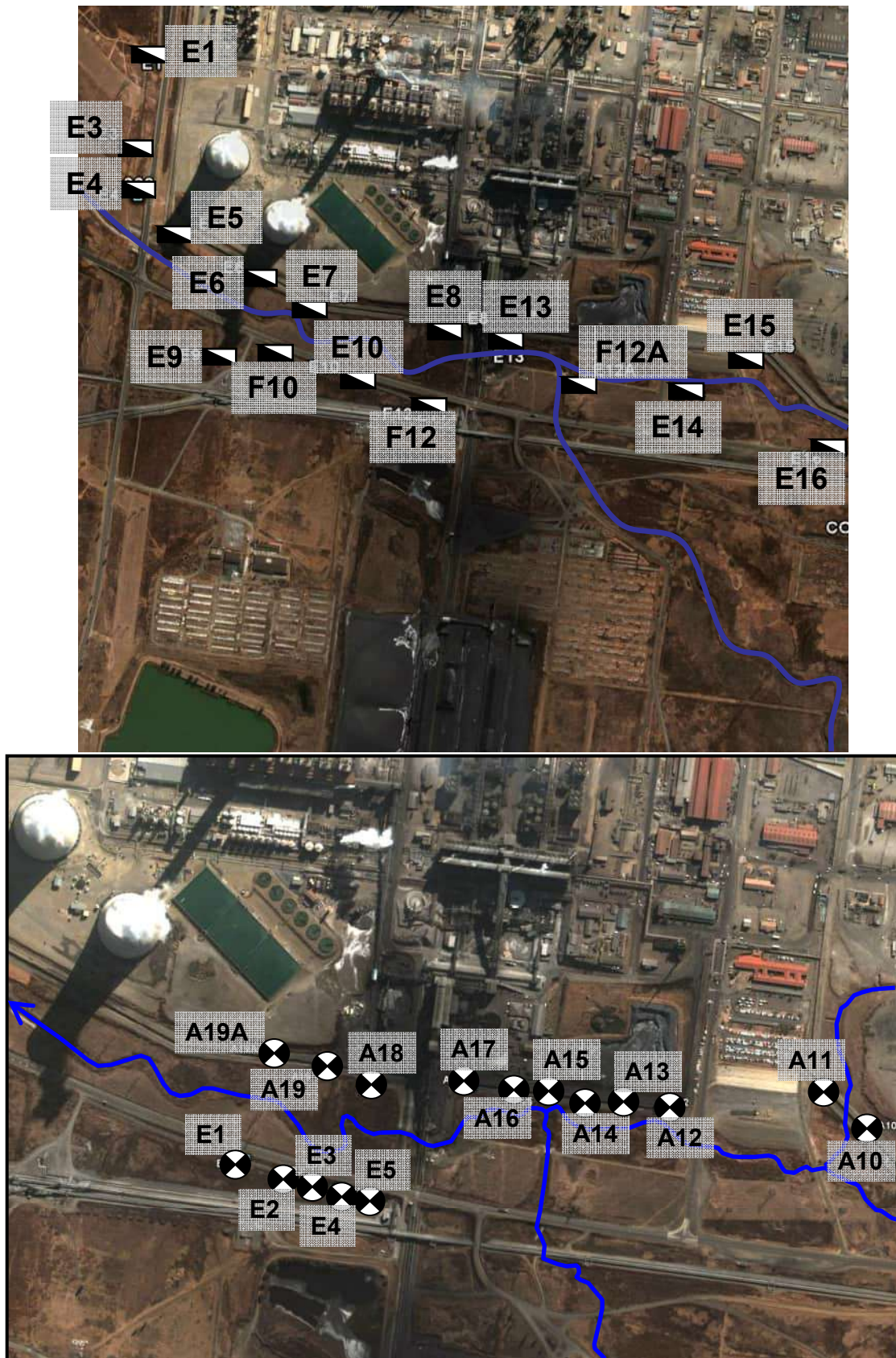


Figure 44 Testpits (a) and auger holes (b) at the south-western corner of the primary plant

6.11 SCS(W) pollution control dam

An increase in the Bossiespruit was noted in the area between the Primary area and SCS(W). This increase could be attributed to pollution sources from either or both SCS(W) and the plant. This section will consider the SCS(W) PC dam.

Walkover survey and desk study

No visible signs of seepage could be observed at the PC dam.

Testpit and auger hole investigation

A row of testpits and auger holes were constructed north of SCS(W) PC dam as shown on Figure 44a and b. These testpits were numbered F12, E10, F10 and E9, shown in Figure 44a. The detailed profiles for these are given in Appendix C.

The soil profile consists of a layer of fill on top of alluvium. The alluvium is underlain by either residual Siltstone or residual Sandstone usually at approximately 5m depth. Red staining was noted in E02 in the residual Siltstone, this layer appeared to be brittle. Table 12 summarises the seepage in the testpits and auger holes.

Seepage was noted in all of the testpits and auger holes apart from testpit E9. The seepage rates varied over this seepage area from moderately strong to very slight. Measured conductivities were the highest recorded below ground level in the entire study. The highest conductivities in this seepage area was measured close to the SCS(W) PC dam. The conductivity in this dam was measured during the low flow stream survey as 8,400 $\mu\text{S}/\text{cm}$. Conductivity peaked in E02 which was situated downstream of the middle of the dam wall at 6,460 $\mu\text{S}/\text{cm}$. Auger hole E05 and testpit E10 are only 12m apart however a significant improvement in water quality could be noted. It was found that moderate to strong general seepage at 5.5m was observed in auger hole E05. This depth is beyond the reach of the TLB. Consequently it was assumed that the extent of pollution originating from the pollution control dam probably extends to the position of testpit E10.

Conclusions

Seepage has been identified in this area and the seepage area has been delineated with reasonable certainty. Seepage occurred in the residual Sandstone, residual Siltstone and occasionally in the alluvium layer. The measured conductivity of seepage in this area peaked at 6,460 $\mu\text{S}/\text{cm}$ implying that contaminants are quite concentrated in this area.

Table 12 Testpits and Auger holes to investigate the SCS(W)

Testpit or Auger hole [no]	Strength of seepage [no]	Conductivity [$\mu\text{S}/\text{cm}$]
F12	1	5,850
E10	1	1,830
E01	3	3,250
E02	3	6,460
E03	3	2,260
E04	0.5	n.a.
E05	4	3,070

6.12 Ash conveyor canal near SCS(W)

Walkover survey and desk study

As noted during the stream survey, dirty water is collected in a canal below the ash conveyor belt. This canal was built to divert clean runoff around the ash conveyor, however the catchment of the canal has become dirty.

Testpit and auger hole investigation

Testpits F10 and E9 were constructed next to this canal as shown in Figure 44a. A reasonably high conductivity value was recorded in F10, however seepage was only slight. Conductivity in this canal at the point where it crosses the conveyor belt (in a concrete pipe) was measured during the low flow stream survey to be 6,200 $\mu\text{S}/\text{cm}$. It is clear, due to the weak seepage observed, that the majority of contaminant transport in this case takes place as surface flow.

Conclusions

The catchment of this clean water canal has become dirty. Contaminants flow overland in this canal to the Bossiespruit during runoff events. A small amount of the water in the canal has entered the groundwater; however no significant seepage rate was encountered.

Table 13 Testpits and Auger holes in seepage area in the south western corner of the plant

Testpit or Auger hole [no]	Strength of seepage [no]	Conductivity [$\mu\text{S}/\text{cm}$]
E9	0	<i>n.a.</i>
F10	1	4150

6.13 Twistdraai Export plant discard dump towards Wollie se gat

Walkover survey and desk study

Constant overflow of Wollie se gat was observed irrespective of seasonality. This implied that a constant source was supplying water to Wollie se gat. As Wollie se gat was a Dolerite quarry it is situated on a Dolerite dyke. Seepage was observed between Wollie se gat and the Discard dump. As the discard dump is topographically situated on a high point next to Wollie se gat; it is believed that the source of seepage to Wollie se gat is the discard dump.

Testpit investigation

Geology in this area is complex and cannot be investigated by the shallow methods used in this study. Testpit E24 was constructed next to Wollie se gat to ascertain what the shallow soil conditions were in the area. The detailed profile is given in Appendix C. In the testpit 1.4m of fill material was found overlying alluvium, and moderate seepage at a conductivity of 2,200 $\mu\text{S}/\text{cm}$ was observed in the alluvium. This seepage is however not believed to be the seepage feeding Wollie se gat.

Conclusions

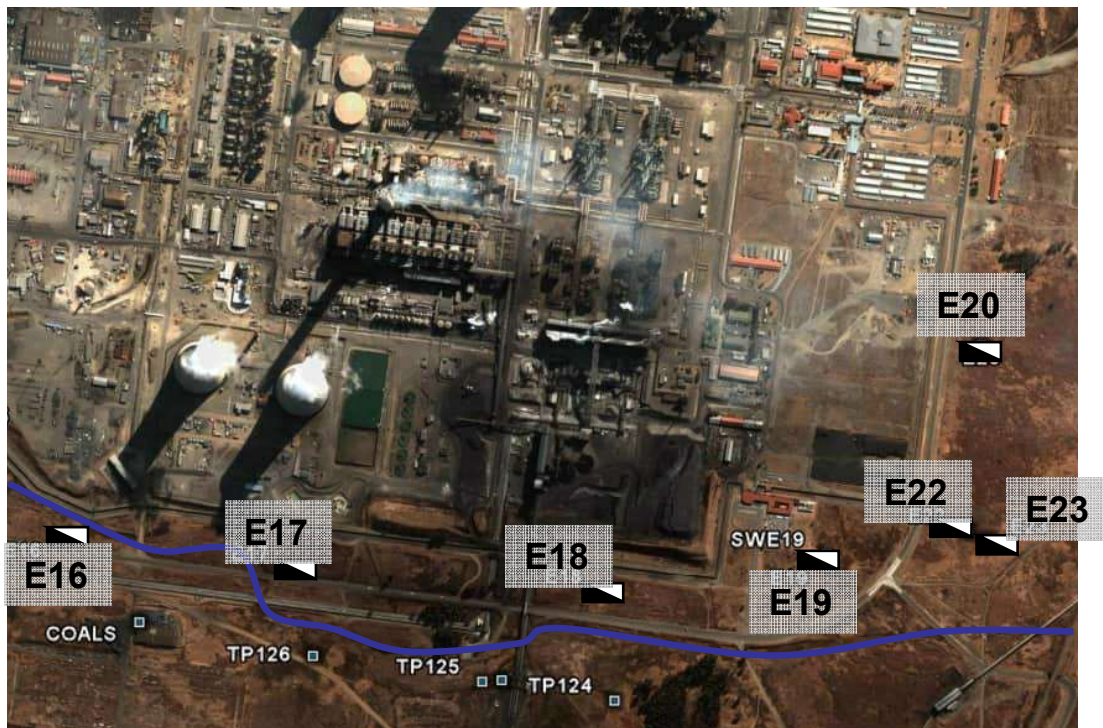
Seepage in this area is believed to be flow in a geological discontinuity. An in depth study of the area was undertaken by IGS (Rep no. 2006/19/PDV).

6.14 Other areas investigated

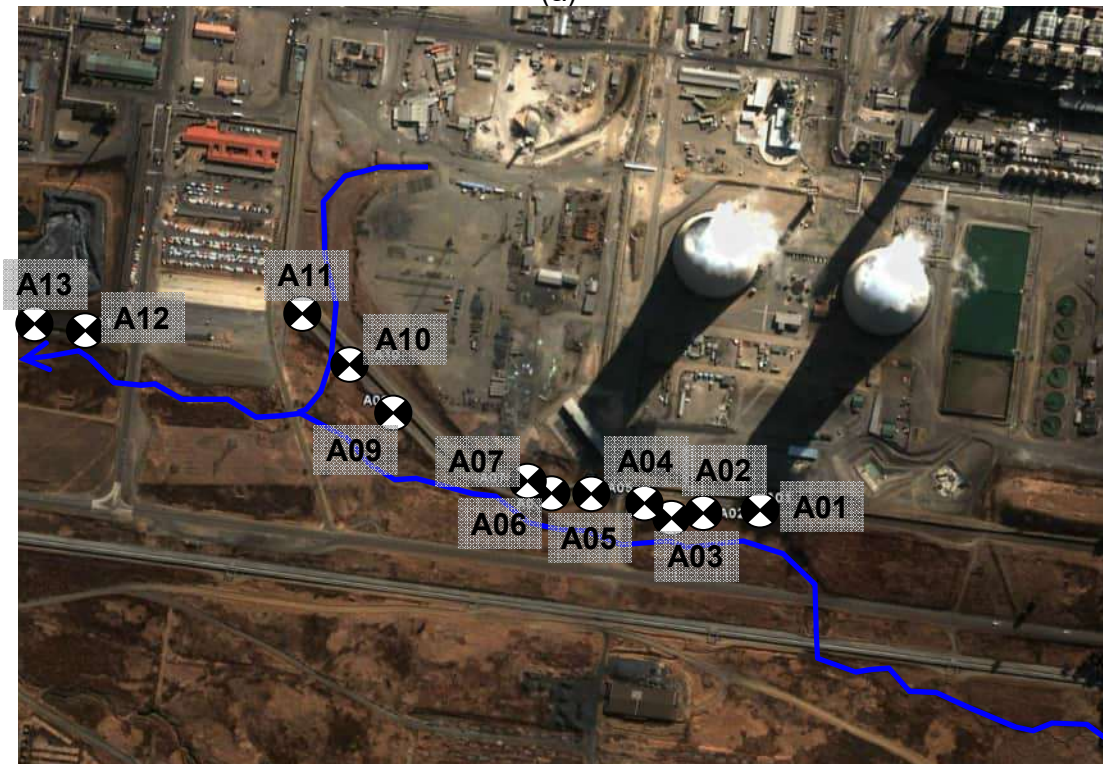
An investigation was conducted south and southwest of the Primary area. This investigation was not aimed at investigating a specific observed source of contamination, but rather to find new sources of contamination. The results of that section are included in this section. Figure 45 shows the layout of the testpits and auger holes constructed and Table 14 summarises the results. No other well definable sources of seepage were found in this area. A generally wet area was noted in the vicinity of A09. This auger hole collapsed due to the strong rate of seepage into it. It is understood that a vehicle wash down area is located in the primary area in the vicinity which may be the cause of the excess water in this area.

Table 14 Testpits and Auger holes to investigate the SCS(W)

Testpit or Auger hole [no]	Strength of seepage [no]	Conductivity [μ S/cm]
E16	5	1,180
E17	0	<i>n.a.</i>
E18	0	<i>n.a.</i>
E19	4	935
E20	0	<i>n.a.</i>
E22	1	<i>n.a.</i>
E23	0	<i>n.a.</i>
A01	3	1,562
A03	1	1,660
A06	3	1,184
A07	5	398
A09	5	Hole collapse
A10	1	1,176



(a)



(b)

Figure 45 Testpits at the south-eastern corner of the primary plant

7. BOREHOLE INSTALLATION AND NUMERICAL MODELING

Four pairs of boreholes were installed as a part of this study. Boreholes were installed in pairs so as to separate the weathered and fractured aquifers. The detailed borehole logs and chemical analyses are given in Appendix B. Surveyed co-ordinates of the boreholes are shown in Table 15 and conductivity values measured from samples taken in these boreholes in Table 16. Figure 46 indicates the positions of the boreholes.

As the section of the Bossiespruit at the south-western corner of the plant showed a marked increase of contaminant load over this section, boreholes were installed either side of the stream to investigate the groundwater aquifers in this area. Pump tests indicated that the transmissivity in the residual siltstone underlying this area is relatively low. Conductivity values were found to be in the order of 1,000 $\mu\text{S}/\text{cm}$, except for REGM 233S where a value of 3,040 $\mu\text{S}/\text{cm}$ was measured.

A detailed report on the numerical modelling is presented in Appendix C. The findings of the report indicate that seepage from the plant is not a major contaminant source. The increase in conductivity in the stream is therefore likely to be as a result of contaminated surface flow.

Table 15 Surveyed borehole locations; southern seepage study

(Projection Lo29 - Ellipsoid WGS84)

Borehole	Y	X	Z (lid)	Z(ground)
REGM 231D	-14605.68	2939122.58	1582.18	1581.41
REGM 231S	-14602.18	2939120.54	1581.91	1581.35
REGM 232D	-15153.48	2939284.49	1582.20	1581.69
REGM 232S	-15149.18	2939284.40	1582.18	1581.57
REGM 233D	-15289.29	2939326.75	1582.04	1581.46
REGM 233S	-15284.94	2939327.46	1581.96	1581.45
REGM 234D	-15023.22	2939455.10	1581.56	1581.11
REGM 234S	-15021.15	2939451.29	1581.58	1581.02

Table 16 Conductivity measurements in the new boreholes

Borehole	Conductivity [$\mu\text{S}/\text{cm}$]
REGM 231D	1,070
REGM 231S	979
REGM 232D	557
REGM 232S	1,090
REGM 233D	1,030
REGM 233S	3,040
REGM 234D	986
REGM 234S	1,370

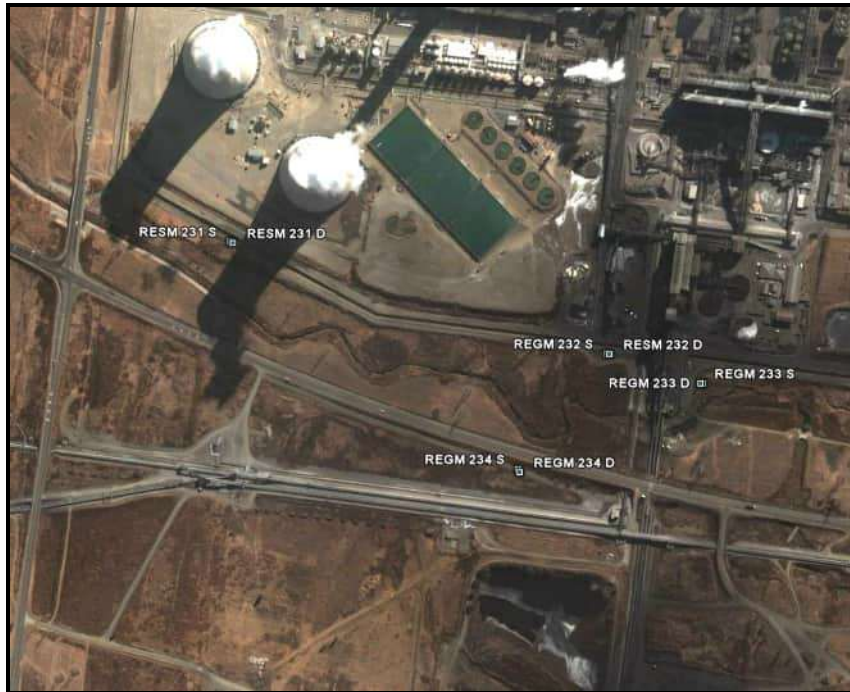


Figure 46 Boreholes installed as a part of the southern seepage study

8. **SEEPAGE VOLUME ESTIMATION, PROPOSED REMEDIAL MEASURES AND COST ESTIMATE**

The seepage areas identified and investigated in the previous chapter are again dealt with in this chapter. This chapter addresses the following points:

- estimation of contaminant contribution from the sources to RESM 1,
- a description of the proposed remedial measures and
- a cost estimate for the proposed remedial measures.

Sources are not dealt with in order of importance; instead sources along the Groot Bossiespruit are dealt with followed by sources along the Bossiespruit. Remedial measures are suggested for all the areas of concern; however a priority rating for these will only be given in the next chapter.

The data analysis in Section 3.5 clearly indicates that the conductivity at RESM 1 varies greatly with seasonality and during rainfall events. The contribution from any source must therefore be separated in terms of the mechanism of contaminant transport. The following mechanisms have been identified:

- seepage,
- contaminated runoff and
- non containment of process water.

If the mechanism of contaminant transport was found to be seepage or non containment of process water, the contribution of contaminants will not be dependant on rainfall water to transport contaminants. Contribution of contaminants to RESM 1 has therefore been calculated for three scenarios:

- low (winter) flow,
- high (summer) flow and
- flow during rainfall events.

Please note that the seepage estimation volumes are based primarily on the stream survey data. This data may be seen as a snapshot of flow in the study area. The complexity of variables involved are however immense and will change from day to day. This method is therefore by no means an exact science; we do however believe that the data provides a sound basis for prioritisation of the different seepage sources.

The runoff contribution was based on the following assumptions:

- a design rainfall event resulting in an increase in flow of $1\text{m}^3/\text{s}$ and an increase in conductivity of $500\ \mu\text{S}/\text{cm}$, Figure 14 shows that an event of this magnitude was recorded in late April 2006,
- the runoff sources identified as well as runoff from the Brandspruit being the only contributors of the increase in contaminants and
- contaminant contribution was calculated using estimated catchment area and measured conductivity values.

As before note that this data is also subject to a vast number of variables and will not yield precise answers, however the results provide a sound basis for prioritisation. The event log from which a sample is shown in Table 2 could be used to check for these results to an extent.

Also note that the cost estimates are based on J&W experience of similar projects and without carrying out any design work. The estimates are therefore indicative and can only be refined when the measures have been designed in detail. The cost estimations done for the previous

study during 2005 have to be appreciated for 2007 rates if they are to be compared to the cost estimations from this report.

The effect of blow down has been removed mathematically from the stream survey data as it dominates the stream conductivity values. The values calculated are therefore an indication of what the effect of the various areas of concern would have been on RESM 1 if blow down was not running. This was only the case during the high flow stream survey. The contribution to contamination at RESM 1 when blow down was running was also calculated for this case. These values are shown in brackets in the relevant tables.

8.1 Ostrich area

Mechanism of contamination

The mechanism of contamination in this area is unclear. It has been speculated that historical irrigation of Nitro effluent on the land below the SMX Magazines and/or irrigation on neighbouring farms using Nitro effluent may be responsible.

Contaminant contribution

Scenario description	% of salt load at RESM 1	Conductivity influence at RESM 1 [$\mu\text{S}/\text{cm}$]
Low Flow	2%	+2
High flow	3% [1%]	+6
Rainfall event	Insignificant	Insignificant

Proposed remedial measures

As this source contributes only a small amount of the salt load at RESM 1, and the source of contamination is unclear, no remedial measures are suggested for this section.

Cost estimate of the proposed remedial measures

Zero.

8.2 Fertiliser dam 8

Mechanism of contamination

The prevalent mechanism in this area is contaminated runoff.

Contaminant contribution

Scenario description	% of salt load at RESM 1	Conductivity influence at RESM 1 [$\mu\text{S}/\text{cm}$]
Low Flow	Insignificant	Insignificant
High flow	Insignificant [Insignificant]	Insignificant
Rainfall event	24%	+159

Note that the event log from which a sample is shown in Table 2 supports the finding that a very large contribution of contaminants during a rain event emanates from Fertiliser.

Proposed remedial measures

The size of Dam 8 must be increased to accommodate the design storm event (1:50yr, 24hr storm). This equates to a volume of approximately 8000 m³. Due to the high concentration of contaminants in the runoff water, this dam will have to be lined. In addition the pump system installed must be upgraded to be capable of emptying the dam in 48 hours. A pump rate of 50l/s is required.

The water balance at the Fertiliser plant will have to be able to accommodate the additional water generated. Alternatively the catchment size of Dam 8 could be reduced significantly. This will however require the emptying and rehabilitation of Fertiliser Dam 7.

Cost estimate of the proposed remedial measures

The estimated cost for the proposed measures is R3 million.

8.3 Fertiliser dam 7

Mechanism of contamination

The prevalent mechanism in this area is seepage from Dam 7 which daylight downstream of the existing seepage cut-off trench. Due to a wash down effect of collected seepage during rainfall events, this area is mainly associated with a contaminant contribution during rainfall events.

Contaminant contribution

Scenario description	% of salt load at RESM 1	Conductivity influence at RESM 1 [μS/cm]
Low Flow	2%	+6
High flow	4% [1%]	+4
Rainfall event	27%	+210

Note that the event log from which a sample is shown in Table 2 supports the finding that a very large contribution of contaminants during a rain event emanates from Fertiliser.

Proposed remedial measures

At least two seepage collection sumps equipped with a pump have been built in the area where seepage is surfacing. These however did not seem to be operational. Remedial measures suggested for this area include the refurbishment of these sumps with pumps and pipes to return seepage water to Dam 7, as well as the installation of a sub surface network of seepage collection drains to route seepage water to these sumps.

Alternatively Dam 7 could be decommissioned and rehabilitated, eliminating the seepage source. Rehabilitation of the seepage interception canal would assist with the reduction of catchment area draining to Dam 8 noted in the previous section.

Cost estimate of the proposed remedial measures

The estimated cost for the proposed measures is R0.6 million.

8.4 SCS(E) PC dam

Mechanism of contamination

The prevalent mechanism in this area is seepage. Seepage from both the seepage collection canal and the return water dam has been identified.

Contaminant contribution

Scenario description	% of salt load at RESM 1	Conductivity influence at RESM 1 [μS/cm]
Low Flow	8%	+20
High flow	2% [Insignificant]	+2
Rainfall event	Insignificant	Insignificant

Proposed remedial measures

The section of seepage canal close to the return water dam should be upgraded. Concrete lining of this section is suggested. The work will entail lining of approximately 100m of the canal. The profile of the canal lining required is assumed to be 1.5 m deep with a 1.5 m wide base and 1:1 side slopes.

A seepage cut-off trench should be constructed to intercept seepage from the return water dam. Shallow seepage was encountered at approximately 2-2.5m depth, and the underlying siltstone was found to be reasonably impermeable. A 3m deep seepage cut-off trench is therefore required over the 250m length of the dam wall. A seepage collection pipe should be installed in this trench that drains to a collection sump from where the water is pumped back to the pollution control dam.

Cost estimate of the proposed remedial measures

The estimated cost for the proposed measures is R1.1 million.

8.5 Canal near SCS(W)

Mechanism of contamination

The prevalent mechanism in this area is contaminated runoff. An associated increase during the low flow survey indicates that seepage and/or non containment of process water may also be present.

Contaminant contribution

Scenario description	% of salt load at RESM 1	Conductivity influence at RESM 1 [μS/cm]
Low Flow	5%	+14
High flow	Insignificant [Insignificant]	Insignificant
Rainfall event	2%	+9

Proposed remedial measures

The catchment of the clean water canal has become contaminated due to a new coal storage area. The two options for this area are to either clean up the catchment area or to provide water management measures to contain the contaminated runoff water.

Cost estimate of the proposed remedial measures

The estimated cost for cleanup of the catchment is R0.8 million.

8.6 Twistdraai Export plant PC dam

Mechanism of contamination

The prevalent mechanism in this area is seepage.

Contaminant contribution

Scenario description	% of salt load at RESM 1	Conductivity influence at RESM 1 [μS/cm]
Low Flow	2%	+5
High flow	0.5% [0.2%]	+0.3
Rainfall event	Insignificant	Insignificant

Proposed remedial measures

A shallow cut off trench (2m deep) along the length of the dam is required to intercept seepage in this area. A seepage collection pipe should be installed in this trench that drains to a collection sump where the water is pumped back to the pollution control dam.

Cost estimate of the proposed remedial measures

The estimated cost for the proposed measures is R0.5 million.

8.7 Load-out silo at Twistdraai Export plant

Mechanism of contamination

The prevalent mechanism in this area is the non containment of process water.

Contaminant contribution

Scenario description	% of salt load at RESM 1	Conductivity influence at RESM 1 [μS/cm]
Low Flow	19%	+55
High flow	2%* [1%*]	+2*
Rainfall event	Small contribution	Small contribution

* Note that the influence of the silo could not be separated from that of the discard dump during the high flow. The value given in the table is half of the total contribution from the two sources in this area.

Proposed remedial measures

A small return water dam has been constructed next to the silo to intercept the process water. The surface drainage does however not channel water to this dam. Remedial measures proposed for this area include:

- the lining of the return water dam,
- reshaping and concrete lining of the area directly adjacent to the silo to ensure drainage takes place to the return water dam and
- installation of a pump and return water pipeline to the Twistdraai Export plant process water dams.

Cost estimate of the proposed remedial measures

The estimated cost for the proposed measures is R4.6 million.

8.8 Twistdraai Export plant discard dump towards railway loop

Mechanism of contamination

The prevalent mechanism in this area is seepage through complex geological features.

Contaminant contribution

Scenario description	% of salt load at RESM 1	Conductivity influence at RESM 1 [μS/cm]
Low Flow	12%	+41
High flow	2%* [1%*]	+2*
Rainfall event	Small contribution	Small contribution

* Note that the influence of the silo could not be separated from that of the discard dump during the high flow. The value given in the table is half of the total contribution from the two sources in this area.

Proposed remedial measures

The complex nature of the geology and the fact that the seepage towards the Bossiespruit does not occur at shallow depth, such that it can effectively be intercepted by a seepage cut-off trench, will make it very difficult to manage contaminated seepage towards the Bossiespruit. As the seepage probably occurs along discrete geological features it will also be very difficult to contain the migration of the contamination through a series of dewatering boreholes. Experience in this area has shown that geophysics was not effective in accurately delineating geological features so that the correct placement of dewatering boreholes would be problematic.

A mitigating factor that should be considered is the extension of the discard and fine coal slurry disposal area, which is currently under construction, which is located to the north-east of the watershed and further away from the Bossiespruit.

Continued monitoring should be carried out when deposition on the discard dump moves eastwards to assess the impact of the change in deposition area on the seepage towards the south-western boundary of this facility

For the reasons stated above, no immediate remedial measures are proposed for this area.

Cost estimate of the proposed remedial measures

Zero.

8.9 SCS(E) conveyor and coal stockpile area

Mechanism of contamination

The prevalent mechanism in this area is the non containment of process water.

Contaminant contribution

Scenario description	% of salt load at RESM 1	Conductivity influence at RESM 1 [μS/cm]
Low Flow	8%	+20
High flow	2% [1%]	+2
Rainfall event	0.3%	+2

Proposed remedial measures

Water was seen ponding under the conveyor belt during the low and high flow surveys. The source of this water seemed to be related to the coal handling process. A small concrete lined return water dam has been built next to the conveyor. Drainage of water from the dirty areas below and directly surrounding the conveyor needs to be channelled towards this return water dam. The proposed remedial measures in this section thus include:

- shaping of the ground below the conveyor to ensure drainage,
- construction of a 100m long concrete lined canal (0.6m base, 0.5m height, 1:1 side slopes) to channel water to the return water dam and
- upgrading of the pipe and pump system in the return water dam to accommodate the extra water make if necessary.

Cost estimate of the proposed remedial measures

The estimated cost for the proposed drainage measures is R0.7 million.

The estimated cost for cleanup of the catchment is R0.5 million.

8.10 SCS(W) to Synfuels coal handling

Mechanism of contamination

The prevalent mechanism in this area is the non containment of process water.

Contaminant contribution

Scenario description	% of salt load at RESM 1	Conductivity influence at RESM 1 [μS/cm]
Low Flow	10%*	+32*
High flow	59%*	+47*
Rainfall event	8%	+32

- Note that three sources contribute in this area and their relative contributions could not be determined mathematically. These are the Ash conveyor canal near SCS(W), SCS(W) return water dam and the SCS(W) to Synfuels coal handling area. The total contribution from these areas was calculated and separated into the three sources based on the site walkover assessment.

Proposed remedial measures

A project is under way to remediate runoff in the coal handling area. The design of the remedial measures have been conducted by Jones & Wagener, project no A730. Refer to drawing A730-00-019 for details of the remedial measures. These remedial measures should resolve the majority of contaminant contribution from this area. Continued monitoring of this area is required as there is a concern that the areas directly east and west of the intended remedial work may also generate contaminated runoff.

Cost estimate of the proposed remedial measures

The cost of the current project is R1.2 million.

The estimated cost for future extension of this project is R0.5 million.

8.11 SCS(W) PC dam

Mechanism of contamination

The prevalent mechanism in this area is seepage.

Contaminant contribution

Scenario description	% of salt load at RESM 1	Conductivity influence at RESM 1 [µS/cm]
Low Flow	7%*	+22*
High flow	1%*	+1*
Rainfall event	Insignificant	Insignificant

- Note that three sources contribute in this area and their relative contributions could not be determined mathematically. These are the Ash conveyor canal near SCS(W), SCS(W) return water dam and the SCS(W) to Synfuels coal handling area. The total contribution from these areas was calculated and separated into the three sources based on the site walkover assessment.

Proposed remedial measures

Seepage has been detected from this pollution control dam. Either a seepage cut-off trench or lining of the dam is suggested as the conductivity in this dam and the seepage detected is reasonably high. This will also assist with the rehabilitation of the Ash conveyor canal near SCS(W) (see next section).

A seepage cut-off trench will have to be installed 4m deep along the 200 m length of the dam wall. The dam basin size is approximately 22,800 m².

Cost estimate of the proposed remedial measures

The estimated cost for the seepage cut-off trench is R1.0 million.

The estimated cost for the lining of this dam is R4.4 million.

8.12 Ash conveyor canal near SCS(W)

Mechanism of contamination

The prevalent mechanism in this area is contaminated runoff.

Contaminant contribution

Scenario description	% of salt load at RESM 1	Conductivity influence at RESM 1 [µS/cm]
Low Flow	2%*	+6*
High flow	15%*	+14*
Rainfall event	4%	+24

- Note that three sources contribute in this area and their relative contributions could not be determined mathematically. These are the Ash conveyor canal near SCS(W), SCS(W) return water dam and the SCS(W) to Synfuels coal handling area. The total contribution from these areas was calculated and separated into the three sources based on the site walkover assessment.

Proposed remedial measures

This canal was originally built as a clean water diversion canal. Water in this canal has however been contaminated by, it is believed, seepage from the return water dam and some of the catchment becoming dirty.

If the seepage cut-off for the return water dam is built as discussed in the previous section, the amount of contaminants in this canal should reduce significantly. In addition to this it should be ensured that the catchment area of this canal remains clean. Continued monitoring of the canal is suggested after the return water dam has been remediated and the catchment has been cleaned up.

Cost estimate of the proposed remedial measures

The estimated cost for cleanup of the catchment is R0.6 million.

8.13 Twistdraai Export plant discard dump towards Wollie se gat

Mechanism of contamination

The prevalent mechanism in this area is seepage through complex geological features. The majority of the seepage reports in an old quarry named Wollie se gat.

Contaminant contribution

Seepage from this area reports to the Klipspruit and did therefore not form part of the stream survey. A rudimentary method was used to measure the flow from Wollie se gat, giving a measurement of 2 l/s at a conductivity of 2,900 $\mu\text{S/cm}$. Using this single measurement an estimate has been made of the contribution of the flow from Wollie se gat on RESM 1.

Scenario description	% of salt load at RESM 1	Conductivity influence at RESM 1 [$\mu\text{S/cm}$]
Low Flow	5%	+23
High flow	2%	+9
Rainfall event	Insignificant	Insignificant

Proposed remedial measures

The majority of seepage from this area is reporting to Wollie se gat. A small tributary stream joins the overflow from Wollie se gat along the way to the Klipspruit as shown in Figure 34. A seepage collection pond should be constructed in this stream. This pond should be lined to avoid further seepage into the graben and dolerite dykes in the vicinity. Water from this pond should then be returned to the Twistdraai Export plant or mine water system as process water. An initial assessment is that about 150m³ to 200m³ per day of water will be returned to the mine water system. This estimate will however have to be confirmed by flow measurement over a longer period. An assessment of whether this process water can be accommodated needs to be compiled. A pipeline to either the Twistdraai Export plant or some other destination will have to be constructed depending on where this water can be accommodated.

Cost estimate of the proposed remedial measures

8.14 Runoff passing RESM 9 in the Brandspruit

Although this stream does not fall within the study area the relative contribution to the design rainfall event also had to be calculated and is included in this report.

Mechanism of contamination

The prevalent mechanism in this area is contaminated runoff due to concentration of contaminants in the Brandspruit.

Contaminant contribution

As a rule water in the Brandspruit is pumped from RESM 9 into the Clear Ash Effluent dams. During rainfall events the flow in the Brandspruit far exceeds the capacity of the pumps, resulting in an overflow at this RESM station.

Scenario description	% of salt load at RESM 1	Conductivity influence at RESM 1 [$\mu\text{S}/\text{cm}$]
Low Flow	Insignificant	Insignificant
High flow	Insignificant [Insignificant]	Insignificant
Rainfall event	36%	+64

Proposed remedial measures

Remedial measures for this area include the cleaning of a seepage collection trench at the toe of the discard dump, lining of the Brandspruit where it runs close to the toe of the discard dump and a seepage cut-off trench at the south eastern corner of the discard dump as discussed in the previous seepage study.

Cost estimate of the proposed remedial measures

The estimated cost for the proposed measures is R3.8 million.

9. CONCLUSIONS AND RECOMMENDATIONS

A seepage study of the area to the south of the Sasol plat has been completed. A number of areas of concern were investigated, and using the data gained an estimate of their contributions to the conductivity at RESM 1 has been made. The mechanism of contaminant transport influenced the level of impact of the sources during different times of the year (for instance winter or summer rainfall patterns).

Table 17 gives a summary of the results of the assessment. The values given in this table are not precise; however they provide a sound basis for prioritisation of the remedial measures. Remedial measures have been proposed for the areas investigated, and the cost of these measures has been estimated as shown in Table 17.

Based on these results a plan of action could be devised as discussed in the rest of this chapter.

Table 17 Areas of concern noted in the Southern seepage study as well as estimates of their contribution to conductivity at RESM 1

Area of concern	Contaminant contribution [$\mu\text{S}/\text{cm}$]			Cost of remedial measures
	Low flow	High flow	Rainfall event	R (million)
Ostrich area	2	6		n.a.
Fertiliser dam 8			159	3.0
Fertiliser dam 7	6	4	210	0.6
SCS(E) PC dam	20	2		1.1
Canal near SCS(W)	14		9	0.8 (clean coal area)
Twistdraai Export plant PC dam	5	0.3		0.5
Load-out silo at Twistdraai Export plant	55	2		4.6
Twistdraai Export plant discard dump towards railway loop	41	2		-
SCS(E) conveyor and coal stockpile area	20	2	2	0.7 (drainage measures) 0.5 (clean coal area)
SCS(W) to Synfuels coal handling	32	47	32	1.2 (current project) 0.5 (future extension)
SCS(W) PC dam	22	1		1.0 (cut off) 4.4 (lining)
Ash conveyor canal near SCS(W)	6	14	24	0.6 (clean coal area)
Twistdraai Export plant discard dump towards Wollie se gat	23	9		3.8

9.1 Stream monitoring

Stream flow monitoring at some of the RESM stations has been corrected. This correction should be implemented at all the RESM stations before remedial measures are implemented. This will enable accurate monitoring of stream flow so as to assess the impact of remedial measures implemented.

RESM 12 has not been built as a properly engineered flow gauging structure. An accurate flow measurement at this position would be beneficial as it appears that a large proportion of the contamination due to runoff flows past this RESM station.

Measurement of the overflow from 'Wollie se gat' is advised so as to gauge accurately the volume and concentration of contaminants flowing towards the Klipspruit in this area. Note that the flow measurement should be done some distance downstream of the overflow from 'Wollie se gat' as described in this report. The gauging structure should be built as a lined structure that can accommodate a pump system to facilitate possible water recycling in future.

Water flowing past RESM 9 has been shown to contribute significantly during rainfall events to the peaks observed at RESM 1. An existing RESM flow monitoring station was modified such that water could be pumped from this station to the Ash system. During rainfall events this system overtops. It is recommended that a measuring weir be reinstated in the stream to measure any overflow at this RESM station both in terms of volume and conductivity.

9.2 Process decisions

A number of process decisions need to be taken to ensure that the correct remedial measures are implemented. The following issues need to be addressed:

- Will Fertiliser Dam 7 be decommissioned in the near future especially taking into account the additional water that will be generated by the increase of the size of Fertiliser dam 8?
- Are the coal (or other contaminated products) stockpile areas identified that are not within water management areas necessary for operational purposes? If so, water management measures for these should be designed.
- Can the water overflowing from 'Wollie se gat' be accommodated as process water?

9.3 Remedial measures

Based on the information gained during the study, remedial options were recommended. Remedial options are separated into four groups depending on whether the measure:

- is a legal requirement,
- is a significant contributor of contaminants,
- needs further monitoring or
- is an insignificant contributor of contaminants.