INTEGRATED WATER AND WASTE MANAGEMENT PLAN (IWWMP) 2023: TSF PHASE 2 PROJECT AND ANNUAL UPDATE	GAMSBERG ZINC MINE

PROJECT NAME	GAMSBERG ZINC MINE
APPLICANT	1 PENGE ROAD AGGENEYS, NORTHERN CAPE
PROPERTIES	BLOEMHOEK 61 PORTION 1, GAMS 60 PORTION 1, AROAMS 57 RE, NORTHERN CAPE PROVINCE
CONSULTANT	AQUASTRAT SOLUTIONS Marli Burger (EAP No. 220/2019; Pr. Sci. Nat 115534; MSc Aquatic Health) P O Box 72194, Lynnwood Ridge, 0040 Cell: +27 72 284 9332 Email: oryxsolutionsafrica@gmail.com Website: www.aquastratsolutions.co.za

Rev	Description	Date
V.1.0	Draft IWWMP for comment	30 April 2024

Executive Summary

The Gamsberg Zinc Mine is located in the Northern Cape Province of South Africa, approximately 14 km east of the town of Aggeneys and 120 km east of Springbok along the N14. Black Mountain Mining (Pty) Ltd, a subsidiary of Vedanta Zinc International (VZI), owns and operates the Gamsberg Zinc Mine (hereafter referred to as "the mine"). The mine has been in operation since June 2016 and is currently mining up to 4 million tonnes per annum (mtpa) and producing up to 250 000 tonnes per annum (tpa) of zinc concentrate for export. The approved Phase 2 will expand the mining capacity to 10 mtpa (SLR, 2021). BMM plans to mine a total of 150 000 000 tons of ore from the Gamsberg Zinc Mine over a 19-year Life of Mine (LoM). Of this expected LoM tonnage, approximately 18 000 000 tons of zinc concentrate will be extracted. Based on the relatively low grade of the zinc deposit, the treatment process will generate approximately 132 000 000 tons of tailings and approximately 1.5 billion tons of waste rock over the LoM (Golder, 2022b).

Black Mountain Mining (Pty) Ltd (BMM) received an Environmental Authorisation (EA) from the Regional Department of Mineral Resources and Energy (DMRE) in 2022 to construct a new zinc smelter and associated infrastructure to produce 300 000 tpa special high grade zinc metal by processing 680 000 tpa of zinc concentrate (Gamsberg Smelter Project). As a by-product 450 000 tpa of pure sulphuric acid is produced for both export and consumption within South Africa (adapted from SLR, 2021).

BMM received a Waste License, No 12/9/11/L955/8, for a class H:H (Storage of hazardous waste in lagoons, Reuse of general and hazardous waste and wastewater treatment works), on 17 December 2013.

Black Mountain Mining (Pty) Ltd was issued with a Water Use License, WUL No 14/D82C/ABCGIJ/2654, in 2014, and an amendment was issued in April 2016.

The previous IWWMP was compiled in 2019 by SRK Consulting (Reference number:525272/4) and updated by Golder Associates Africa (Pty) Ltd in December 2019 as part of the annual update, followed by an IWWMP for the Smelter Complex by SLR (2021).

AquaStrat Solutions (Pty) Ltd via Knight Piésold (Pty) Ltd was appointed in 2023 by Black Mountain Mining (Pty) Ltd to undertake the water use authorisation process as well as the compilation of the IWWMP for the proposed construction and operation of the Gamsberg Zinc Phase 2 TSF in accordance with Section 21 of the National Water Act (NWA, Act 36 of 1998).

The following is a summary of the Water uses authorized by the **2014 WUL** (refer to Table 13 for details):

- S.21(b): Storage of water from Pella Drift Water Board in Raw Water Storage Dam and Process Water Dam.
- S.21(c) & (i): Pipeline, open cast pit, tailings facility and demarcation fence in the regulated area of drainage lines.
- S.21(g): Disposal of waste and/or wastewater into TSF 1, PCDs, Wast Rock Dump Facility, Sewage Sludge Collection Sump, Treated Sewage Effluent Dam, Salvage Yard Stormwater Dam, Wash Bay Collection Sump; and dust suppression around plant area and on haul road
- 21.(j): Pit dewatering

Water uses authorized by the **2016 WUL** (amended; refer to Table 13 for details):

- S.21(c) & (i): Pipeline, Magazine Area, Plant Area.
- S.21(g): Disposal of waste and/or wastewater into Plant Storm Water Dam and into Process Water Dam.

Water uses (IWULA/WUL Amendment) **submitted in 2020**, not included in WUL (refer to Table 14 for details):

- S.21(b): Storage of water from Pella Drift Water Board in 10ML reservoir for Smelter
- S.21(b): Storage of water in Firewater Tank for Smelter

- S.21(c) & (i): Pipelines for Smelter; TSF and Seepage Collection Pond; Magazine Area, Plant Area, demarcation fence; Secured Landfill Facility and protection berm, Business Partner Camp and Laydown area, and Smelter Complex (SLR, 2021) in 1:100 year flood line of a drainage line.
- S.21(g): Secured Landfill Facility for Jarofix and ETP cake disposal; Jarosite Storm Water Dam; Refinery Storm Water Dam; Sewage Treatment Plant capacity increase (SLR, 2021). Disposal of dirty stormwater into PCD 2; disposal of waste water into Plant Storm Water Dam, Process Water Dam and Pit Area.

Proposed Water Uses (2023)

The proposed water uses are summarized in the table below.

Water use	Facility/Activity	Capacity, Dimensions, Volume, Area/length	Property
21 (c) & (i)	Removal of diversion channel north of TSF 1	2 022m	RE of Aroams 57
21 (g)	TSF 2*	6 183 412 m^3/a slurry (333 333t/month at 1.61t/ m^3) 116 ha 32 000 000 m^3	
	RWD with silt trap for TSF 2	Capacity below spillway invert 96 706 m3 RWD: 120 000 m^3 Spillway: 10 x 2 x 0.8m depth Double silt trap measuring 25 m x 15 m x 1.5 m deep with a drying bed measuring 25 m x 4.7 m wide	
	Disposal of tailings slurry into TSF 2	770m^3/hr or 548 tph	
	Disposal of wastewater into RWD	800 m^3/hr	
	Pipelines for disposal into TSF 2 and RWD	7 500m 3 155m	

*Four coordinates authorized in 2016 Amendment covers 95% of existing TSF and proposed TSF 2 footprint.

Physical Environment

The part of the Northern Cape Province where the Gamsberg Smelter Project is located, is classified as a hot desert region, and has an arid climate where rainfall can occur in summer and winter (average of 98 mm/year) as the area lies in a transition zone between winter and summer rainfall areas. Summers are hot with cooler winters.

In terms of groundwater, no regional aquifers are developed in the area and groundwater occurs mainly in secondary fractured-rock aquifers. Groundwater levels as measured from regional monitoring boreholes have an average groundwater level of 30.8 meters below ground level (mbgl) and mine monitoring boreholes an average of 30.6 mbgl. Groundwater monitoring results for boreholes within the Gamsberg Zinc Mine Mining Right Area (MRA) and on neighbouring farms indicate that the present groundwater conditions do not indicate negative impacts on the groundwater environment because of current mining and processing operations.

In terms of surface water, the Gamsberg Zinc Mine MRA is influenced by four quaternary catchments D81G, D82A, D82B and D82C with the Gamsberg inselberg situated within quaternary catchment D81G, which drains in a northerly direction towards the Orange River (SLR, 2021). The D82C catchment is an interior drainage basin that does not drain into another catchment (Golder, 2022a). Most of the water courses in the area are ephemeral with the most significant watercourse for the Gamsberg Smelter Project being a drainage line running parallel to the N14 at the base of the northern side of the Gamsberg inselberg, and its tributaries from the north (SLR, 2021). Natural drainage patterns are poorly defined in the area and watercourses are ephemeral (water only flows after heavy rainfall events). The drainage features of the area are characteristic of very dry areas where soil structures are relict and not favourable to the formation of riparian soils. However, during extreme rainfall events, these features become significant rivers and wetlands during a short period of time (Golder, 2022a).

Socio-economic Environment

The Gamsberg Zinc Mine is situated in the Khâi-Ma Local Municipality, which is one of six local municipalities within the Namakwa District Municipality in the Northern Cape Province.

The Khâi-Ma Municipality had a population of ~12 000 people in 2016.Population density is around one person per square kilometer, with the majority of the population living in the rural areas.

More than 92% of households live in formal dwellings, while 6.4% live in informal dwellings. The language most spoken at home is Afrikaans (95%).

Close to 45% of the working age population are unemployed. Around 80% of Black Mountain Mining (Pty) Ltd employees are from the Northern Cape, including 60% from the Namakwa district (mainly Khâi-Ma and Nama Khoi municipal areas).

The main economic sectors in the Municipality are agriculture, mining, tourism and community services, with renewable energy projects now also coming online (SLR, 2021).

Gamsberg Zinc Mine employs in excess of 1479 persons, operating as the largest private employer in the Namakwa region, and Black Mountain Mining (Pty) Ltd has been stable employer for the last 30 years. Approximately 80% of the employees are from the local area, with 62% from the Namakwa, Khai-Ma and Nama Khoi municipal areas (Golder, 2022b).

This document serves as the updated Integrated Water and Waste Management Plan (IWWMP), as prescribed by GN 267 of 2017, for the Water Use License Application for the **Gamsberg Zinc Mine** on behalf of **Black Mountain Mining (Pty) Ltd**, the licensee for the activities on **Portion 1 of Bloemhoek 61, Portion 1 of Gams 60 and Remaining Extent of Aroams 57**.

This IWWMP includes the water use activities, basic design description, summary of waste classification, risk consideration, and Water and Waste Management Strategies for the expansion of the Tailings Storage Facility project, referred to as TSF Phase 2.

This IWWMP also aims to consolidate information from previous IWWMPs and specialist reports to provide a coherent and updated report of the authorized water uses (2014 WUL and 2016 WUL amendment), as well as the pending (2020 amendment application) and new application (TSF Phase 2). **Please note: The consolidation of previous IWWMP's in this manner is not for the purposes of license consolidation but solely for the purpose of improving management effectiveness on site.**

The existing WUL includes GPS coordinates that overlap approximately 95% with the current TSF and proposed expansion. Therefore, the new application includes amending the coordinates of the TSF footprint, and applying additionally for the associated pipelines, security fence, Return Water Dam and silt trap, and disposal of waste into the TSF 2 and RWD.

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ABBREVIATIONS

ARD	Acid Rock Drainage
BEE	Black Economic Empowerment
BMC	Black Mountain Mining Complex
BMM	Black Mountain Mining (Pty) Ltd
CCD	Counter Current Decantation
CGG	Continuous Galvanizing Grade
DENC	Department of Environment and Nature Conservation
DFFE	Department of Forestry, Fisheries and Environment
DMRE	Department of Mineral Resources and Energy
DWAF	Department of Water Affairs and Forestry (now known as DWS)
DWS	Department of Water and Sanitation
EA	Environmental Authorisations
EE	Employment Equity
EIS	Ecological Importance and Sensitivity
ELU	Existing Lawful Use
EMPr	Environmental Management Programme report
EMS	Environmental Management System
ETP	Effluent Treatment Plant
GA	General Authorisation
GCL	Geosynthetic Clay Liner
GNR	Government Notice Regulation
GOP	Gross Domestic Product
HDSA	Historically Disadvantaged South Africans
HOPE	High Density Polyethylene
HRD	Human Resources Development
HSEC	Health, Safety, Environment and Community
I&AP	Interested and Affected Parties
IWWMP	Integrated Water and Waste Management Plan
LED	Local Economic Development
LOM	Life of Mine
MAE	Mean Annual Evaporation
mamsl	meters above mean sea level
MAP	Mean Annual Precipitation
MAR	Mean Annual Run-off
mbgl	meters below ground level
ML	Megalitre
MPRDA	Mining and Petroleum Resources Development Act (Act No. 28 of 2002)
MQA	Mining Qualifications Authority
MSDS	Material Safety Data Sheet
mtpa	Megatonnes per annum
NEM;WA	National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008)
NEMA	National Environmental Management Act, 1998 (Act No. 107 of 1998)
NGO	Non-Governmental Organisation
NL	Neutral Leaching
NQF	National Qualifications Framework
NWA	National Water Act, 1998 (Act No. 36 of 1998)
NWRS	National Water Resource Strategy
PCD	Pollution Control Dam
PES	Present Ecological State
PPE	Personal Protective Equipment
RLE	Roast-Leach-Electrowinning

ROD	Record of Decision
ROM	Run of Mine
RQO	Resource Quality Objectives
RSIP	Rehabilitation Strategy and Implementation Programme
RWD	Return Water Dam
RWQOs	Receiving Water Quality Objectives
SACNASP	South African Council of Natural Scientific Professionals
SAHRA	South African Heritage Resources Agency
SAWIC	South African Waste Information Centre
SHE	Safety, Health and Environment
SLF	Secured Landfill Facility
SLP	Social and Labour Plan
SLP	Social Labour Plan
SMME	Small, Micro and Medium Enterprises
SSC	Shared Service Canter
STP	Sewage Treatment Plant
SWD	Storm Water Dam
SWM	Storm Water Management
SWMP	Storm Water Management Plan
tpa	Tonnes per annum
TSF	Tailings Storage Facility
TSF	Tailings Storage Facility
TWQR	Target Water Quality Range
VZI	Vedanta Zinc International
WAL	Weak Acid Leach
WBD	Water Balance Diagram
WC/WDM	Water Conservation and Water Demand Management
WMA	Water Management Area
WML	Waste Management Licence
WUA	Water Use Authorisation
WUE	Water Use Efficiency
WUL	Water Use License
WUL	Water Use License
WULA	Water Use License Application
WWTWs	Wastewater Treatment Works

1 Chapter 1: Introduction

1.1 Activity Background

Black Mountain Mining (Pty) Ltd, a subsidiary of Vedanta Zinc International (VZI), owns and operates the Gamsberg Zinc Mine. In 2010 Vedanta Resources Limited acquired Black Mountain Mining (Pty) Ltd from Anglo American as part of the acquisition of the zinc base metal mine take over. Following the acquisition of the Black Mountain Mining (Pty) Ltd properties and rights a feasibility and optimisation of technology for the Gamsberg Zinc Mine was done. BMM plans to mine a total of 150 000 000 tons of ore from the Gamsberg Zinc Mine over a 19-year Life of Mine (LoM). Of this expected LoM tonnage, approximately 18 000 000 tons of zinc concentrate will be extracted (Golder, 2022b).

Vedanta Resources Plc is a globally diversified natural resources group with wide ranging interests in aluminum, copper, zinc, lead, silver, iron ore, oil and gas and power. Its operations in Southern Africa, Vedanta Zinc International (VZI), include Black Mountain Mining (SA) and Skorpion Zinc (Namibia). Black Mountain Mining (Pty.) Ltd. (BMM) comprises of The Black Mountain Mine (Deeps and Swartberg Operations) and the Gamsberg Project. Both zinc-lead mines are located near Pofadder in the Northern Cape Province, along the N14 National highway linking Upington to Springbok.

The Gamsberg Project is one of VZI's flagship projects in the journey of realizing their vision to produce 500 Ktpa of finished zinc metal from Gamsberg. It will exploit one of the largest, known, undeveloped zinc ore bodies in the world. The first step was Phase 1 (4 Mtpa Mines & Concentrator) which has been commissioned in September 2018 and is currently in Operation. Phase 1 is currently producing ~ 250 ktpa Zn Metal in Concentrate (MIC) (Knight Piésold, 2023a).

An Environmental Impact Assessment (EIA) process was completed in 2013 (and approved on 12 August 2013- Permit 43/2013) and amended on 2 December 2014 (Permit 43/2013 Amendment 2) (Ref: NC/EINNAM/KHNAGG/2012). The Smelter Complex EIA process was completed in 2021 and the latest EMPr amendment was approved in 2017. In addition, a Waste Management Licence (WML) (Ref: 12/9/11/L.955/8) and Water Use Licence (WUL) (Ref:14/D82C/ABCGI/2654) for their open pit mining activities and concentrator plant were approved and an amendment was issued in April 2016. No updating of the Waste Management Licence or EMPr is required for the proposed addition of the TSF Phase 2, as these activities were included in the latest authorizations.

The mining activities commenced in June 2016 when overburden stripping for the open pit commenced. The mining plan for Phase 1 consisted of three smaller open pits in the footprint of the 10 million tonne per annum (mtpa) footprint. Development of the opencast mine and concentrator plant has been done in phases. The construction of the concentrator plant commenced in 2017 with the official opening in February 2019. Phase 2 will expand the mining capacity to the approved 10 mtpa. The Gamsberg Zinc Mine is currently mining up to 4 mtpa and producing up to 250 000 tonnes per annum (tpa) of zinc concentrate for export (SLR, 2021).

The previous IWWMP was compiled in 2019 by SRK Consulting (Reference number:525272/4) and updated by Golder Associates Africa (Pty) Ltd in December 2019 as part of the annual update (SRL, 2021).

AquaStrat Solutions (Pty) Ltd via Knight Piésold (Pty) Ltd was appointed in 2023 by Black Mountain Mining (Pty) Ltd to undertake the water use authorisation process as well as the compilation of the IWWMP for the proposed construction and operation of the Gamsberg Zinc Phase 2 TSF in accordance with Section 21 of the National Water Act (NWA, Act 36 of 1998).

The summary of Water uses authorized by the 2014 WUL and 2016 amendment, as well as the water uses submitted in the amendment application of 2020, are represented in Table 13 and Table 14 in the next section of this report.

Proposed Water Uses

The existing WUL includes GPS coordinates that overlap approximately 95% with the current TSF and proposed expansion. Therefore, the new application includes amending the coordinates of the TSF footprint, and applying additionally for the associated pipelines, security fence, Return Water Dam and silt trap, and disposal of waste into the TSF 2 and RWD.

The current Phase 1 TSF will reach its end of life in (2030) and requires a new TSF to be constructed for Phase 2 (Knight Piésold, 2023a).

The proposed water uses included in the 2023 amendment application are summarised in the table below.

Table 1. Water uses applied for in September 2023

Water use	Facility/Activity	Capacity, Dimensions, Volume, Area/length	Property
21 (c) & (i)	Removal of diversion channel north of TSF 1	2 022m	RE of Aroams 57
21 (g)	TSF 2*	6 183 412 m^3/a slurry (333 333t/month at 1.61t/ m^3) 116 ha 32 000 000 m^3	
	RWD with silt trap for TSF 2	Capacity below spillway invert 96 706 m^3 RWD: 120 000 m^3 Spillway: 10 x 2 x 0.8m depth Double silt trap measuring 25 m x 15 m x 1.5 m deep with a drying bed measuring 25 m x 4.7 m wide	
	Disposal of tailings slurry into TSF 2	770m^3/hr or 548 tph	
	Disposal of wastewater into RWD	800 m^3/hr	
	Pipelines for disposal into TSF 2 and RWD	7 500m 3 155m	

*Four coordinates authorized in 2016 Amendment covers 95% of existing TSF and proposed TSF 2 footprint.

Table 2. Contact details of the Licensee

Licensee	Black Mountain Mining (Pty) Ltd
Postal address	1 Penge Road Aggeneys, Northern Cape
Telephone number	+27 54 983 8520
Contact person	Pieter Venter - Environmental Manager
Email address	Pventer@vedantaresources.co.za
Contact person	Pieter Venter- Environmental Manager

Email address	pventer@vedantaresources.co.za

Table 3. Contact details of the IWWMP Consultant

IWWMP Consultant	AquaStrat Solutions (Pty) Ltd
Report Author:	Marli Burger
Email:	oryxsolutionsafrica@gmail.com
Cell:	+2772 284 9332

1.2 Regional Setting and Location of Activity

The Gamsberg Zinc Mine is located 14km east of the town of Aggeneys and 120km east of Springbok, within the Khâi-Ma Local Municipality and the Namakwa District Municipality in the Northern Cape Province. Project locality information is outlined below in Table 4.

1.3 Property Description

The following property information is relevant to the Gamsberg Zinc Mine, with activities of the 2023 Application proposed to take place on the Remainder of Farm Aroams 57.

Table 4. Property Information

Description	Details
Farm Name	Bloemhoek 61 Portion 1 Gams 60 Portion 1 Aroams 57 RE
Magisterial district	Khâi-Ma Local Municipality Namakwa District Municipality.
21-digit Surveyor General Codes	Bloemhoek 61Portion 1 C05300180000006100001 Gams 60 Portion 1C05300180000006000001 Aroams 57 RE C0530018000000057000RE

Land ownership

The landowners for the Gamsberg Mining Right Area are listed in Table 5**Error! Reference source not found.**. The proposed additional water uses (2023 amendment application) are situated on The Remainder of Farm Aroams 57.

Table 5. Property Information for the Gamsberg Mine

Farm	Portion	Landowner	Title deed number
Aroams 57	Portion 57	Black Mountain Mining (Pty) Ltd	T41686/2010CTN
Gams 60	Portion 1	Black Mountain Mining (Pty) Ltd	T41686/2010CTN
Gams 60	Portion 4	Black Mountain Mining (Pty) Ltd	T41685/2010CTN
Bloemhoek 61	Portion 1	Black Mountain Mining (Pty) Ltd	T41686/2010CTN

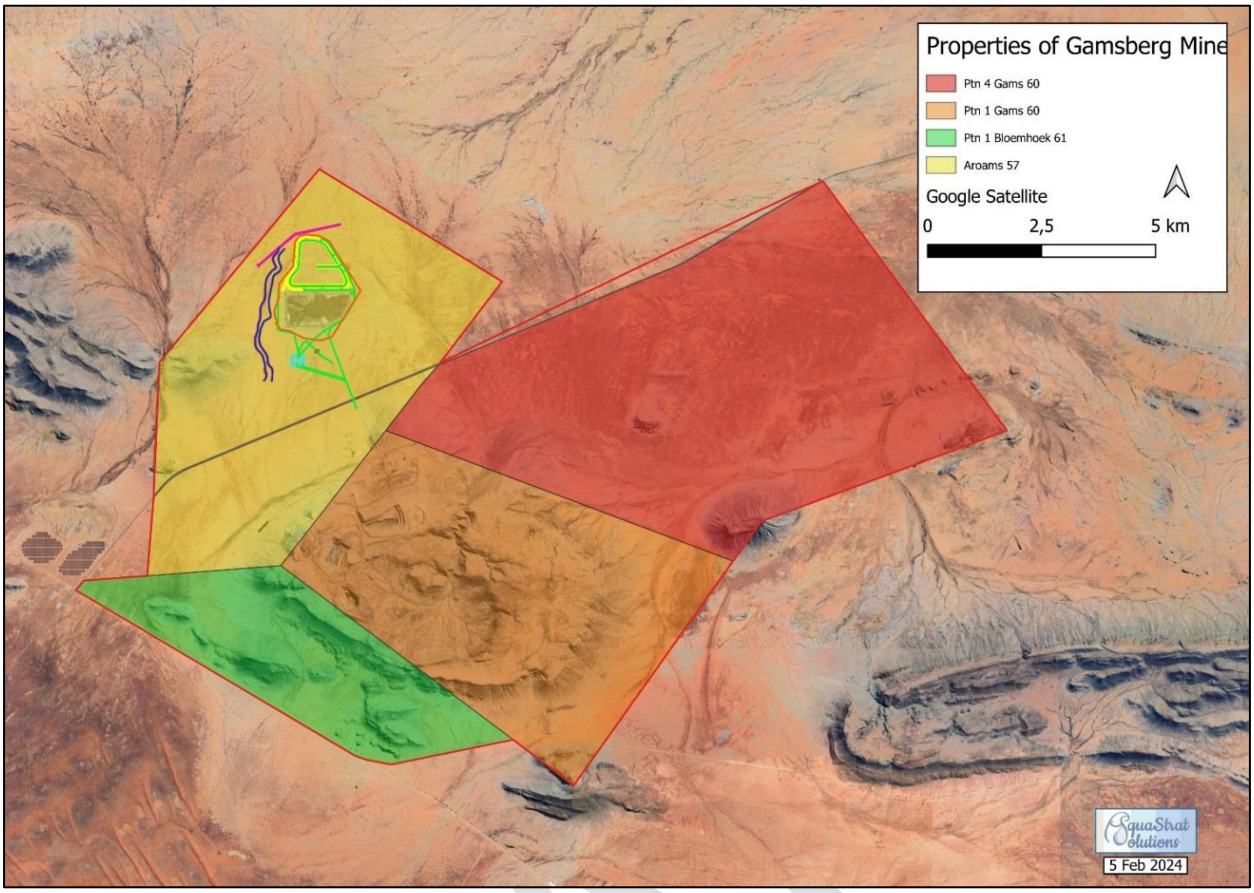

Figure 1. Properties of the Gamsberg mining area showing the locality of the proposed TSF 2.

Land Claims

The Department of Rural Development and Land Reform: Land Claims Commissioner was contacted on 30 October 2019 to confirm whether any land claims had been lodged on the properties affected by the proposed development of the Gamsberg Smelter Project. The Land Claims Commissioner confirmed that no land claims have been lodged on the affected properties. Proof of correspondence from the Land Claims Commissioner was included in the 2021 IWULA (SLR, 2021).

1.4 Purpose of IWWMP

"The Integrated Water and Waste Management Plan (IWWMP) must supply the Department of Water Affairs (DWS) with a very clear management commitment to ensure the implementation of the IWWMP action plan. The completed IWWMP needs to be endorsed and implemented by the water user, and it will be captured as a water use licence condition. The implementation of an IWWMP is therefore enforced through the water use licence conditions in the water use authorisation process" (DWA, 2010).

An IWWMP is a simple, feasible, implementable plan for the site activity that considers the National Water Resource Strategy (NWRS), the relevant Catchment Management Strategy (CMS), any established resource quality objectives (RQOs) and the sensitivity of the receiving water resource. It also considers up- and down-stream cumulative impacts of the water use activities and provides an updated interpretation of monitoring data to enable adaptive management (DWA, 2010).

This IWWMP complies with the requirements of Government Notice Regulation (GNR) 267 published in terms of the NWA on 24 March 2017 (DWS, 2017).

The purpose of the IWWMP is to define the water uses and waste management practices, as well as to identify potential impacts and relevant mitigation measures for surface and groundwater resources associated with the Gamsberg Zinc TSF Phase 2.

Additionally, this IWWMP includes an update of water uses authorized by the 2014 WUL and 2016 Amendment of the WUL, summary of the water uses applied for in 2020 (WUL Amendment Application, Golder) and summary of associated waste management practices.

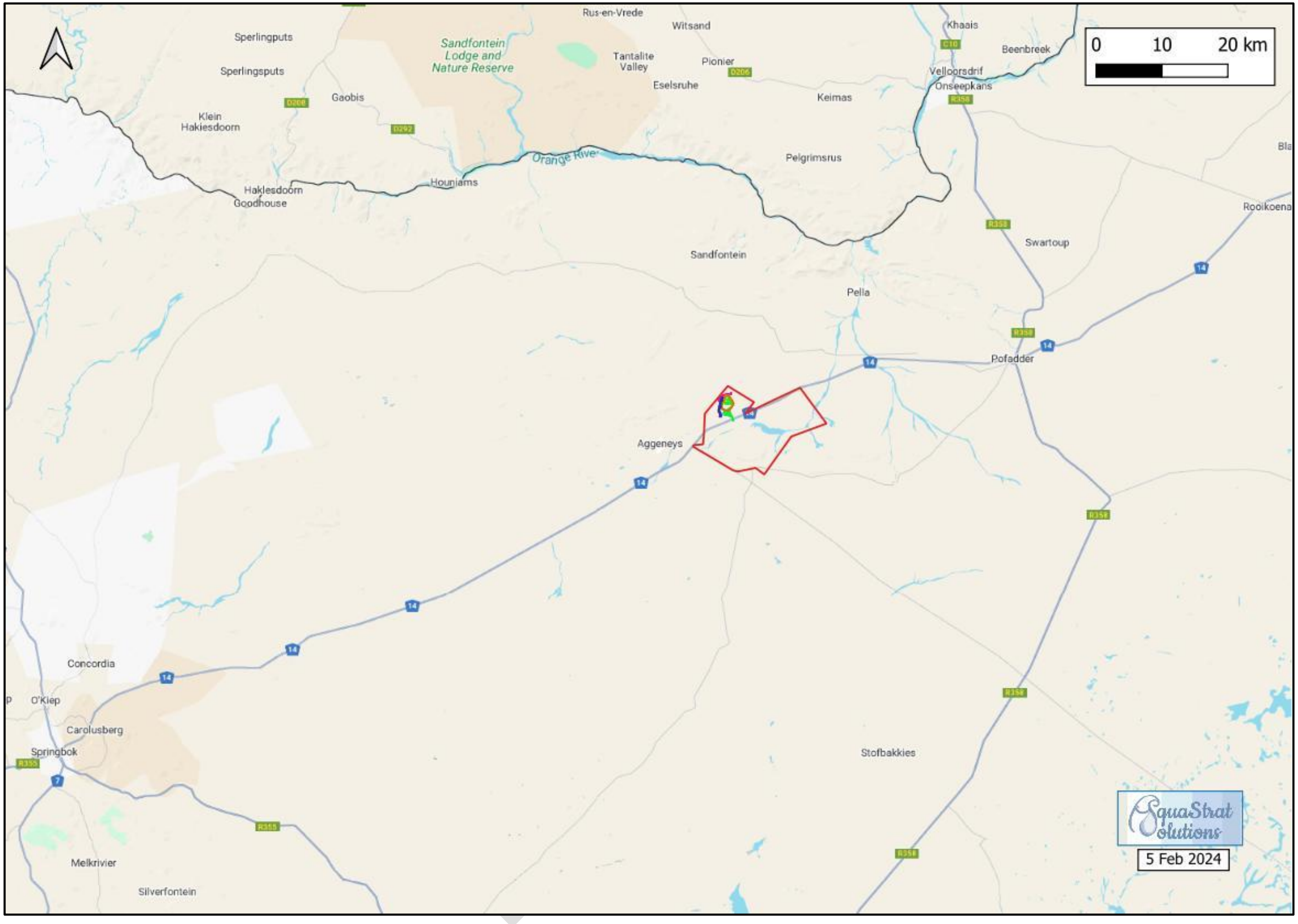

Figure 2. Locality of Gamsberg Zinc Mine.

2 Chapter 2: Conceptualisation of activity

2.1 Description of Activity

Black Mountain Mining (Pty) Ltd is proposing the construction and operation of the TSF Phase 2 with associated RWD, silt trap, pipelines and stormwater diversion channel within the Gamsberg Zine Mine mining right area. The development footprint for the TSF Phase 2 Project and the associated infrastructure would have an extent of approximately 200 ha within the approved mining right area which is a total extent of 9 505.73 ha.

2.1.1 Existing activities and 2020 Amendment Application activities

The Gamsberg Zinc Mine is an approved open pit zinc mine and is currently approved to mine10 mtpa to produce zinc and lead concentrate. A detailed description of the current mine activities is provided in Table 6 (SLR, 2021) and the activities applied for in the 2020 WUL Amendment in Table 7.

Table 6. Gamsberg Zinc Mine Existing Activities (SLR, 2021).

Infrastructure	Description of Activity
Open Pit	The final open pit is expected to cover a total area of 600 ha, which is expected to be the result of the extraction of some1.55 billion tons of material. The final depth of the open pit is estimated at approximately 650 metres, while the width and length of the pit are expected to extend 2 220 metres and 2 700 metres. Blasting takes place on average once per day with the explosive's magazine situated to the south east of the existing concentrator plant. Hauling of ore to the primary crusher and waste rock to the waste rock dump Is undertaken using large capacity haul trucks (typically between 220 t and 300 t capacity).
Primary Crusher	Upon stripping of overburden, the ore is transported via haul trucks to the primary crusher located adjacent to the open pit along the northern slope. The bulk ore Is transported to the primary crushers that have a total processing capacity of 10 mtpa (currently processing 4 mtpa). From the Primary Crushers the ore is transported to the Run of Mine (ROM) ore stockpile via a conveyor system. Ore Is conveyed through a reclaim conveyor to the milling circuit.
Waste Rock Dumps	An estimated 1.5 billion tonnes of waste rock will be generated during the life of mine. The trucks transport the waste material to the edge of the inselberg where it is tipped over the edge to form a waste rock dump. To achieve the natural angle of repose, the footprint of the rock dump Is estimated to cover 490 hectares.
Mine Bulk Fuel and Lubricant Storage Facility	The mine bulk storage tank farm is located adjacent to the Mine workshop area. This tank farm stores approximately 500 m^3 of diesel and covers a total area of approximately 2,500 m^2. Approximately 5 000 litres of various grades of lubricants are stored in a bunded area adjacent to the Mine workshop area.
Concentrator Plant	The full production capacity of the mine will be 10 mtpa of ore, the current production capacity is 4 mtpa. The concentrator plant will produce 1.1 mtpa of zinc and lead concentrate. The concentrator processing plant area consists of the following: • Milling circuit. • Ore stockpile • Flotation • Dewatering, filtration and zinc concentrate handling • Tailings facility (see tailings section below) • Material lay down and storage areas

Infrastructure	Description of Activity
	• Bulk storage of diesel and petrol (a total capacity of 100 m^3 of diesel and petrol covering an area of 400 m^2) • Equipment wash areas Additional on-site plant infrastructure.
Tailings Storage Facility	The treatment of 10 mtpa ROM ore is expected to lead to approximately 9 mtpa of tailings material (approximately 6.9 million m^3 of slurry containing approximately 4.5 million m^3 of water). The mineral wastes (tailings) are sent to the thickener to reduce the water content and then pumped to the TSF. Percolated water in the tailings dam is extracted, returned to a process plant and reused in the concentrating process, via a return water dam. Based on the expected production of tailings material, two tailings dams in close proximity on the 290 hectare footprint will be constructed (one of which has already been constructed), with a total storage capacity of 132 million tons. The tailings dam is situated to the north of the N14. To mitigate risk, use of a suitable impermeable lining system with HDPE geomembrane liner, was constructed along the entire TSF footprint area. The lining system constructed consist of a 1.5 mm thick HDPE geomembrane as approved by DWS. The geomembrane was placed over 300 gsm nonwoven needle-punched geotextile and was placed all along the slopes and base of the TSF.
Services	Power Supply The current power supply consists of the following Infrastructure: • The 220kV/66V substation • 66 kV/11kV sub-station • Two 66 kV distribution lines from Aggeneys to the Gamsberg Zinc Mine.
	Water Water is currently supplied by Sedibeng Water via two existing pipelines from the Orange River. The existing water system has a common intake, low lift pump house and low lift pipeline. The low lift pumping system is feeding two circuits, namely the Black Mountain Mine circuit and the Gamsberg Zinc Mine circuit. Both the circuits consist of a flash mixer, clarifier, dosing system, sludge handling facility, balancing reservoir, high lift pump house, high lift pipelines and Horseshoe Reservoir with associated facilities. The current water demand, with the Black Mountain Mine operation and Phase 1 concentrator plant at Gamsberg, is 28 ML/day, the existing intake water pumping system has been designed for 40.8 ML/day. The existing bulk water pipeline infrastructure running from the Horseshoe Reservoirs to the Gamsberg take-off covers approximately 4 km and consists of one 400 mm diameter underground pipeline and one 400 mm aboveground pipeline. A 400 mm High Density Polyethylene (HDPE) diameter aboveground bulk water pipeline runs from the Gamsberg take-off where the pipeline splits off from the Main Bulk Water Pipeline to the Gamsberg reservoir (25 Ml) extending over 3 km. The water supplied by these pipelines also supplies water to the towns of Aggeneys, Pofadder and Pella on the original Black Mountain Mine underground pipeline. The raw water storage dam at the concentrator plant has a total capacity of 6 800 m^3 and provides water to the plant, mine and fire hydrant systems. A process water dam is fed with recycled water from the plant, treated water and make-up water from the raw water dam and has a total storage capacity of 25,000 m^3. The sewage treatment plant is also located at the concentrator plant and has a daily processing capacity of approximately 500 m^3/day.

Table 7. Gamsberg Zinc Mine 2020 WUL Amendment Activities (Tata, 2019; SLR, 2021)

Infrastructure	Subcomponents	Description of Activity
Smelter Complex	Summary	The Smelter Complex is designed to beneficiate 680 000 tpa of zinc concentrate produced by the concentrator plant with a footprint of 22ha (adapted from SLR, 2021).
	Smelter Plant	The conventional roast-leach-electro winning (R-L-E) process has been chosen to produce zinc metal. The full process will involve the treatment of zinc concentrate from the concentrator plant to produce high grade zinc ingots for export (SLR, 2021).
	Raw Material Handling & Storage	Zinc concentrate would be transported from the concentrator plant by side tipper trucks using internal roads to the designated stockpiles within the smelter complex footprint (50 trucks per day carrying a volume of 30 tonnes/truck). A total of 680 000 tpa of zinc concentrate from the concentrator plant would be fed into the smelter. Two stockpiles with storage for five days each are proposed. Front-end loaders would then be used to reclaim material from the stockpiles and feed concentrate into the ground hoppers. From the ground hoppers material would be extracted by weigh feeders which in turn would feed the material to the belt conveyor. Zinc concentrate would be transferred into the respective day bins at each roaster plant via a series of conveyor belts. Dross material from the cathode melting and casting process would be added to the feed material before the vibrating screen. Several spraying nozzles in the concentrate storage hall, as well as on the conveyor belt before the concentrate feed bin, would moisten the concentrate.
	Roasting Plant: Two Roasters, two waste heat recovery boilers, two Steam Turbine Generators (STG), one gas cleaning plant, one acid plant and acid loading section including acid storage tanks	The concentrate is roasted in a fluid bed composed of spent roasted concentrate (zinc oxide). Process air is injected to the roaster with the roaster air blower. The process air is controlled via a variable speed drive (VSD) at the blower motor and the adjustable inlet guide vanes (IGV). It serves both as a carrier medium for the fluidized bed and as a source of oxygen for the predominant reaction, which converts zinc sulphide to zinc oxide and sulphur dioxide. The reaction in the roaster is strongly exothermic, and the gases leave the roaster at a temperature of approximately 930 ° C – 975 ° C and with a Sulphur Dioxide (SO2) concentration of approximately 10% by volume, dry basis. A slight draught suction is maintained at the roaster gas outlet to ensure the safety of the roaster operation and operate the system in slight suction to eliminate dust and SO2 emissions. The SO2 blower of the acid plant controls the required draft. Calcine is the metal containing portion of the concentrate after the sulphurous component has been roasted off. Calcine produced at the roasting plant is used as feed material to the leaching plant. The roaster material receives pre-treatment of fine material, and is followed by discharge into the Calcine Discharge System, Waste Heat

Infrastructure	Subcomponents	Description of Activity
		Recovery Boiler, Hot Gas Cleaning, Wet Gas Cleaning, and Acid Plant.
	Leaching area including calcine silo and manganese removal	The feed material to the leaching plant is the metal containing calcine, produced at the roasting plant. The main function of the leaching plant is to dissolve and to recover the zinc contained in the calcine as a solid free, pre-purified neutral zinc sulphate solution. The leach residue together with the iron, precipitated as sodium Jarosite, is removed as a cake with an iron content of approximately 25%. The leaching plant is a continuous operating plant and can be divided into the following main units: calcine storage and dosing; neutral leaching (NL); weak acid leach (WAL); manganese removal; conversion section; Jarosite filtration; Jarofix and magnesium removal.
	Purification section	The purification of the neutral solution would be carried out in two steps: hot purification for the removal of copper (Cu), cadmium (Cd), cobalt (Co) and nickel (Ni) as major impurities and the polishing step to ensure the required quality of the purified solution
	Enrichment Plant	The enrichment plant would be designed to recover as much of the zinc as possible from the hot purification filter press cake and to keep all other unwanted impurities in the cake. The amount of treated cake will depend on the impurities content of the calcine leached in the leaching section. The enrichment unit consists of four leaching tanks, a sodium hydroxide (NaOH) solution tank and four filter presses. The leached cake will be filtered and washed and stored. Filtrate is then returned to the hot purification for conversion.
	Gypsum removal section	Gypsum removal would be required to purge calcium from the electrolyte circuit and control the build-up of gypsum in the cell house and leaching plant equipment. The neutral solution that is saturated with gypsum will be cooled in three atmospheric cooling towers from 86° C to 34° C. This causes crystallization of gypsum from the solution. The gypsum would then be removed in a thickener. The thickener overflow would be taken to the purified solution storage tanks and the underflow pumped to the conversion process.
	Cell house	In the cell house the zinc from the purified solution would be deposited as metallic zinc on the aluminium cathodes. This cathode zinc is then removed from the cathodes and sent to the melting and casting plant where the cathodes are melted and cast to special high grade (SHG) zinc ingots. To have a production buffer between leaching electrolysis plant sections, four solution storage tanks are proposed, two for purified solution and two for spent electrolyte. The purified, loaded electrolyte produced in the leach/purification process would be fed to the circulating stream of zinc electrolyte to replenish zinc in solution at a rate equal to that being plated. Heat generated by the electrolytic process would be transferred to the electrolyte as it passes through the cells and evaporative cooling towers to maintain the solution temperature at

Infrastructure	Subcomponents	Description of Activity
		38ºC. Spent electrolyte would be withdrawn from the circuit and pumped to the leaching plant to balance purified solution inflows and to meet leaching needs. Each pair of rows would be equipped with a fully automated crane for the removal and replacement of cathodes for stripping for zinc deposits. Each crane would also remove and replace the anodes for cleaning.
	Melting and casting including product storage	Cathode zinc from the cell house would be melted using three induction furnaces (one alloy furnace). Molten metal would be withdrawn from the furnaces by centrifugal pump to the continuous casting section which would consist of two slab ingots casters and one jumbo caster or continuous galvanizing grade (CGG) jumbo ingots. The ingots would be automatically stacked into bundles and strapped for shipment. Forklift trucks would be used to move the bundles to temporary storage facilities and into trucks for shipment. Dross would be skimmed from the top of the metal bath into bins and transported to the dross separation facility. The zinc dross would be charged into ball mills to separate the metallic fraction of the dross from the powdery oxidised material. Metallics would be returned to the melting furnaces and the oxide transported to the concentrate handling section for retreatment in the roaster.
	Zinc dust plant	The zinc dust plant would be designed to produce the zinc dust (fine and coarse) from zinc slabs, which would be required at the purification plant. This plant would be integrated with the melting and casting plant and would consist of induction furnaces, atomizing furnaces, double expansion chamber/ bin, double deck zinc dust screen and two zinc dust bins (one for coarse and one for fine dust).
	Effluent Treatment Plant	The ETP would be located on the western side of the smelter complex as the salts/ ETP Cake from the ETP would be dispatched to the secured landfill facility which would be located approximately 1 km to the west. Water from the ETP would be recycled into the smelter complex for reuse.
	Utility Services	1. Raw water reservoir, water treatment plant, cooling towers 2. Oxygen Plant 3. Power supply 4. ETP and Oxygen/Ozone plant (for Manganese removal) 5. Laboratory 6. Central stores 7. Workshop 8. Plant office 9. Weighbridge 10. Access road 11. Gate house and security

Infrastructure	Subcomponents	Description of Activity
		12. Raw water reservoir, water treatment plant, cooling towers and air compressors
Secured Landfill Facility		21 ha footprint; includes pipeline from Horseshoe Reservoirs to Gamsberg Zinc Mine. A new aboveground 630 mm HDPE pipeline would be laid down from the Horseshoe Reservoirs to the proposed new 10 Ml reservoir to be placed within the smelter complex. The proposed new pipeline section will be approximately 7 km long. The secured landfill facility is planned to be approximately 1 km to the west of the smelter complex and would be connected by a paved/ bitumen road for the transportation of the Jarofix and ETP cake for disposal. The initial design of the secured landfill facility would be sized based on the generation of Jarofix for the first 5 years. The total design will accommodate 15 years of disposal in cells with lifespans of about 5 years each such that the first cell can be closed when the advanced Fumer technology becomes viable. The Fumer technology would oxidize, and thus stabilise, the Jarosite to a product that would not leach and could be used for road construction or in cement industry.
Laydown area		15 ha footprint; The space for the construction office and storage area would be provided within a boundary fence demarcating the laydown area to the south of the smelter complex
Business Partners camp		12 ha footprint; The business partner camp would consist of worker 's, supervisor's and manager's accommodation. These buildings would be temporary porta-cabin type.
Sewage treatment plant		The sewage treatment plant has been planned in conjunction with the existing sewage treatment plant built for the concentrator plant. The existing sewage treatment plant is a modular unit and can thus be expanded as necessary. The current volume of sewage being treated at the sewage treatment plant is 500 m^3/day. The capacity would be doubled to 1 000 m^3/day for the proposed Gamsberg Smelter Project. The wastewater from toilets from the various buildings would be collected in the inspection chambers, constructed outside the buildings and would be transferred to the sewage treatment plant through underground sewer pipes. After treatment in the sewage treatment plant, treated sewage water would be transferred to the already approved sewage effluent dam and used for the gardens, horticulture and dust suppression, both in the smelter complex and the construction camp area as previously approved.
Change House, Canteen; Fire & first aid station		Supporting facilities and staff safety.

2.1.2 Proposed Activities

Black Mountain Mining (Pty) Ltd is proposing to the construction and operation of the TSF Phase 2 with associated RWD, silt trap, pipelines and stormwater diversion channel within the Gamsberg Zine Mine mining right area. The current operational zinc Tailings Storage Facility (TSF) for Phase 1 is located approximately 2.5 km to the northwest of the plant site. The current Phase 1 TSF will reach its end of life in (2030) and requires a new TSF to be constructed for Phase 2 (Knight Piésold, 2023a).

Table 8. Gamsberg Zinc Mine Proposed Activities (2023)

No	Facility	
1	Tailings Storage Facility: Phase 2	• 6 439 994 m^3/a slurry (333 333t/month at 1.61t/ m^3) • 122.398 ha overall footprint • Class C, 1080 GSM geotextile, overlayed by 1.5mm HDPE geomembrane • Underdrains with leak detection
2	Return Water Dam: Phase 2	• 120 000 m^3 with each compartment having approximately 60 000 m^3 of storage capacity. • The RWD will be double lined with 1.5mm HDPE liner • A cuspated layer in between the liners with act as leakage detection and drainage layer • The cuspated layer feeds to two sumps at the southern ends of the compartments which can be drained with a pump
3	Silt trap	• 17 600m^2 • Before the TSF decant water enters their respective RWD the water goes through a double silt trap with sluice gates to control water flow • Components of silt trap: Energy Dissipator, Decant Water Pipe, Hanging Wall within Energy Dissipator, Baffle Block, Sluice Gates (Dual), Channel Flow, Second Splitter Box

4	Tailings slurry ringfeed system	• Each ringfeed pipeline branch system consists of the following components:
		  ○ External ringfeed pipeline routed along the largest part of the external perimeter of the TSF, just outside of the solution trench outlining the TSF
		  ○ Deposition valve stations installed at 407m intervals along the External ringfeed pipeline to allow for diversion of tailings through offtake riser pipework and for more operational flexibility for maintenance of the internal ringfeed pipeline
		  ○ Internal ringfeed pipeline; each of the spigot offtakes is fitted with a cyclone station installation
		  ○ Cyclone station installation

5	Tailings decant pipeline	• Return water will be decanted from the pool of the New Phase 2 TSF and transferred to the silt trap for of the New Phase 2 Return Water Dam (RWD), using a relocatable land-based pump system connected to a floating shallow water intake device which will float on the surface of the TSF pool. • Suction pipeline and pipe fittings connecting the shallow-water intake device with the pump unit.

		• Pump Unit: Dry self-priming pump with an electrical motor mounted on a skid (one duty and one standby pump unit). • Delivery pipeline and connecting pipe fittings, transferring return water to the RWD
6	Return water dam pump station and pipeline systems	• Water will be abstracted from the pool of the proposed Phase 2 RWD via new pump units and transferred via a two pipeline system (one number of duty pipeline and one number of assist pipeline in parallel) from the RWD to the tie-in point on the existing return pipeline transferring return water back to the existing Process Water Tank (PWT) at the plant. • Suction pipelines and pipe fittings abstracting water from the dam outlet structure sump constructed within the internal embankment of the RWD. • Pump units: Dry self-priming pump units, each consisting of an electrical motor mounted on a skid. • Delivery pipelines and connecting pipe fittings, transferring return water to the existing Process Water Tank (PWT)

2.2 Extent of Activity

The construction and operation of the TSF Phase 2 with associated RWD, silt trap, pipelines and stormwater diversion channel, within the Gamsberg Zinc Mine mining right area, would have an extent of approximately 120 ha within the approved mining right area which is a total extent of 9 505.73 ha.

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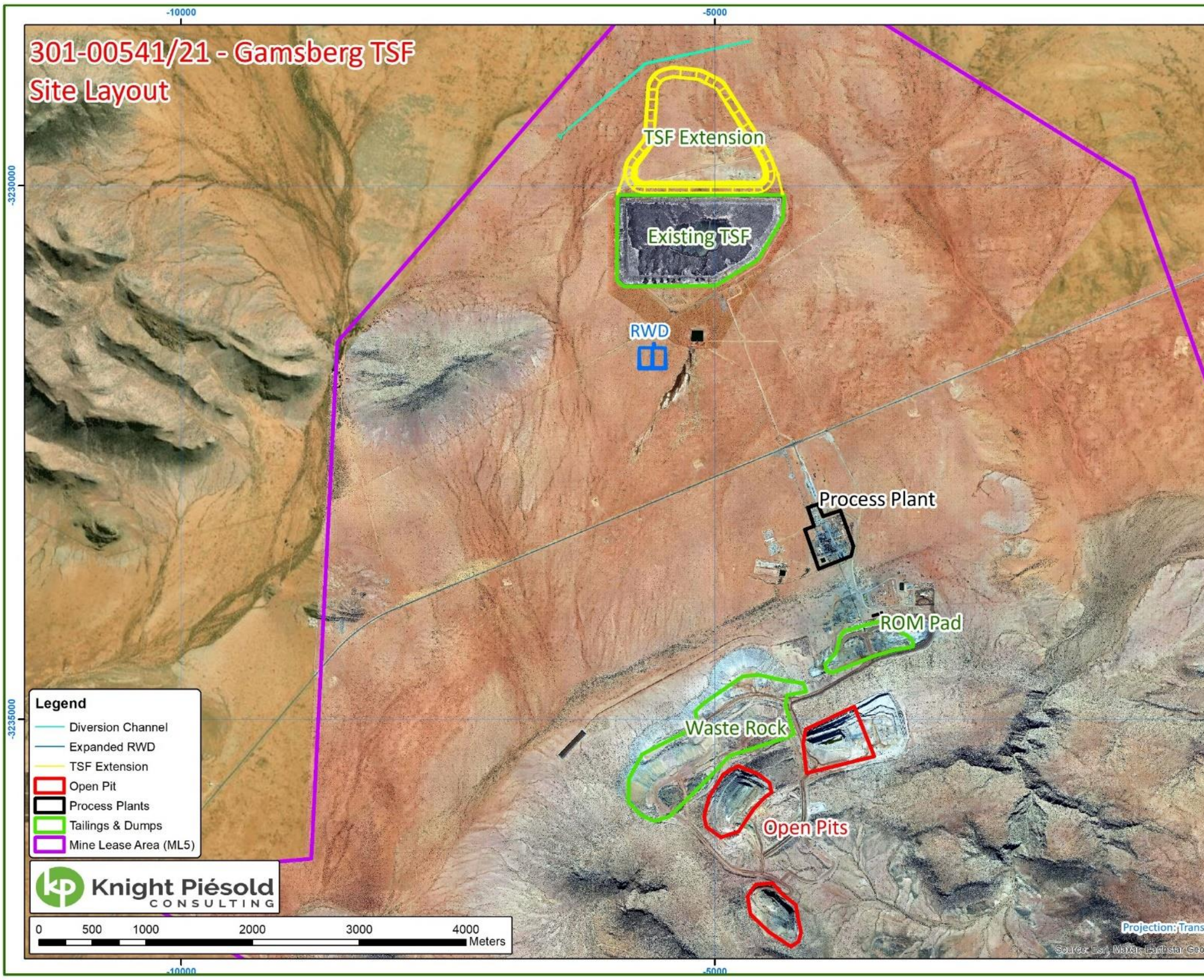

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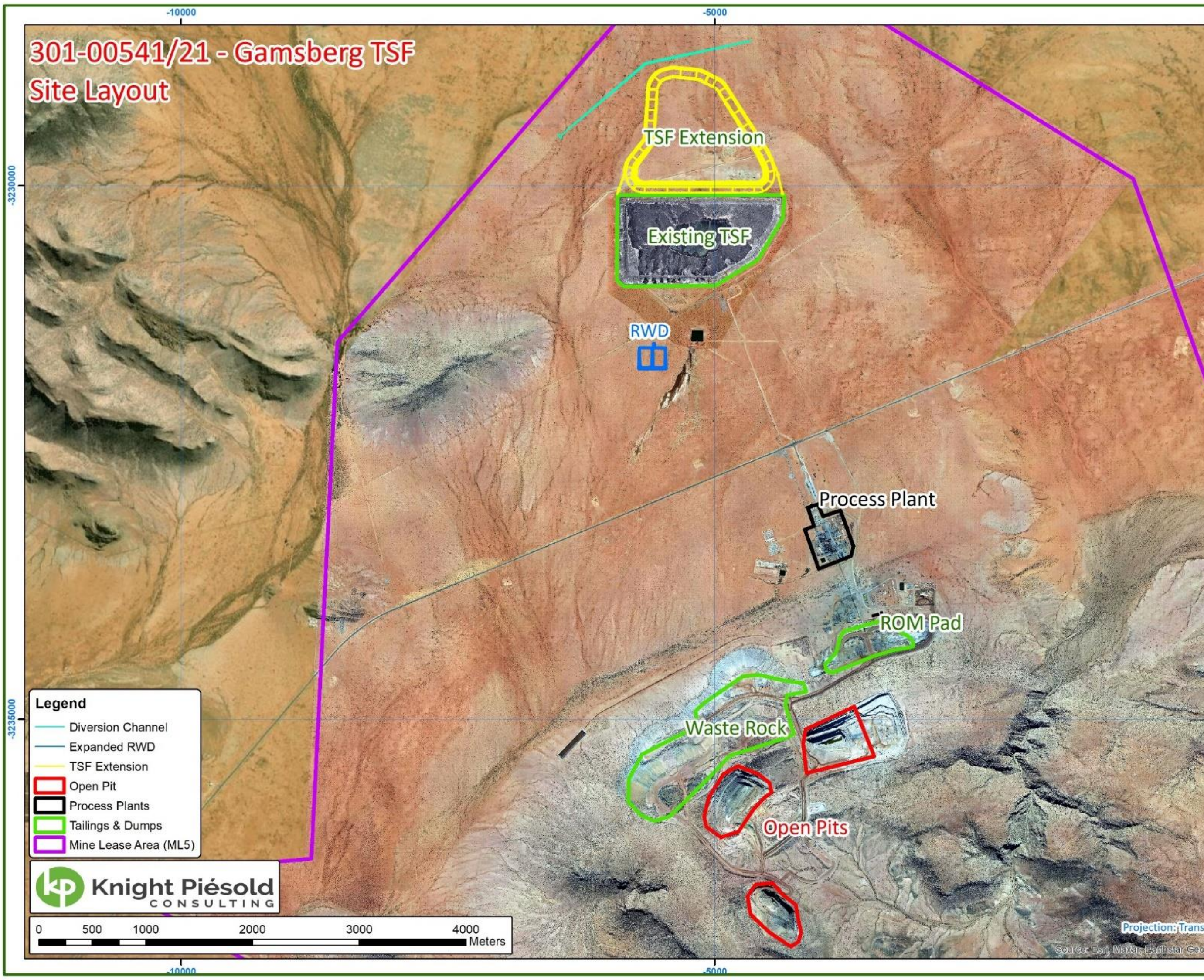


Figure 3. Detailed Master layout of Gamsberg Zinc Mine.

Table 9.

2.3 Key Activity Related Processes and Products

The Tailings Facility Phase 2 infrastructure include:

TSF Phase 2

Liner requirements as per GN 636 is determined to be Class C, 1080 GSM geotextile, overlayed by 1.5mm HDPE geomembrane, and a minimum freeboard requirement of 2m. Drainage above and below liner.

Return Water Dam

Two separate compartments were designed in order to allow cleaning of an individual compartments. The final size required was 120 000 m^3 with each compartment having approximately 60 000 m^3 of storage capacity.

The RWD will be double lined with 1.5mm HDPE liner, a cuspated layer in between the liners with act as leakage detection and drainage layer should the top liner leak. The cuspated layer feeds to two sumps at the southern ends of the compartments which can be drained with a pump, this should routinely be checked for leakage. The protection layer is a concrete filled HDPE hyson cells in order to allow cleaning with light machinery such as TLB's (KP, 2023b).

RWD Transfer System

Water will be abstracted from the pool of the proposed Phase 2 RWD via new pump units and transferred via a two pipeline system (one number of duty pipeline and one number of assist pipeline in parallel) from the RWD to the tie-in point on the existing return pipeline transferring return water back to the existing Process Water Tank (PWT) at the plant. The duty and assist pipelines will alternate and hence not operate simultaneously at any given time. The Phase 2 RWD is a dual compartment dam and therefore require a duty and standby pump unit for each compartment.

The proposed Return Water Dam transfer system will consist of the following key components:

- Suction pipelines and pipe fittings abstracting water from the dam outlet structure sump constructed within the internal embankment of the RWD.
- Pump units: Dry self-priming pump units, each consisting of an electrical motor mounted on a skid.
- Delivery pipelines and connecting pipe fittings, transferring return water to the existing Process Water Tank (PWT) (KP, 2023a).

Decant system

The system will be an electrically supplied land-based pump system with a floating suction head. The system will supply water from the TSF pool to the silt trap prior to the return water dam (KP, 2023b).

Return water will be decanted from the pool of the New Phase 2 TSF and transferred to the silt trap for of the New Phase 2 Return Water Dam (RWD), using a relocatable land-based pump system connected to a floating shallow water intake device.

The decanting system will consist of the following key components:

- A shallow-water intake device which will float on the surface of the TSF pool.
- Suction pipeline and pipe fittings connecting the shallow-water intake device with the pump unit.
- Pump Unit: Dry self-priming pump with an electrical motor mounted on a skid (one duty and one standby pump unit).
- Delivery pipeline and connecting pipe fittings, transferring return water to the RWD (KP, 2023a).

Silt trap

Before the TSF decant water enters their respective RWD the water goes through a silt trap in order to allow sediment to filter out of solution. All dirty water draining to the RWD2 drains into a silt trap which is located in the middle of the two compartments. The silt trap has been designed to comfortably pass the 50-year storm event. A double silt trap measuring 25 m x 15 m x 1.5 m deep with a drying bed measuring 25 m x 4.7 m wide is located on the northern side of the return water dam. The double silt trap has been designed with sluice gates to control water flow into the relevant silt trap that is operational at the time.

Silt from dirty water runoff is captured in the silt trap, once the majority of silt is removed from the dirty water it is then directed into the return water dam. Cleaning of the silt trap is by means of a TLB. The silt trap has been designed for (8 t vehicle) or similar weight and type of vehicle.

The silt trap system is composed of a series of essential components, meticulously engineered to perform distinct functions, ensuring efficient sediment separation and water flow management. These integral components encompass:

1. **Energy Dissipator**: Strategically positioned at the inlet, the energy dissipator serves the critical purpose of mitigating water flow velocity to a subcritical level before it interacts with the primary structure. This reduction in kinetic energy minimizes potential erosion and turbulence effects, safeguarding the overall integrity of the system.
2. **Decant Water Pipe**: Functioning as a conduit for water transfer, the decant water pipe directs water from the upstream source to the energy dissipator. Its configuration facilitates controlled deposition into the energy dissipator, enabling optimal interaction between water and its subsequent flow-altering elements.
3. **Hanging Wall within Energy Dissipator**: Positioned within the energy dissipator, the hanging wall acts as a flow obstruction mechanism, particularly regulating the outflow from the decant water pipe. This deliberate hindrance ensures calibrated water discharge, contributing to enhanced sediment settling within the trap.
4. **Baffle Block**: Positioned at the base of the energy dissipator, the baffle block serves as an additional energy-dissipating element. Its design is engineered to further dissipate the remaining kinetic energy of the water, culminating in a controlled transition to the subsequent trap compartments.
5. **Sluice Gates (Dual)**: The silt trap incorporates two distinct sluice gates, each leading into separate silt trap compartments. These gates provide selective control over water ingress, enabling tailored sediment deposition and facilitating efficient maintenance operations.
6. **Channel Flow**: Positioned at the terminal end of the silt trap, the channel flow design ensures the gradual transition of water into a subcritical flow state. This design consideration is vital to prevent sediment resuspension and optimize the hydraulic efficiency of the system, thereby facilitating its downstream movement.
7. **Second Splitter Box**: The secondary splitter box, a pivotal element in the trap configuration, allows for dynamic redirection of water flow. It provides the flexibility to channel water towards the designated return water dam, contributing to efficient water resource management and sediment containment.

Each of these components is characterized by unique design specifications, carefully selected materials, and precise dimensions. These attributes are tailored to ensure optimal performance, longevity, and resilience of the silt trap system while collectively addressing the intricate challenges posed by sediment-laden water flows (KP, 2023d).

Seepage Management

Underdrains have been provided above and below the liner. The drains above the liner will facilitate drainage and reduce the overall pore pressure regime, increasing water recovery and the stability of the facility. The drains below the liner have been designed to detect any potential leakage from the primary barrier (KP, 2023b).

Ringfeed Pipeline System

The tailings pump system consists of a duty and standby pump train, each pump train with its own transfer pipeline extending to the new Phase 2 TSF, and each of the pipelines (one duty and one standby pipeline) consisting of DN300 Std (KP, 2023a). Each ringfeed pipeline branch system consists of the following components:

- External ringfeed pipeline routed along the largest part of the external perimeter of the TSF, just outside of the solution trench outlining the TSF
- Deposition valve stations installed at 407m intervals along the External ringfeed pipeline to allow for diversion of tailings through offtake riser pipework and for more operational flexibility for maintenance of the internal ringfeed pipeline
- Internal ringfeed pipeline; each of the spigot offtakes is fitted with a cyclone station installation
- Cyclone station installation (KP, 2023a).

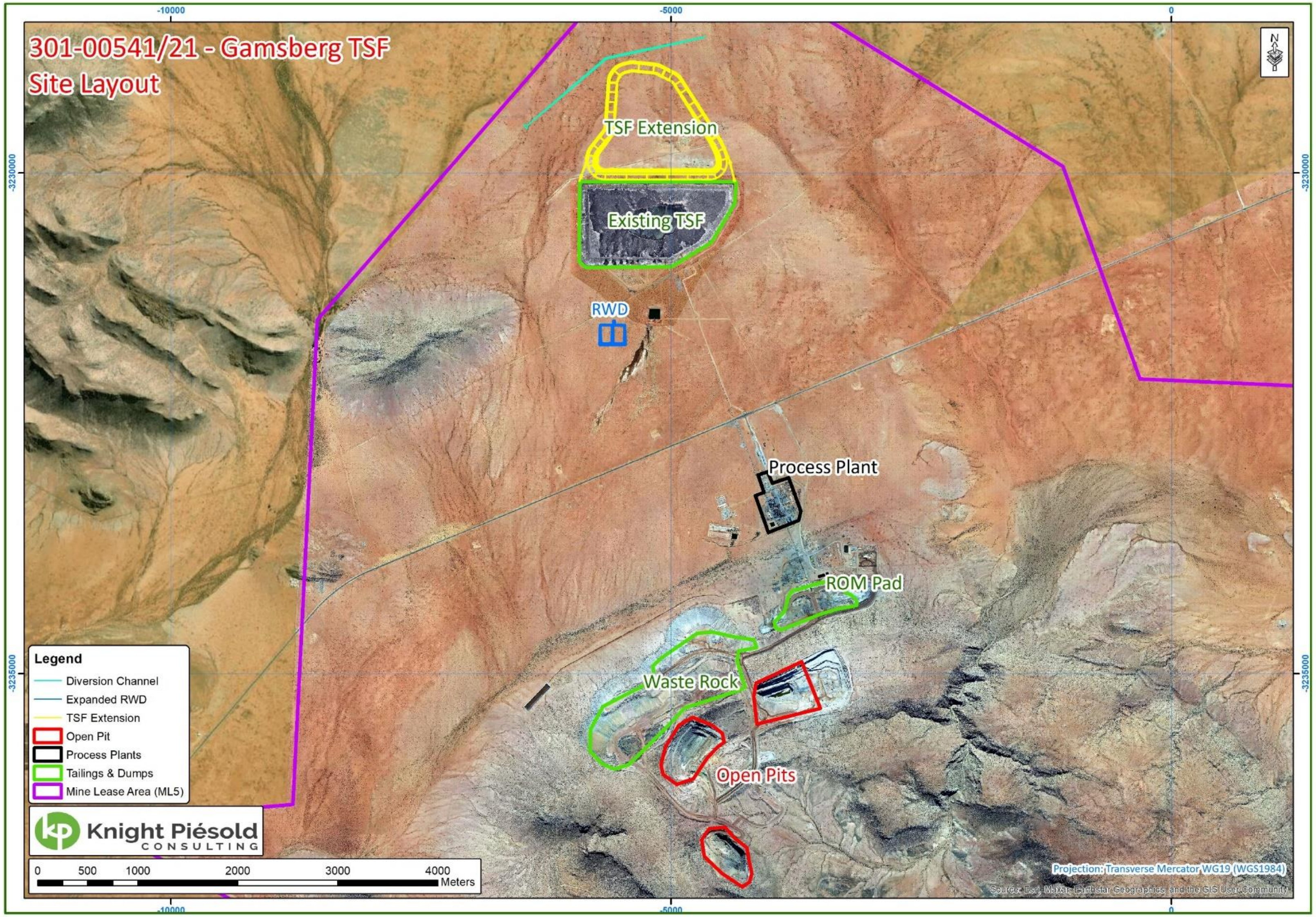


Figure 3. Detailed Master layout of Gamsberg Zinc Mine.

Table 9. Key infrastructural and activity description (updated from latest version in Golder, 2019, originally adapted from ERM 2013b)

Project Component	Master Layout Reference	Specification Detail
Open Pit Zinc Mine	Gamsberg Mountain	Maximum pit dimensions: • The final open pit is expected to cover a total area of 600 ha • 1.65 billion tons of material • Final depth approximate 650 m with 2 220m x 2 700m area • Slope angles – 45 to 53 degrees • Blasting takes place on average once per day • Hauling of ore to the primary crusher and waste rock to the waste rock dump by haul trucks with 220 t and 300 t capacity
Primary Crusher	Located on northern side slope of the Inselberg.	• Total processing capacity of 10 000 000 tpa • Total height of crusher 35 m above ground level • Total area of 0.1 ha • Ore is transported to the Run of Mine (ROM) ore stockpile via a reclaim conveyor to the milling circuit.
Waste Rock Dumps		• Estimated 1.5 billion tonnes of waste rock will be generated during the life of mine • Footprint estimated as 490 ha
Concentrator Plant	Located between N14 and the Inselberg.	• Full production capacity: 10 mtpa of ore treatment capacity • Plant will produce 1.1 mtpa of zinc and lead concentrate • 40 m high • A total number of 4 dust extraction vents that are approximately 30 m high • Total area of 45 ha • Includes Milling circuit, Ore stockpile, Flotation, Dewatering, filtration and zinc concentrate handling; Tailings facility, Material laydown and storage areas, Bulk storage of diesel and petrol, Equipment wash areas, on-site plant infrastructure.

Project Component	Master Layout Reference	Specification Detail
Bulk Supply	Water: Sedibeng Water from Orange River.	• 2 000 m³ of water per day required. • Supplied by Sedibeng Water, sourced from the Orange River via 2 existing pipelines. • Feeding two circuits, namely the Black Mountain Mine circuit and the Gamsberg Zinc Mine circuit • Current water demand, with the Black Mountain Mine operation and Phase 1 concentrator plant at Gamsberg, is 28 ML/day, the existing intake water pumping system has been designed for 40.8 ML/day. • Raw water storage dam at the concentrator plant has a total capacity of 6 800 m³ and provides water to the plant, mine and fire hydrant systems • Process water dam with 25 000 m³ capacity receives treated and raw (make-up) water with recycled plant water. • Smelter Water Storage: 10 ML tank is proposed with 2 000 m³ Firewater tank.
	Power:	• Supply to be drawn through Eskom to a 10 MVA transformer • Two sub-stations along the northern and southern border of the N14 and two connecting distribution lines. • 220kV/66V substation - total area of 2 ha and reach a total height of 8 m • 66 kV/11kV sub-station - total area of 1 ha and reach a total height of 8 m; and • Two 66 kV distribution lines from Aggeneys to the Gamsberg Zinc Mine. • The connecting distribution lines will extend 3 km and require 12 pylons, with a span length of 6 m each. • The distribution lines will cover a total distance of 10 km and total footprint of 2 ha.
	Sewage: Located within the Contractors Camp	• Sewage treatment plant with 500 m³/day processing capacity to be expanded by another 500 m³/day capacity with construction of the Smelter Complex.

	Fuels and lubricants: Located within the contractor's camp
	Mine bulk storage tank farm is located
		Contractor's camp:
		• 50 m² bund area
		• Total storage of 100 m³ per day Lubricants:
		    ▪ 10 m² bund area
		    ▪ Total storage of 20 m³

Project Component	Master Layout Reference	Specification Detail
	adjacent to the Mine workshop area	• Bulk Storage tank farm • Tank Farm stores 500 m^3 of diesel • 2 500m^2 • 5 000L of lubricants in bunded area adjacent to Mine workshop area
Construction Camp	Just on the south side of the plant	A total area of 2 to 4 hectares, including the following facilities: • Workshop • Office complex • Truck yard and vehicle parking • Washing and servicing of equipment
Waste Management Facilities	Contractors' camp	Contractors employed to collect and dispose domestic and hazardous wastes. ● Domestic wastes: ○ Paper and plastics will be recycled ○ Disposed of at a registered landfill facility: Existing landfill facility ○ Industrial waste include steel, packaging material and material off-cuts ● Hazardous wastes: ○ Mainly oil contaminated wastes ○ Storage facility capacity: 0.5 ha ○ Disposed of at a registered hazardous landfill facility ○ Collected and disposed of once in a month • Total area of 100 m^2
Tailings Dam (TSF 1)	Located approximately 2 km north of the Gamsberg Inselberg, along the northern border of the N14.	• Final height of 70 m high • Cover a total area of 290 ha (both TSF 1 and TSF 2) • Total storage capacity of 132 million tonnes (Life of Mine) • The treatment of 10 mtpa ROM ore is expected to create 9 mtpa of tailings material (approximately 6.9 million m^3 of slurry containing approximately 4.5 million m^3 of water). • Tailings goes through thickener to reduce water content before being pumped into TSF

Project Component	Master Layout Reference	Specification Detail
		• Percolated water is reused in concentrating process via RWD • HDPE geomembrane liner (1.5mm) placed over 300 gsm nonwoven needle-punched geotextile, along the slopes and base of the TSF
Waste Rock Dump	Located on the North side of the Inselberg.	• Final capacity of 1.5 billion tonnes (Life of Mine) • Total final area of 490 ha • Total final height of 215 m • Waste rock slopes with an average slope angle of 35o
One Modular Sewage Plant	A Sewage treatment plant located near the Concentrator mineral processing plant.	• Processing capacity (design capacity) of 500 m^3 per day • It will service an expected workforce of 2 500 people • Treated effluent will be used for dust suppression and plantation • Sludge will be used in the rehabilitation purposes
Sewerage Collection sump	Near the Concentrator Plant.	• Expected to service mine work force of approximate 140 people • Total capacity of 70 m^3 (7 days storage) • Total area of 40 m^2
Treated Sewage Effluent Dam	Located near Sewage Treatment Plant.	• 7 day capacity • HDPE lined pond • Total depth of 4.5 m • Total height above ground is maximum 1.5 m • Total storage capacity of 1 200 m^3 • Total area of approximate 250 m^2
Salvage Yard	Located within the Plant.	• Total footprint of 750 m^2 • Total storage capacity of 1 800 m^3 for general wastes • Maximum height of 3 m

Project Component	Master Layout Reference	Specification Detail
Domestic Waste Facility	Located within the Plant.	• Total footprint of 100 m² • Total capacity of 150 m³ • Maximum height of 2 m • Waste to be disposed of at designated site
Temporary Hazardous Waste Management Facility	Located within the Plant.	• Storage capacity of 100 m³ • Total area of 150 m² • Maximum height of 2 m • All hazardous waste collected will be transferred to the Vissershoek hazardous waste disposal facility
Internal Haul and Mine Area Roads	All haul and mine area roads are shown on the site layout map.	• 10 km of internal haul and mine area roads • All haul roads, including the pit access road, is 45 m wide gravel road • All mine roads would be 10 m wide • Gravel road, compacted with surface material • Total footprint area of internal haul and mine area roads 55 ha • Surface material sourced from suitable overburden material and/or available burrow pits at Lemoenplaas
Plant Area Roads	Plant area roads are shown on the site layout map.	• 4 km of total plant area road • 6 m and 8 m wide, depending on function • The construction footprint of the plant roads is maximum 12 m wide • Total area of off-road parking 5 000 m² • Access tracks for inspection and maintenance: Total area of 1 000 m²
Material Laydown and Storage Area	Located within the Plant.	• Total area of 2 500 m²
Equipment and Engineering Workshops	Workshop one located within the Plant.	• Total area of 1 ha

Project Component	Master Layout Reference	Specification Detail
	Workshop two (heavy duty workshop) located between the process plant and waste rock dump sites.	• Total area of 1.5 ha
Ore Stockpiles	In-pit open stockpile area (prior to primary crushing).	• Total area of 1 ha • Maximum height of 4 m
	Open stockpile area located within the Plant	• Total area of 1 Ha.
	Pre-milling open stockpiles (High Grade, Low Grade and Blended) area located within the Plant.	• Total area of 1 ha each i.e. 3 ha in total • Maximum height of 20 m
	Zinc concentrate stockpile located within the Plant.	• Storage capacity of 7 days • Total area of 0.25 ha • Maximum stockpile height of 12 m • 50 m in length
Administrative Office Block	Located within the Plant.	• Total area of 1 500 m^2 • Maximum height of 12 m • Expected to contain more than 100 employees, working 7 days a week

Project Component	Master Layout Reference	Specification Detail
Control Rooms	Control room 1: Located within the Plant.	• Total area of approximately 300 m² • Maximum height of 12 m
Equipment Wash Area	Located within the Plant.	• Total area of 750 m² • 45 000 m³ of water will be required annually • The water will be sourced from the process water dam
Explosives Storage Area and Ammonium Nitrate and Emulsion Silos	Located on the north of Inselberg, in the plain area.	• Total area of 2 ha • Total height of 12 m
Parking Area	Located adjacent to the Plant.	• Total area of 5 000 m² • The material to tar the road will be sourced from waste rock / borrow pit • It will accommodate 300-350 vehicles
Stormwater Management Infrastructure	A Stormwater dam to be constructed adjacent to and south of the Plant and along the western foothills of the Inselberg.	• Total storage capacity will be 5 000 m³ • Dam will cover a total area of 1 000 m² • Wall height above ground of 3 m (Partially below ground)
Bulk Fuel Storage Tank Farms	Located adjacent to the mine workshop area (Fuel, oil & lubricant storage).	• Store 500 m³ of diesel • Total area of 2 500 m² • 6 re-fueling bays • 5 000 litres of lubricants • Total area of 1 000 m²

Project Component	Master Layout Reference	Specification Detail
Medical Clinic	Located within the Plant.	• Total area of 80 m^2 • Total height of 6 m • Result in production of medical waste of +- 6 kg per month
Internal Conveyor System	From the Primary crusher located at open pit to the northern face of the Inselberg up to the stockpiles.	• Closed system • Dimensions of conveyor (breath and width) are 2 m • Total length is approximately 2.5 km
Raw Water Storage Dam	Located within the Plant.	• Storage capacity of 25 000 m^3 • Wall height of 4.5 m • Source of water: Orange River, via the Pella Water Board water supply system (Pella Water Board Allocation)
Process Water Dam	Located within the Plant.	• A total number of 1 dam • Storage capacity of 25 000 m^3 • Wall height of 4.5 m • Sources of process water: recycled water from the plant, treated water and make-up water from raw water dam
Dust Suppression Tank	Located in the plain area adjacent to the plant.	• There will be one metallic/concrete tank • Storage capacity of 1 000 m^3 • Max height of 5 m • Source of water: raw water dam
Fire Control System	Water from raw water storage dam is pumped to a clean	• There will be a tank with a storage capacity of 2 000 m^3 • Wall height of 5 m • Source of water: raw water dam

Project Component	Master Layout Reference	Specification Detail
	water tank. From there it will be pumped to the fire hydrant pipe network.	
Return water dams	Located between the tailings dam and N14.	• Tailings Seepage Collection Sump
Entrance and Exit Points	Main entrance/exit point will be located along the southern border of the N14. Second entrance/exit point will be located along the western border of the Inselberg, leading onto the existing Loop 10 gravel road.	• Main entrance/exit point: Total width of 45 m; tar road. • Second entrance/exit: Total width of 15 m; compacted gravel road. • Surface material sourced from existing borrow pit located north of the Inselberg.
Security and induction training areas	Near the main entrance, along the southern border of the N14.	• Security single storey building, covering a total area of approx 120 m². • Induction training area covering a total area of approx 500 m².
2020 WUL Amendment Application Activities		
Smelter Complex		• Smelter Plant: conventional roast-leach-electro winning (R-L-E) process • Raw Material Handling & Storage: 680 000 tpa of zinc concentrate from the concentrator plant would be fed into the smelter • Roasting Plant: Two Roasters, two waste heat recovery boilers, two Steam Turbine Generators (STG), one

Project Component	Master Layout Reference	Specification Detail
		gas cleaning plant, one acid plant and acid loading section including acid storage tanks • Leaching area: (including calcine silo and manganese removal) to dissolve and to recover the zinc contained in the calcine • Purification section: hot purification for the removal of copper (Cu), cadmium (Cd), cobalt (Co) and nickel (Ni) as major impurities and the polishing step to ensure the required quality of the purified solution • Enrichment Plant: to recover as much of the zinc as possible from the hot purification filter press cake and to keep all other unwanted impurities in the cake • Gypsum removal section: to purge calcium from the electrolyte circuit and control the build-up of gypsum in the cell house and leaching plant equipment • Cell house: the zinc from the purified solution would be deposited as metallic zinc on the aluminium cathodes • Melting & casting: (including product storage) Cathode zinc from the cell house would be melted using three induction furnaces (one alloy furnace). Molten metal would be withdrawn from the furnaces by centrifugal pump to the continuous casting section • Zinc dust plant: to produce the zinc dust (fine and coarse) from zinc slabs, required at the purification plant. • Oxygen plant: A new Air Separation Unit (ASU) will be installed at the smelter complex for the supply of oxygen to the smelter, with new oxygen storage tanks for up to 1900 m^3 of liquid oxygen, used in the roaster and the manganese removal section. • Effluent Treatment Plant: salts/ ETP Cake to be dispatched to the secured landfill facility • Utility Services:
Pipeline and 10ML Reservoir		• A new aboveground 630 mm HDPE pipeline would be laid down from the Horseshoe Reservoirs to the proposed new 10 Ml reservoir to be placed within the smelter complex. The proposed new pipeline section will be approximately 7 km long
Secured Landfill Facility		• 21 ha • Includes pipeline from Horseshoe Reservoirs via new 630mm HDPE pipeline to the new 10ML reservoir over 7km.

Project Component	Master Layout Reference	Specification Detail
		• 15 years of disposal in cells
Laydown area		• 15 ha • Construction office and storage area south of proposed smelter complex
Business Partners camp		• 12 ha • worker's, supervisor's and manager's accommodation of temporary porta-cabin type
Sewage treatment plant		• Expansion of modular unit from 500 m^3/day to 1000 m^3/day
Change House, Canteen; Fire & first aid station		• Supporting facilities and staff safety.
2023 Proposed Activities		
Tailings Storage Facility: Phase 2	(Included in TSF total footprint described above)	• Class C, 1080 GSM geotextile, overlayed by 1.5mm HDPE geomembrane • Underdrains with leak detection
Return Water Dam: Phase 2		• 120 000 m^3 with each compartment having approximately 60 000 m^3 of storage capacity. • The RWD will be double lined with 1.5mm HDPE liner • A cuspated layer in between the liners with act as leakage detection and drainage layer • The cuspated layer feeds to two sumps at the southern ends of the compartments which can be drained with a pump
Silt trap		• Before the TSF decant water enters their respective RWD the water goes through a double silt trap with sluice gates to control water flow • Components of silt trap: Energy Dissipator, Decant Water Pipe, Hanging Wall within Energy Dissipator, Baffle Block, Sluice Gates (Dual), Channel Flow, Second Splitter Box

Project Component	Master Layout Reference	Specification Detail
Tailings slurry ringfeed system		• Each ringfeed pipeline branch system consists of the following components: • External ringfeed pipeline routed along the largest part of the external perimeter of the TSF, just outside of the solution trench outlining the TSF • Deposition valve stations installed at 407m intervals along the External ringfeed pipeline to allow for diversion of tailings through offtake riser pipework and for more operational flexibility for maintenance of the internal ringfeed pipeline • Internal ringfeed pipeline; each of the spigot offtakes is fitted with a cyclone station installation • Cyclone station installation
Tailings decant pipeline		• Return water will be decanted from the pool of the New Phase 2 TSF and transferred to the silt trap for of the New Phase 2 Return Water Dam (RWD), using a relocatable land-based pump system connected to a floating shallow water intake device which will float on the surface of the TSF pool. • Suction pipeline and pipe fittings connecting the shallow-water intake device with the pump unit. • Pump Unit: Dry self-priming pump with an electrical motor mounted on a skid (one duty and one standby pump unit). • Delivery pipeline and connecting pipe fittings, transferring return water to the RWD
Return water dam pump station and pipeline systems		• Water will be abstracted from the pool of the proposed Phase 2 RWD via new pump units and transferred via a two pipeline system (one number of duty pipeline and one number of assist pipeline in parallel) from the RWD to the tie-in point on the existing return pipeline transferring return water back to the existing Process Water Tank (PWT) at the plant. • Suction pipelines and pipe fittings abstracting water from the dam outlet structure sump constructed within the internal embankment of the RWD. • Pump units: Dry self-priming pump units, each consisting of an electrical motor mounted on a skid. • Delivery pipelines and connecting pipe fittings, transferring return water to the existing Process Water Tank (PWT)

2.4 Activity Life Description

Current LoM: 19 Years; estimated to be operational until 2040.

Table 10. Validity of Authorizations of the Gamsberg Mine:

Authorization	Date Issued	Date Expire
Gamsberg Zinc Mine WUL 14/D28C/ABCGIJ/2654	30 September 2014	30 Sept 2034
Gamsberg Zinc Mine WUL Amendment 14/D28C/ABCGIJ/2654	14 April 2016	
Water Use Registration for road upgrade and widening of existing road 27/2/2/D382/3/3	27 April 2019	Update of GN 509 of 2016 expected to allow for activities and monitoring to continue.
Water Use Gamsberg clean runoff attenuation system	26 September 2022	
NEM:WA Waste Licence No 12/9/11/L955/8	17 December 2013	
Environmental Authorisation NC/EIA/NAM/KHA/AGG/2012 NCP/EIA/0000155/2012	10 December 2014	
NHRA Approval Ref. 9/2/066/0001 Case No. 2215	15 May 2013	
EMPr 2000: NC-S 5/3/2/782	2 November 2000	Updated
EMPr 2003 Addendums: NCS 5/3/2/782 NCS 5/3/2/762 NCS 6/2/2/138 NCS 6/2/2/153	23 January 2003	Updated
EMPr Amendment: (NCS) 30/5/1/2/3/2/1/518 EM	31 March 2013	Updated
EMPr Section 102 Amendment: (NCS) 30/5/1/2/3/2/1/518 EM	22 March 2017	Latest approved
NEM:AQA AEL		
Mining Licence JM/FF 15/5/2000 ML5-2000	2 November 2000	
Biodiversity Permit: ODB 3513/2014 and ODB 3514/2014	2 July 2015	

2020 WUL Amendment Application:

Smelter Complex: Authorisation is required for a total life of the smelter (15 years), not including the 36 months for construction and commissioning.

2023 WUL Amendment Application:

TSF 2 and related infrastructure is expected to service the mine for the next 12 years (design life) and will be in place for the LoM.

2.5 Activity Infrastructure Description

Water Supply

Water is currently supplied to the mine by Sedibeng Water via two existing pipelines from the Orange River. The existing water system has a common intake, low lift pump house and low lift pipeline. The low lift pumping system is feeding two circuits, namely the Black Mountain Mine circuit and the Gamsberg Zinc Mine circuit. Both the circuits consist of a flash mixer, clarifier, dosing system, sludge handling facility, balancing reservoir, high lift pump house, high lift pipelines and Horseshoe Reservoir with associated facilities. The current and future water demand, within the Black Mountain Mine operation, including Aggeneys, Pofadder and Pella towns is 43.45 ML/day, the existing intake water pumping system has been designed for 40.8 ML/day.

The existing bulk water pipeline infrastructure running from the Horseshoe Reservoir to the Gamsberg take-off covers a distance of approximately 4 km and consists of one 400 mm diameter underground pipeline and one 400 mm aboveground pipeline. A 400mm HDPE diameter aboveground bulk water pipeline runs from the Gamsberg take-off where the pipeline splits off from the Main Bulk Water Pipeline to the Gamsberg reservoir(25Ml) over a distance of 3km (SLR Consulting, 2020).

Plant Water System

Water received from Horseshoe Reservoir (as supplied from Sedibeng Water) would be treated with sodium hydrochloride in the new water treatment plant located on the north west side of the smelter complex. Water would be conveyed from Horseshoe Reservoir by a gravity fed pipeline. The water treatment begins in the Clarified Water Reservoir, which would be a concrete reservoir of approximate 10 ML capacity (equivalent to one day's water requirement). The various water supply and treatment components of the smelter complex are further described in Table 11.

Table 11. Plant Water System (SLR, 2021)

Water System	Water System Description
Make Up Water System	It is envisaged that the makeup water for the process plant would be taken from the Clarified Water Reservoir.
Cooling Water System	Four separate cooling water circuits (CT-1, CT-2 & CT-3) for roaster-1and roaster-2 and the CT-4 circuit for melting, casting. purification and other miscellaneous areas have been considered. The cooling water recirculation circuit would consist of a cooling tower, cold water basin; cooling water feed pumps and other necessary arrangements.
Demineralised Water System	Demineralised (DM) water is required for the Waste Heat Recovery Boiler. The DM water unit would consist of an ultra-filtration module, cartridge filter, reverse osmosis (RO) module, degasser unit, mixed bed filter, necessary pumps and intermittent storage tanks. The DM water unit would be fed water from the plant filter water reservoir.
Potable Water System	The potable water system would consist of a dual media filter, filtered water storage tank, sodium hypochlorite dosing system for disinfection and two drinking water supply pumps. Potable water would be supplied via pumps and piping network for use in the ablutions, for drinking, washing and other uses in the office, canteen and kitchen as well as for use in safety showers.

Water System	Water System Description
Fire Water System	A dedicated 3 ML storage tank would be kept in the plant site storage reservoir for the fire water system. The fire water system would be provided with pumps, piping network and other associated facilities as per the appropriate National Fire Protection Association (NFPA)/ South African National Standards (SANS) codes. An external fire hydrant system would be provided around all buildings/ facilities. Internal hydrants would also be provided for multi-storied buildings and basements. An Automatic High Velocity Water Spray (HVWS) system would be provided to protect large oil filled transformers. Generally, the oil filled transformers with a capacity of 10 MVA and above or oil storage capacity of more than 2 000 litres would be protected by a HVWS system. A Medium Velocity Water Spray (MVWS) system would be provided for hydraulic/lubricating oil cellars and major cable vaults in electrical buildings. Water-based automatically activated medium expansion foam-based protection systems would be provided for oil storage tanks. An inert gas flooding system would be provided for server rooms/ PLC rooms/ battery rooms and chemically corrosive areas. Portable fire extinguishers would be provided inside all buildings.

Water Demand

The current water demand, with the Black Mountain Mine operation and Phase 1 concentrator plant at Gamsberg, is 28 ML/day, the existing intake water pumping system has been designed for 40.8 ML/day.

Water required for the Gamsberg Smelter Project, would include water for the process plant, drinking, sanitation and other miscellaneous uses such as the canteen, safety showers, etc. The individual water demand for the various consumers, the existing Gamsberg Zinc Mine activities including the concentrator plant as well as the proposed smelter complex and all associated activities is presented in **Figure 9**. The figures indicated for the towns of Aggeneys, Pofadder and Pella have considered the increased demand due to the existing and future developments, including the Phase 2 expansion of the Gamsberg Zinc Mine concentrator plant and the Gamsberg Zinc Smelter (SLR, 2021). No additional use for TSF 2 is required.

Table 12. Demand in ML/Day for Existing and Proposed Plant (SLR, 2021)

Consumers	Black Mountain Mine Operations		Gamsberg Operations		
	1.6 MTPA (Existing)	2.0 MTPA (Future)	Concentrator - 1 (Existing)	Concentrator - 2 (Future)	Smelter - 1 (This Project)
Plant	3	0.5	7	6	8
Mining	3	0.5	2	1.5	-
Aggeneys town	4	-	0.75	0.6	1.5
Pofadder town	1	-	-	0.2	0.5
Pella town	3	-	-	0.2	0.2
Total average	14	1	9.75	8.5	10.2
Total Cumulative	14	15	24.75	33.25	43.45

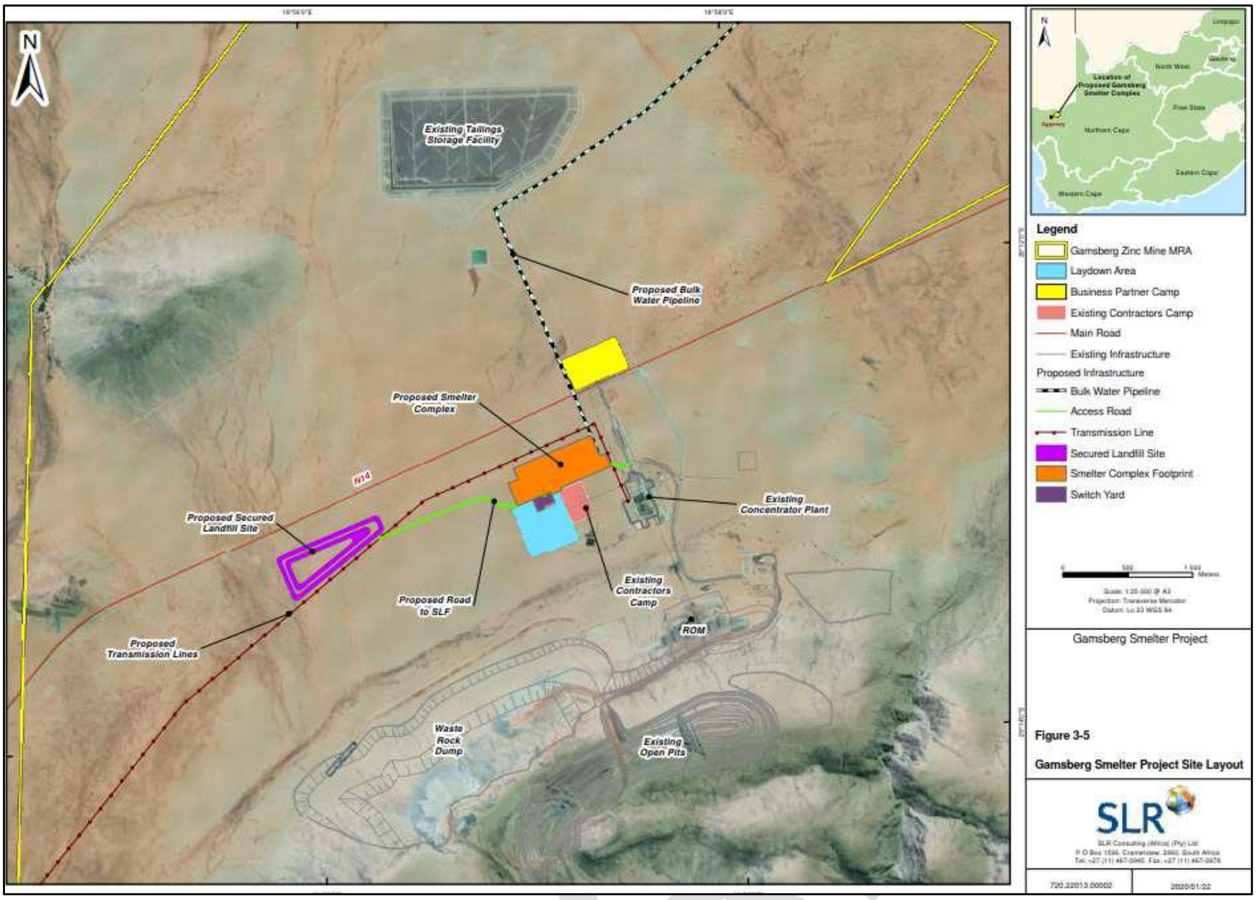


Figure 4. Gamsberg Smelter Project Site Layout showing proposed bulk water pipeline (SLR, 2021)

Stormwater Management

Stormwater management plans for the quarry, Tailings Storage Facility (TSF) and Waste Rock Dump (WRD), portions of the ROM stockpile as well as the Plant and roads are in place. There are existing stormwater toe drains around TSF Phase 1. New stormwater toe drains around TSF Phase 2 have been sized, and these drains flow into the existing toe drains and terminate into the Stormwater Dam (SWD). The Storm Water Dam (SWD) is located to the south of the Phase 1 TSF and has three compartments that are interconnected. Stormwater diversion berms prevent runoff from entering the mine pits as far as possible. Sediment traps have been constructed in the "Kloof" outside the mining area to capture sediment so that it does not enter the Kloof. Runoff from the WRD drains into a stormwater channel and ultimately into a lined Stormwater Dam (referred to as the WRD PCD) for reuse in the Processing Plant. The Plant PCD and Stormwater Dam are designed to collect dirty stormwater runoff from the Processing Plant area; it either evaporates or is returned to the Processing Plant for reuse under normal (design) operating conditions. Stormwater management infrastructure is required at the crushed ore stockpile and the ROM stockpile extension (SRK, 2022).

The three principle sections of Regulation 704 (4 June 1999) that are applicable to the stormwater management of the proposed project include:

- Condition 5 - indicates that no residue or substance which causes or is likely to cause pollution of a water resource may be used in the construction of any dams, impoundments or embankments or any other infrastructure which may cause pollution of a water resource.
- Regulation 6 - describes the capacity requirements of clean and dirty water systems. Clean and dirty water systems must be kept separate and must be designed, constructed, maintained, and operated such that these systems do not spill more than once in 50 years.

- Regulation 7 - requires that measures must be taken to protect water resources from all dirty water or substances which cause or are likely to cause pollution of a water resource either through natural flow or by seepage.

Diversion of clean and dirty water

Any dirty run-off collected from the smelter complex, the secured landfill facility or associated roads and other infrastructure would be collected in a series of open channels and circular culverts that would divert any dirty water to the respective pollution control dams. The clean and dirty water catchment areas were delineated and classified according to the expected quality of the stormwater runoff which is expected to be generated from each catchment, where:

- Clean water catchment areas include the areas upstream and to the north east of the smelter complex and secured landfill facility; and
- Dirty water catchment areas include the smelter complex and secured landfill facility. Most of the dirty water catchment within the smelter complex will be paved.

Two Pollution Control Dams (PCDs) were designed, one at the smelter complex and one at the secured landfill facility (SLR, 2020b).

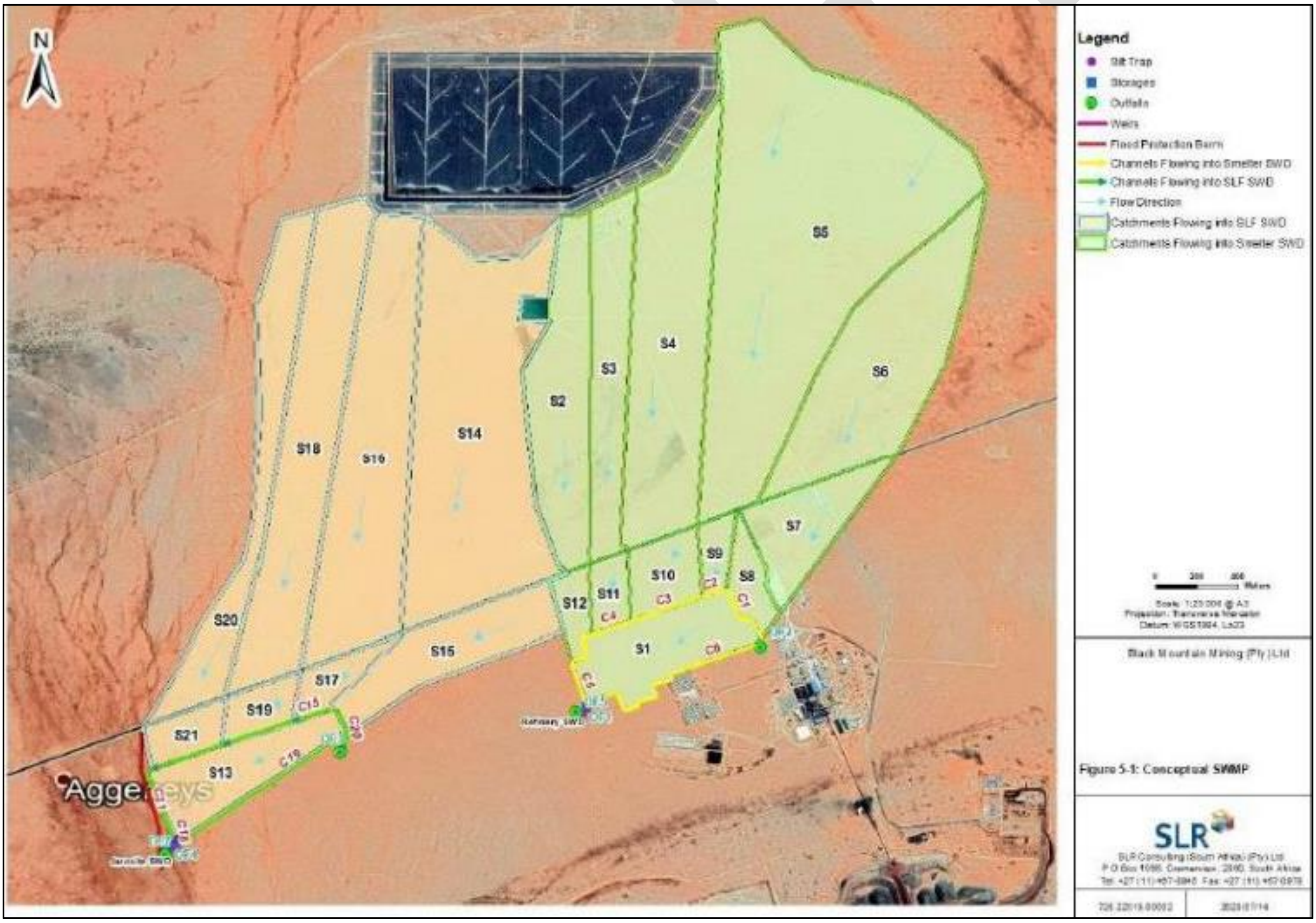


Figure 5. Sub-catchments and Proposed Storm Water Infrastructure Layout associated with the Smelter Project (SLR, 2020b).

River diversion (Golder, 2022e).

An attenuation weir will collect the runoff emanating from sub-catchment (S1_2.). The attenuation weir will then release the flow into HDPE pipelines via a decant system. Water will thereafter be discharged downstream directly into the natural river (environment). The river will also collect runoff generated from sub-catchment (S1_1).

Clean water diversion channel north of TSF 2 (Knight Piésold, 2023b)

A new clean water diversion channel is required in to divert clean water runoff coming from the north around the TSFs. The design flow for the channel was calculated from the Rational Method as 4.65 m³/s which gave a trapezoidal channel size of bottom width of 2 m, with side slopes of 1:2.5 and a depth of 1 m. Since the site has a general fall from north to south the channel was given a longitudinal slope of 1:250 and the channel flows from the east to the west before turning south to follow the natural ground. Due to the topography the channel starts at a depth of 1 m at the inlet of the channel and reaches a depth of 2.88 m at the bend where the channel turns south and is sloped in order to daylight to the environment.

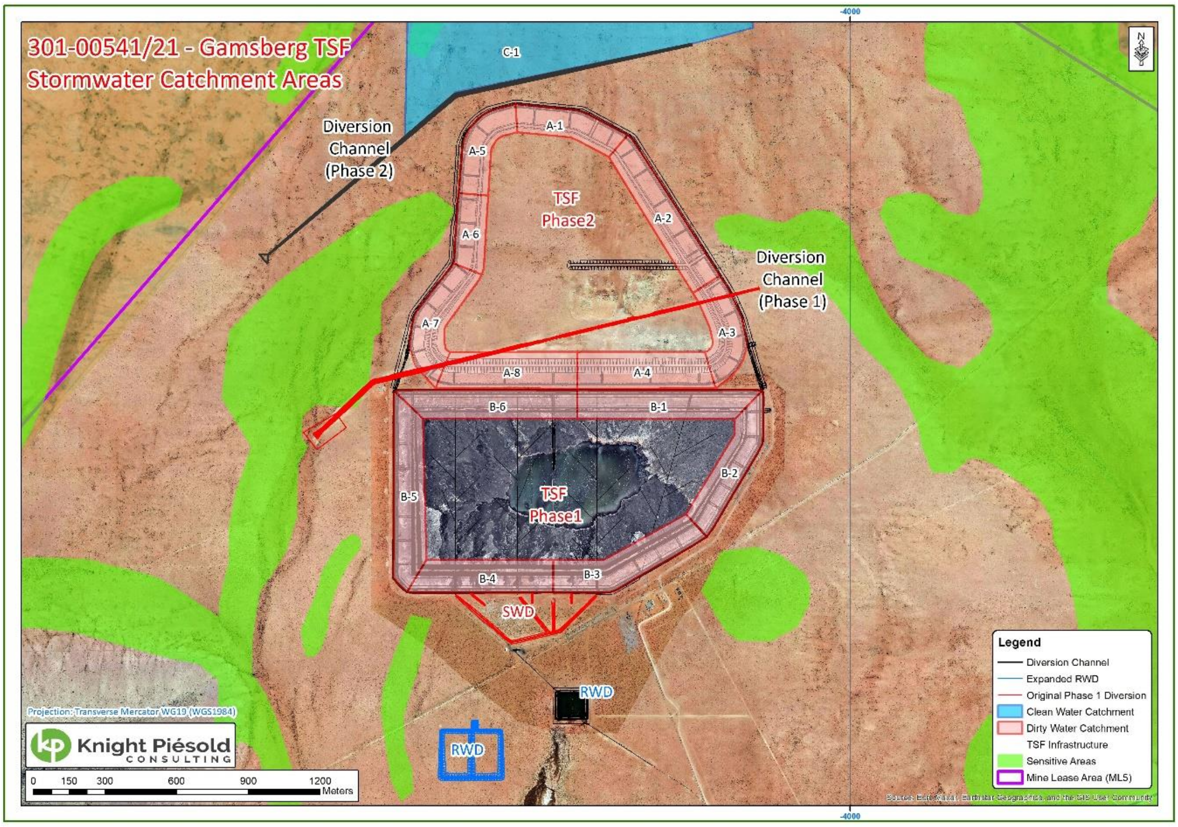


Figure 6. Stormwater diversion channels (existing – Phase 1; and proposed - Phase 2)

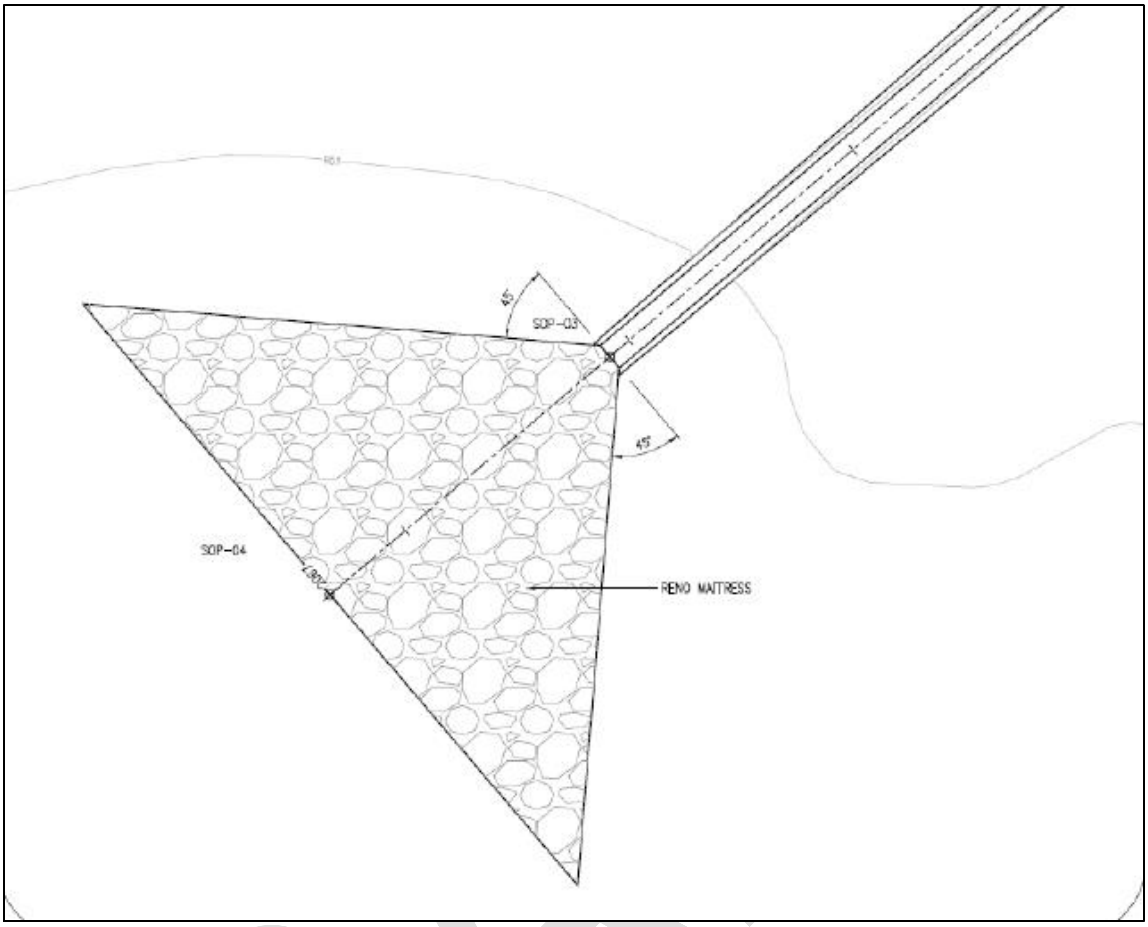


Figure 7. Outlet of clean water diversion channel.

Stormwater Dam (Knight Piésold, 2023b)

The Storm Water Dam (SWD) is located to the south of the Phase 1 TSF and has three compartments that are interconnected. The SWD water balance model considers stormwater inflows and direct rainfall against evaporation losses and a daily abstraction rate and estimates the volume of water in the SWD for each day of the simulation. The abstraction rate from the SWD will need to be pumped out at 4 800m^3/day or 200m^3/hour. A freeboard of 0.8 m should be provided above full supply level

Stormwater Toe Drains (Knight Piésold, 2023b)

New stormwater toe drains around TSF Phase 2 have been sized, and these drains flow into the existing toe drains and terminate into the Stormwater Dam (SWD).

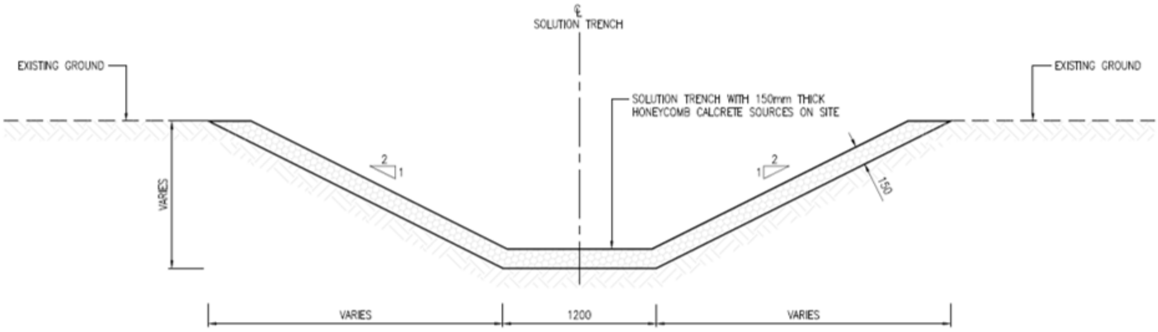


Figure 8. Cross section of stormwater drains around TSF 2

2.6 Key Water Uses and Waste Streams

2.6.1 Water Uses

According to the updated IWWMP undertaken by Golder (2019) a number of water uses take place at Gamsberg and these have been authorised in terms of the Gamsberg Zinc Mine WUL, Licence No.14/D82C/ABCGIJ/2654, dated 30 September 2014 and its subsequent amendment dated 14 April 2016.

As per the Gamsberg WUL and its subsequent amendment, the following water uses are taking place onsite:

- Section 21(b) of the Act: Storing Water;
- Section 21(c) & (i) of the Act: Impeding or diverting the flow of water in a watercourse;
- Section 21(i) of the Act: Altering the beds, banks, course or characteristics of a watercourse;
- Section 21(g) of the Act: Disposing of waste in a manner which may detrimentally impact on a water resource, and
- Section 21(j) of the Act: Removing, discharging or disposing of water found underground if it is necessary for the efficient continuation of an activity or for the safety of people.

Black Mountain Mining (Pty) Ltd is in the process of updating the 2016 WUL to include additional water uses. The existing and approved water uses, and the proposed additional water uses to be authorised as a result of the proposed construction and operation of the Gamsberg Smelter Project are outlined in the tables below.

Table 13. WUL 2014 & 2016 Approved Water Uses for the Gamsberg Zinc Mine (updated from SLR, 2021 and 2016 Amendment WUL)

Infrastructure	Detail	Capacity, Dimensions & Volume (m^3/annum, m^3 or tonnes/annum)	Area/length of infrastructure (ha)/(km)	Property	Water Use Map Reference	Coordinates
Section 21 (b) – Storage of water						
Storage of water	Storage of water from Pella Drift Water Board into the Raw Water Storage Dam	• 6 734 322 m^3 per annum Capacity = 25 000m^3		Portion 1 and 4 of Gams 60	1	S29º 12' 59" E18º 57' 38.7"
	Storage of water from Pella Drift Water Board into the Process Water Dam	• 2 375 058m^3 Capacity = 2 000m^3		Remaining Extent of the Farm Aroams 57	2	S29º 13' 1.4'' E18 º 57' 33.9''
Section 21(c) - Impeding or diverting the flow of water in a watercourse, and Section 21(i) - altering the bed, banks, course or characteristics of a watercourse						
Location of pipeline within regulated area of watercourse	Location of the pipeline within 100m of the flood line or the 1:50 year flood line buffer of drainage lines	• Length: 250m • Breath: 2m	N/A	Remaining Extent of Farm Aroams 57	3	S29º 14' 44.9" E18º 58' 34.9''
Location of pipeline within regulated area of watercourse	Location of the pipeline within 100m of the flood line or the 1:50 year flood line buffer of drainage lines	• Length: 250m • Breath: 2m	N/A	Remaining Extent of Farm Aroams 57	18	S29°14'44.91" E18°56'38.40" S29°13'56.14" E18°58'17.3" S29°14'59.65" E18°59'40.55" S29°15'58.45" E18°58'28.44"
Locality of open cast pit within	Locality of open cast pit within 1:50 year flood line buffer of drainage	N/A	N/A	Portion 1 and 4 of Farm Gams 4	4	S29º 14' 19'' E22º 56' 28.2''

Infrastructure	Detail	Capacity, Dimensions & Volume (m³/annum, m³ or tonnes/annum)	Area/length of infrastructure (ha)/(km)	Property	Water Use Map Reference	Coordinates
1:50 year flood line buffer of drainage lines	lines					
Locality of tailings within 100m of the flood line or 1" 50-year flood line buffer of drainage lines.	Locality of tailings within 100m of the flood line or 1" 50-year flood line	N/A	N/A	Remaining Extent of Farm Aroams 57	5	S29º 12' 55.9'' E18º 56' 28.2''
Locality of Tailings Storage Facility and associated Seepage Collection Pond within 1 00m of the flood line or 1 :50 year flood line buffer of drainage lines	1:50 year flood line buffer			Remaining Extent of Farm Aroams 57	5 amended	S29° 11' 23.40" E18° 56' 20.05" S29° 09' 58.7" E18° 56' 58.86" S 29° 1 0' 54.38" E18° 58' 39.36" S29° 12' 17.12" E18° 57' 37.71"

Infrastructure	Detail	Capacity, Dimensions & Volume (m³/annum, m³ or tonnes/annum)	Area/length of infrastructure (ha)/(km)	Property	Water Use Map Reference	Coordinates
Location of Mine demarcation fence within 100m of the flood line or1:50 year flood line buffer of drainage lines	Location of Mine demarcation fence within 100m of the flood line Or 1:50-year flood line buffer of drainage lines	N/A		Remaining Extent of Farm Aroams 57 Portion 1 and 4 of Farm Gams 4 Potion 1 of Farm Bloemhoek 61	6 (not indicated on layout, no coordinate s available)	Indicated as "various points" in WUL & SLR, 2021.
Location of Mine demarcation fence within 100m of the flood line or1:50 year flood line buffer of drainage lines	1:50-year flood line buffer			Remaining Extent of Farm Aroams 57, Portion 1 and 4 of Farm Gams 60, Potion 1 of Farm Bloemhoek 61	6 amended	Indicated as "various points" in WUL
Location of Magazine Area within 1 00m of the flood line or 1 :50 year flood	Within 100m of flood line			Remaining Extent of Farm Aroams 57	19	S29°12'50" E18°57'58" S29°12'50" E18°58'05" S29° 12'56"

Infrastructure	Detail	Capacity, Dimensions & Volume (m³/annum, m³ or tonnes/annum)	Area/length of infrastructure (ha)/(km)	Property	Water Use Map Reference	Coordinates
line buffer of drainage lines						E18° 57'58" S29°12'56" E18°58"05"
Location of Plant Area within 1 00m of the flood line or 1 :50 year flood line buffer of drainage lines	Within 100m of flood line			Remaining Extent of Farm Aroams 57	20	S29° 12'53" E18°57'07" S29° 12'43" E18° 57'32" S29°13'15" E18° 57'19" S29°13'04" E18°57'46"
Section 21 (g)-disposing of waste in a manner which may detrimentally impact on a water resource						
Disposal of slimes into the Tailings Facility 1	Disposal of slimes into the Tailings Facility 1	• 69 473.6t/a	280ha	Remaining Extent of Farm Aroams 57	7	S29º 12' 52.6'' E18º 56' 23.4''
Disposal of wastewater into Seepage Collection Pond (Pollution Control Dam)	Disposal of wastewater into Seepage Collection Pond (Pollution Control Dam)	• 1 825m³/a	• 0.5ha	Remaining Extent of Farm Aroams 57	8	S29º 12' 04.74'' E18º 56' 25.5"

Infrastructure	Detail	Capacity, Dimensions & Volume (m³/annum, m³ or tonnes/annum)	Area/length of infrastructure (ha)/(km)	Property	Water Use Map Reference	Coordinates
Disposal of waste rock into Waste Rock Dump Facility	Disposal of waste rock into Waste Rock Dump Facility	• 78 947 368.4t/a	• 490ha	Remaining Extent of Farm Aroams 57	9	S29º 15' 14.7'' E18º 56' 04.6"
Disposal of dirty storm water generated from Waste Rock Dump into PCD 1	Disposal of dirty storm water generated from Waste Rock Dump into SWD 1	• 1 825m^3/a	• 0.5ha	Remaining Extent of Farm Aroams 57	10	S29º 14' 06.7'' E18º 55'48.1"
Disposal of domestic sewage into the Sewage Sludge Collection Sump	Disposal of domestic sewage into the Sewage Sludge Collection Sump	• 70m^3 • 178 850m^3/a		Remaining Extent of Farm Aroams 57	11	S29º 13' 24.4'' E18º 57' 55.2"
Disposal of Treated Sewage Effluent into the Dam	Disposal of Treated Sewage Effluent into the Dam	• 219 000m^3/a • 1 150m^3		Remaining Extent of Farm Aroams 57	12	S29º 13' 09.6'' E18º 57' 26.0"

Infrastructure	Detail	Capacity, Dimensions & Volume (m³/annum, m³ or tonnes/annum)	Area/length of infrastructure (ha)/(km)	Property	Water Use Map Reference	Coordinates
Disposal of dirty stormwater into the Salvage Yard Stormwater Dam	Disposal of dirty stormwater into the Salvage Yard Stormwater Dam	• 1 800m³/a	• 0.5ha	Remaining Extent of Farm Aroams 57	13	S29º 13' 10.3'' E18º 57' 24.3"
Disposal of wastewater into the Wash Bay Collection Sump	Disposal of wastewater into the Wash Bay Collection Sump	• 45 000m³/a	• 750m²	Remaining Extent of Farm Aroams 57	14	S29º 13' 25.5'' E18º 58' 06.3"
Dust suppression around plant area and roads using water recovered from mine pit	Dust suppression around plant area and roads using water recovered from mine pit	• 301 695m³/a	N/A	Remaining Extent of Farm Aroams 57 Portions 1 and 4 of Gams 60 Portion 1 of Bloemhoek 61	15 (not indicated on layout, no coordinates available)	Indicated as "various properties" in WUL & SLR, 2023
Dust suppression on haul road using effluent	Dust suppression on haul road using effluent water	• 219 000m³	N/A	Remaining Extent of Farm Aroams 57 Portions 1 and 4 of Gams 60 Portion 1 of Bloemhoek 61	16 (not indicated on layout, no coordinate	Indicated as "various properties" in WUL & SLR, 2023

Infrastructure	Detail	Capacity, Dimensions & Volume (m³/annum, m³ or tonnes/annum)	Area/length of infrastructure (ha)/(km)	Property	Water Use Map Reference	Coordinates
water					s available)	
Disposal of dirty storm water generated from Waste Rock Dump into PCD 2		1 825 m^3/a 0.5 ha			21	S29°14' 54.80" E18° 55' 04.26"
Disposal of waste water into the Pit Area		Capacity 20 $000m^3$		Gams 60 Portion 1 & 4	22	S29° 14' 33.8" E18° 57' 40.6"
Disposal of wastewater into Plant Storm Water Dam		Capacity: 5 $000m^3$		Remaining Extent of Farm Aroams 57	23	S29° 13'11" E18 27 26
Disposal of wastewater into Process water dam				Remaining Extent of Farm Aroams 57	24	S29° 13' 02" E18° 57' 35"
Section 21 (j): removing, discharging or disposing of water found underground if it is necessary for the efficient continuation of an activity or for the safety of people						
Pit dewatering for the efficient continuation of mine operations	Pit dewatering for the efficient continuation of mine operations	• 301 $695m^3/a$		Portions 1 and 4 of Gams 60	17	S29º 14' 33.8" E18º 57' 40.6''

Table 14. WUL Amendment Application 2020 Additional Water Uses – Gamsberg Smelter Project

Infrastructure	Detail	Capacity, Dimensions & Volume (m^3/annum, m^3 or tonnes/annum)	Area/length of infrastructure (ha)/(km)	Property	Water Use Map Reference	Coordinates
Section 21 (b) - Storing water						
Construction of a 10 ML reservoir.	The Gamsberg Smelter Project will require the construction of a 10ML reservoir for the operations of the smelter complex.	Capacity:10ML or 10 000 m^3 Dimension: 58 m x 58 m =3 364 m^2	0.002 ha (20 m^2)	Remaining Extent of Farm Aroams 57	26	S29º12'52.10" E18º57'15.27"
Installation of a 2000 m^3 firewater tank at the smelter complex.	The Gamsberg Smelter Project will require the construction of a 2 000 m^3 firewater Tank for the operation of the smelter complex.	Capacity: 2 000 m^3 Dimension: wall height- 5 m (source raw water dam)	0.001ha (10 m^2)	Remaining Extent of Farm Aroams 57	27	S29º12'52.10" E18º57'15.27"
Section 21(c) -Impeding or diverting the flow of water in a watercourse, and **Section 21(i) - altering the bed, banks, course or characteristics of a watercourse**						
Construction of linear infrastructure within a 1:100-year flood line of a drainage line.	Construction of the new pipeline from Horseshoe reservoir and associated watercourse crossings	• Pipeline: 8ML/day or • 8 000 m^3/day or 2 920 000 m^3/annum • Above ground 630 mm HOPE pipeline	• 7km	• Remaining Extent of farm Aroams 57	28	Start S29º10'23.118" E18º58'57.11" Middle S29 º58'20.908" E18º10'51.123" End S29º11'20.689" E18º57'42.487" Start S29º12'19.892" E18º57'8.949" Middle S29º12'21.236" E18º57'9.557"

Infrastructure	Detail	Capacity, Dimensions & Volume (m³/annum, m³ or tonnes/annum)	Area/length of infrastructure (ha)/(km)	Property	Water Use Map Reference	Coordinates
						End S29º12'22.723" E18º57'10.202"
	The Gamsberg smelter Project will require the construction of a new road to connect the smelter complex and the secured landfill facility as well as crossings for the return water pipeline from the secured landfill facility to the smelter complex. Associated watercourse crossings will be required.	• Length of crossing approx. 40m • Width of crossing approx. 13m	• Access Road: 13m wide and up to 1.5km long	• Access Road: Remaining Extent of Farm Aroams 57	29	Start S29º13'1.509" E18º56'54.838" Middle S29º13'0.609" E18º56'52.349" End S29º12'59.71" E18º56'49.861"
Location of the secured landfill facility and associated flood protection berm	The proposed SLF and flood protection berm are located within a 1: 100-year flood line of a drainage line.	382 800 m³/annum	• 21ha	• Remaining Extent of Farm Aroams 57	30	S29º13'13.846" E18º55'49.782" Start S29º13'13.145" E18º55'48.753" Middle S29º13'18.202" E18º55'50.783" End S29º13'23.482" E18º55'53.392"

Infrastructure	Detail	Capacity, Dimensions & Volume (m³/annum, m³ or tonnes/annum)	Area/length of infrastructure (ha)/(km)	Property	Water Use Map Reference	Coordinates
Location of Business Partner camp	The proposed Business Partner camp is located within a 1:100- year flood line of a drainage line.	N/A	• 12 ha	• Remaining Extent of Farm Aroams 57	31	S29º12'25.549" E18º57'12.116"
Location of the laydown area	The proposed laydown area is located within a 1:100-year flood line of a drainage line.	N/A	• 15 ha	Remaining Extent of Farm Aroams 57	32	S29º13'2.372" E18º56'56.154"
Location of the smelter complex	The proposed smelter complex is located within a 1:100-year flood line of a drainage line.	10.2ML/day	• 22 ha	Remaining Extent of Farm Aroams 57	33	S29º12'56.075" E18º56'55.639"
Section 21 (g)-disposing of waste in a manner which may detrimentally impact on a water resource						
Construction and operation of a new secured landfill facility (SLF)	The Gamsberg Smelter Project will require the construction and operation of a SLF for the disposal of Jarofix and ETP cake which has the potential to leach into underground water sources.	382 800 m³/annum	• 21 ha	Remaining Extent of Farm Aroams 57	34	S29º13'11.90" E18º56'5.07"
Jarosite SWD	Dirty storm water collected in the secured landfill facility sub-catchment will collect in the Jarosite SWD.	Capacity: 15 000 m³ total Dimension: 0.5 ha	• 0.5 ha	Remaining Extent of Farm Aroams 57	35	S29º13'23.225" E18º55'55.104"
Refinery SWD	Dirty storm water collected in the smelter complex sub-catchment will collect in the Refinery SWD.	Capacity: 18 000 m³ total	• 0.6 ha	Remaining Extent of Farm Aroams 57	36	S29º13'2.206" E18º56'57.452"

Infrastructure	Detail	Capacity, Dimensions & Volume (m³/annum, m³ or tonnes/annum)	Area/length of infrastructure (ha)/(km)	Property	Water Use Map Reference	Coordinates
Sewage Treatment Plant		Capacity: Increase by 500 m³ /day to a total of 1 000 m³ /day	• 0.5 ha	Remaining Extent of Farm Aroams 57	37	S29º13'10.22" E18º55'27.08"

Table 15. WUL Amendment Application 2023 Additional Water Uses – Gamsberg TSF 2 Project

Infrastructure	Detail	Capacity, Dimensions & Volume (m³/annum, m³ or tonnes/annum)	Area/length of infrastructure (ha)/(km)	Property	Water Use Map Reference	Coordinates
Section 21(c) -Impeding or diverting the flow of water in a watercourse, and Section 21(i) - altering the bed, banks, course or characteristics of a watercourse						
Removal of diversion channel north of TSF 1	Currently in proposed TSF 2 footprint; new channel not in regulated area	N/A	20 22m		38 - 39	Start: 29°11'22.42"S 18°56'9.13"E End: 29°11'2.36"S 18°57'17.95"E
Section 21 (g)-disposing of waste in a manner which may detrimentally impact on a water resource						
TSF 2 Facility (coordinates includes entire TSF complex)	Class C, 1080 GSM geotextile, overlayed by 1.5mm HDPE geomembrane	32 000 000	116 ha	RE of Aroams 57	40 - 45	a: 29°11'43.32"S 18°56'21.12"E b: 29°11'15.08"S 18°56'21.03"E c: 29°10'40.24"S 18°56'34.26"E d: 29°10'40.38"S 18°56'53.48"E e: 29°11'16.62"S 18°57'23.67"E f: 29°11'43.06"S 18°57'4.67"E

Infrastructure	Detail	Capacity, Dimensions & Volume (m³/annum, m³ or tonnes/annum)	Area/length of infrastructure (ha)/(km)	Property	Water Use Map Reference	Coordinates
RWD with silt trap for TSF 2	Double lined with 1.5mm HDPE liner, a cuspated layer in between the liners with act as leakage detection and drainage layer Silt trap: Reinforced Concrete lined with railway tracks	RWD: 120 000 Spillway: 10 x 2 x 0.8m depth	Double silt trap measuring 25 m x 15 m x 1.5 m deep with a drying bed measuring 25 m x 4.7 m wide		46	29°12'5.93"S 18°56'33.27"E
Disposal of slimes into TSF 2	From Plant	510 /hr	N/A		47	29°10'59.84"S 18°56'48.79"E
Disposal of wastewater into RWD	Percolating water from PCD	340 /hr	N/A		46	29°12'5.93"S 18°56'33.27"E
Pipelines for disposal into TSF 2 and RWD	Duty and standby pipelines; transferring return water back to existing Process Water Tank at Plant	DN300 Sch. Steel with 10mm HDPE lining DN355 PE 100 PN16	7500m 3155m		48 - 53	a: 29°12'39.77"S 18°57'21.04"E b: 29°12'19.77"S 18°57'11.94"E c: 29°12'9.69"S 18°56'32.80"E d: 29°11'43.18"S 18°56'59.79"E e: 29°11'16.99"S 18°57'19.75"E f: 29°10'39.15"S 18°56'53.57"E

The figures below show the 2014(•) and 2016(•) WUL authorized uses, as well as the 2020 (•) WUL amendment application uses and the newly proposed uses of 2023(•).

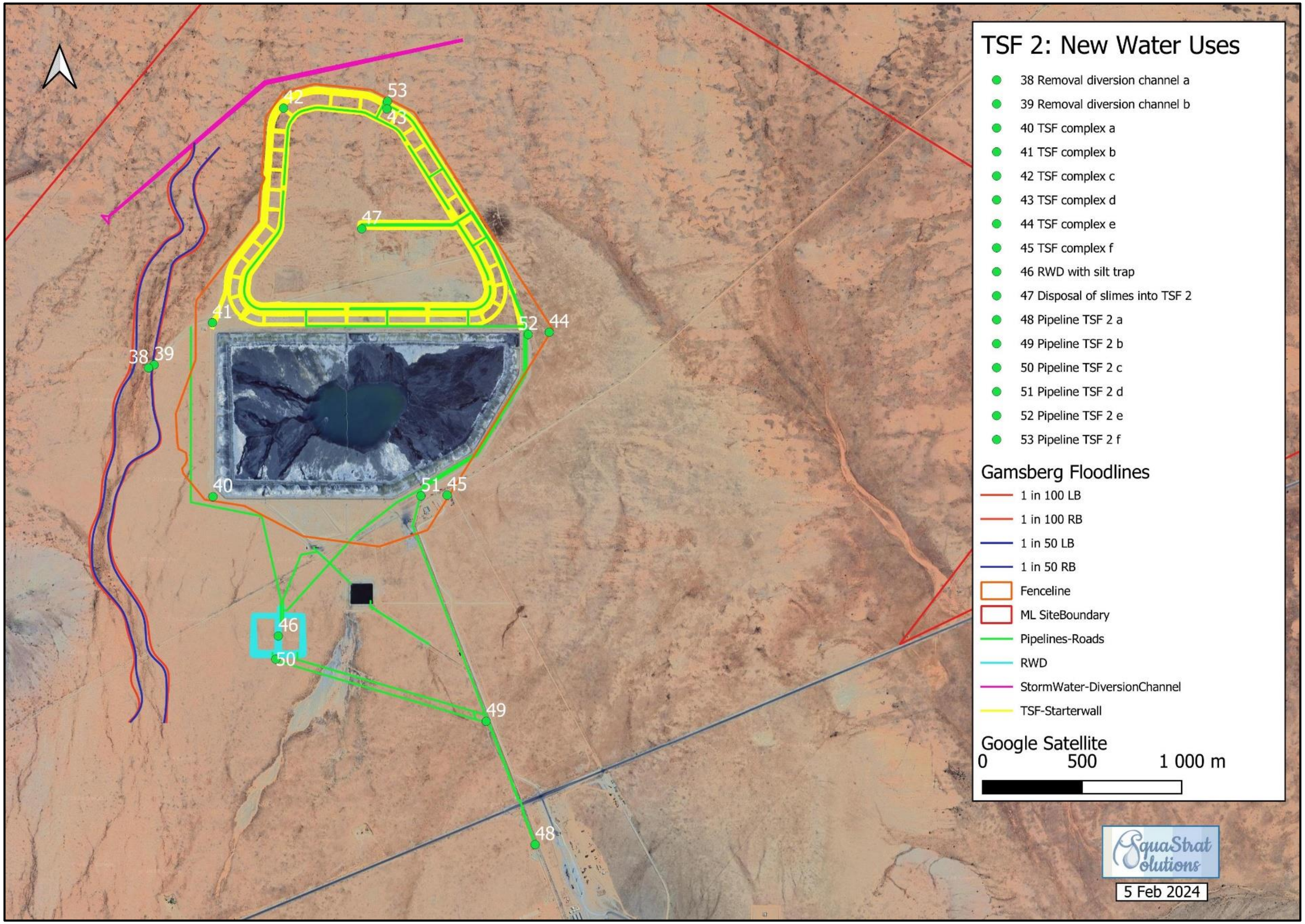


Figure 9. Proposed Water Uses for the Gamsberg TSF 2 Project (2023) showing the WUL approved TSF footprint.

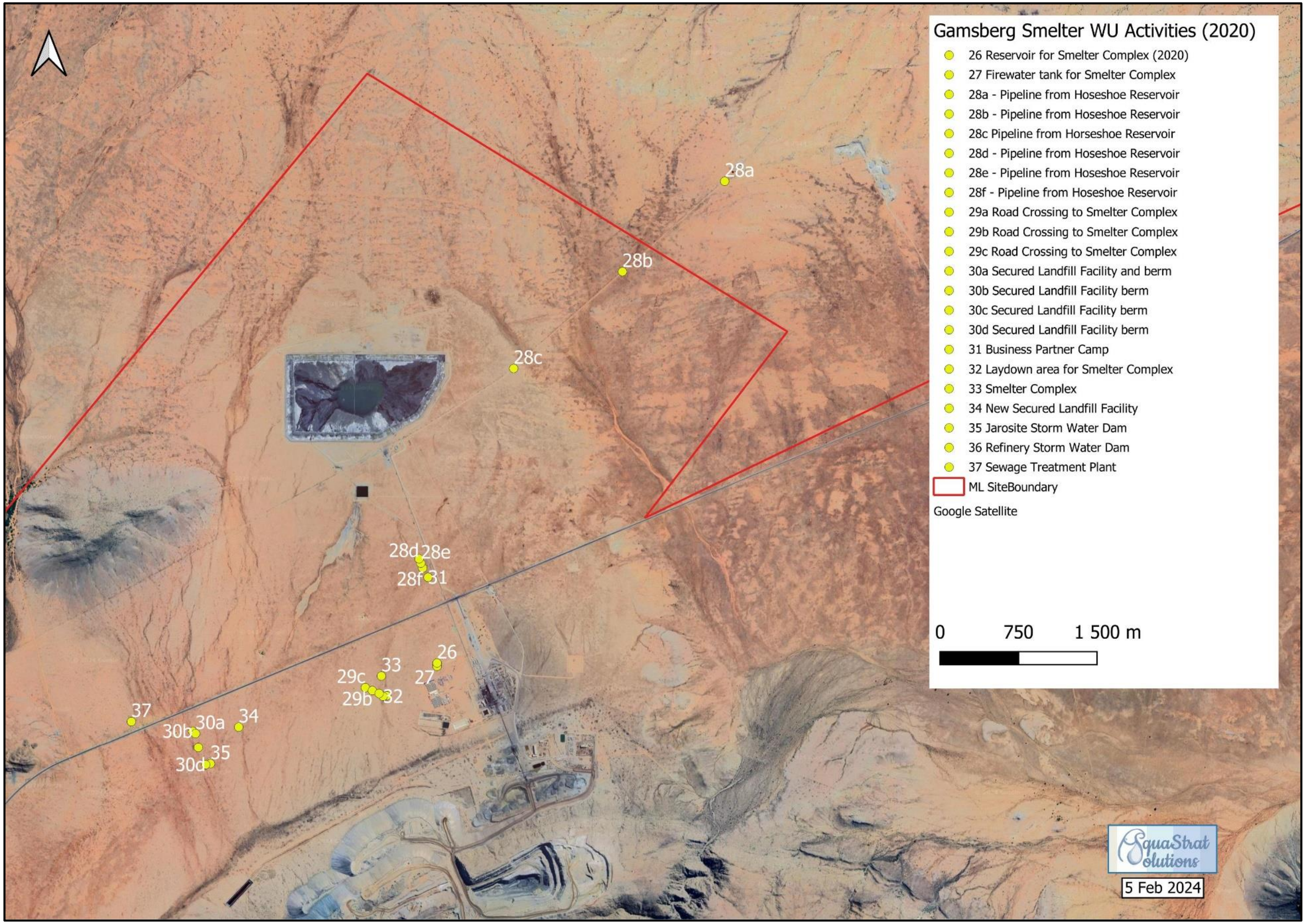


Figure 10. Water Uses for the Gamsberg Smelter Project (2020)

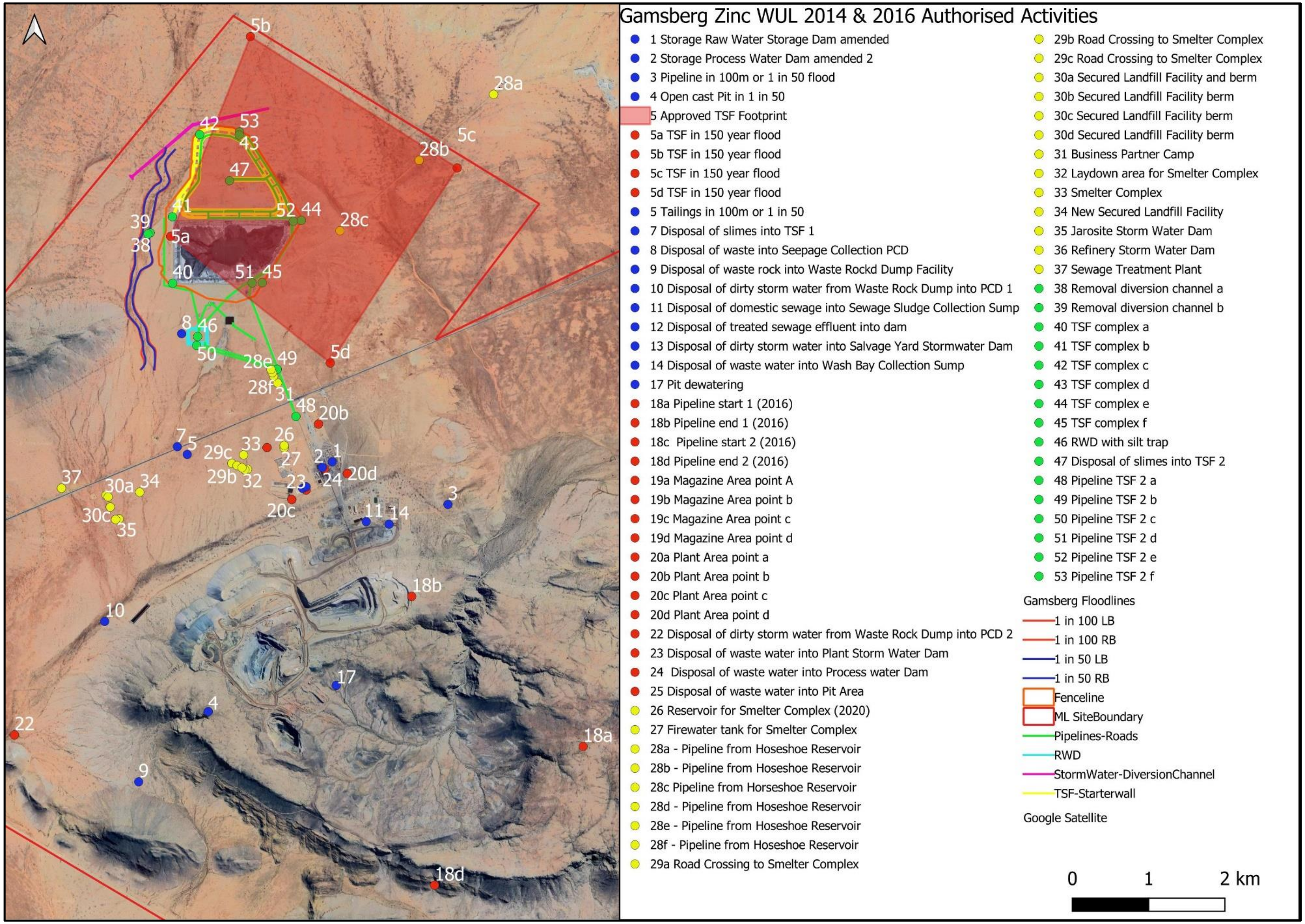


Figure 11. Overall Water Uses for the Gamsberg Zinc Mine [2014 (x), 2016 (x), 2020 (x), 2023 (x)]

2.6.2 Waste Streams and By-products

The treatment of 10 mtpa ROM ore is expected to lead to approximately 9 mtpa of tailings material (approximately 6.9 million m^3 of slurry containing approximately 4.5 million m^3 of water). The mineral wastes (tailings) are sent to the thickener to reduce the water content and then pumped to the TSF. Percolated water in the tailings dam is extracted, returned to a process plant and reused in the concentrating process, via a return water dam.

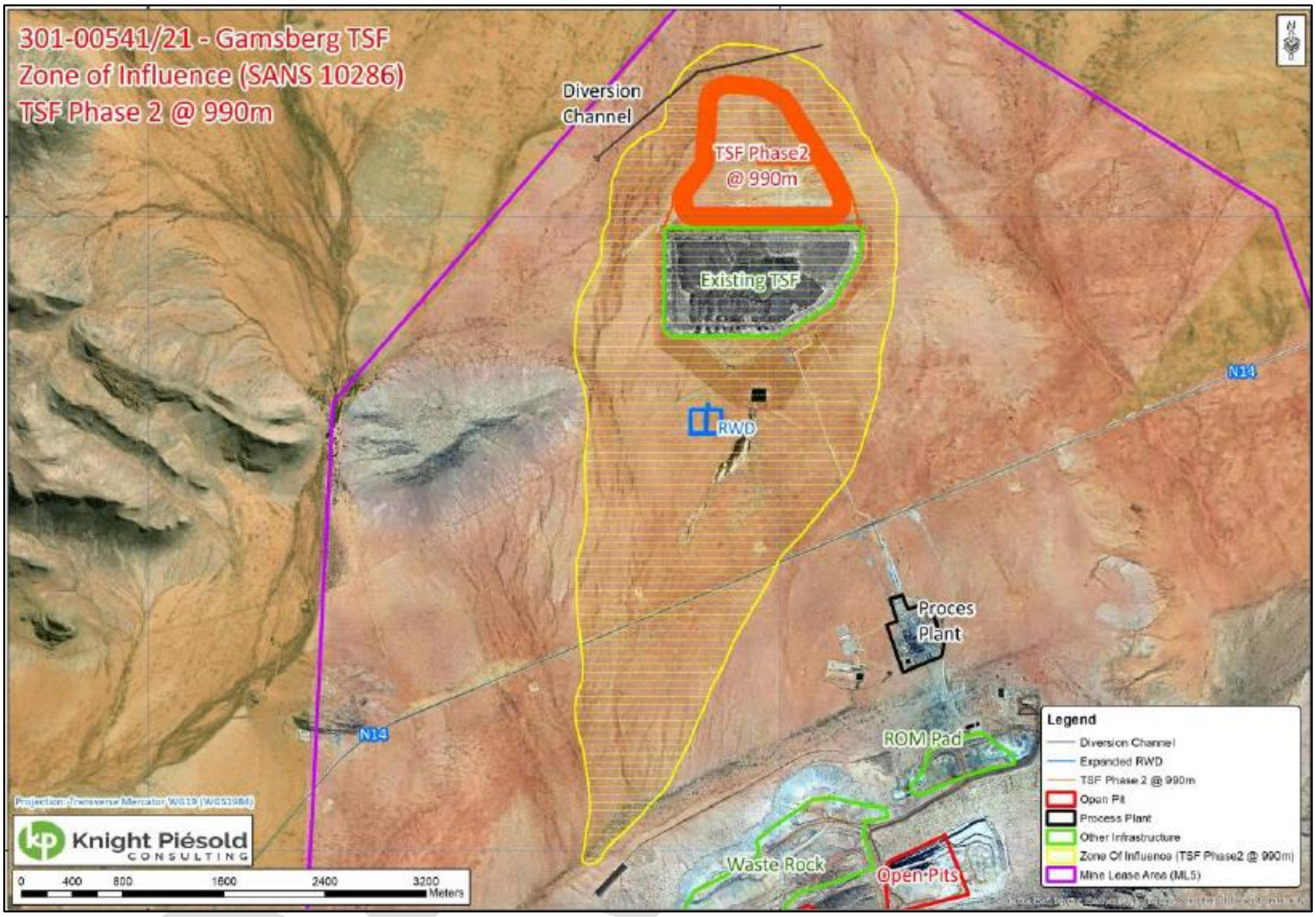


Figure 12. SANS 10286 Zone of Influence (KP, 2023b)

Based on the ZOI the facility is classified as medium hazard facility.

Table 16. SANS 10286 hazard classification (KP, 2023b)

Classification	Number of residents in zone of influence	Number of workers in zone of influence[1]	Value of third-party property in zone of influence[2]	Depth to underground mine workings[3]
High Hazard	>10	> 100	> R20million	< 50m
Medium Hazard	1 - 10	11 – 100	R2million – R20million	50m – 200m
Low Hazard	0	<10	R0million – R2million	> 200m

[1] Not including workers employed solely for the purposes of operating the deposit.
[2] Values are as per SANS 10286 1998
[3] The potential for collapse of the residue deposit into the underground workings effectively extends the zone of influence to below ground level.

Table 17. Summary of the waste streams of the Gamsberg Mine

Description	Waste Type (GN 636)	Mitigation/Controls	Volume/Capacity
Waste Rock	hanging wall and foot wall waste rocks are predominantly non-acid generating (ERM, 2013a).		1.5 billion tonnes for LOM
Oil/steel contaminated ore	various	Hazardous waste management policy	unspecified
Tailings Facility 1	Type 1 waste	A High-Density Polyethylene (HDPE) geomembrane with a 300 mm thick soil layer modified with 6% bentonite (mineral liner) liner system	
Tailings Facility 2	Type 3 waste	Class C liner	6 439 994 m^3/a slurry 116 ha 32 000 000m^3
Sewage Package Plant		Modular unit	500m^3/day (to be expanded with Smelter Complex for another 500m^3/day)
Secured Landfill Facility	Total waste from Smelter is 382 800tpa (refer to Table 18 and Table 19)	Class A liner	382 800m^3/a

Smelter Process waste:

Table 18. Waste Products Generated during the Smelting Process (SLR, 2021)

Waste types	Volume (tpa)	Disposal
Fe cake stabilized (dry), Jarofix	290 000	SLF
ETP cake (dry)	24 000	SLF
Evaporation pond salts (dry)	67 000	SLF
Cell house sludge (dry)	1 800	SLF

Table 19. By-products Generated during the Smelting Process (SLR, 2021)

By-products	Volume (tpa)	Disposal
Manganese cake (dry)	17 500	Sale
Cu-Cd cement (dry)	2 600	Sale
Co-Ni cement (dry)	410	Sale
Sulphuric Acid (wet)	545 000	Sale

Other wastes likely to be generated throughout the process include:

Domestic waste

- Used cooking oil;
- General household waste (incl. plastic);
- Cans (aluminium);
- Paper;
- Glass;
- Organic waste;
- Leaves, grass cuttings, branches/tree cuttings;
- Wood products; and
- Perishable produce.
- Salvageable items;
- Salvageable steel;
- Tyres; and
- Other, including wood, plastic, pipes, cables, bricks, paint tins and rubber.
- Sewage sludge and screenings from the sewage works.

Hazardous waste

- Hydrocarbons (e.g. Used hydraulic oil, diesel spillage);
- Batteries;
- Rubber;
- Contaminated PPE;
- Empty grease drums;
- Empty chemical containers (plastic and glass);
- Fluorescent tubes;
- Oil-contaminated soil, paper, plastic, rags;
- Empty oil drums;
- E-Waste;
- Appliances;
- Printers, copiers and scanners;
- Laptops;
- Cables;
- Computers, monitors, keyboards, mouse;
- TVs; and
- Miscellaneous (CDs, punch cards, etc.).

Construction waste

- Building rubble
- Contaminated (chemical/ hydrocarbon) spillage

2.7 Organisational Structure of Activity

Details of the management structure for the construction phase are presented in the figure below. All official communication and reporting lines, including instructions, directives and information shall be channelled according to this organisational structure.

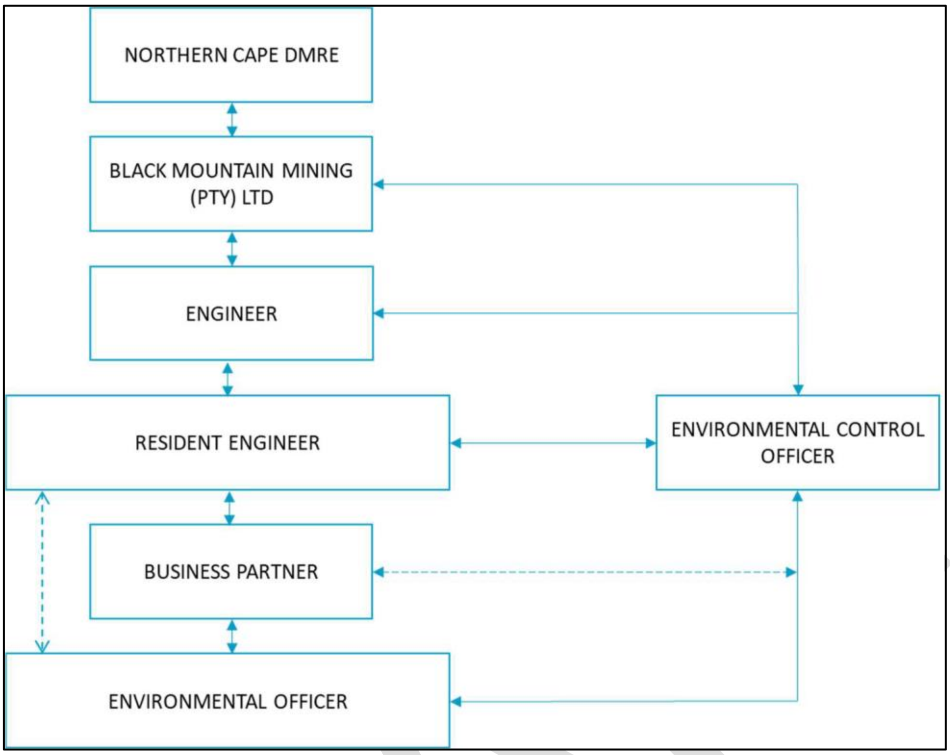


Figure 13. Construction Phase Organisational Structure (SLR, 2021)

Details of the management structure for the operational phase are presented in Figure 14. All official communication and reporting lines, including instructions, directives and information shall be channelled according to this organisational structure.

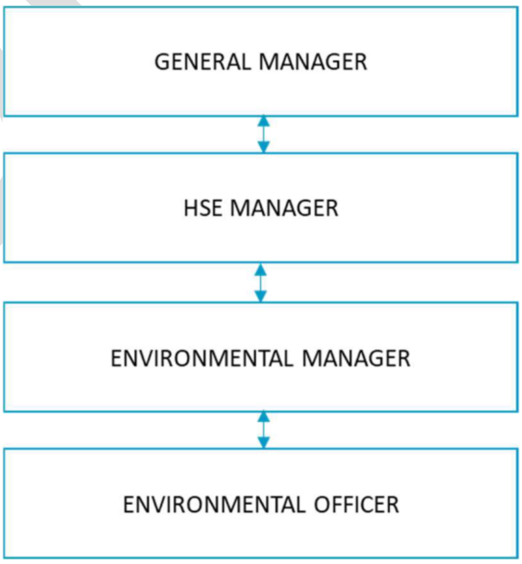


Figure 14. Operational Phase Roles and Responsibilities (SLR, 2021)

2.8 Business and Corporate Policies

Black Mountain Mining (Pty) Ltd has implemented numerous policies at the Gamsberg Zinc Mine, specifically relating to water and waste management.

Table 20. Black Mountain Mining (Pty) Ltd Environmental Policies and Procedures (SLR, 2021)

Reference	Description	Implementation Date	Review Date
Environmental-related policies			
SSD-POL-001	Safety and Sustainable Development	30/06/2018	Rev13, 25/06/2019
SSD-POL-003	Biodiversity Policy	01/05/2015	Rev4, 25/06/2019
SSD-POL-004	Water Management	01/05/2015	Rev4, 25/06/2019
SSD-POL-005	Product Stewardship	01/05/2015	Rev4, 25/06/2019
SSD-POL-007	Energy and Carbon Management	01/05/2015	Rev3, 25/06/2019
Environmental-related Procedures			
SSD-ENV-STD-040	Handling, Storage and Disposal of Waste	01/05/2015	Rev12,06/07/2019
SSD-ENV-STD-050	Environmental Water Monitoring and Analysis	15/01/2018	Rev7, 12/07/2019

Black Mountain Mining (Pty) Ltd and the Gamsberg Zinc Mine as part of the larger Vedanta Zinc International (VZI) Group operate under numerous corporate standards which outline Vedanta's procedures, vision's and procedures with regards to health, safety, environment and community (HSEC). Some of the management and technical standards adopted at the Gamsberg Zinc Mine are listed below in Table 21.

Table 21. Implemented Technical Standards Related to HSEC (SLR, 2021)

No.	Description
MS011	Management Standard- Incipient Reporting, Classification and Investigation
MS012	Management Standard – Auditing and Assurance
MS013	Management Standard – Corrective and Preventive Action Management
MS014	Management Standard – Management Review and Continual Improvement
TS 001	Technical Standard – Cultural Heritage
TS 003	Technical Standard – Land and Resettlement Management
TS 004	Technical Standard – Grievance Mechanisms
TS 005	Technical Standard – Stakeholder Engagement
TS 007	Technical Standard – Biodiversity Management
TS 008	Technical Standard – Conducting ESA to International Standards V2
TS 009	Technical Standard – Resource Use and Waste Management
TS 010	Technical Standard – Safety Management
TS 011	Technical Standard – Environmental Management
TS 012	Technical Standard – Occupational Health Management

No.	Description
TS 013	Technical Standard – Emergency and Crisis Management
TS 014	Technical Standard – Water Management
TS 016	Technical Standard – Energy and Carbon Management

3 Chapter 3: Regulatory water and waste management framework

3.1 Summary of all Water Uses

Authorized water uses are represented in Table 13, water uses applied for in 2020 are represented in Table 14 and Figure 8 and the water uses of the 2023 application as part of the TSF Phase 2, in Table 15 and Figure 7 of this report. The overview of all water uses is represented in Figure 9. The water uses authorized by the 2014 WUL and 2016 WUL Amendment include:

- 21(b): Storage of water from Pella Drift Water Board into Raw water storage dam and Process water dam
- 21(c) & (i): pipelines; open cast pit; TSF area; seepage collection pond; fence; magazine area; plant area
- 21(g): Disposal of
  - slimes into TSF 1;
  - wastewater into seepage collection pond (PCD);
  - waste rock into waste rock dump facility;
  - dirty waste rock dump stormwater into SWD 1 & PCD 2;
  - domestic sewage into sewage sludge collection sump;
  - dirty stormwater into salvage yard stormwater dam;
  - wastewater into wash bay collection sump;
  - dust suppression;
  - wastewater into pit area;
  - Waste water into plant storm water dam & Process water dam
- 21(j): Pit dewatering

The water uses applied for in 2020 for the Smelter Complex include:

- 21(b): Smelter complex 10ML reservoir; 2000m^3 Firewater tank
- 21(c) & (i):
  - Pipeline & Road crossings from horseshoe reservoir;
  - Secured Landfill facility (SLF) and protection berm
  - Business partner camp
  - Laydown area
  - Smelter complex
- 21(g):
  - SLF for disposal of jarofix and etp cake
  - Jarosite SWD
  - Refinery SWD
  - Sewage treatment plant (increase capacity by 500m^3/day to total of 1 000m^3/day)

The water uses being applied for in this application for the TSF Phase 2 include:

- S21(c) & (i):
  - Removal of diversion channel north of TSF 1
- S21(g):
  - TSF 2

- RWD with silt trap for TSF 2
- Disposal of slimes into TSF 2
- Disposal of wastewater into RWD
- Pipelines for disposal into TSF 2 and RWD

3.2 Existing Lawful Water Uses

There is no ELU registration relevant on the properties for the proposed water uses.

Black Mountain Mining (Pty) Ltd holds a WUL issued by the then Department of Water and Sanitation (DWS) on 30 September 2014 for the Gamsberg Zinc Mine. An amendment to amend certain conditions of the WUL was issued on 14 April 2016. A summary of the authorized water uses is tabulated in Table 13. Copies of the WULs for the Gamsberg Zinc Mine are included in Appendix A.

3.3 Relevant Exemptions

None for the Gamsberg Zinc Mine.

Black Mountain Mining (Pty) Ltd lodged an application with the IWUL application of 2021 (SLR, 2021); in terms of Regulation 3 of Government Notice (GN) 704 of 4 June 1999 for the exemption from Regulation 4(a): Restrictions on use of material of the same notice.

3.4 Generally Authorised Water Uses

Table 22. Water Use Authorisations Associated with the Gamsberg Zinc Mine (updated from SLR, 2021)

Type	Title & Reference	Description	Authorised Water Uses	Date Issued	Relevant Area
License	Gamsberg Zinc Mine WUL 14/D28C/ABCGIJ/2654	Water Use License (WUL)	Section 21(b), (c) (i), (g) and (j)	30 September 2014	Gamsberg
License	Gamsberg Zinc Mine WUL Amendment 14/D28C/ABCGIJ/2654	Water Use License (WUL) Amendment	Section 21(b), (c), (i), (g) and (j)	14 April 2016	Gamsberg
Registration	Registration for road upgrade and widening of existing road 27/2/2/D382/3/3	Water Use Registration	Section 21(c) and (i)	27 April 2019	Gamsberg
Registration	Gamsberg clean runoff attenuation system	Water Use Registration	Section 21(c) and (i)	26 September 2022	Portion 1 of Gams 60; Portion 0 of farm Aroams 57

3.5 New Water Uses to be Licenced

The water uses being applied for as part of this WUL Amendment for the TSF 2 and associated structures, as well as water uses applied for in 2020 for the Gamsberg Smelter Project, are summarised in Table 15 with

Figure 9, and Table 14 with

Figure 10 respectively.

3.6 Waste Management Activity (NEM:WA)

BMM received a Waste Licence, No 12/9/11/L955/8, for a class H:H (Storage of hazardous waste in lagoons, Reuse of general and hazardous waste and wastewater treatment works), on 17 December 2013.

One of the major amendments effected by the National Environmental Management Waste Amendment Act 2014 is the insertion of section 24(5), as a result of which the NEM:WA is now also applicable to mining residue deposits and residue stockpiles, as follows:

"Management of residue stockpiles and residue deposits 24(5) Residue stockpiles and residue deposits must be deposited and managed in accordance with the provisions of the National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008), on any site demarcated for that purpose in the environmental management plan or environmental management programme in question."

GN R.633 Regulations on the Amendments to the List of Waste Management Activities that have, or are likely to have, a detrimental effect on the Environment. These regulations make provision for the inclusion of Mine Residue Stockpiles and Deposits into the list of activities requiring a waste management licence (WML).

The Regulations Regarding the Planning and Management of Residue Stockpiles and Residue Deposits from a Prospecting, Mining, Exploration or Production Operation (GN R. 632 of 2015) set out a risk-based approach to mine residue facilities but specified that the barrier design was prescribed by GN R.635 and GN R. 636 of 2013. Therefore, the barrier design for a mine residue deposit (dump/stockpile) continues to be driven by the waste Type prescribing the corresponding Class of barrier design. The regulations published in July 2015 under GN R.632 and R.633 refers to: GN R. 632 Regulations regarding the Planning and Management of Residue Stockpiles and Reside Deposits from a Prospecting, Mining, Exploration or production operation.

As part of the proposed Smelter project a WML from the DMRE in terms of the NEM:WA is required for the proposed construction and operation in terms of Category B Activity 7 (*the disposal of any quantity of hazardous waste to land) and Activity 10 (the construction of a facility for a waste management activity listed in Category B of this Schedule (not in isolation to associated waste management activity)*. The application for the WML from the DMRE is still pending (SLR, 2021).

Table 23. NEM:WA Category B Listed Activities (GNR 921) (SLR, 2021)

Activity No.	Listed Activity	Applicability of the Activity
7	The disposal of any quantity of hazardous waste to land.	Development of the secured landfill facility for the disposal of Jarofix, ETP Cake and precipitated salts from RO plant.

10	The construction of a facility for a waste management activity listed in Category B of this Schedule (not in isolation to associated waste management activity).	The secured landfill facility is being constructed for the disposal of both Jarofix, ETP cake and precipitated salts.

3.7 Waste Related Authorisations

The Gamsberg Zinc Mine has a WML (Ref: 12/9/11/1!155/8) which was issued by the Department of Environmental Affairs on 17 December 2013 for their open pit mining activities and concentrator plant. The licensed activity is *"Storage of hazardous waste in lagoons, reuse of general and hazardous waste and wastewater treatment works".*

3.8 Other Authorisations (EIAs, EMPs, RODs, Regulations)

The Gamsberg Zinc Mine has numerous permits /licenses which pertain to the mining activities. The outlined authorisations and permits in Table 24 have been obtained from the Environmental Legal Register.

Table 24. Other Authorisations and Permits Associated with the Gamsberg Zinc Mine (updated from SLR, 2021).

Authorisation	Reference	Date Issued	Authority
Environmental Authorisations (EAs) / Permits / Approvals			
EA	NC/EIA/NAM/KHA/AGG/2012NCP/EIA/00001 55/2012 (Gamsberg Zinc Mine)	10 December 2014	DENC
SAHRA Approval	9/2/066/0001 Case No.: 2215	15 March 2013	SAHRA
Environmental Management Programmes (EMPrs)			
EMPr	Approval of an amendment to the Environmental Management Programme in terms of Section 102 of the MPRDA (NCS) 30/5/1/2/3/2/1/518 EM	22 March 2017	DMRE
	Approval of amended EMPr for a Mining Right in respect of Zinc and Lead Ore (NCS) 30/5/1/2/3/2/1/518 EM	31 March 2014	DMRE
	EMPr for Gamsberg NC-S 5/3/2/782	2 November 2000	DMRE
	EMPr Addendum Approval NCS 5/3/2/782 NCS 5/3/2/762 NCS 6/2/2/138 NCS 6/2/2/153	23 January 2003	DMRE
Licenses			
Mining License /Permit	JM/FF 15/5/2000 ML5/2000 NC-S 5/3/2/782	2 November 2000	DMRE
Permits			

Biodiversity Permit Commitment Agreement – ODB 3513/2014 & ODB 3514/2014	ODB 3513/2014 ODB 3514/2014	2 July 2015	DENC

4 Chapter 4: Present Environmental Situation

4.1 Climate

The area is one of the hottest and driest areas in South Africa with desert and semi-arid conditions. The area experiences extreme climate conditions with temperature maximums exceeding 40°C in the summer months. Rainfall in the summer months is dominated by thunderstorms. Winter temperatures can drop as low as -2°C at night with localised frost and dew from June to August. During winter, however, the days can be pleasantly warm with temperatures averaging 21°C SRK, 2010).

The area experiences between 30 and 45 very hot days (temperature exceeds 35"C) per year and is characterised as a hyper-arid environment with potential evapotranspiration being almost 20 times greater than rainfall experienced (Promethium, 2020 from SLR, 2021).

Airshed showed in 2019 that wind over the period 2016 to 2018 is primarily from the south. During the day, the predominant wind direction is from the south and the north-northwest (SLR, 2021).

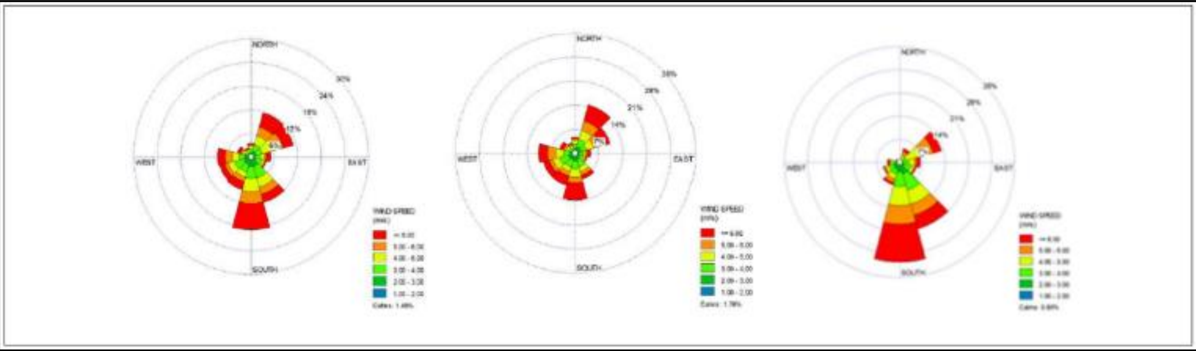


Figure 15. Wind Roses for the Period 1 January to 31 December 2018 (from SLR, 2021)

4.2 Regional Climate/Rainfall

Based on the uniformity of the monthly rainfall distribution, the altitude and the reliability of the data, the 0246555 W Aggeneys (POL) Station was chosen as the most representative station for this study. This also happens to be the closest station to the mine (Knight Piésold, 2023a). The dataset is from 1 January 1950 to 31 July 2000 (50 years), the weather station at 825masl, and indicates the MAP as 92.22mm/a.

The MAP at the monitoring station is defined as 56.8 mm/annum and the RE is a significant variation in annual rainfall where, 30% of the years' in the rainfall record experienced less than 53 mm. Whilst the driest year, which was 2019, experienced only 1mm of rainfall and the wettest year. which was 1976, experienced 233 mm of rainfall (SLR, 2021).

The actual recorded rainfall from the TORAS (Technical and Operational Risk Assessment System) shows the Mean Annual Precipitation (MAP) for the Aggeneys area varied between 72 mm and 484 mm between 1920 and 1989. The annual average used is 200.6 mm. The computed design rainfall ranged from 127.1 mm (February) to 35.1 mm (June) for the 1:100 year 24-hour storm event. The Mean Annual Evaporation (MAE) for the facility has been estimated from the records of Pofadder and Pella weather stations (Knight Piésold, 2023b).

Table 25. Rainfall and Evaporation data (Knight Piésold, 2023b)

Month	Average Monthly Rainfall (mm)	Average Monthly Evaporation (mm)	Storm Event (mm)
January	4.7	497.5	74.7
February	10.9	402.1	127.1
March	16.2	354.2	72.4
April	20.0	237.9	68.2
May	24.9	174.8	49.8
June	31.9	136.8	35.1
July	26.2	152.4	54.4
August	27.4	191.5	63.5
September	12.0	256.9	59.2
October	10.9	358.0	83.0
November	6.9	436.6	61.1
December	8.7	496.0	70.6
Total	200.6	3694.7	-

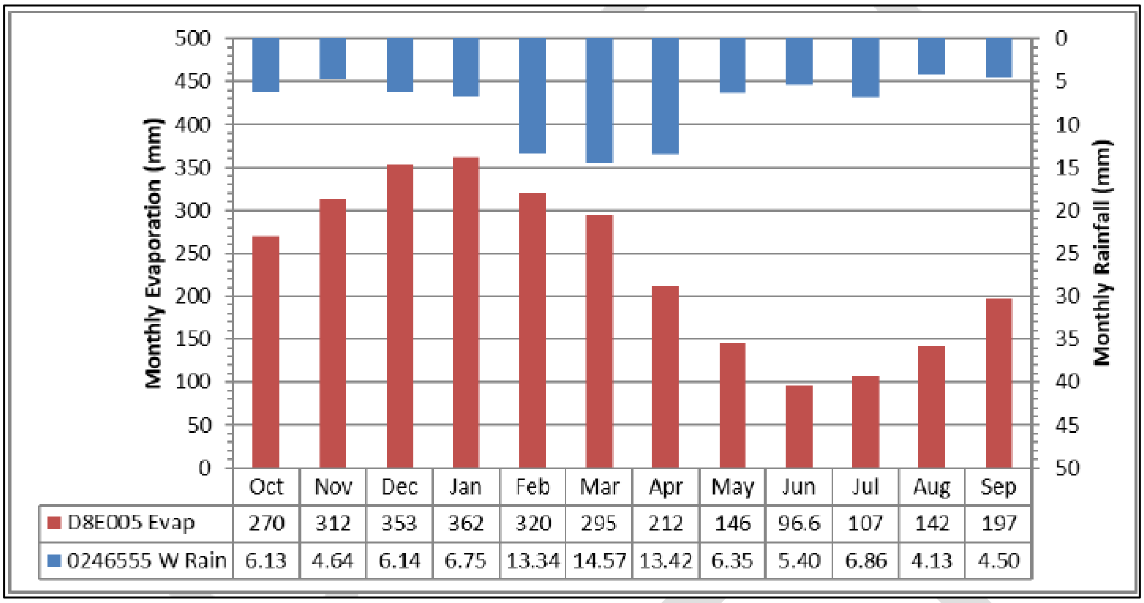
4.3 Evaporation

Evaporation data was retrieved from the DWS website for the D8E005 station since it is the most recent daily recorded data available. This station had both a Symmons Pan (S-Pan) and A-Pan evaporation pans installed in 1983 however the S-Pan was removed in 2019. In addition, the S-Pan data is missing multiple years of data. The data used in this study was the A-Pan data since the A-Pan data has a longer record and the mean annual evaporation (MAE) is approximately 110 mm less than the recorded Span data and thus more conservative.

Table 26. Evaporation data (KP, 2023b)

Evaporation (mm)	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	MAE
A-Pan	398	452	502	508	432	399	292	209	148	165	218	295	4019
S-Pan (recorded)	341	392	447	457	381	349	241	167	117	134	179	245	3450
S-Pan (converted A-Pan)*	334	381	426	431	363	335	241	167	114	129	176	243	3339
Open water	270	312	353	362	320	295	212	146	97	107	142	197	2813

*This data was converted to S-Pan by means of conversions as detailed by Bosman (1990)



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
D8E005 Evap	270	312	353	362	320	295	212	146	96.6	107	142	197
0246555 W Rain	6.13	4.64	6.14	6.75	13.34	14.57	13.42	6.35	5.40	6.86	4.13	4.50

Figure 16. Monthly rainfall and evaporation for 0246555 W Station and D8E005 Station (KP, 2023b).

4.4 Surface Water

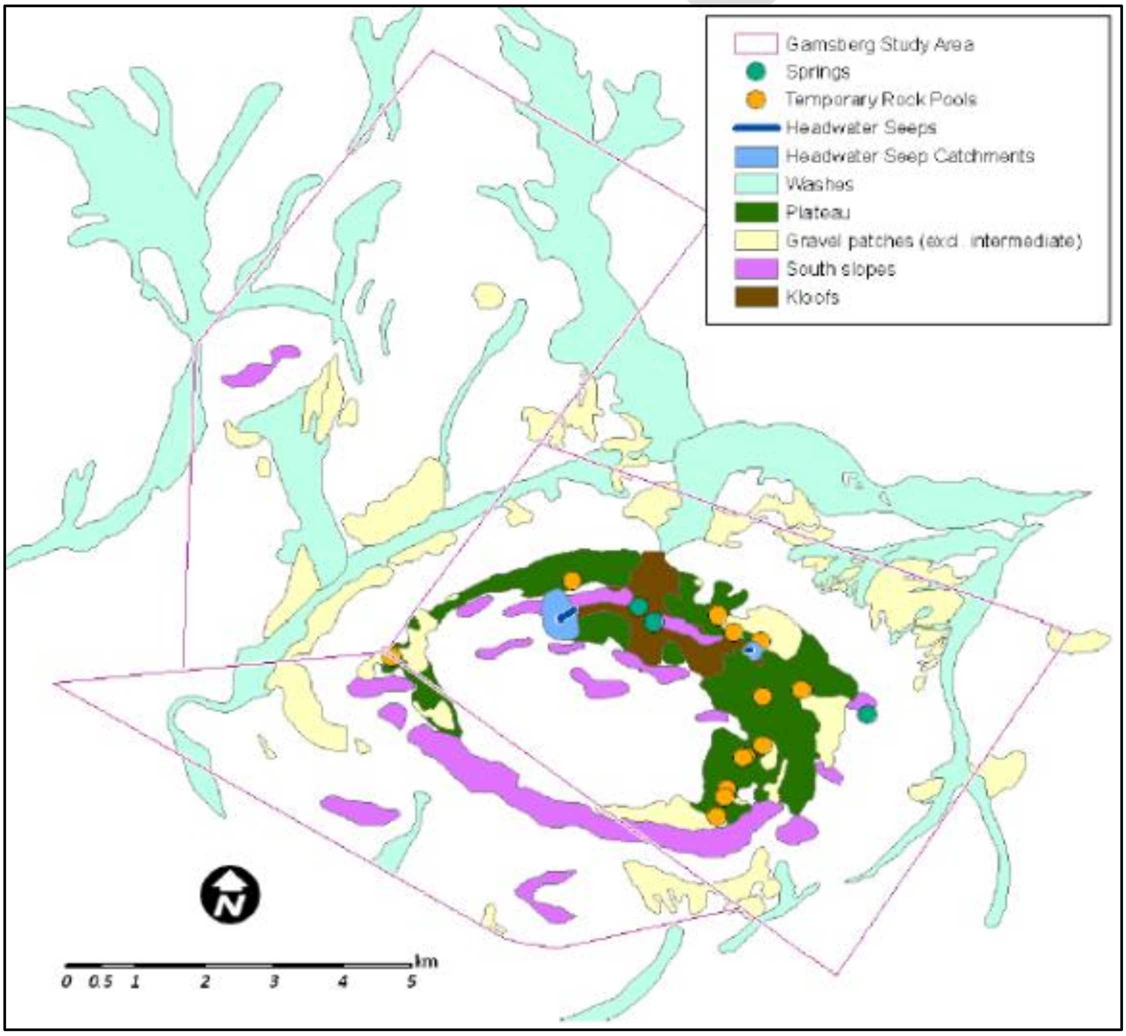


Figure 17. Habitats of conservation concern at the Gamsberg Zinc Mine (Desmet, 2013).

The watercourses identified as habitats of conservation concern (Desmet, 2013) include drainage lines (washes), Seeps, Springs and Temporary Rock Pools. These are further discussed in detail in the section below. Although saline pans are a feature of the Bushmanland plains landscape none occurs in the study area.

The Faunal Biodiversity report (GroundTruth, 2013) indicates the aquatic ecosystems, consisting of ephemeral streams, springs and rock pools, as part of the overall faunal sensitive habitat, shown in the figure below.

The Aquatic Biodiversity Compliance Statement (Golder, 2022c) indicates that the NWM5 database indicated that the ephemeral drainage line to the north of the proposed West dump is a river, and that a potential area of 'channelled valley bottom wetland' habitat occurs on site, and that the Present Ecological Status of that system is considered largely to severely/critically modified. No wetlands were identified in the area mapped as 'channelled valley bottom wetland habitat' by the NWM5 database. It is clear that the watercourse that is situated within the study area (rock dumps, proposed Smelter Complex and water pipeline) is highly ephemeral and does not support surface water flows or soil saturation hydroperiod that is long enough to sustain aquatic biodiversity, or wetland conditions. As such, the system is not considered to support wetland or riparian habitat, and is best described as a typically dry, highly ephemeral drainage area.

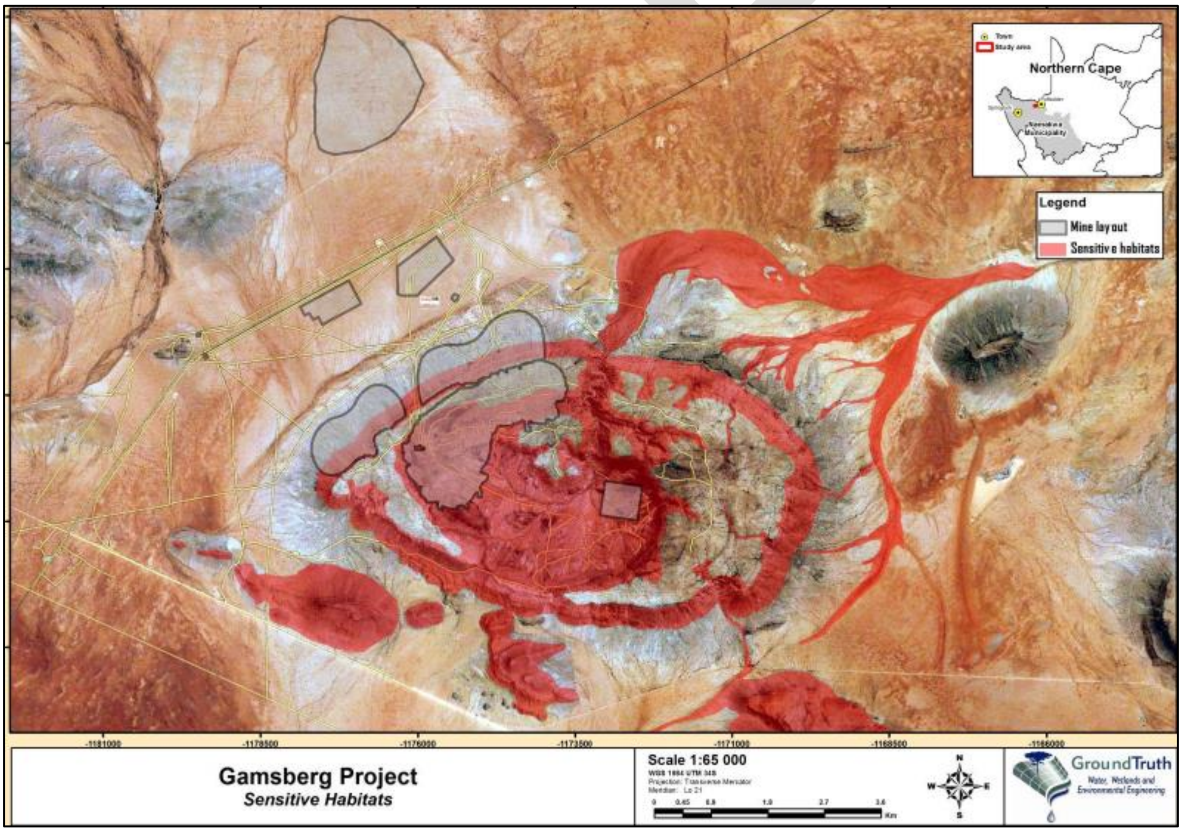


Figure 18. Habitat sensitivity at the Gamsberg Zinc Mine (GroundTruth, 2013).

The majority of the washes identified in the 2013 Vegetation assessment also form part of the National Wetlands Map Version 5 (SANBI, 2018). The figure below shows the NWM5 watercourses on site.

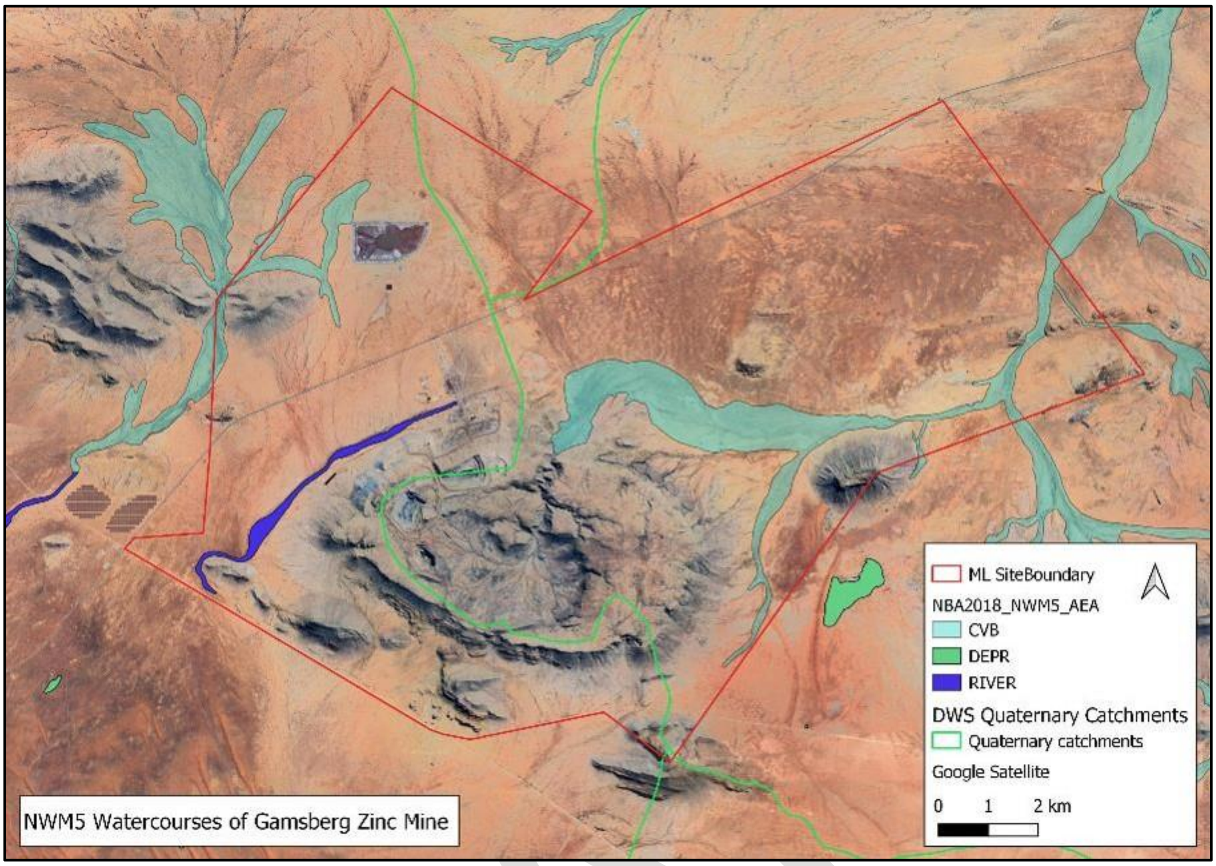


Figure 19. National Wetlands Map 5 watercourses relevant to the site.

Information in the section below was sourced from the Vegetation Baseline and Impact Assessment Report (Desmet, 2013).

4.4.1 Drainage lines (Washes)

Washes as they are defined and mapped here contain all drainage-lines in the study area. Washes and Dry River Beds are floristically and ecologically located at other ends of a drainage line development continuum. Larger drainage lines associated with larger catchments are associated with sub-surface water flow and as a result are characterised by the presence of larger trees. Sub-surface flow is typically absent from washes and hence trees are not absent but not characteristic of the habitat.

Drainage-lines on the Gamsberg, as with all inselbergs in the BIR, tend to be well defined, narrow with rock and boulder beds. On the plains washes tends to be wide, sandy and often very difficult to detect were it not for the presence of key indicator species (e.g. *Sisyndite spartea*). The vegetation of washes tends to be fairly heterogeneous due to a spatially and temporally dynamic and heterogenous environment. For the most part the vegetation of washes is most similar to that of the surrounding vegetation. Many species found growing on the surrounding plains or mountain slopes can be found growing in the washes, usually larger specimens. Added to this “back-ground” species mix are the wash specialist species, those adapted to high disturbance regimes and those dependent on the water associated with washes. Being exposed to periodic flooding, washes are naturally high disturbance habitats. Understandably the vegetation is characterized by weedy species adapted to a high disturbance regime. Also the greater amount of groundwater associated with these features also promotes phreatophytic species (deep-rooted plants that obtain water from a permanent ground supply or from the water table), mainly trees and large shrubs. Alien plants most often make their appearance in the landscape in these habitats due to the high disturbance regime and availability of water.

The characteristic species of the plains drainage lines are *Sisyndite spartea, Indigofera heterotricha, Salsola aphylla, Aptosimum indivisum, Aptosimum spinescens, Sesamum capense, Tribulus cf. zeyheri, Zygophyllum retrofractum* and *Zygophyllum simplex*. Common species include *Boscia foetida subsp. foetida, Euclea undulata, Lycium cinereum* and *L. prunus-spinosa, Zygophyllum retrofractum, Rhigozum trichotomum, Monechma incanum, Aptosimum spinescens, Geigeria plumosa, Gazania lichtensteinii, Hermbstaedtia glauca and Didelta carnosa*.

Characteristic species of the inselberg drainage lines include *Sericocoma pungens, Rosenia humilis, Zygophyllum retrofractum and Drosanthemum godmaniae*. Other common species include larger trees and shrubs such as *Boscia foetida subsp. foetida, Pappea capensis, Euclea undulata, Rhus burchellii, Ehretia rigida, Diospyros ramulosa, Montinia caryophyllacea and Nymania capensis*, as well as other large woody shrubs namely *Hermannia stricta, Lycium prunus-spinosa, Rhigozum trichotomum, Hermbstaedtia glauca*, and smaller shrubs and herb *Monechma spartioides, Geigeria plumosa, Gazania lichtensteinii,* and *Didelta carnosa*.

Although washes contain no species of conservation concern, they are important from an ecosystem process perspective. Washes are the major conduits of water in the landscape and should be considered and avoided when developing a landscape so as to maintain this natural process. A priorii identification and mapping these features can save considerable cost later. The town of Aggeneys was built in the middle of a wash (sheet-wash plain). After Aggeneys was constructed, berms had to be constructed around the town when the town was flooded after a thunderstorm event. If mine planners had been aware that were building their town in the middle of a river, they may have sited the town in a more environmentally sensitive location.

Groundwater drawdown as a result of the pit will lower the level of permanent subsurface flow in the Dry River Beds. This will permanently negatively impact the survival and recruitment of tree species dependent on this resource. Trees in the desert landscape are a keystone ecological resource (forage, habitat, nest sites, etc.) and loss of trees form the system will impact the broader landscape.

4.4.2 Headwater Seeps

At the headwaters of both of the side kloofs there are small “headwater seeps” at the plateau/kloof interface. These seeps have shallow (<30cm), slightly humic loamy soils over an underlying layer of solid quartzite rock and gravel. After significant rainfall events these seeps appear to be waterlogged for several weeks and damp for several months. In both situations the seep is located at the base of a local valley and upstream of an exposed bedrock sill or nick-point below which the gradient of the stream increases and the character changes to a vegetated rock and boulder channel. The western seep is the largest being about 100m long and 5-10m wide. The eastern seep is significantly smaller been 20m long and 5m wide. The vegetation of both seeps is dominated by the geophyte *Eriospermum bakerianum* subsp. *bakerianum*, a species of cotton seed. This is a summer rainfall species found throughout Namibia and Botswana. It’s occurrence on the Gamsberg represents the most southern known locality for this species making it very important at a regional level. Also, the density of the populations, particularly in the western seep which conservatively could number in the hundreds of thousands, is also remarkable for a geophyte in the BIR where geophytes usually to have low population densities. The seep is shared with other geophytes (possibly a species of Cyanella) and sedges. In the dry season these seeps are literally “mined” by porcupines feeding on the dense mass of cotton seed corms. No doubt these seeps comprise a keystone foraging resource for porcupines and perhaps baboons.

In the BIR this habitat appears to be restricted to the Gamsberg. A regional search for similar habitats and combination of species did not locate any other patches of similar vegetation. Given that the dominant species in the seep (*E. bakerianum*) is widespread in central Namibia it is likely that this habitat is a summer rainfall relic that could be common in south-central Namibia. This is important in assessing the impact significance of losing nearly the entire known extent of this habitat in South Africa.

4.4.3 Springs

In addition to the two springs in the kloof there is a second permanent spring on the Gamsberg at the north-eastern base of the inselberg below a small ravine. This spring has been significantly altered by humans but still supports a diversity of aquatic and water-loving plants in particular the small population of the palaeo-relic tree Azima tetracantha. It is uncertain if this spring was ever represented by a permanent pool of water or if this was created by pastoralists to provide water for their stock. There is another seasonal spring located at the base of the small kloof/ravine on the southeastern corner of the Gamsberg. It is uncertain, however, if this spring is natural or created by pastoralists as there is no characteristic flora associated with the site.

No plant species were found that are exclusively associated with these springs (i.e. endemic species). Most species associated with the springs are widespread in southern Africa in more mesic areas outside of the BIR. The presence of freshwater springs in the landscape does represent one of the most ecologically important habitats in the BIR. This is a keystone refuge habitat for water dependent plant species (e.g. trees and aquatic plants). They are also likely a keystone habitat for fauna at the landscape level from a water provisioning perspective and aquatic habitat.

There are only four known freshwater springs in the BIR - two on the Gamsberg, one in the kloof at Achab and one on Naip. There is a permanent sulphur-spring associated with the Big Syncline on Aggeneryseberg, but this water is brack and not palatable. There is an unconfirmed occurrence of another freshwater spring near Lemoenplaas at Aggeneyseberg.

4.4.4 Temporary rock pools

Temporary rock pools or vernal pools are shallow pan-line structures less than two meters in diameter that have standing water in them for long enough after rain for a distinct ephemeral pan ecosystem to develop. They are restricted to the flattest parts of the Gamsberg plateau. During the site visits in 2009 49 temporary rock pools were mapped, mostly on the eastern plateau of the Gamsberg. These pools are generally devoid of perennial plants except occasionally the succulent Crassula deltoidea is found growing in them. They have not been studied whilst inundated to determine the presence of plants during their wet phase.

Only in recent years has the existence of these features become apparent as they are mostly dry (at least 95% of the time) and easily overlooked. In April 2006 free swimming crustaceans were observed swimming in these pools but no samples were taken for identification. A significant distinction between these pools or pans and pan on the Bushmanland plains, besides their diminutive size, is that the plateau pans are non-saline whereas the plains are hyper-saline suggesting that the crustacean community on the plateau are likely to be unique to the plateau and other similar fresh-water temporary pools elsewhere in the BIR.

There has been some research on similar mountain-plateau temporary rock pools elsewhere in South Africa (Vanschoenwinkel et al. 2008a, Vanschoenwinkel et al. 2008b, Vanschoenwinkel et al. 2009). They have been recognised as highly unique and complex ecosystems due to the unique faunal communities and extreme spatial and temporal heterogeneity and dynamics.

At present a biodiversity or ecological understanding of the temporary rock pools is a very limited. They are endorheic drainage systems (i.e. internal draining) therefore very sensitive to accumulation of toxic inputs. The Faunal Specialist Study does not address these features.

4.5 Water Management Area

The project area is located within the Orange Water Management Area. The major rivers associated with this water management area include the Modder, Riet, Caledon, Kraai, Ongers and Hartbees Rivers, which ultimately drain into the Orange River (SLR, 2020b). The Gamsberg Zinc Mine MRA is influenced by four quaternary catchments D81G, D82A, D82B and D82C (Figure 20). The Gamsberg inselberg is situated within quaternary catchment D81G, which drains in a northerly direction towards the Orange River some 35km away. The D82C catchment is an interior drainage basin that does not drain into the other catchments (SLR, 2021). The small catchment area on top of the Gamsberg inselberg contains a spring and can experience seasonal flows (SRK, 2010).

The watercourse that is situated within the study area is highly ephemeral and does not support surface water flows or soil saturation hydroperiod that is long enough to sustain aquatic biodiversity, or wetland conditions. As such, the system is not considered to support wetland or riparian habitat, and is best described as a typically dry, highly ephemeral drainage area. Natural drainage patterns are poorly defined in the area and watercourses are ephemeral (water only flows after heavy rainfall events). The drainage features of the area are characteristic of very dry areas where soil structures are relict and not favourable to the formation of riparian soils. However, during extreme rainfall events, these features become significant rivers and wetlands during a short period of time (Golder, 2022b).

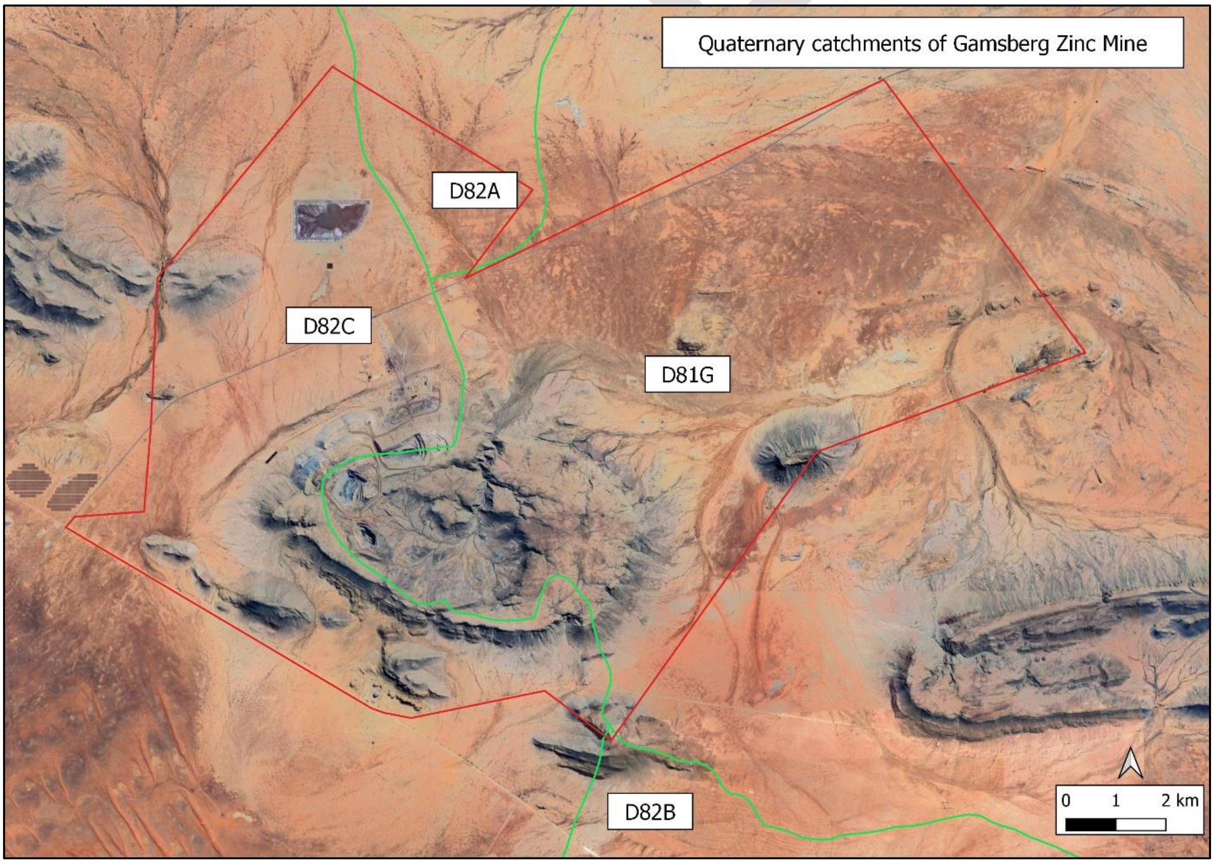


Figure 20. The Quaternary catchments associated with the site

4.6 Surface Water Hydrology

Most of the water courses in the area are ephemeral but the small catchment area on top of the Gamsberg inselberg contains a spring and can experience seasonal flows. The most significant watercourse for the Gamsberg Smelter Project is a drainage line running parallel to the N14 at the base of the northern side of the Gamsberg inselberg, and its tributaries from the north. The northern section of the Project area drains into the Orange River Basin, whereas the southern section drains into a catchment referred to as an endoreic area, (i.e., an interior catchment that doesn't feed out into the ocean) (SRK, 2010).

The Gamsberg Zinc Mine Mining Right Area (MRA) is influenced by four quaternary catchments D81G, D82A, B82B and B82C. The D81G catchment drains into the Orange River and the D82C catchment is an interior drainage basin that does not drain into the sea. Most of the water courses in the area are transient but the small catchment area on top of the Gamsberg Mine contains a spring and can experience seasonal flows (SLR, 2020b).

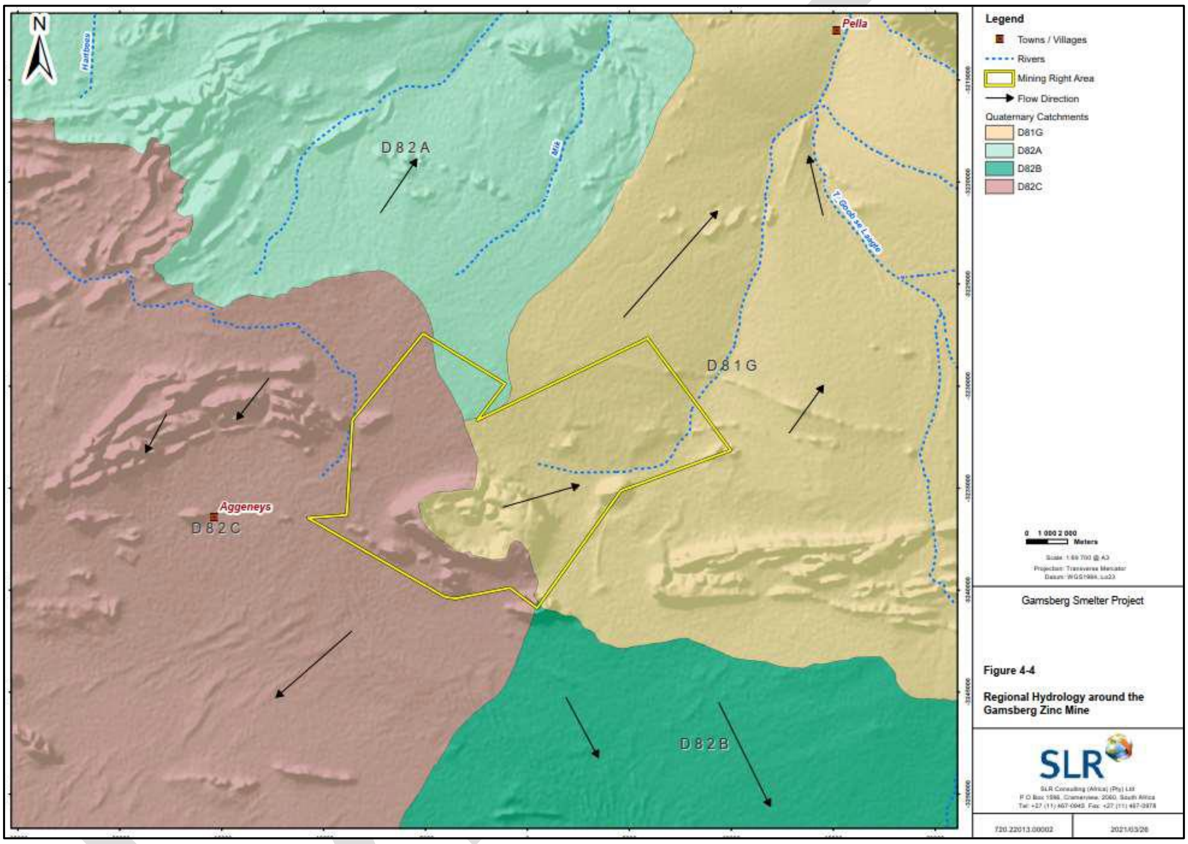


Figure 21. Regional hydrology around the Gamsberg Zinc Mine (SLR, 2021)

Flood lines for the 1:50-year and 1:100-year recurrence intervals were determined for the current river network passing through the project site and with the 100 m buffer from the watercourses (SLR, 2021).

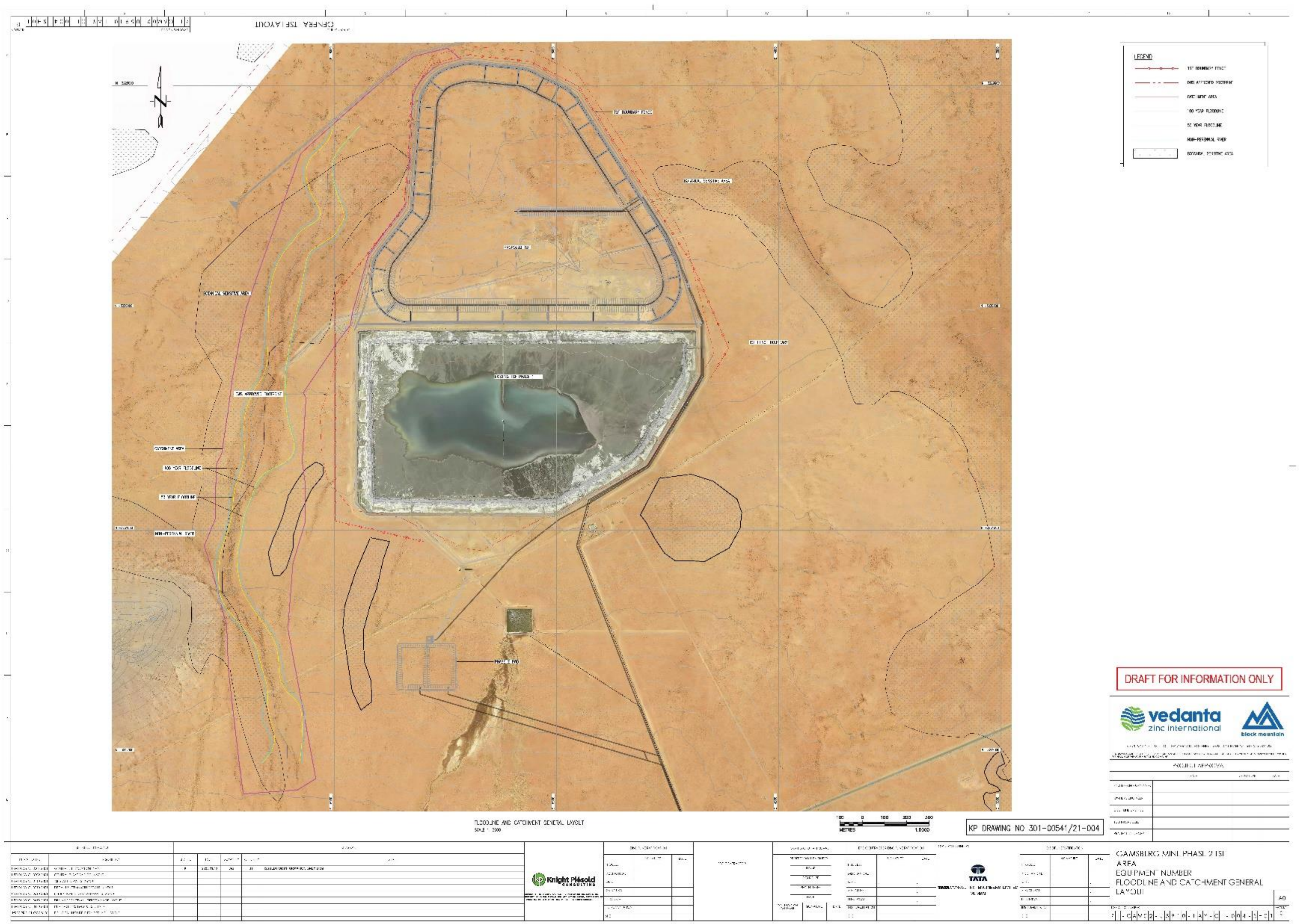


Figure 22. 1:100 year flood line for the streams adjacent to the proposed TSF 2 of Gamsberg Zinc Mine (KP, 2024).

4.7 Surface Water Quality

The surface water quality baseline consists of a one-year record of water quality data (SRK, 2010). The existing baseline water quality was undertaken prior to the start of mining at Gamsberg Zinc Mine.

The 2010 results have been compared to the South African National Standards (SANS) for drinking water quality (SANS241:2006) and the Department of Water Affairs Guidelines for livestock Watering (DWAF,1996) since these are the two most likely water uses for the springs and farm dams in the area. All parameters were within the limits of the SANS241:2006. The livestock Watering Guidelines showed exceedances in barium noted at the monitoring points GAMS 1SW and GAMS 3SW.

According to SRK Consulting (2010), the water emerging as springs from the Gamsberg Inselberg was fit for domestic use and livestock watering. However, it must be noted that although the barium values comply on average over the monitoring period there were instances where certain samples did not comply with the WHO guideline concentration level for drinking water. These exceedances could be due to historical barite mining activities north of the site.

The results were consistent between consecutive months over the monitoring period for the majority of parameters monitored with the most notable exception being nitrate in GAMS lSW (Figure 23). Nitrate in July and August was ten times greater than that in May and June although still within the SANS for Class I drinking water quality. This high concentration in nitrate was considered likely to be related to fertilizer, livestock or sanitation impacts.

Some seasonal variation during the higher rainfall months of February and March may be anticipated with an initial peak in concentrations due to constituents that have built up on surfaces being washed into runoff or infiltrating into the groundwater, followed by dilution effects once these first flush constituents have been removed. These effects are likely to be less evident in the natural springs due to the filtering effects of the soil and the time lag for recharge to groundwater (SRK, 2010).

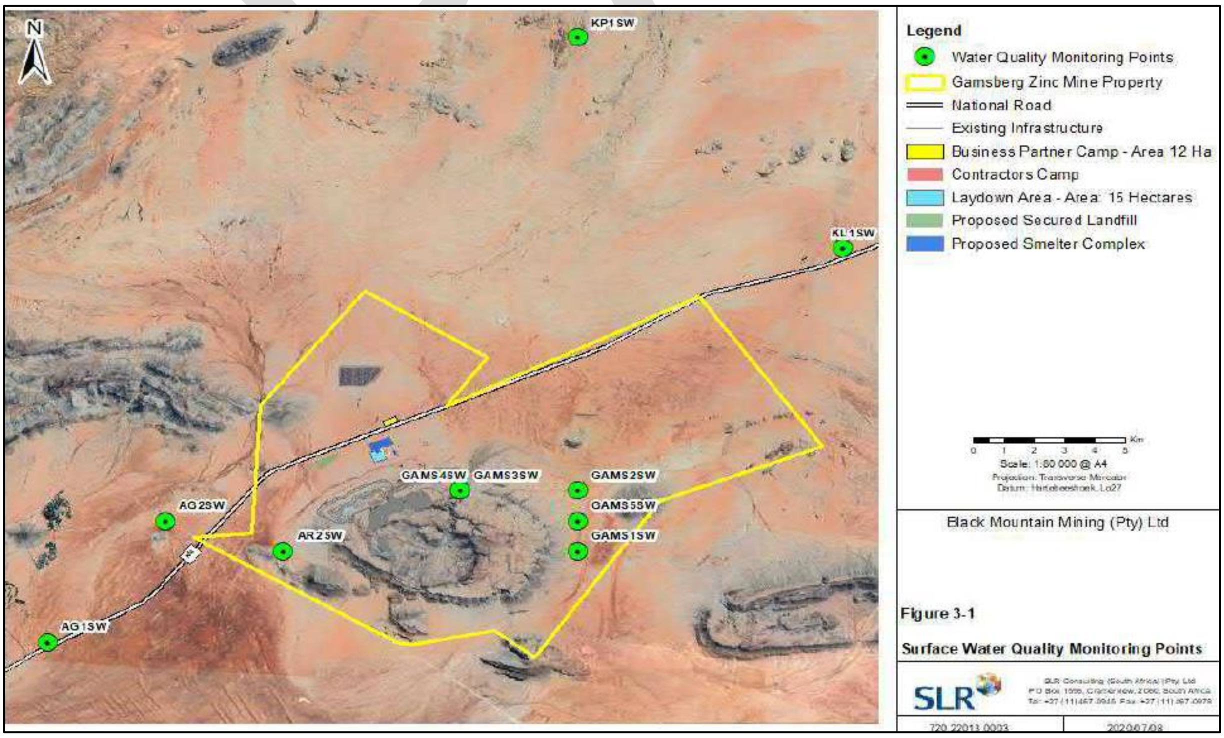


Figure 23. Water Quality Sampling points (SRK, 2010 as cited in SLR, 2020b).

Table 27. Surface water quality data (SRK, 2010 as cited in SLR, 2020b).

Parameter	Units	South African National Standard for drinking water (SANS241: 2006)		Livestock Watering Guidelines (DWAF, 1996)			09-May	09-Jun	09-Jul	09-Aug	09-May	09-Aug	09-May	09-Jun	09-Jul	09-Aug
		Class I (recommended)	Class II (max allowable)	Target Range	Chronic effects	Acute effects	GAMS 1SW (spring)				GAMS 3SW (spring)		GAMS 1SW (spring)			
pH Value @ 20°C	Unitless	5.0 – 9.5	4.0 – 10.0	-	-	-	6.5	6.6	6.4	6.2	7.9	6.6	7.1	8.2	8.2	8.1
Conductivity mS/m @ 25°C	mS/m	<150	> 150 – 370	-	-	-	23.3	24	23.4	23.3	52.5	16.1	35.1	54.6	58.1	53
Total Dissolved Solids	mg/l	<1000	>1000 – 2400	0 – 2000	2000 – 7000	>7000	214	162	152	156	418	124	294	363	406	374
Calcium, Ca	mg/l	<150	>150 – 300	0 – 1000	1000 – 2000	>2000	10.6	8.7	10.5	6.9	57	6.4	46	48	54	46
Magnesium, Mg	mg/l	<70	>70 – 100	-	-	-	9.1	7.8	7.7	8.1	19.6	6.5	11.9	17.7	17.4	16.2
Sodium, Na	mg/l	<200	>200 – 400	0 – 2000	2000 – 4000	>4000	29	27	25	23	36	15.1	21	35	44	35
Potassium, K	mg/l	<50	>50 – 100	-	-	-	2.6	1.8	2.5	1.9	3.2	3	6.6	4.8	4.3	2.4
Total Alkalinity as CaCO3	Ns	Ns	Ns	Ns	Ns	Ns	28	19	20	21	140	16	120	137	138	124
Bicarbonate, HCO3	Ns	Ns	Ns	Ns	Ns	Ns	34	23	24	26	171	20	146	167	168	151
Carbonate, CO3	Ns	Ns	Ns	Ns	Ns	Ns	Nil	0	0	Nil	Nil	Nil	Nil	0	0	Nil
Chloride, Cl	mg/l	<200	>200 – 600	0 – 3000	3000 – 6000	>6000	47	45	37	37	72	22	37	62	74	69
Sulfate, SO_4	mg/l	<400	>400 – 600	0 – 1000	1000 – 2000	>2000	18.6	25	17.1	18.1	21	30	13.4	22	30	28
Nitrate, NO_3 as N	mg/l	<10	>10 – 20	0 – 200	200 – 400	>400	0.4	0.3	4.5	3.9	0.3	0.2	0.4	0.2	0.1	0.1
Fluoride, F	mg/l	<1.0	>1.0 – 1.5	0 – 6.0	6.0 – 12	>12	0.2	1	0.2	0.2	0.1	<0.1	0.2	0.2	0.1	0.1
Total Suspended Solids	mg/l	Ns	Ns	Ns	Ns	Ns	<1	-	<1	<1	<1	<1	<1	-	<!	<1
Turbidity, NTU	mg/l	<1.0	1.0-5.0	Ns	Ns	Ns	0.6	-	-	0.5	0.54	0.55	0.65	-	-	0.8
Total Phosphate, PO_4	mg/l	Ns	Ns	Ns	Ns	Ns	0.2	-	<0.1	0.8	0.7	0.4	2.1	-	<0.1	0.4
Ortho Phosphate, PO_4	mg/l	Ns	Ns	Ns	Ns	Ns	0.1	-	<0.1	0.4	0.7	0.3	2.1	-	0.2	0.3
Free Ammonia as NH_4	mg/l	<1.0	1.0-2.0	Ns	Ns	Ns	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1
Total Nitrogen as PO4	Ns	Ns	Ns	Ns	Ns	Ns	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1
Arsenic, As	mg/l	0.01-0.05	>0.05	<1.0	1-1.5	>1.5	0.002	<0.001	<0.02	0.002	0.002	<0.001	0.002	0.001	<0.02	0.01
Aluminium, Al	mg/l	0.3-0.5	>0.5	<5	5.0-10	>10	<0.009	0.008	<0.009	<0.009	<0.009	0.01	0.09	0.008	0.009	0.36
Manganese, Mn	mg/l	0.1-1.0	>1.0	<10	Oct-50	>50	<0.001	<0.001	0.03	0.005	0.005	<0.001	0.15	<0.001	0.03	0.02
Iron, Fe	mg/l	0.2-2.0	>2.0	<10	Oct-50	>50	0.04	0.12	0.05	0.09	0.09	0.06	0.1	0.07	1.1	0.23
Zinc, Zn	mg/l	5.0-10	>10	-	-	-	0.51	0.04	0.82	0.41	0.41	<0.005	0.55	0.07	1.1	0.74
Lead, Pb	mg/l	0.02-0.05	>0.05	<0.1	0.1-1.0	>1.0	<0.001	<0.001	<0.01	0.003	<0.001	<0.001	<0.001	<0.001	<0.01	0.001
Copper, Cu	mg/l	1.0-2.0	>2.0	<0.5	0.5-10	>10	0.005	<0.002	<0.002	0.007	0.005	<0.003	0.003	<0.002	<0.002	0.03
Chromium, Cr (VI)	mg/l	0.1-0.5	>0.5	<1.0	1.0-2.0	>2.0	<0.003	<0.003	<0.003	0.008	<0.003	<0.003	<0.003	<0.003	<0.003	0.007
Cadmium, Cd	mg/l	0.005-0.01	>0.01	<0.01	0.01-0.02	>0.02	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	<0.001
Uranium, U	mg/l	Ns	Ns	Ns	Ns	Ns	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Barium, Ba	mg/l	<0.7	-	Ns	Ns	Ns	0.08	0.36	0.22	1.3	0.1	0.05	0.11	0.78	0.04	1.2

Aquatic biodiversity

Aquatic biodiversity assessments were carried out at four key sites representing the aquatic ecosystems of Gamsberg. Four sites were sampled for diatoms during the May 2009 survey. Three of these sites were re-sampled again during the November 2012 survey. SASS5 sampling was conducted at a single site (the Gamsberg River within the kloof) during the May 2009 survey, with no additional sampling possible during the November 2012 survey due to the limited availability of sampling habitat in accordance with the SASS5 protocol. No fish were observed during surveying around the inselberg. This is not an unexpected result for these aquatic ecosystems. Two range-restricted frogs, Namaqua Stream Frog *Strongylopus springbokensis* and Paradise Toad *Vandijkophrynus robonsoni*), have been observed in the study area, although the latter more abundant (GroundTruth, 2013).

Diatom assessment

Diatom indices are designed to reflect a number of potential environmental impacts, the chief of these being plant nutrients, organic matter and salts. An increase in any of these water quality variables is generally deemed to be indicative of some form of pollution. However, when variables such as salts

are naturally high in stream the index values still show this as an impact. In the Gamsberg samples a common dominant species is *Planothidium engelbrechtii*, this species was originally described from the Jakkals River in the Western Cape – this stream has naturally high levels of sodium chloride to which *P. engelbrechtii* is tolerant. Other species found in the Gamsberg samples such as *Eolimna minima* and *Sellaphora seminulum* are also typically considered to be indicators of pollution, however, these species are also considered as pioneer species and colonise habitats with irregular flow and are also tolerant of osmotic fluctuations. Although diatom indices in general give a good indication of environmental conditions they may show a pollution impact were none exists in the case of naturally highly saline waters or waters with intermittent flow.

Interestingly, there was an increase in the proportion of pollution tolerant valves (diatoms) within each of the sites between the 2009 and 2012 surveys. This corresponds with the drier conditions experienced within this system during 2012 compared to 2009. The drier conditions would have increased the salt/"pollutant" concentrations (due to higher evaporation) and hence the apparent pollution effect. Hence, the apparent "poor" results, which may need to be regionally modified to account for the conditions within this particular system. The baseline species data will however form a key component of future monitoring (GroundTruth, 2013).

Table 28. Summarised Benthic Diatom Indices and River Health Classification (GroundTruth, 2013).

Site	Number of species	Specific Pollution sensitivity Index (SPI[6])	% Pollution Tolerant Valves (% PTV [7])	River Health Classification
May 2009				
Gamsberg spring	12	8.7	6.3	Poor
Gamsberg River	16	8.5	0.8	Poor
Southern spring	19	5.5	46.3	Poor
Eastern spring	13	7.4	48.5	Poor
November 2012				
Gamsberg spring	11	7.4	61.2	Poor
Gamsberg River	11	5.2	86.5	Poor
Southern Spring	Spring dry and not sampled			
Eastern spring	10	11.8	36.2	Fair

Aquatic macroinvertebrates

Indications from the SASS5 assessment of 2013 shows that the ecological condition of the Gamsberg River is “poor” as reflected by the aquatic macro-invertebrates present, the families and their respective tolerances to water quality. This result is initially congruent with the diatom results reported earlier for this same site. However, as described under the diatom results, the diatoms are probably principally responding to elevated salts within the system. On the other hand, the aquatic macroinvertebrates are probably responding to the limited available habitat for typical SASS5 sampling. Typically, the “richest” habitat type is usually the fast flowing, rocky riffle (rheophilic) habitat where a large proportion of the sensitive invertebrate families (rheophiles) would be resident. However, under no flow conditions, the rheophilic species would not survive and are hence not present at this site. This may partially account for the results obtained in the table below. Hence, these results need to be interpreted with caution. These biotopes in turn were considered limited from a macro-invertebrate perspective (GroundTruth, 2013).

Table 29. Aquatic Macroinvertebrate River Health Metrics for the Gamsberg River during May 2009 (GroundTruth, 2013).

Health metrics (scores)	Gamsberg River (Site AQ04)
SASS5 Score	66
Average Score per Taxon (ASPT)	4.7
Number of Families	14
River Health Classification	Poor

4.8 Mean Annual Runoff (MAR)

The naturalized runoff for quaternary catchments D81G, D82A, D82B and D82C was simulated using the WRSm^{2}000 hydrological model (SLR, 2020) at a unit runoff of 0.28 mm per annum. The runoff is 0.5% when it is expressed as a percentage of rainfall. The monthly runoff for quaternary catchments D81G, D82A, D82B and D82C is presented in Table 30. The low flows of the areas can be attributed to high evaporation rates within the region.

Table 30. Mean Annual Runoff (mm) for catchment D81G, D82A, D82B and D82C (SLR, 2020).

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
0.00	0.01	0.01	0.01	0.02	0.02	0.03	0.02	0.09	0.04	0.02	0.01	0.28

The expected post-development MAR reduction was calculated by Golder (2022a) as 8% of the D82C quaternary catchment.

Table 31. Anticipated post development MAR reduction (Golder, 2022a).

Sub-Catchment	Quaternary Catchment	Quaternary Catchment Area (km^2)	Post-Development Sub-Catchment MAR (X10^3 m^3)	Reduction in Sub-Catchment MAR (%)	Sub-Catchment Contribution to MAR (%)
North	D82C	3,996	7.09	8%	0.2%
South	D81G	2,007	4.05	31%	0.2%

4.9 Resources Class and River Health Receiving Water Quality Objectives and Reserve

NFEPA

In terms of the importance and conservation value of the onsite drainage features, the National Freshwater Ecosystem Priority Area (NFEPA) atlas identifies the quaternary catchments associated with the Gamsberg area as important. In terms of the Present Ecological State (PES) of the drainage tributaries within the vicinity of Gamsberg, a general natural to good class is given to all ephemeral and seasonal streams as a result of its uniqueness and the inability at present to qualify the actual PES (no methods available due to the difficulty of providing reference conditions to these type of hydro geomorphic features). In general, the Lower Orange River catchment in the study area is regarded to have a PES of B (good class) and is considered essential for conservation but not very important in terms of its irreplaceability and sensitivity (Status is not threatened) (Golder,2019).

RQOs

RQOs are currently being developed for the quaternary catchments of the Orange Water Management Area (pers. comm. ORASECOM specialist, 2023), as the latest available RQOs were published in 2009 and includes only D82F, D82K and D82L, and none for D82C or the catchments directly adjacent.

4.10 Surface Water User Survey

The arid nature of the region results in the ephemeral rivers that only flow after significant rainfall events. There are no surface water users in the Gamsberg area. There are no known downstream users of surface water, given the unreliable nature of this resource (Golder, 2022a).

4.11 Sensitive Areas Survey

The watercourses identified as habitats of conservation concern (Desmet, 2013) include drainage lines (washes), Seeps, Springs and Temporary Rock Pools (detailed summary in Section 4.4 of this report). Although saline pans are a feature of the Bushmanland plains landscape none occurs in the study area.

The Faunal Biodiversity report (GroundTruth, 2013) indicates the aquatic ecosystems, consisting of ephemeral streams, springs and rock pools, as part of the overall faunal sensitive habitat.

The Aquatic Biodiversity Compliance Statement (Golder, 2022c) indicates that the NWM5 database indicated that the ephemeral drainage line to the north of the proposed West dump is a river, and that a potential area of 'channelled valley bottom wetland' habitat occurs on site, and that the Present Ecological Status of that system is considered largely to severely/critically modified. No wetlands were identified in the area mapped as 'channelled valley bottom wetland habitat' by the NWM5 database. it is clear that the watercourse that is situated within the study area (rock dumps, proposed Smelter Complex and water pipeline) is highly ephemeral and does not support surface water flows or soil saturation hydroperiod that is long enough to sustain aquatic biodiversity, or wetland conditions. As such, the system is not considered to support wetland or riparian habitat, and is best described as a typically dry, highly ephemeral drainage area.

According to Golder (2019) the Kloof Spring located at the top of the Gamsberg Inselberg is the only surface water resource which is sensitive as it provides habitat and resources for various faunal and flora species in the area.

Regulated Area

The watercourse west of the TSF is indicated by the studies mentioned above to be an ephemeral drainage line with no wetland or riparian habitat. The “regulated area” (as per GN 509 of 2016 in terms of the NWA, 1998) of the TSF 2 project, as per GN 509 of 2016 definition, is therefore the 1:100 flood line.

4.12 Groundwater

Regional Geology

The Gamsberg mine is situated in the Bushmanland Terrane, one of the Northern Cape's tectonically bound terrains. The area consists of hard-rock formations; metasedimentary, metavolcanic and intrusive rock units of the Namaqua Metamorphic Province, or Namaqua-Natal Province.

Rock types in the area are assigned to a regionally developed sequence of Precambrian-age metamorphic rocks and intrusives collectively termed the Namaqua-Natal Province. This is a tectono-stratigraphic province embracing igneous and metamorphic rocks formed or metamorphosed during the Namaqua Orogeny at "'1200- 1000 Ma (mega-annum). The rocks in the Northern Cape (Namaqua Province) are subdivided into several tectonically bound terranes:(1) the Bushmanland Terrane (2) Richtersveld Subprovince (3) Kakamas Terrane (4) Areachap Terrane and (5) Kaaien Terrane. The study area is in the Bushmanland Terrane of which the Hartbees River Thrust forms the eastern boundary, the Groothoek Thrust and Wortel Belt the northern boundaries and is overlain by Karoo-age rocks to the south.

The Bushmanland Terrane is a large supra-crustal block, the volcano-sedimentary rocks of which have been subjected to multiple phases of deformation and medium- to high-grade metamorphism. The Bushmanland Terrane is composed of basement granitic rocks (1700-2 050 Ma), supracrustal sequences of sedimentary and volcanic origin (1200,1600 & 1900 Ma) and intrusive charnokite to granitic rocks (950, 1030-1060 & 1200Ma) (SLR, 2020a).

The Hydrogeology assessment of 2013 (Seyler) referenced the mean annual evaporation rate as high 3500 mm/a in SRK (2010), 3700 mm/a in AATS (2000, as cited in Seyler, 2013) and 2650 mm/a in Midgley & Middelton (1994, as cited in Seyler, 2013) compared to annual rainfall on the plains, hence a permanent water deficit exists in the area. This deficit reaches a peak of 400 mm in November to January and droughts are therefore common in the area.

Local Geology

The following broad scale geological units were encountered during the 2016 geotechnical investigation: Angular quartz talus or sheetflood deposit, schist and gneiss of the Hotson Formation, Bushmanland Group and Koeipoort Gneiss of the Gladkop Metamorphic Suite. Secondary pedogenic surface deposits of calcrete and sand of the Kalahari Group are also abundantly represented. Recent alluvial deposits appear to be absent or very thin in the dry surface river channels. Structurally, the regional area is influenced by the Zuurwater and Rozynbosch thrust faults (GCS, 2016).

Gamsberg forms part of the Bushmanland Group and comprises basalleucocratic gneiss of the Gladkop Group and is overlain by quartzite and mica-sillimanite schist of the Aggeneys Subgroup. The rocks of the Aggeneys- Gamsberg area are summarised below:

- The basement Gladkop Group is made up of various meta- granodiorite, granite, granitoid and gneissic rocks. These basement rocks are overlain by various depths of surficial, relatively thin cover of wind- blown sand, dunes, scree rubble, sandy soil, and alluvium.

- The basement lithology is unconformably overlain by the Wortel Formation and is composed of a basal biotite-sillimanite schist and quartzite, with sporadic magnetite-rich lenses. lenses of amphibolite and sillimanite occur sporadically throughout. The overlying Witputs Formation is lithologically similar and is therefore grouped together with the Wortel Formation.
- The Skelmpoort Formation comprises dark quartzite grading into graphite- bearing quartz-muscovite schist with fuchsite patches. The Skelmpoort Formation ranges from 47-58 m in thickness. The T'hammaberg Formation, 270 m in thickness, is characterised by quartz-muscovite-sillimanite schist interlayered with quartzite with sporadic fuchsite and graphite. The Skelmpoort and T'hammaberg Formations do not occur within the Gamsberg, but outcrop further west and north within the other mineralised deposits.
- The mineralised Hotson Formation comprises quartzite, quartz-feldspar gneiss, and biotite-sillimanite schist. This formation varies from 70 m thick in the west to 500 m thick in the east and the upper 100m is made up of a mineralised (sulphide) banded iron formation, the Gams Member. The Hotson Formation is unconformably overlain by the Koeris Formation (maximum thickness 634 m) comprising of amphibolite, quartz-feldspar-biotite-muscovite gneiss with sporadic pebbles of meta-conglomerate, quartzite, and quartz-feldspar gneiss (possible meta-rhyolite).
- The upper contact to the Koeris Formation represents an unconformity, possibly a thrust fault (SLR 2020a).

Levels and Flow Direction

The Gamsberg Zinc Mine currently has an existing groundwater monitoring network and monitoring is conducted and reported by GHT Consulting Scientists on a quarterly basis. This monitoring network consists of 22 "farm" boreholes on surrounding privately-owned farm areas and 31 mine property boreholes.

The average groundwater levels measured during the Golder (2007), SRK (2010), and ERM (2013a) hydro census investigations were 31.7 metres below ground level (mbgl), 28.1mbgl, and 29.4 mbgl respectively. The groundwater levels ranged between artesian conditions and 178.8 mbgl.

Farm borehole groundwater levels ranged between 8.6 mbgl and 78.9 mbgl with an average groundwater level of 30.8 mbgl (as measured in April 2019 by GHT). The mine borehole groundwater levels ranged between 11.6 mbgl and 52.3 mbgl with an average groundwater level of 30.6 mbgl.

In general, water levels in the Gamsberg area mimic the surface topography (based on April 2019 measured groundwater levels). Figure 24 shows an inferred groundwater level contour map of the area. Groundwater levels were contoured to groundwater elevation above mean sea level. The groundwater contour map indicates that groundwater flow is radially to the northeast and southwest away from the Gamsberg Inselberg (SLR, 2020a).

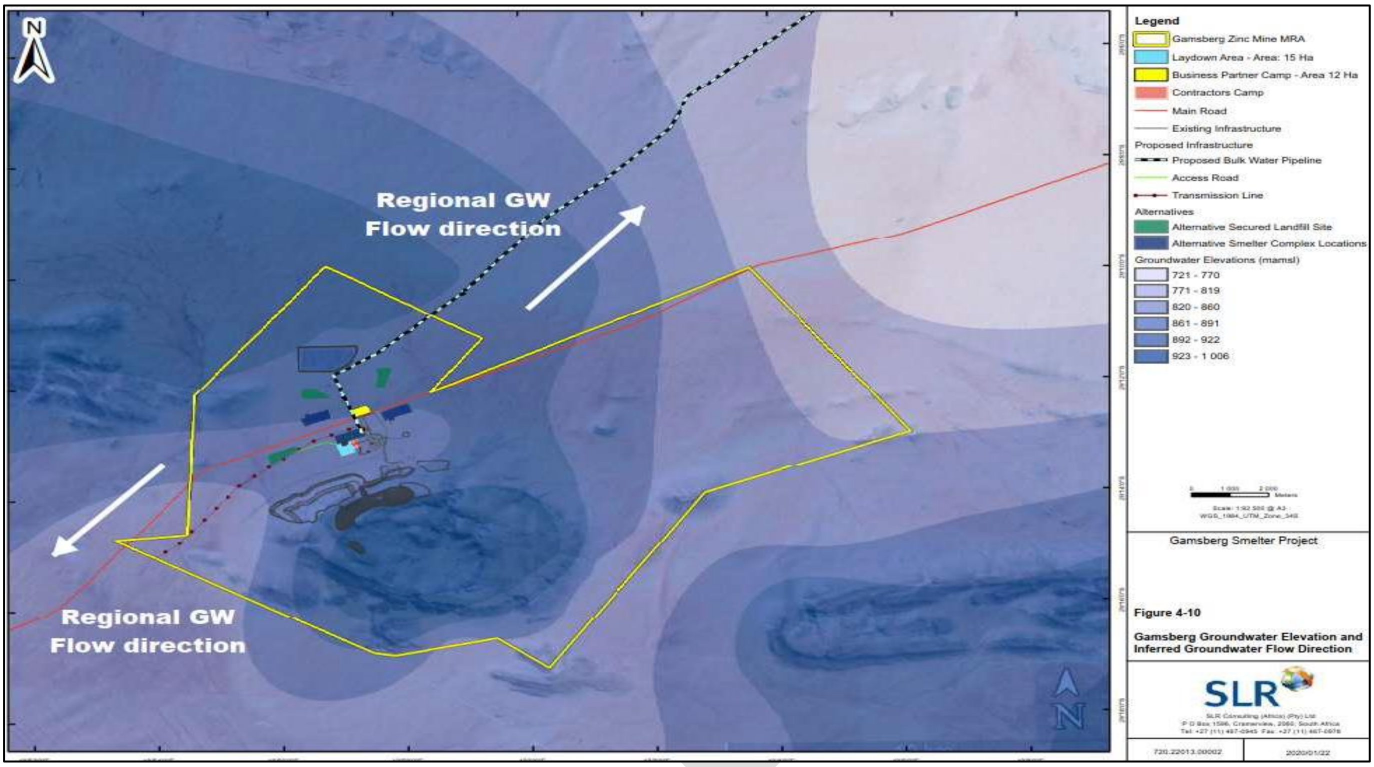


Figure 24. Gamsberg Groundwater Elevation and Inferred Groundwater Flow Direction (SLR, 2020a).

4.13 Aquifer Characterisation

Aquifer Classification

Vegter (2000, as cited in SRK, 2010) indicated that no regional aquifers are developed in the in the Namaqualand Metamorphic Complex area and groundwater tends to be concentrated preferentially along fractures within hydraulically isolated rocks of low permeability, which dominate the surrounding plains. Primary weathered zone aquifers are rare and localised because soils are thinly developed. Based on the aquifer classification map the aquifer system underlying the site is regarded mainly as a poor groundwater region. A poor groundwater region consists of a low to negligible yielding aquifer system of moderate to poor water quality (SRK, 2010).

The recommended level of groundwater protection based on the Groundwater Quality Management (GQM) Classification is <1 and therefore a limited to low-level groundwater protection is required for the aquifer within the study area (SRK, 2010).

Aquifer units in the Gamsberg area generally have very low to low permeability and increased groundwater occurrence is only associated with secondary structures such as faults and fractures. The TSF, smelter complex and secured landfill facility are all located on basal gneiss of the Gladkop Group and no regional scale lineaments are located within the footprint of these facilities (SLR, 2020a).

The hydraulic conductivity calibrated in numerical modelling by AATS in 2000 (Seyler, 2013), are summarised as:

- The inner areas of the inselberg (assumed equivalent to the Gamsberg Iron Formation) has 1E-05 m/d
- The outer areas of the inselberg (assumed equivalent to Pella Quartzite and Schist grouped) has 3E- 5 m/d
- The plains (assumed equivalent to alluvium and gneiss grouped) has 1E-03 m/d
- Structurally controlled preferential drainage lines are set at 4E-01 m/d and 1E+00 m/d

Groundwater Vulnerability

Groundwater vulnerability gives an indication of how susceptible an aquifer is to contamination. Based on the national scale results, the aquifer underlying the project area has a low vulnerability rating indicating a low tendency or likelihood for contamination to reach a specified position in the groundwater system after introduction at some surface location above the uppermost aquifer.

Local-scale groundwater vulnerability was determined and concluded that approximately 58% of the study area had a medium high vulnerability, mostly occurring on the plains surrounding the Gamsberg. The mountainous regions were predominantly of medium low to very low vulnerability the south to southeast, in the region of the windblown sand and dune sand, the vulnerability was classified as high. The mine infrastructure is situated in areas of medium high vulnerability (SLR, 2020a).

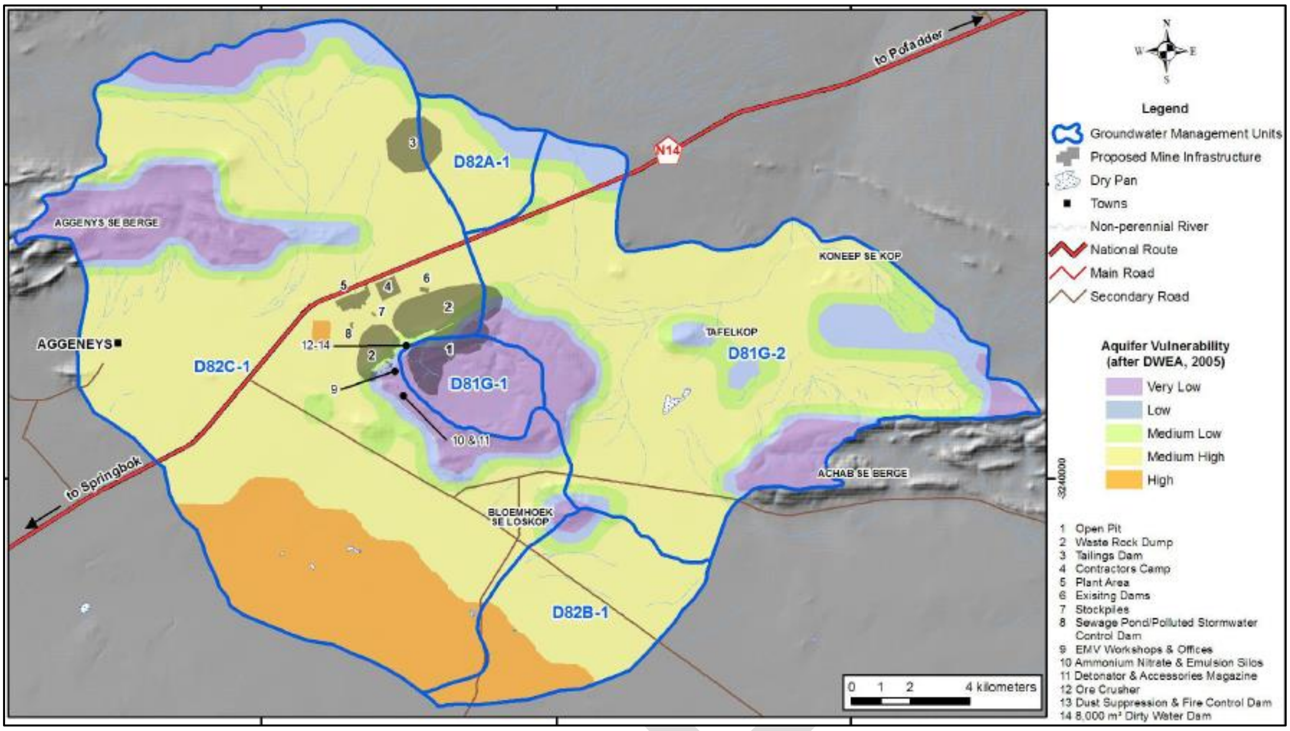


Figure 25. Aquifer vulnerability map (SRK, 2010b).

From the 2010 pump test readings it was evident that the ranges for various units are similar. This supports the interpretation that depth from surface due to weathering, and local (cross cutting) structural controls will be the greatest control on hydraulic parameters, rather than rock type.

Fitting characteristic curves to the constant discharge tests shows a broadly confined character for each test (AATS, 2000 as cited in Seyler, 2013). This is a usual characteristic for fractured rock environments, even though there is no low permeability layer overlying the aquifers in question, as the fractured rock essentially is self-confining (Seyler, 2013).

4.14 Groundwater Quality

The site has an existing groundwater monitoring network and monitoring is conducted and reported by GHT Consulting Scientists. Historical monitoring consisted of several sampling periods from 2007 - 2019 and groundwater quality monitoring results of the various monitoring periods are summarised below (the results of the 2020 – 2023 monitoring is included in Section 5.5 of this report):

2007 Golder

- Water samples were collected from 3 boreholes and 1 spring during the 2007 hydrocensus investigation. The inorganic analytical results were compared to SANS-241 (2006) drinking water quality guidelines.
- The pH of the groundwater samples ranged between 6.92 and 7.39 with an average value of 7.20. The EC ranged between 24 mS/m and 117 mS/m with an average value of 83 mS/m. The SO4 concentrations ranged between 16.96 mg/L and 70.33 mg/L with an average concentration of 57.73 mg/L.

- Apart from elevated fluoride concentration in one sample, the groundwater quality was good with no other constituents elevated above the guideline limits. An elevated fluoride concentration of 1.05 mg/L was noted in sample GAMB1. This concentration was marginally above the Class I guideline of 1 mg/l but is less than the Class II guideline of 1.5 mg/l (SLR, 2020b).

2010 SRK

- During the initial hydro census, five groundwater samples were collected in April (RS1, AG1, BLH1, KGT2 and GAMS3) and a further 10 in May 2009 during completion of the hydro census (ACH1 + duplicate ACH2, AG1, AR1, BLH1, GAMS2, GAMS4, GAMS8 GAMS10 and GBH3) along with four surface water samples (GAMS1SW, GAMS3SW, GAMS4SW and GAMS4SW2). Ten groundwater samples were also collected during the first groundwater monitoring round in August 2009.
- The pH of the groundwater samples ranged between 6.20 and 8.50 with an average value of 7.54. The EC ranged between 16 mS/m and 660 mS/m with an average value of 159 mS/m. The SO4 concentrations ranged between 14.6 mg/L and 947 mg/L with an average concentration of 170.0 mg/L SRK, 2020b).
- The ECs of the groundwater sampled in boreholes close to the Gamsberg Inselberg (GAMS-2, -3, -4 & -5) are much lower than the EC of water samples taken from water sources in the plains (Figure 26) surrounding Gamsberg, reflecting the higher recharge and younger groundwater (shorter flow path) in this area. The pH values of water sampled during the hydro census range between 6.15 and 8.45, with a mean of 7.45 (SRK, 2010).

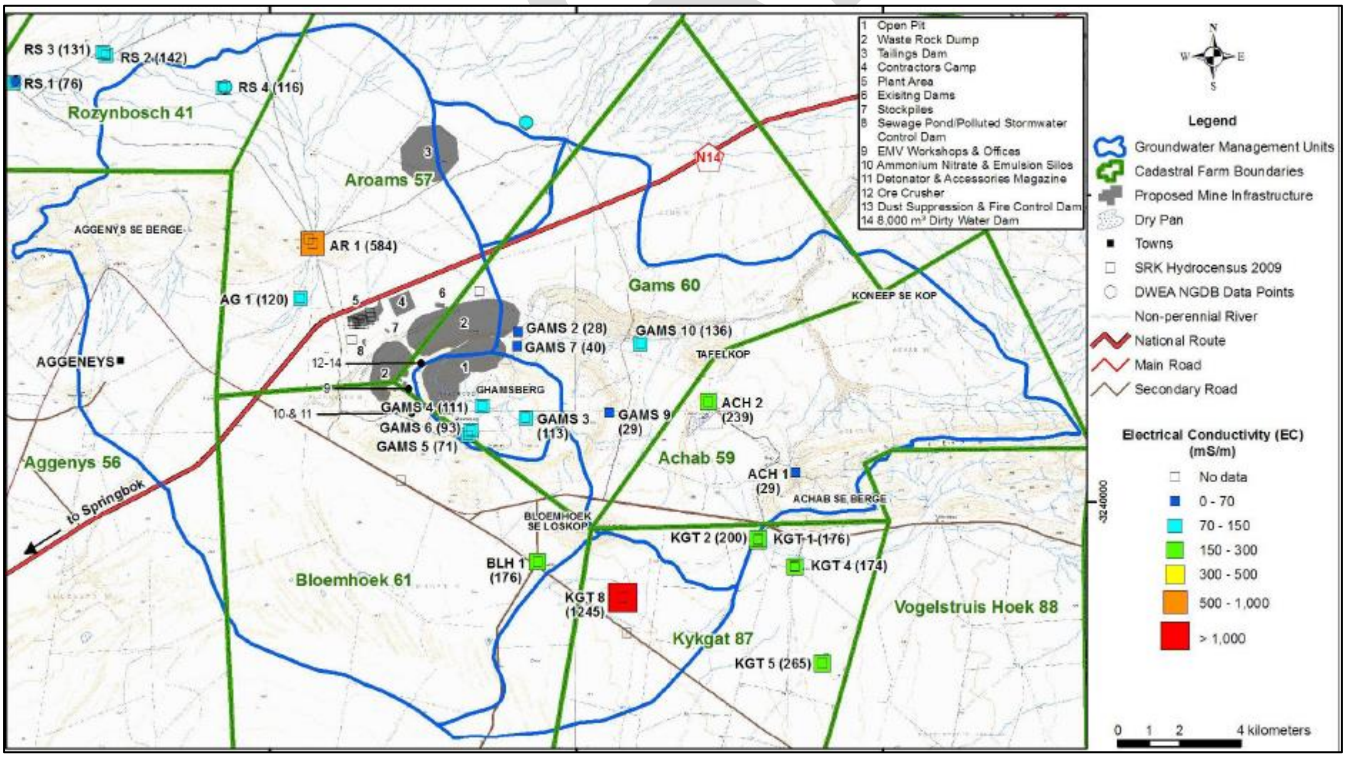


Figure 26. Groundwater monitoring points indicating EC (Hydro census, SRK, 2010b).

Table 32. April 2009 groundwater data (SRK, 2010b)

Determinant	Units	RS3	AG1	BLH1	KGT2	GAMS3
pH @ 20°C	pH units	7.8	8.2	8.3	8..0	7.6
EC @ 25°C	mS/m	133	129	182	204	114
Total Dissolved Solids	mg/ℓ	934	836	1 172	1 312	796
Total Alkalinity	mg/ℓ $CaCO_3$	165	263	272	346	216
Sodium	mg/ℓ Na	108	142	169	198	90
Chloride	mg/ℓ Cl	226	179	295	331	167
Calcium	mg/ℓ Ca	104	51	110	130	73
Magnesium	mg/ℓ Mg	38	35	42	50	73
Sulphate	mg/ℓ SO_4	116	102	168	201	97
Potassium	mg/ℓ K	4.9	28.0	17.6	12.6	5.9
Fluoride	mg/ℓ F	3.3	3.4	3.0	4.2	0.7
Arsenic	mg/ℓ As	<0.001	<0.001	<0.001	<0.001	<0.001
Aluminium	mg/ℓ Al	0.009	0.01	0.01	<0.009	0.009
Manganese	mg/ℓ Mn	<0.001	<0.001	<0.001	<0.001	<0.001
Iron	mg/ℓ Fe	0.01	0.02	0.02	0.005	0.01
Zinc	mg/ℓ Zn	0.10	0.04	0.03	0.03	0.08
Lead	mg/ℓ Pb	0.003	0.004	<0.001	<0.001	0.003
Copper	mg/ℓ Cu	<0.002	<0.002	<0.002	<0.002	<0.002
Total Chromium	mg/ℓ Cr	<0.003	<0.003	<0.003	<0.003	<0.003
Cadmium	mg/ℓ Cd	<0.001	<0.001	<0.001	<0.001	<0.001
Uranium	mg/ℓ U	<0.004	0.006	0.008	0.13	<0.004
Barium	mg/ℓ Ba	0.07	0.07	0.07	0.06	0.07
Nitrate	mg/ℓ N	12.2	0.9	12.4	5.2	1.4

= SANS 241:2006 Class I / WHO   = SANS 241:2006 Class II   > SANS 241:2006 Class II

Table 33. May 2009 groundwater data (SRK, 2010b)

Determinant	Units	ACH1	ACH2 (ACH1 dupl)	AG1	AR1	BLH1	GAMS2	GAMS4	GAMS8	GAMS10	GBH3
pH @ 20°C	pH units	6.4	6.3	8.4	8.0	8.0	6.2	7.4	7.7	7.3	8.0
EC @ 25°C	mS/m	30.8	30.7	114	660	171	35.6	114	145	105	208
Total Dissolved Solids	mg/ℓ	240	238	732	4 448	1060	264	764	876	788	1252
Total Alkalinity	mg/ℓ $CaCO_3$	28	71	276	347	265	50	337	307	92	238
Sodium	mg/ℓ Na	29	73	156	912	201	38	98	135	110	270
Chloride	mg/ℓ Cl	47	52	151	1 654	256	52	111	174	215	395
Calcium	mg/ℓ Ca	17.8	17.2	53	261	114	19.7	130	159	54	103
Magnesium	mg/ℓ Mg	11.2	9.5	33	149	40	13.1	36	31	44	45
Sulphate	mg/ℓ SO_4	25	30	80	947	169	51	72	176	100	195
Potassium	mg/ℓ K	3	3.1	15.4	86	17.8	5.8	6.6	26	4.6	21.0
Fluoride	mg/ℓ F	0.3	0.2	3.5	4.2	3.1	0.7	1.4	1.9	2	3.4
Arsenic	mg/ℓ As	<0.001	<0.001	<0.001	0.009	0.002	0.004	0.003	0.002	<0.001	<0.001
Aluminium	mg/ℓ Al	<0.009	<0.009	0.01	0.01	<0.009	<0.009	<0.009	0.01	0.01	0.02
Manganese	mg/ℓ Mn	<0.001	<0.001	<0.001	<0.001	0.004	2.1	<0.001	0.19	0.03	0.01
Iron	mg/ℓ Fe	0.04	0.03	0.04	0.04	0.05	41	0.04	0.42	0.09	0.04
Zinc	mg/ℓ Zn	0.90	0.56	0.49	0.68	0.45	3.0	0.39	0.48	1.1	0.29
Lead	mg/ℓ Pb	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	mg/ℓ Cu	0.07	0.07	0.01	0.005	0.002	<0.002	0.02	0.01	0.007	0.004
Total Chromium	mg/ℓ Cr	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
Cadmium	mg/ℓ Cd	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001
Uranium	mg/ℓ U	<0.004	<0.004	0.007	0.03	0.009	<0.004	<0.004	0.01	<0.004	0.01
Barium	mg/ℓ Ba	0.09	0.08	0.08	0.02	0.02	0.05	0.06	0.05	0.06	0.04
Nitrate	mg/ℓ N	8.8	15.1	1.9	22	15.4	0.3	2.8	1.9	0.6	5.0

= SANS 241:2006 Class I / WHO; = SANS 241:2006 Class II; > SANS 241:2006 Class II

Table 34. August 2009 groundwater data (SRK, 2010b)

Determinant	Units	GAMS4	GBH3	GAMS2	GAMS8	GAMS7 (SPRING KLOOF)	BHL1	ACH1	GAMS 10	AR1	AG1
pH @ 20°C	pH units	7.2	7.7	8	7.3	6.6	7.9	6.4	6.8	8.4	8.5
EC @ 25°C	mS/m	114	199	26.8	124	16.1	185	32.4	104	660	150
Total Dissolved Solids	mg/ℓ	754	1 380	180	834	124	1 236	216	684	4 352	984
Total Suspended Solids	mg/ℓ	6	13	63	<1	<1	190	<1	<1	<1	<1
Turbidity	NTU	0.7	0.8	15	6.5	0.55	2.5	0.4	15	0.4	1
Total Alkalinity	mg/ℓ $CaCO_3$	420	230	49	276	16	259	29	95	352	278
Sodium	mg/ℓ Na	103	279	42	140	15.1	183	32	121	976	178
Chloride	mg/ℓ Cl	105	365	57	139	22	316	49	198	1603	212
Calcium	mg/ℓ Ca	104	83	8	83	6.4	104	13.1	46	211	65
Magnesium	mg/ℓ Mg	31	39	5.9	28	6.5	43	11.3	41	156	36
Sulphate	mg/ℓ SO_4	99	245	14.6	154	30	170	31	124	691	163
Potassium	mg/ℓ K	6.3	18.5	7.3	23	3	19.3	3.8	2.4	52	16.6
Fluoride	mg/ℓ F	1.4	3.5	0.5	2	<0.1	3.2	0.2	2	4.2	3.1
Arsenic	mg/ℓ As	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Aluminium	mg/ℓ Al	0.05	0.13	<0.009	0.15	0.01	0.05	0.02	0.03	0.08	0.03
Manganese	mg/ℓ Mn	<0.001	<0.001	0.04	0.24	<0.001	0.001	<0.001	0.10	<0.001	<0.001
Iron	mg/ℓ Fe	0.01	0.05	0.41	0.29	0.06	0.04	0.007	0.50	0.01	0.02
Zinc	mg/ℓ Zn	<0.005	0.02	0.23	<0.005	<0.005	0.19	0.22	2.0	0.24	0.09
Lead	mg/ℓ Pb	<0.001	0.004	0.007	0.003	<0.001	<0.001	0.001	<0.001	0.01	<0.001
Copper	mg/ℓ Cu	0.007	0.002	<0.002	<0.002	<0.003	<0.002	0.09	<0.002	<0.002	<0.00
Total Chromium	mg/ℓ Cr	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.005	0.009	0.005
Cadmium	mg/ℓ Cd	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Uranium	mg/ℓ U	0.01	0.04	<0.004	0.02	<0.004	0.03	<0.004	<0.004	0.13	0.02
Barium	mg/ℓ Ba	0.04	0.04	0.009	0.04	0.05	0.01	0.05	0.05	0.07	0.04
Free/Saline Ammonia	mg/ℓ N	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Nitrate	mg/ℓ N	0.6	<0.1	<0.1	<0.1	0.2	7.0	3.6	<0.1	43	0.4
Total Phosphate	mg/ℓ PO_4	0.4	0.3	0.9	0.2	0.3	0.8	0.1	<0.1	0.1	<0.1
Soluble Phosphate	mg/ℓ PO_4	0.1	0.3	<0.1	0.1	0.1	0.2	<0.1	<0.1	<0.1	<0.1

Seyler (2013)

- Laboratory **pH** varies from 5.8 to 8.7. All but one of the pH measurements (pH 5.8 in sample GAMS5) fall within the DWAF target range for domestic water use (pH 6-9).
- **Electrical conductivities** range from 24 mS/m (GAMS9) to 1626 mS/m (AR2). The majority of the EC values exceed the domestic water target of 70 mS/m. The higher EC concentrations are generally detected in boreholes located in the plains surrounding the Gamsberg inselberg. Salts concentrating in the soil by evaporation of rainfall can be

washed through the soil by rainfall. As limited recharge occurs on the plains, the concentration of salts in recharge is likely to be high.

- **Chloride** concentrations range from 29 mg/L (GAMS5) to 5234 mg/L (AR2). The majority of the groundwater samples exceed the DWAF domestic target value of 100 mg/L for chloride. The target value for livestock watering (1500 mg/L) is exceeded in three samples: KGT7, AR1 and AR2.
- **TDS** concentrations reflect the EC values: TDS concentrations range from 116 mg/L in GAMS9 to 11097 mg/L in AR2. The majority of the samples exceed the target for domestic use (450 mg/L) and a number of samples also exceed the target for livestock watering (1000 mg/L). Higher TDS concentrations are detected in samples collected from boreholes in the plains surrounding the Gamsberg inselberg.
- **Sulphate** concentrations range from 22 mg/L (GAMS9) to 1706 mg/L (AR2). A number of samples exceed the domestic water target value of 200 mg/L. The sulphate concentration in sample AR2 (1706 mg/L) exceeds the target for livestock watering (1000 mg/L). Well AR2 is located in the kloof at the eastern end of Aggeneys Berg.
- Groundwater **nitrate** concentrations range from <0.057 mg/L (GAMS5) to 32 mg/L (KGT3). A number of nitrate concentrations exceed the DWAF target value for domestic water use (6 mg/L). Elevated levels appear to be located on farms surrounding the inselberg and are possibly related to livestock farming.
- **Fluoride** concentrations range from <0.183 mg/L (GAMS5) to 5.2 mg/L (AR2). The majority of the groundwater samples contain concentrations exceeding both the domestic use and livestock watering target values of 1 mg/L and 2 mg/L, respectively. Naturally occurring, high levels of fluoride in groundwater in the Northern Cape are well documented (Ncube & Schutte, 2005).
- **Calcium** concentrations in the groundwater samples range from 10 mg/L (GAMS9) to 878 mg/L (AR2). The majority of the samples have concentrations exceeding the DWAF domestic target value of 32 mg/L.
- The concentrations of **magnesium** in the samples range from 7.72 mg/L (GAMS9) to 473 mg/L (AR2). The majority of the samples have concentrations exceeding the DWAF domestic target value of 30 mg/L.
- **Sodium** concentrations in the groundwater samples range from 19 mg/L (GAMS5) to 2333 mg/L (AR2). The DWAF target value for domestic use (100 mg/L) is exceeded in most of the samples and the target value for livestock watering (2000 mg/L) is exceeded in one sample (AR2).
- **Potassium** concentrations range from 1.89 mg/L (GAMS10) to 113 mg/L (AR2). The domestic use target value of 50 mg/L is exceeded in three samples (KGT7, AR1 and AR2).
- The domestic use target values for iron (0.1 mg/L), **manganese** (0.05 mg/L) and **lead** (0.01 mg/L) are exceeded in several samples. The highest iron (84.32 mg/L), manganese (69.3 mg/L) and lead (0.028mg/L) concentrations were detected in sample GAMS5, which has the lowest pH of any of the samples. Concentrations of iron and manganese in this sample exceed the target values for livestock watering. GAMS5 was also found to contain the highest concentration of **zinc** (11.25 mg/L), exceeding the domestic target value of 3 mg/L.
- Almost half of the water samples contain **uranium** concentrations exceeding the DWAF domestic target value of 0.07 mg/L. Concentrations range from <0.01 to 0.32 mg/L (AR2).

Occurrence of elevated uranium in groundwater in the Northern Cape is well documented (Van Wyk & Coetzee, 2008).

- **Arsenic** concentrations were reported as being below the laboratory limit of detection (0.023 mg/L). This limit of detection, however, is higher than the DWAF target value for domestic use.

- Some samples also indicate a tendency to **sulphate** dominance. These samples are GAMS2, GAMS5, GAMS6 and ACH2. The GAMS samples are all within the inselberg, and likely to be affected by the sulphide-rich ore deposit. GAMS5 has the highest proportion of sulphate and the lowest pH of water samples collected, and may indicate acid rock drainage (Seyler, 2013).

GHT (2019, from SLR, 2020a)

- **Gamsberg Regional Monitoring Boreholes**
  - A total of 14 farms and 22 mine boreholes were sampled by GHT Consulting as part of the site groundwater monitoring programme conducted between November 2017 and April 2019. GHT Consulting compared groundwater quality results to the South African National Standards (SANS241-2015 and SANS241-2006), the South African Water Quality Guidelines, Volume 5 -Agricultural Use: Livestock Watering, and the Gamsberg Mine Water Use License (WUL No.: 14/D82C/ABCGIJ/2654) - Water Resource Quality Objectives (SLR, 2021).
  - The pH of the groundwater samples ranged between 7.10 and 8.44 with an average value of 7.60. The EC ranged between 33 mS/m and 523 mS/m with an average value of 224 mS/m. The S04 concentrations ranged between 28.5 mg/L and 509.6 mg/L with an average concentration of 253.8 mg/l. The farm production boreholes and associated regional monitoring boreholes had elevated concentrations of As, Fe, Pb, U, EC, TDS, Na, Ca, Mg, Cl, S04, F, N03-N, and Mn above the relevant guideline limits, as shown in Table 35. GHT Consulting found that the background groundwater qualities, of the naturally occurring aquifer waters of the farm areas, in general exceeded drinking water standards (SLR, 2020a).

Table 35. Gamsberg – Regional Monitoring Boreholes Groundwater Quality Results (GHT, 2019)

Date	Station ID	Al (mg/L)	As (mg/L)	Ca (mg/L)	Cd (mg/L)	Cu (mg/L)	Fe (mg/L)	K (mg/L)	Mg (mg/L)	Mn (mg/L)	Na (mg/L)	Pb (mg/L)	U (mg/L)	Zn (mg/L)	pH (Value at 25°C)	Electrical Conductivity in mS/m at 25°C	Total Dissolved Solids at 180°C *	Chloride as Cl	Sulphate as SO_4	Fluoride as F	Nitrate as N
IWUL				201					30		463				5.6 - 9.5	414		554	202	4.8	12.1
SANS 241 (2015) Operational		0.3													5 - 9.7						
SANS 241 (2015) Aesthetic							0.3			0.1	200			5		170	1200	300	250		
SANS 241 (2015) Acute Health																			500		11
SANS 241 (2015) Chronic Health			0.01		0.003	2	2			0.4		0.01	0.03							1.5	
DWAF TWQG (Livestock Watering) TQR		5	1	1000	0.01	[a]0.5	10		500	10	2000	0.1		20			[b]1000	[c]500	1000	[d]2	100
20190504	AR11	< 0.01	< 0.005	137	< 0.002	< 0.01	0.02	25.5	60.7	< 0.01	262	< 0.01	0.11	0.12	7.32	235	1418	469	258	2.02	2.84
20190504	AR12	< 0.01	< 0.005	68.2	< 0.002	< 0.01	< 0.01	8.6	25.7	< 0.01	51.3	< 0.01	< 0.01	< 0.01	7.9	81.5	458	112	81.2	0.79	3.45
20190503	KGT78	< 0.01	0.01	75.8	< 0.002	< 0.01	< 0.01	38.3	94.7	< 0.01	531	< 0.01	0.04	< 0.01	8.44	353	2176	714	510	6.87	1.8
20190503	KGT3	< 0.01	< 0.005	99.5	< 0.002	< 0.01	0.04	8.85	38	< 0.01	132	< 0.01	0.07	< 0.01	7.92	144	807	232	104	2.24	7.49
20190503	KGT1	< 0.01	0.01	354	< 0.002	< 0.01	0.03	20	123	< 0.01	545	0.01	0.04	< 0.01	7.21	510	3088	1365	462	1.99	7.51
20190503	NAM3	0.02	< 0.005	107	< 0.002	< 0.01	< 0.01	7.41	27.1	< 0.01	150	< 0.01	< 0.01	< 0.01	7.49	150	866	286	132	2.39	12.8
20190503	NAM2	< 0.01	< 0.005	81.8	< 0.002	< 0.01	< 0.01	5.93	21.7	< 0.01	102	< 0.01	0.02	0.04	8.16	111	619	213	93.8	1.55	4.58
20190503	NAM1	0.01	0.01	420	< 0.002	0.05	0.02	18.4	127	0.01	562	0.01	0.04	0.02	7.38	523	3287	1445	502	1.64	25
20190503	WIT1	< 0.01	0.01	127	< 0.002	< 0.01	0.09	8.2	42.7	0.01	510	< 0.01	0.03	0.28	7.63	339	1961	725	388	6.47	6.61
20190504	AROAMS 02	< 0.01	< 0.005	68.7	< 0.002	< 0.01	0.02	2.31	17.5	< 0.01	67	< 0.01	< 0.01	< 0.01	7.77	82.3	446	135	45.5	2.52	3.19
20190430	ACH2	< 0.01	< 0.005	120	< 0.002	0.06	0.06	31.3	39.9	0.02	248	< 0.01	0.02	< 0.01	7.53	200	1333	207	465	4.96	15.1
20190430	ACH4	< 0.01	< 0.005	78.4	< 0.002	< 0.01	< 0.01	5.59	39.6	< 0.01	165	< 0.01	0.06	< 0.01	7.11	148	849	204	194	2.41	1.48
20190430	ACH3	< 0.01	< 0.005	151	< 0.002	< 0.01	0.37	9.97	52.7	0.79	228	< 0.01	0.02	1.59	7.4	221	1326	449	290	2.48	1.8
20190430	ACH1	< 0.01	< 0.005	13.8	< 0.002	< 0.01	< 0.01	3.16	10.8	< 0.01	29.9	< 0.01	< 0.01	< 0.01	7.1	33.5	178	54.4	28.5	0.25	4.03

Note:
[a] 1500: Monogastric & poultry, 3000: Other livestock; [b]0-0.5: Sheep and calves, 0.5-1: Other livestock; [c] 0 – 2: All other livestock, 0 – 6: Ruminants;[d] 1000: Dairy, pigs & poultry, 2000: Cattle and horses, 3000: Sheep
Highlighted cells indicate which water quality standard has been exceeded

- **Gamsberg Zinc Mine Boreholes**
  - The pH of the groundwater samples ranged between 6.57 and 7.66 with an average value of 7.42. The EC ranged between 37 mS/m and 1141mS/m with an average value of 234 mS/m. The 504 concentrations ranged between 35.0 mg/al nd 2 324.0 mg/L with an average concentration of 324.7 mg/l.
  - The mine monitoring boreholes had elevated concentrations of EC, TDS, Na, Ca, Mg, Cl, F, As, Fe, N03-N, Pb, Mn, and U above the relevant guideline limits. GHT Consulting concluded that between November 2017 and April 2019 the RE were no groundwater quality impacts observed in the receiving local aquifer of the Gamsberg Zinc Mine (SLR, 2021)).

Table 36. Gamsberg Zinc Mine Groundwater Monitoring Boreholes – Groundwater Quality Results (GHT, 2019)

Date	Station ID	Al (mg/L)	As (mg/L)	Ca (mg/L)	Cd (mg/L)	Cu (mg/L)	Fe (mg/L)	K (mg/L)	Mg (mg/L)	Mn (mg/L)	Na (mg/L)	Pb (mg/L)	U (mg/L)	Zn (mg/L)	pH (Value at 25°C)	Electrical Conductivity in mS/m at 25°C	Total Dissolved Solids at 180°C *	Chloride as Cl	Sulphate as SO4	Fluoride as F	Nitrate as N
IWUL				201					30		463				5.6 - 9.5	414		554	202	4.8	12.1
SANS 241 (2015) Operational		0.3													5 - 9.7						
SANS 241 (2015) Aesthetic							0.3			0.1	200			5		170	1200	300	250		
SANS 241 (2015) Acute Health																			500		11
SANS 241 (2015) Chronic Health			0.01		0.003	2	2			0.4		0.01	0.03							1.5	
DWAF TWQG (Livestock Watering) TQR		5	1	1000	0.01	[a]0.5	10		500	10	2000	0.1		20			[b]1000	[c]500	1000	[d]2	100
20190503	MH01	0.03	< 0.005	22	< 0.002	< 0.01	< 0.01	3.13	14	0.01	36.3	< 0.01	< 0.01	< 0.01	7.73	44.2	225	64.2	43.7	0.66	< 0.35
20190502	MH02	< 0.01	< 0.005	131	< 0.002	< 0.01	< 0.01	22.3	75.2	< 0.01	260	< 0.01	0.02	< 0.01	7.54	246	1491	522	399	2.03	0.56
20190503	MH03	< 0.01	< 0.005	50.9	< 0.002	< 0.01	0.46	13.2	45	0.86	51.4	< 0.01	< 0.01	< 0.01	7.14	95.9	524	204	131	0.15	< 0.35
20190503	MH10	0.01	< 0.005	19.1	< 0.002	< 0.01	< 0.01	4.9	12.5	0.02	20.2	< 0.01	< 0.01	< 0.01	7.36	33.3	166	375	20.7	0.48	0.46
20190501	GAMS2	< 0.01	< 0.005	15.3	< 0.002	< 0.01	0.1	6.15	9.86	1.59	29.5	< 0.01	< 0.01	0.58	6.57	37.3	182	50.3	35	0.72	< 0.35
20190501	MH06	0.12	< 0.005	158	< 0.002	< 0.01	0.13	15.5	60	0.08	268	< 0.01	0.02	< 0.01	7.56	240	1442	556	255	2.02	1.45
20190501	MM AR11	0.13	< 0.005	154	< 0.002	< 0.01	0.3	18	44.3	0.05	259	< 0.01	0.02	< 0.01	7.57	233	1407	521	266	1.82	9.88
20190501	AR10	< 0.01	< 0.005	182	< 0.002	< 0.01	< 0.01	15	45.2	< 0.01	217	< 0.01	0.02	< 0.01	7.49	229	1369	499	221	1.52	17
20190501	AR09	< 0.01	0.01	157	< 0.002	< 0.01	< 0.01	20	36.9	0.01	320	< 0.01	0.03	< 0.01	7.36	255	1514	509	280	1.67	< 0.35
20190501	AR07	< 0.01	< 0.005	110	< 0.002	< 0.01	< 0.01	15.2	31.9	< 0.01	169	< 0.01	0.03	< 0.01	7.48	164	935	300	124	2.16	7.94
20190501	MBH17	< 0.01	0.01	236	< 0.002	0.05	< 0.01	25.2	69.1	< 0.01	420	< 0.01	0.03	< 0.01	7.56	362	2224	814	442	1.72	21
20190501	SOL PUMP	< 0.01	0.01	446	< 0.002	0.07	0.07	57	79	1.63	449	0.01	0.04	0.02	7.22	433	3239	664	1364	1.32	2.76
20190501	MH08	0.02	0.01	850	< 0.002	0.06	0.08	100	301	4.56	1267	0.03	0.09	0.02	7.14	1141	7774	2776	2324	1.34	0.4
20190501	MH09	< 0.01	< 0.005	99	< 0.002	< 0.01	0.16	15.9	39.2	0.24	159	< 0.01	0.01	< 0.01	7.1	164	862	419	19	1.75	< 0.35
20190501	GBTSF2	0.14	< 0.005	95	< 0.002	< 0.01	0.04	22.5	27.3	0.03	169	0.16	0.08	< 0.01	7.53	153	888	253	137	2.3	5.3
20190501	GBTSF3	< 0.01	< 0.005	100	< 0.002	< 0.01	< 0.01	16.6	29.2	< 0.01	189	< 0.01	0.03	< 0.01	7.56	165	955	313	126	2.27	7.15
20190501	GBTSF4	< 0.01	< 0.005	106	< 0.002	< 0.01	0.02	16	31	0.01	225	0.05	0.02	< 0.01	7.53	184	1072	364	161	2.33	4.21
20190501	GBTSF5	< 0.01	0.01	177	< 0.002	< 0.01	0.02	68.1	42.3	0.19	478	0.04	0.03	< 0.01	7.64	333	2040	735	358	2.13	0.61
20190501	GBTSF6	0.01	0.01	474	< 0.002	< 0.01	0.01	49.1	49.5	0.08	523	0.01	0.04	0.02	7.47	537	3164	1217	769	0.96	9.2
20190501	GBTSF7	< 0.01	0.01	377	< 0.002	< 0.01	0.07	63.8	34.09	0.12	572	0.01	0.04	0.02	7.44	468	3129	976	925	1.07	27
20190501	GBTSF8	< 0.01	< 0.005	153	< 0.002	< 0.01	< 0.01	22.1	33.8	0.05	285	< 0.01	0.02	< 0.01	7.63	246	1407	511	247	1.8	2.05
20190501	GBTSF9	< 0.01	< 0.005	95.9	< 0.002	< 0.01	< 0.01	15.5	25.2	< 0.01	229	< 0.01	0.02	< 0.01	7.52	182	1027	335	150	2.25	5.78

Note:
[a] 1500: Monogastric & poultry, 3000: Other livestock; [b]0-0.5: Sheep and calves, 0.5-1: Other livestock; [c] 0 – 2: All other livestock, 0 – 6: Ruminants;[d] 1000: Dairy, pigs & poultry, 2000: Cattle and horses, 3000: Sheep
Highlighted cells indicate which water quality standard has been exceeded

- **Water Quality of Hydro-census Boreholes**
    - The following info was obtained from the Hydrogeological Assessment for the proposed Smelter Complex (SLR, 2020a).
    - Results from the previous hydro census investigations by Golder (2007), SRK (2010), and ERM (2013a) showed that pH ranged between 5.81and 8.67 with an average value of 7.49. The electrical conductivity (EC) ranged between 16 mS/m and 1626 mS/m with an average value of 161mS/m. The sulphate concentrations ranged between 14.6 mg/L and 1706 mg/L with an average concentration of 163.9 mg/L.
    - In addition, groundwater monitoring results conducted between November 2017 and April 2019 indicated the pH of the groundwater samples ranged between 6.57 and 8.44 with an average value of 7.51. The EC ranged between 33 mS/m and 1141mS/m with an average value of 229 mS/m and sulphate concentrations ranged between 28.5 mg/L and 2 324 mg/L with an average concentration of 289.3 mg/L.
    - The previous hydro census Investigations and groundwater monitoring results showed several constituents that were elevated above relevant guideline limits. Parameters included EC, total dissolved solids (TDS), sodium, calcium, magnesium, chlorine, sulphate, fluoride, nitrate, arsenic, lead, iron, manganese and uranium.
    - The processes of evaporation and long-residence time or the host rock mineralogy (apatite-bearing rocks) may result in elevated fluoride concentrations which is a characteristic feature of the Northern Cape. SRK (2010) concluded that the chemical composition of the water from the area under investigation has undergone natural base-exchange and precipitation processes. The hydrochemistry of the Gamsberg area was interpreted to be indicative of a mature Hydro chemical environment with very limited recharge, which generally only takes place in years of exceptionally high precipitation. Analysis of the April 2019 sampling of the Gamsberg Zinc Mine and farm monitoring boreholes confirmed the findings that the groundwater is indicative of a mature Hydro chemical environment with very limited recharge
    - GHT Consulting concluded that between November 2017 and April 2019 the RE was no indication of pollution emanating from the Gamsberg Zinc Mine site that could affect the groundwater quality of the surrounding farm boreholes (SLR, 2020a).

4.15 Hydro-census

Hydro census investigations were conducted by Golder (2007), SRK (2010),and ERM (2013a) and groundwater level results are summarised below (SLR, 2021). The site has an existing groundwater monitoring network and monitoring is conducted and reported by GHT Consulting Scientists.

- **Golder (2007)**
    - Groundwater levels measured in 15 boreholes and a spring during the Golder 2007 hydro census ranged from artesian conditions to 179 metres below ground level (mbgl). Apart from a single spring and borehole with a groundwater level of 178.7 mbgl, the hydro census boreholes had an average groundwater level of 31.7 mbgl. The elevation of the spring was measured at 915 mamsl but no flow measurement was recorded. The study noted that the only flowing spring had a flow rate of approximately 0.1m^3/hr -1.0 m^3/hr.
    - The results of the hydro census indicated that groundwater flow was generally outward from the Gamsberg Inselberg towards the surrounding plains.

- **SRK (2010)**
    - Groundwater levels were measured in 17 boreholes during the SRK February 2009 hydro census. Groundwater levels ranged from artesian conditions at the two springs (ACH&I AMS7) and 10 mbgl to 51mbglin the plains surrounding the inselberg. Apart from the three springs, the hydro census boreholes had an average groundwater level of 28.1mbgl. The elevation of the springs ACH1, RS5, RS6 were measured at 869 mamsl,873 mamsl, and 927 mamsl. SRK measured the spring flow rate during the 2009 hydro census and noted that flow rates of o.1L/s (0.36 m^3/hr) for springs GAMS7 and GAMS9.The flow rate of spring ACH1,emanating from the Achab se Berge had a flow rate of o.5 L/s (1.8 m^3/hr).
    - It was determined that groundwater flow was radially to the northeast and southwest away from the Gamsberg Inselberg and that water levels in the Gamsberg area mimicked surface topography. A good correlation between surface elevation and groundwater elevation was determined to indicate possible unconfined aquifer conditions.

- **ERM (2013a)**
    - The average groundwater level measured during the hydrocensus investigation was 29.41mbgl, with a range of 4.4 mbgl to a maximum of 178.8 mbgl. ERM (2013a) created a frequency distribution that indicated that most boreholes had groundwater levels ranging from 20-50 mbgl for boreholes on the inselberg and up to 60 mbgl for boreholes on the plains.
    - It was also noted that the springs only had small standing water pools and did not have any significant flow to generate a stream. No spring flow measurements were recorded during the hydrocensus investigation.
    - ERM (2013a) indicated that topography had a dominant control on the groundwater levels and flow direction, and made the following deductions based on the hydrocensus investigation results:

    - Groundwater flowing radially outwards from the inselberg towards the plains with the surface drainage controlling groundwater flow towards the northeast.
    - Groundwater flows with higher hydraulic gradient around the inselberg, and significantly lower gradient in the plains.
    - Two flow divides exist to the northwest of Gamsberg and to the southeast, due to the influence of the Aggeneys Berg and the Achab se Berge, respectively.

- **GeoPollution (2017)**
    - This hydrocensus was performed as a repeat of the hydrocensus performed by ERM in 2013 to calculate recharge to the local aquifer systems. 11 boreholes were available for groundwater level measurement. The groundwater levels varied between a minimum of 21.5 m and a maximum of 52.55 m below ground level

Table 37. Groundwater quality data (GeoPollution, 2017).

Parameter		Unit	SANS 241: 2015 Recommended Limits	Risk	Results		
					MBH1.1	MBH7	MBH9
Physical & Aesthetic determinands							
Electrical conductivity at 25°C	EC	mS/m	≤ 170	Aesthetic	145	322	232
Total Dissolved Solids	TDS	mg/liter	≤ 1200	Aesthetic	1010	2260	1620
pH at 25°C		pH units	≥ 5 to ≤9.7	Aesthetic	7.57	7.91	7.51
Chemical Determinands - Macro determinands							
Nitrate as N	NO_3	mg/liter	≤ 11	Acute Health	8.05	20.2	0
Sulphate	SO_4	mg/liter	Acute Health ≤500; Aesthetic ≤250	Acute Health/Aesthetic	138	504	322
Fluoride	F	µg/liter	≤1500	Chronic Health	3060	2770	2760
Chloride	Cl	mg/liter	≤ 300	Aesthetic	300	802	504
Sodium	Na	mg/liter	≤ 200	Aesthetic	188	466	347
Zinc	Zn	µg/liter	≤5000	Aesthetic	70	0	90
Chemical Determinands - Micro determinands							
Antimony	Sb	µg/liter	≤ 20	Chronic Health	0	0	0
Arsenic	As	µg/liter	≤ 10	Chronic Health	0	0	0
Barium	Ba	µg/liter	≤ 700	Chronic Health	170	180	200
Boron	B	µg/liter	≤ 2400	Chronic Health	770	1700	1420
Cadmium	Cd	µg/liter	≤ 3	Chronic Health	0	0	0
Total Chromium	Cr	µg/liter	≤ 50	Chronic Health	0	0	0
Copper	Cu	µg/liter	≤ 2000	Chronic Health	0	0	0
Total Iron	Fe	mg/liter	Acute Health ≤ 2.0; Aesthetic ≤0.3	Acute/Aesthetic	0	0	0
Lead	Pb	µg/liter	≤ 10	Chronic Health	0	0	0
Total manganese	Mn	mg/liter	Acute Health ≤0.4; Aesthetic ≤0.1	Acute/Aesthetic	0	0	0.53
Nickel	Ni	µg/liter	≤ 70	Chronic Health	0	0	0
Selenium	Se	µg/liter	≤ 40	Chronic Health	0	0	0
Aluminium	Al	µg/liter	≤ 300	Operational	50	220	90
Chemical Determinands - Organic determinands							
Concentration deemed to present an unacceptable health risk for lifetime consumption.							

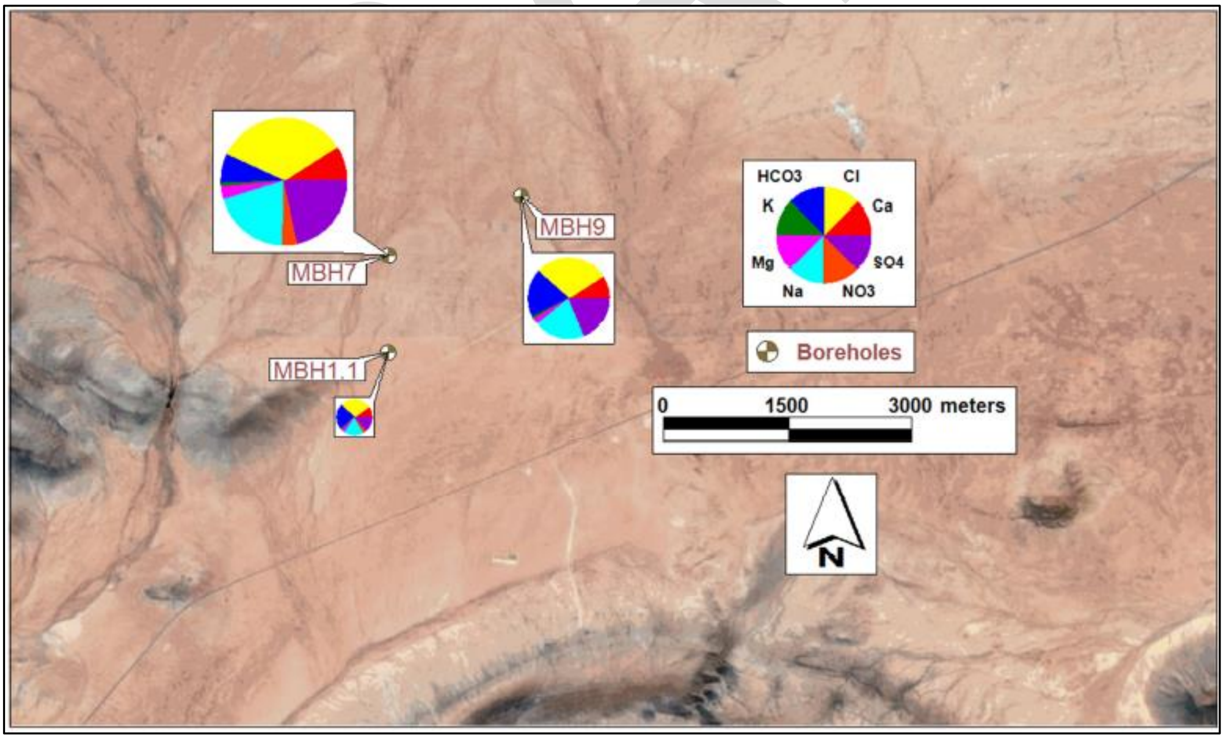


Figure 27. Groundwater chemistry data (GeoPollution, 2017)

Based on information collected during the hydro census it can be concluded that the aquifer system in the study area can be classified as a .Minor Aquifer System., based on the fact that the groundwater quality is variable but generally not fit for human consumption and hydraulic conductivity of the aquifer is low.

- **GHT Consulting (2019)**

    - In general, GHT Consulting (2019) concluded from groundwater monitoring conducted between November 2017 and April 2019 that the boreholes of the regional monitoring network indicated mostly stable groundwater level conditions, with slightly increasing or decreasing static water level elevation trends depending on the specific borehole. GHT Consulting indicated that no dewatering effects from the opencast mining are evident based on the groundwater levels of the regional farm boreholes. Regional boreholes had an average groundwater level of 30.8 mbgl and ranged between 8.6 mbg land 78.9 mbgl for the April 2019 monitoring round.
    - Groundwater level logger data installed in certain regional monitoring boreholes by GHT Consulting indicated that water levels varied significantly between October 2017 and April 2019 mostly due to groundwater abstraction from individual farm production wells. It is important to note that no metered groundwater abstraction rates from farm production boreholes were available. The most notable water level ranges for the regional monitoring boreholes included:
        - Borehole AMBH05 (32- 78 mbgl).
        - Borehole KGT78 (53-90 mbgl).
        - Borehole KGT3 (29- 40 mbgl).
        - Borehole KGTl (24- 49 mbgl).
        - Borehole NAm^{2} (18.5- 24 mbgl).

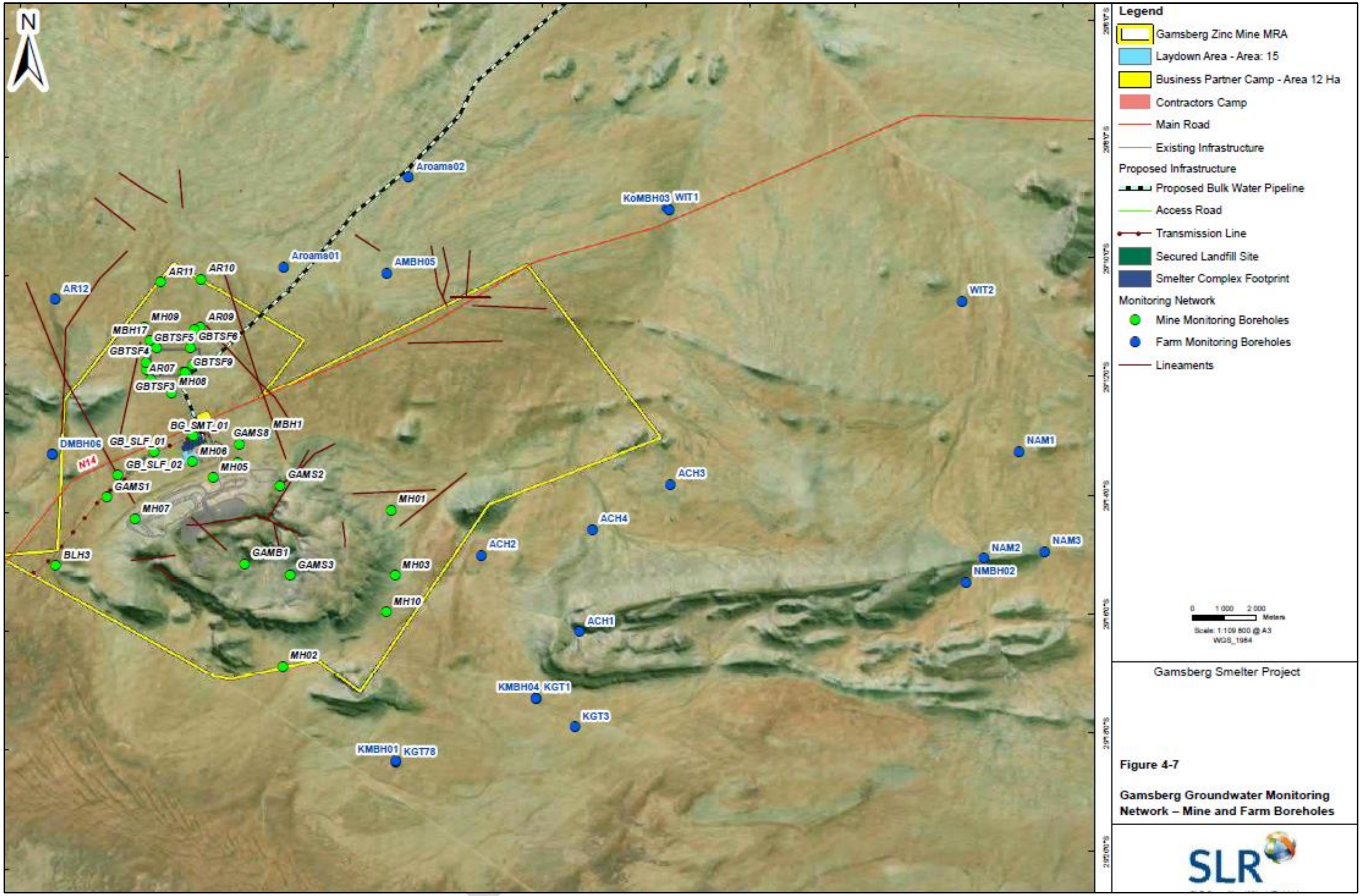


Figure 28. Groundwater monitoring borehole network (SLR, 2020a).

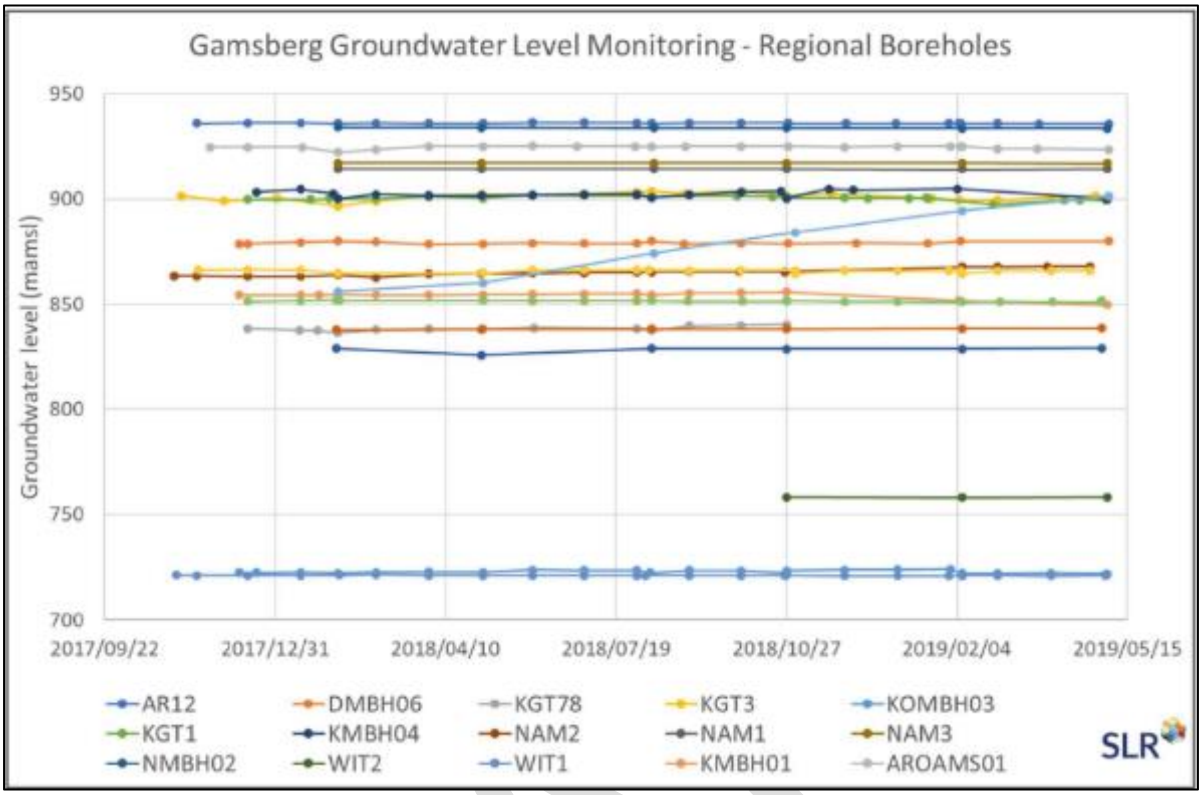


Figure 29. Hydro census of the Gamsberg Regional Boreholes 2017 – 2019 (SLR, 2020a).

Mine Boreholes

In general. GHT Consulting (2019) concluded from groundwater monitoring conducted between November 2017 and April 2019 that the mine monitoring boreholes Indicated stable static groundwater level elevation trends, as illustrated in Figure 29. GHT Consulting indicated that no dewatering effects from the opencast mining are evident based on the groundwater levels of the mine boreholes. Mine monitoring boreholes had an average groundwater level of 30.6 mbgl and ranged between 11.6 mbgl and 52.3 mbgl for the April 2019 monitoring round. The average groundwater levels around the existing TSF, smelter complex and SLF areas were 26.89 mbgl and 42.34 mbgl, respectively. Two groundwater level measurements were taken from borehole AD17 on 06

February 2018 and 02 May 2019, indicating an increase in groundwater level from 687.97 mamsl and 773.87 mamsl during this period. This borehole should be continued to be monitored to explain the increase in groundwater level.

Groundwater level logger data installed by GHT Consulting in certain mine monitoring boreholes Indicated that water levels were mostly stable between October 2017 and April 2019, apart from one production borehole MH03 (used for water supply) that showed a groundwater level ranging between 23 mbgl and 26 mbgl. It is No metered groundwater abstraction rates from Borehole MH03, used by the farmer for livestock watering, were available.

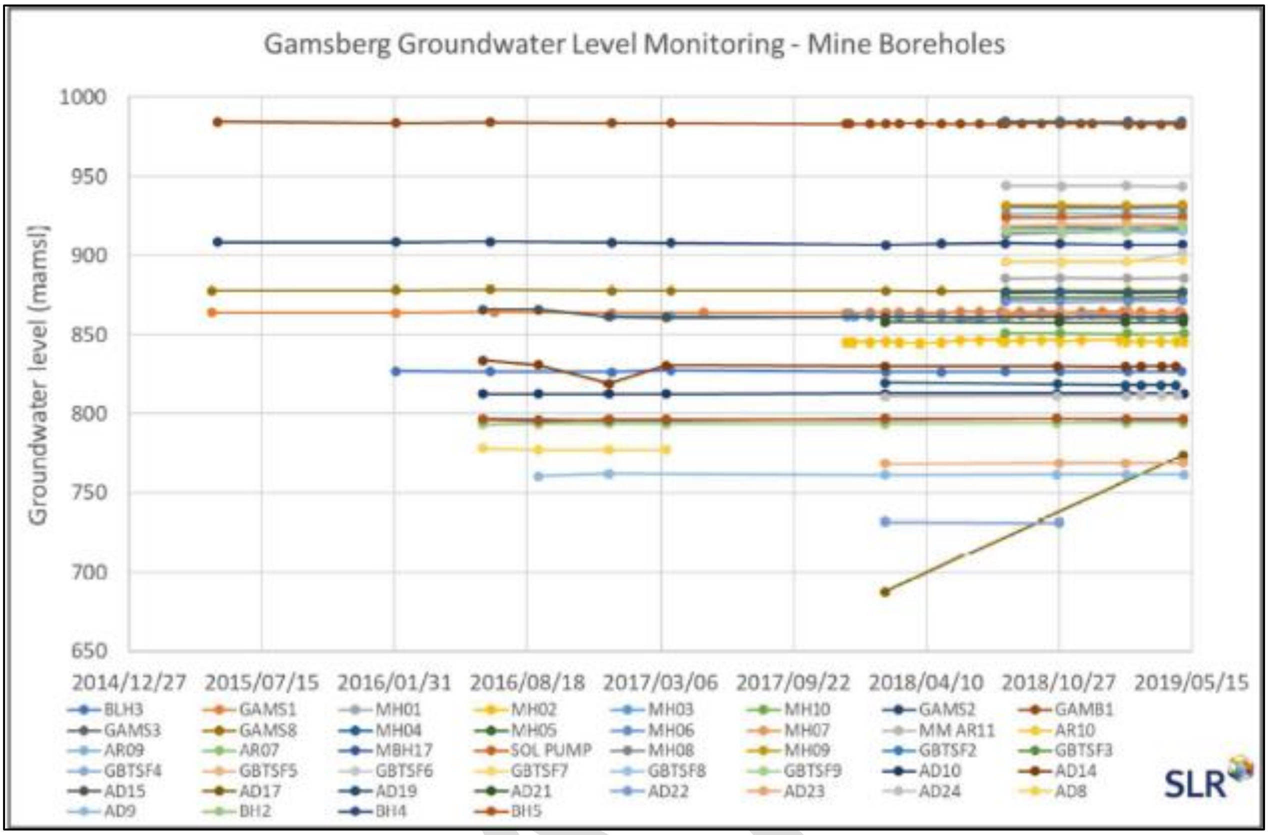


Figure 30. Hydro census of the Gamsberg Zinc Mine Boreholes 2014 – 2019 (SLR, 2020a).

4.16 Potential Pollution Source Identification

BMM appointed Knight Piésold (Pty) Ltd to conduct a Waste Classification of the tailings that will be generated in the processing of the zinc ore deposits, as part of the expansion of the Gamsberg TSF. The current TSF at Gamsberg was constructed prior to 2013 before the legislation to classify tailings as waste according to GNR 634 had been promulgated. Therefore, no waste classification has previously been done on the Gamsberg Zinc tailings. The current monitoring results indicate that the Gamsberg TSF is leaking towards the North-western corner based on an increase in water level that has been observed in the borehole at the NW corner. There is an increase in the concentration of dissolved salts (particularly as Cl and SO4) in the boreholes located to the northwest of the TSF (Knight Piésold, 2023c). The current monitoring results indicate that the Gamsberg TSF is leaking towards the North-western corner based on an increase in water level that has been observed in the borehole at the NW corner. There is an increase in the concentration of dissolved salts (particularly as Cl and SO4) in the boreholes located to the northwest of the TSF. The aqua regia digestion showed that the Gamsberg tailings are enriched in metals and heavy metals: Fe, Al, Mn, Pb, As, Cu and Ni all exceeding 100 mg/kg classifying the tailings as high risk. This information was used to inform the liner requirements as required by regulation (Knight Piesold, 2023c).

Potential contaminant plumes of sulphate, sodium, lead, and antimony are expected to emanate from the proposed Secured Landfill Facility (SLF) in event of liner failure or leaks. The maximum operational and closure phase plume extent is expected to be maximum ~700 m and ~1 000 m from the SLF, respectively, predominantly in a south-westerly direction. No sensitive receptors' boreholes are located within this potential plume development area (SLR, 2020a).

The Gamsberg TSF is expected to generate Acid Rock Drainage (ARD) within a short period of operation (perhaps within 10 years) because of the high sulphide and low neutralisation content of the tailings. Without engineering controls in place, the TSF would seep low pH, saline, metal laden water to groundwater on decommissioning of the TSF (ERM, 2013a).

The potential for the WRD to generate nett acidity will be largely dependent on the relative proportion of GIF A and C materials. Assuming 8 to 9% of GIF A and C and recharge of 60 % of total MAP to groundwater, then the TSF should remain near-neutral for a considerable period (perhaps 350 years) before ARD conditions develop. Sulphate is expected to leach from the WRD at approximately 2 000 mg/L throughout LOM and beyond.

The pit design should aim to minimise contact between side slope runoff and GIF (particularly within benches established in GIF) – both in terms of the quantity of water contacting with GIF and contact (reaction) time.

Ore and concentrate stockpiles are potential sources of ARD and metal leaching but occupy small footprints and could be effectively managed with engineered controls such as bunding, interception channels, silt traps and clean/dirty water containment. Engineered controls and operational practices could minimise wind entrainment or spillage of zinc concentrate during transport and handling, both on site and to the point of export. (ERM, 2013a).

Based on the ABA analysis and AMD classification, the 2023 Gamsberg TSF samples confirms that all the samples will be acid generating. Including the pilot tailings for the TSF expansion. All of the TSF samples had sulphur-sulphide concentrations above 0.3% and an NPR ratio of <1 indicating that these samples are acid generating. The distilled leach testing (SPLP) indicates that the leachate generated from the tailings will have a low pH (3.7-5.6) with high sulphate concentrations and elevated heavy metal concentrations (As, Cd, Cu, Pb, Mn and Zn) (Knight Piésold, 2023b).

4.17 Groundwater Model

Water level drawdown as a result of mining activities in and around the proposed Gamsberg mine were simulated (SRK, 2010) and the following was predicted:

- The 0.05 m drawdown contour extends up to 12.5 km away from the mine at the end of mining for Scenario 1 whilst for Scenario 2, this drawdown contour extends up to 15 km away from the mine
- However, the 1.0 m drawdown contour only extends up to 5 km away from the mine at the end of mining for Scenario 1, whilst for Scenario 2 this contour only extends up to 7.5 km away from the mine;
- A very steep zone of depression with very limited extent develops around the open pit as a result of the relatively low hydraulic conductivity values of the aquifer;
- The higher permeable fault zones in the area largely control the shape of the zone of depression.

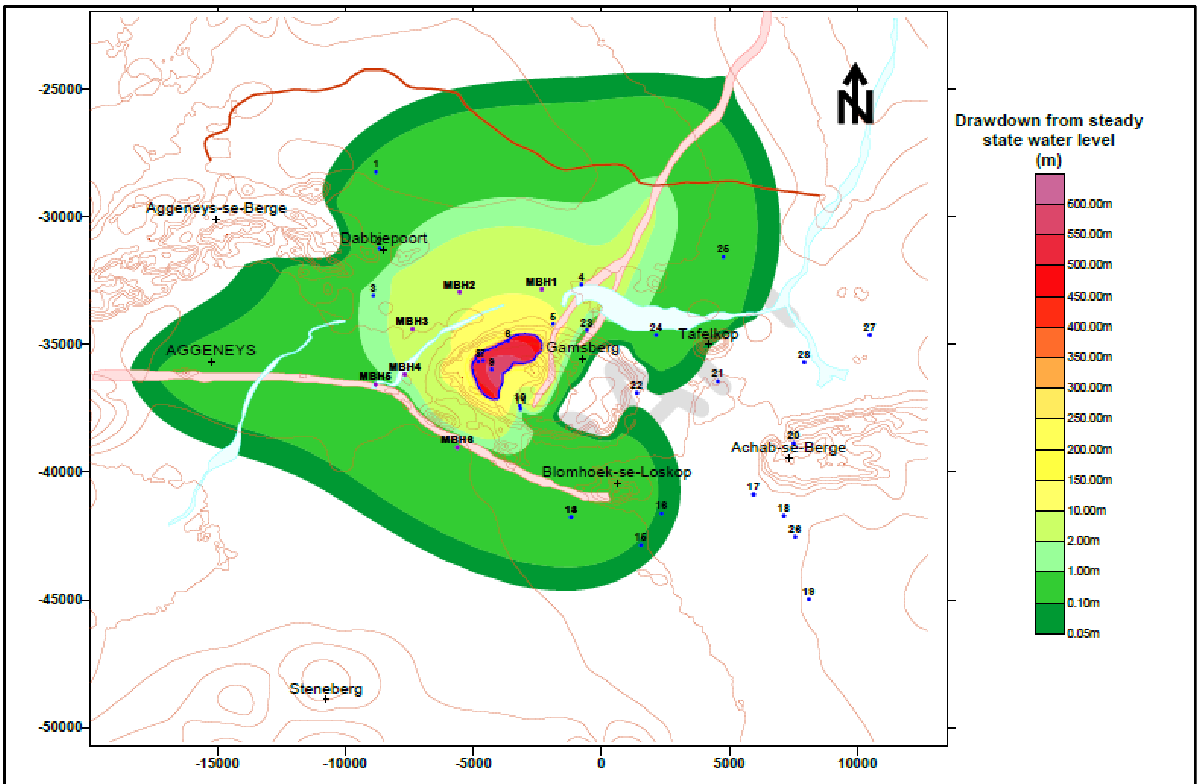


Figure 22: Simulated Zone of Depression (worst case scenario) (AATS, 2000b)

Figure 31. Simulated Zone of Depression (worst case scenario) (AATS, 200b as cited in SRK, 2010).

As part of the licensing conditions, a calibrated groundwater model is required to delineate the pollution plume across the site.

Smelter Project

Numerical Model

The numerical model is to be used to estimate the fate and transport of potential contaminants in groundwater emanating from the secured landfill facility. The potential contaminants were identified from the geochemical assessment and used to predict the fate and transport of Sulphate, sodium, lead, and antimony emanating from the secured landfill facility during operational and closure phases of the Gamsberg project.

The FEFLOW (Finite Element subsurface FLOW and transport system v 7.3.0.18422) modelling code developed by DHI-WASY (Diersch, 2015) was used for the Gamsberg groundwater model. This code is an industry standard groundwater modelling tool widely used in mining and environmental applications (SLR, 2020a).

Operational Phase of Smelter and Secured Landfill Facility

Groundwater Levels

No notable change in groundwater levels were observed for the proposed secured landfill facility and smelter complex area. The total seepage emanating from the proposed secured landfill facility would be minimal if a Class A liner is i and thus limiting any significant change in local and regional groundwater levels. This is largely attributed to the Class A liner, which according to the relevant guidelines the liner material cannot exceed a permeability of 1x 10-7 cm/s (0.03 m/y or 8 x 10·5 m/d). Average groundwater levels around the secured landfill facility were "'40 mbgl (868 mamsl).

Recharge

Recharge is generally very low in the Gamsberg area, with relatively higher recharge occurring on the Gamsberg inselberg compared to the surrounding plains where practically no recharge occurs and is supported by the findings of SRK (2010) and ERM (2013a).

ERM (2013a) provided a summary of estimates for recharge on the Gamsberg, which ranged between 1 mm/a and 2.9 mm/a (1.2 and 2.2% of MAP). The mean annual effective recharge for the study area was estimated by SRK (2010) to be approximately 0.85% of MAP. The estimated recharge obtained for the site through the CMB (Chloride Mass Balance) method was estimated to be very low. The low calculated recharge value is consistent with inferences made by SRK (2010) that recharge only takes place in years of exceptionally high precipitation.

As the SLF will be constructed with a Class A liner, the volume of seepage into groundwater is likely to be very low. In addition, the presence of cement in the Jarofix is likely to cause it to solidify with time, significantly reducing the potential for infiltration into the SLF (SLR, 2020a).

Groundwater Quality

Water seepage and associated contamination to groundwater from the smelter complex was not modelled as it is expected that potential spillages from water and/or chemical storage facilities will only occur in extreme events.

Sulphate, sodium, lead, and antimony were included in the operational phase numerical groundwater contaminant transport models for various seepage rate scenarios. These chemical constituents were identified from the geochemical assessment as potential contaminants.

The numerical groundwater contaminant transport models at the end of the operational phase (15 years) resulted in a maximum plume migration of sulphate, sodium, lead, and antimony of "'600 m,"'580 m,"'600 m, and "'700 m respectively with the installation of the liner. Without the liner installation all four contaminant plumes migrate approximately an additional 100 m from the secured landfill facility. The migration of the sulphate, sodium, lead, and antimony plumes at the end of the operational phase are illustrated in Figure 4-12, Figure 4-13, Figure 4-14, and Figure 4-15 respectively for both Scenario 1(worst-case) and Scenario 3 (liner installation) seepage rates. Scenario 2 resulted in similar plume extents to Scenario 3 and is not illustrated in the operational plume maps. The minimum concentration contour for each map has been specified to the SANS 241-

12015 limits for each potential contaminant. The nearest privately owned farm borehole, DMBH06, is not affected by any of the four plumes and is approximately 1.7 km away from the worst-case Scenario 1 plume extents.

Although the change in seepage rates between Scenario 1and Scenario 3 did not result in a significant change in the plume extents, the installation of a Class A liner does significantly reduce the contaminant salt load to the aquifer. The installation of the liner results in a decrease of up to 23% in total salt load to the aquifer. Since all contaminants were modelled as conservative tracers, a similar reduction in total mass flux for sodium, lead, and antimony were calculated as that of sulphate.

Post-Closure of Smelter and Secured Landfill Facility

Groundwater Levels

No notable change in groundwater levels were observed for the proposed secured landfill facility and smelter complex areas for Scenario 4 – Scenario 6. The total seepage emanating from the proposed secured landfill facility would be minimal if a Class A liner is installed and thus limiting any significant change in local and regional groundwater levels. This is largely attributed to the Class A liner, which according to the relevant guidelines the liner material cannot exceed a permeability of 1 x 10-7 cm/s (0.03 m/y or 8 x 10-5 m/d). Average modelled groundwater levels around the secured landfill facility were ~44 mbgl (864 mamsl).

Groundwater Quality

Water seepage and associated contamination to groundwater from the smelter complex was not modelled as it is expected that potential spillages from water and/or chemical storage facilities will only occur in extreme events.

Sulphate, sodium, lead, and antimony were included in the closure phase numerical groundwater contaminant transport models for various seepage rate scenarios. These chemical constituents were identified from the geochemical assessment as potential contaminants.

The numerical groundwater contaminant transport models at the end of the closure phase (50 years) resulted in a maximum plume migration of sulphate, sodium, lead, and antimony of ~850 m, ~600 m, ~800 m, and ~1 000 m respectively with the installation of the liner. Without the liner installation with seepage rates described in Scenario 6, all four contaminant plumes migrate approximately an additional ~120 m from the secured landfill facility. The migration of the sulphate, sodium, lead, and antimony plumes at the end of the closure phase are illustrated in Figure 36, Figure 37, Figure 38, and Figure 39 respectively for both Scenario 4 (worst-case) and Scenario 6 (liner installation) seepage rates. Scenario 5 resulted in similar plume extents to Scenario 6 and is not illustrated in the closure plume maps. The nearest privately owned farm borehole, DMBH06, is not affected by any of the four plumes and is approximately 1.3 km away from the worst-case Scenario 1 plume extents.

Although the change in seepage rates between Scenario 4 (worst-case) and Scenario 6 (liner installation) did not result in a significant change in the plume extents, the installation of a Class A liner does significantly reduce the contaminant salt load to the aquifer. The installation of the liner results in a decrease of up to 23% in total salt load to the aquifer. Since all contaminants were modelled as conservative tracers, a similar reduction in total mass flux for sodium, lead, and antimony were calculated as that of sulphate.

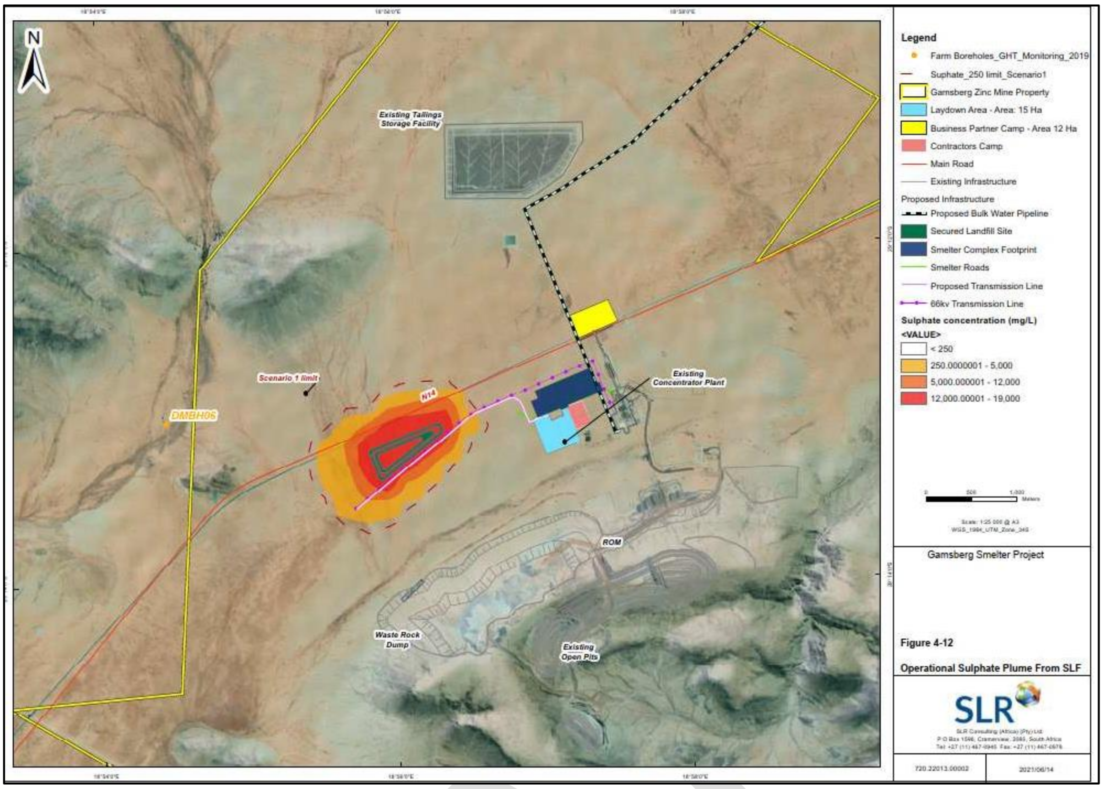


Figure 32. Operational (15 years) Sulphate Plume from Secured Landfill Facility – Scenario 1 (worst case) and scenario 3 (liner) (SLR, 2020a).

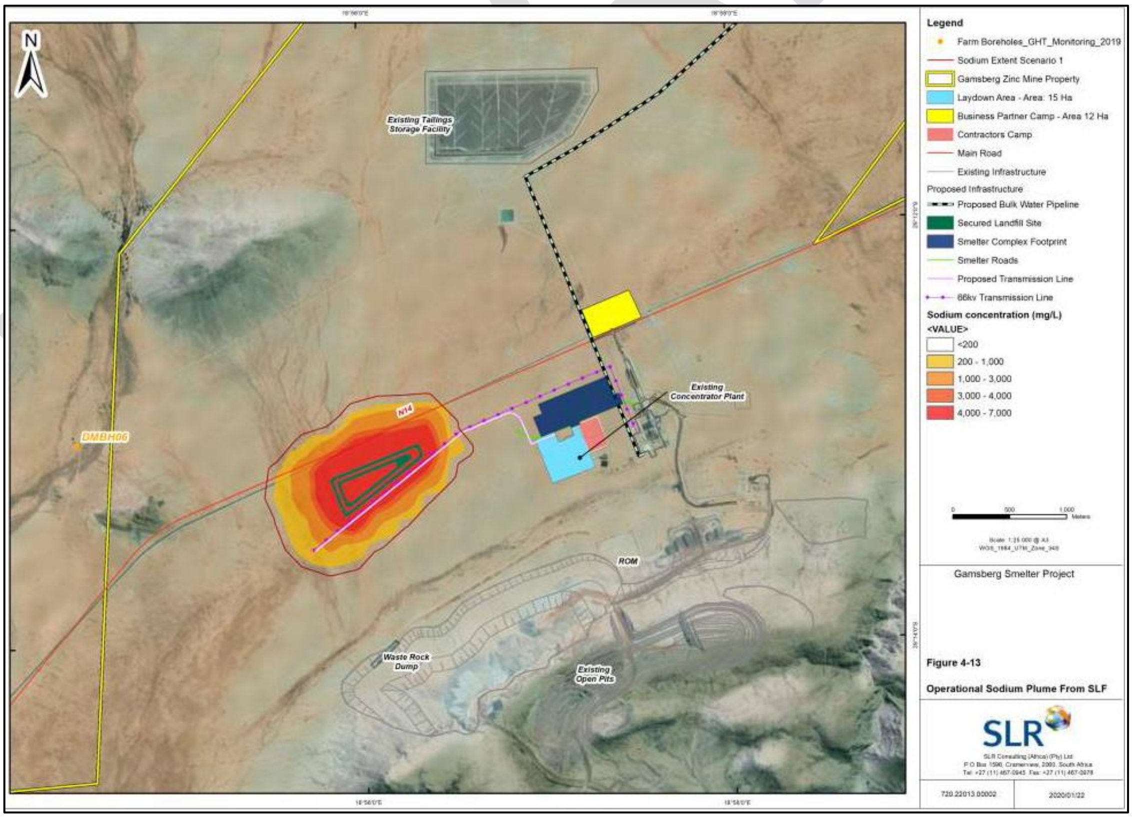


Figure 33. Operational (15 years) Sodium Plume from Secured Landfill Facility – Scenario 1 (worst case) and scenario 3 (liner) (SLR, 2020a).

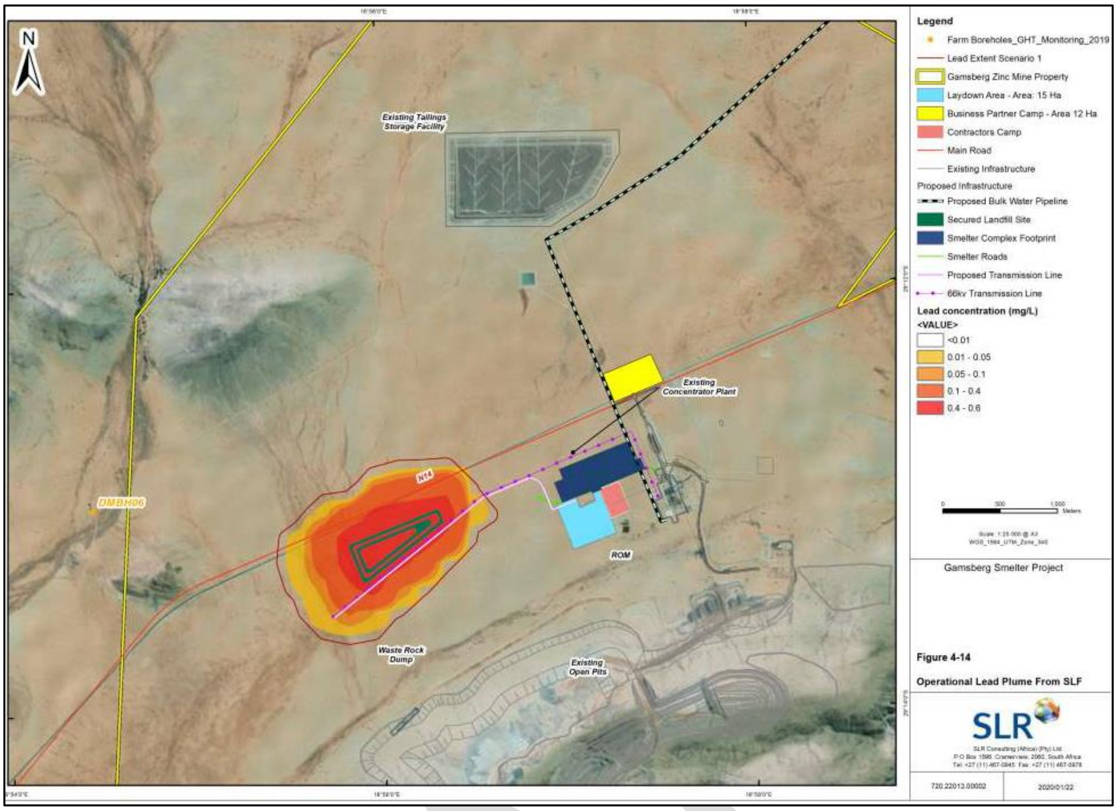


Figure 34. Operational (15 years) Lead Plume from Secured Landfill Facility – Scenario 1 (worst case) and scenario 3 (liner) (SLR, 2020a).

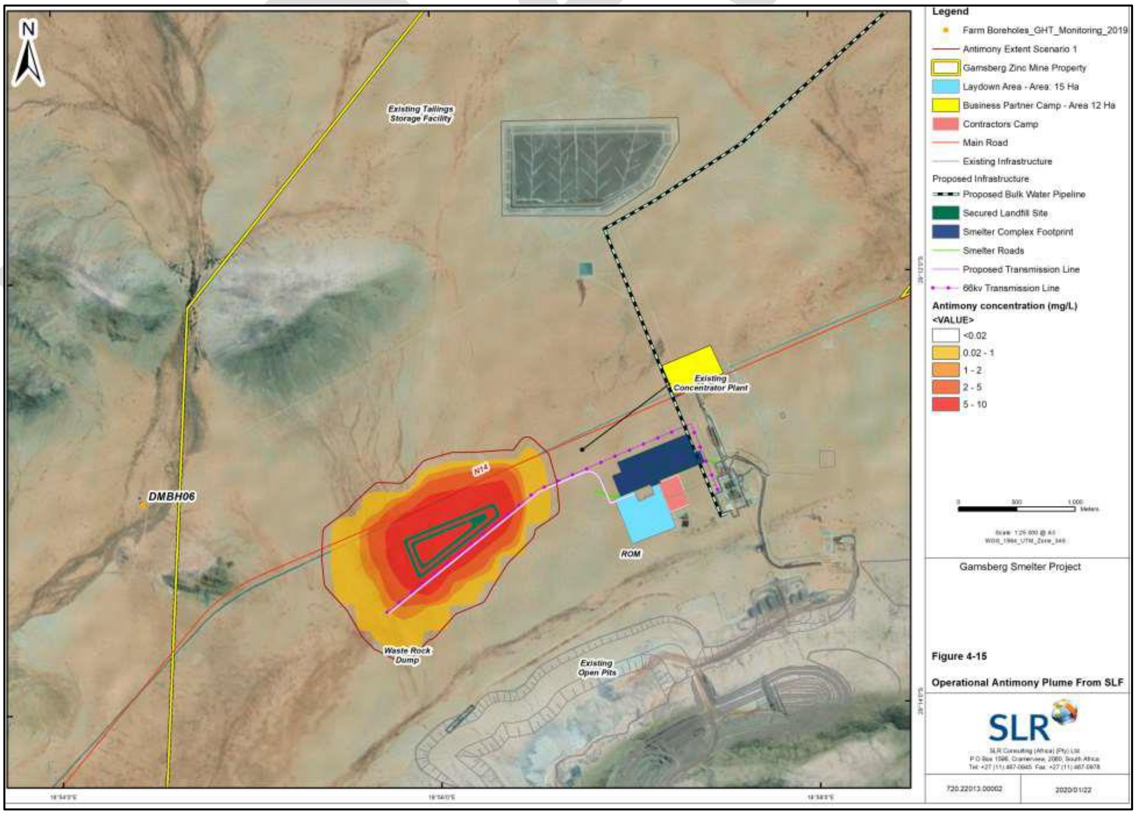


Figure 35. Operational (15 years) Antimony Plume from Secured Landfill Facility – Scenario 1 (worst case) and scenario 3 (liner) (SLR, 2020a).

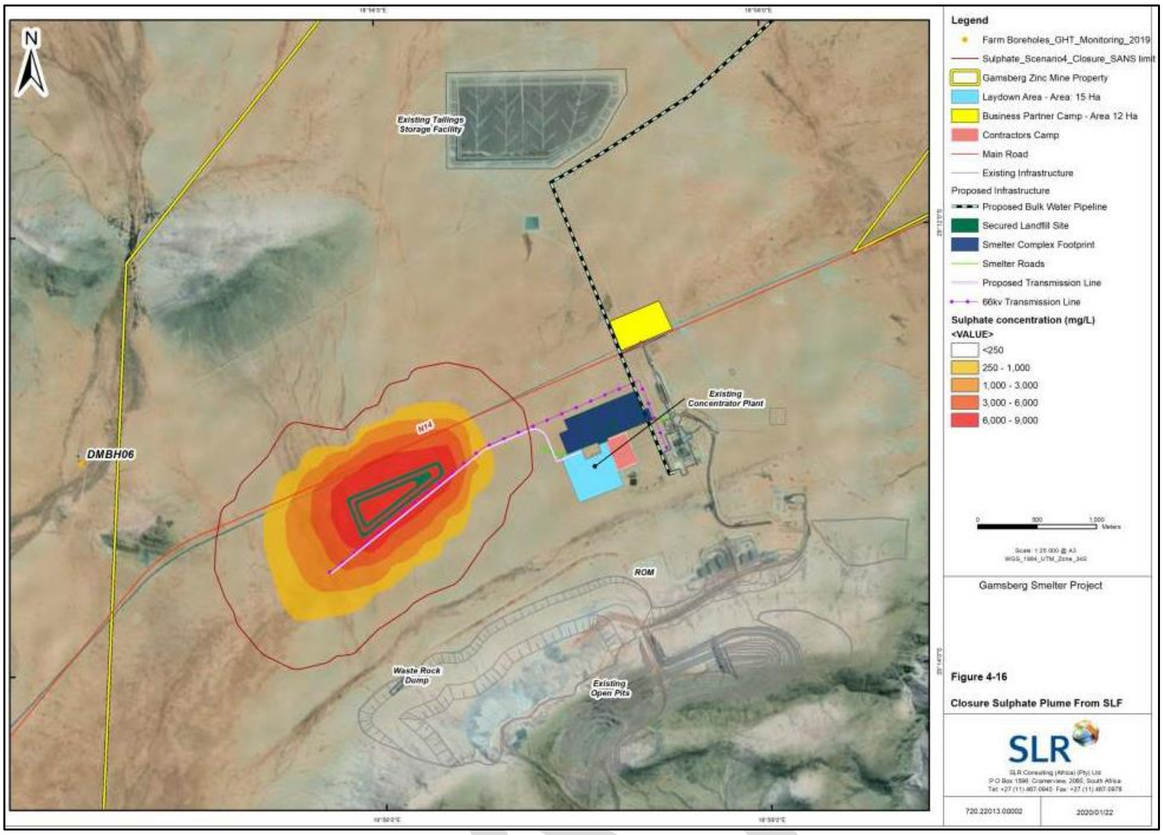


Figure 36. Closure (50 years) Sulphate Plume from Secured Landfill Facility – Scenario 4 (worst case) and scenario 6 (liner) (SLR, 2020a).

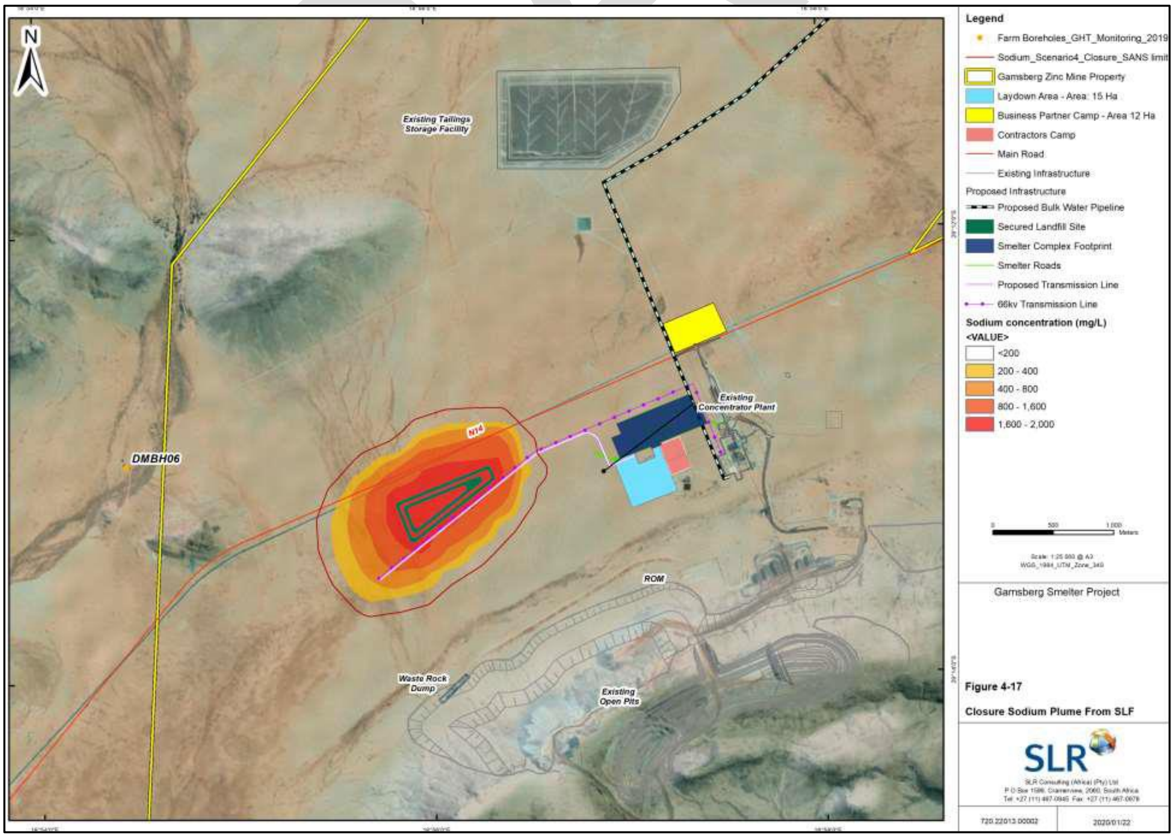


Figure 37. Closure (50 years) Sodium Plume from Secured Landfill Facility – Scenario 4 (worst case) and scenario 6 (liner) (SLR, 2020a).

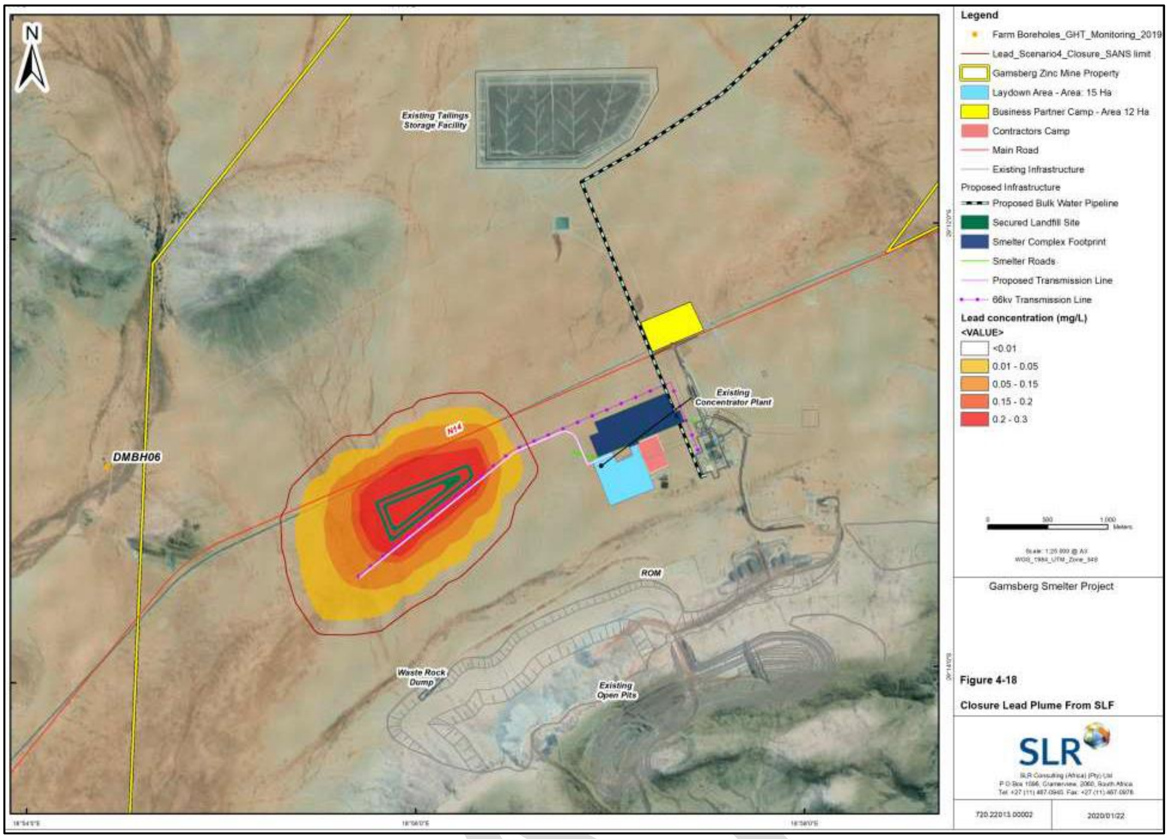


Figure 38. Closure (50 years) Lead Plume from Secured Landfill Facility – Scenario 4 (worst case) and scenario 6 (liner) (SLR, 2020a).

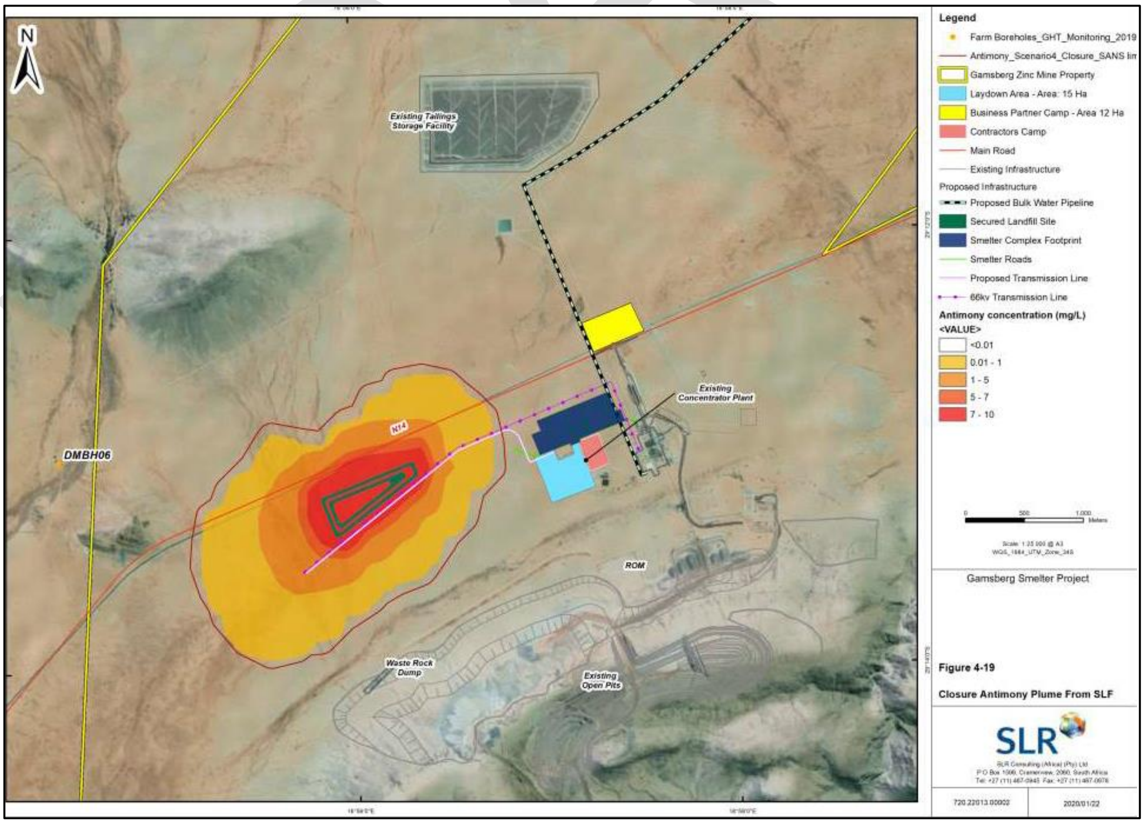
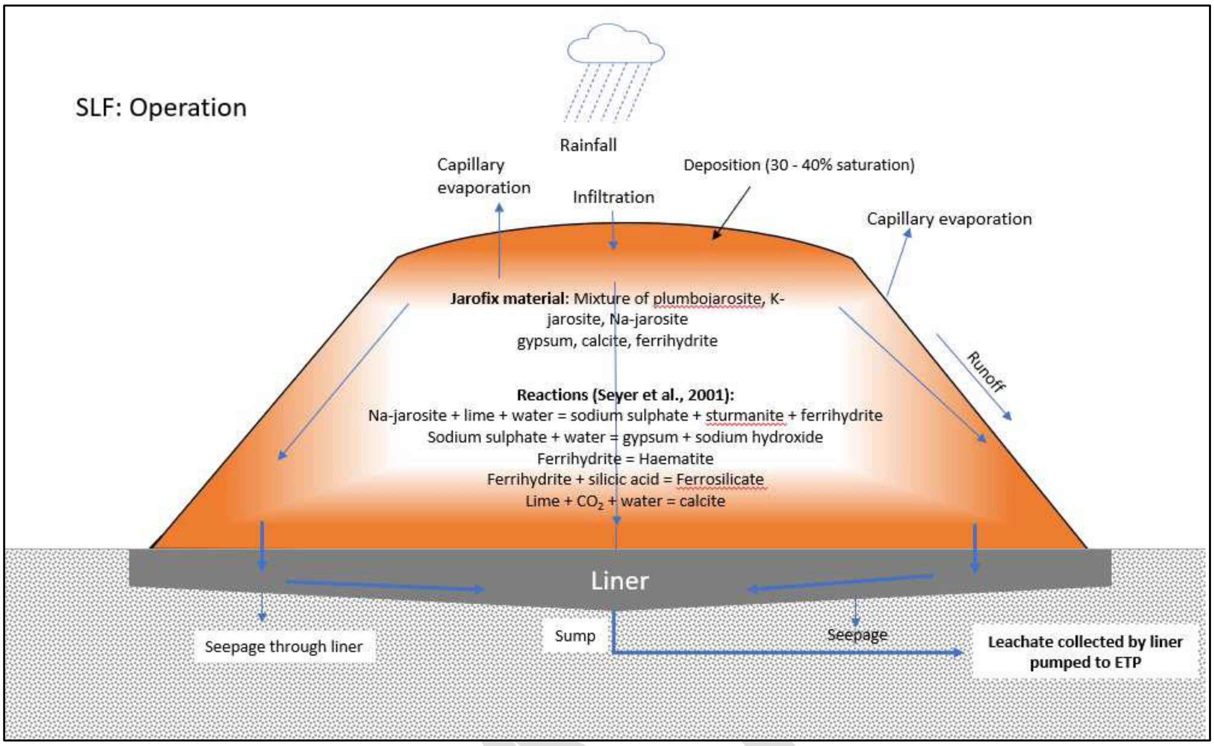


Figure 39. Closure (50 years) Antimony Plume from Secured Landfill Facility – Scenario 4 (worst case) and scenario 6 (liner) (SLR, 2020a).



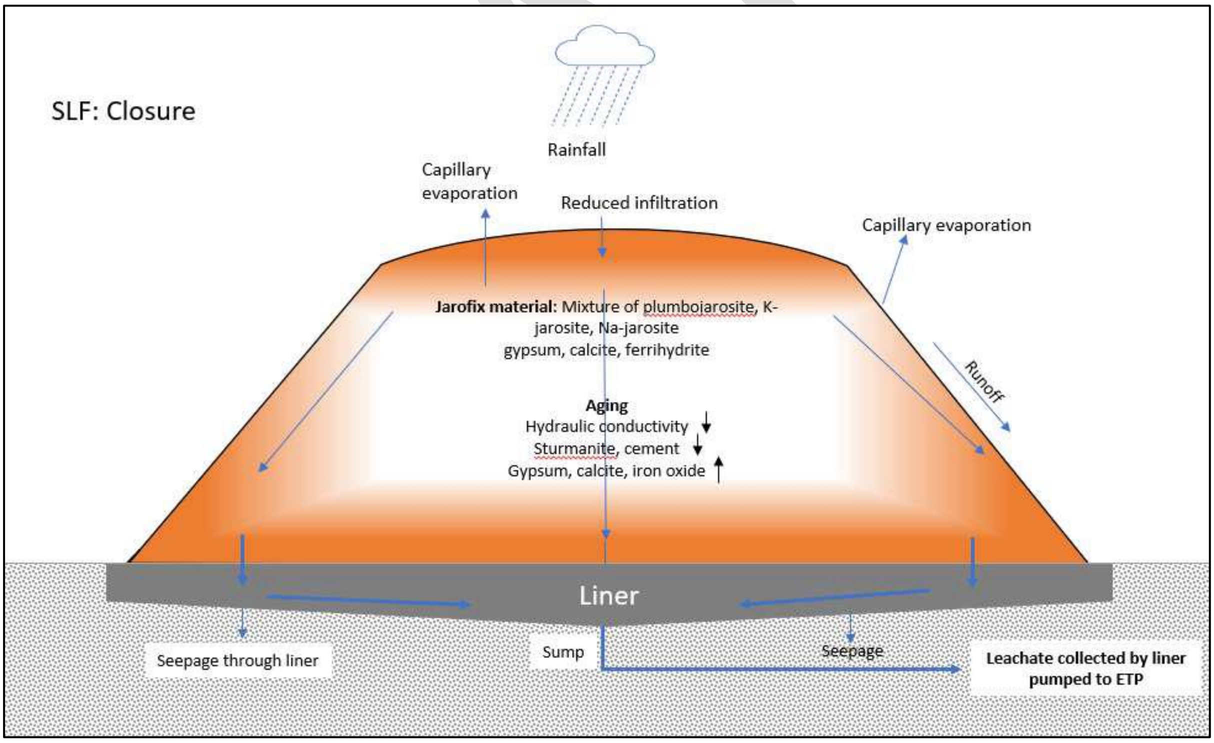


Figure 40. Conceptual geochemical site models of the secured landfill facility- operational and post closure.

4.17.2 TSF Phase 2

The current TSF at Gamsberg has been lined with a High-Density Polyethylene (HDPE) geomembrane with a 300 mm thick soil layer modified with 6% bentonite (mineral liner) liner system.

The current groundwater monitoring data for the boreholes surrounding the TSF were incorporated into the steady state calibration, the groundwater concentrations for SO4 and Zn were used to ensure that the developed plume is consistent with the actual groundwater concentrations. The steady state calibration represents a six year period for the current operational phase of the TSF at Gamsberg Zinc mine. Over the six-year period, two solute migratory patterns for both parameters (SO4 and Zn) are evident with flow towards the north west (NW) and south east (SE). The main component of the plume is located towards the NW, while a small component of flow is evident towards the SE (KP, 2023b).

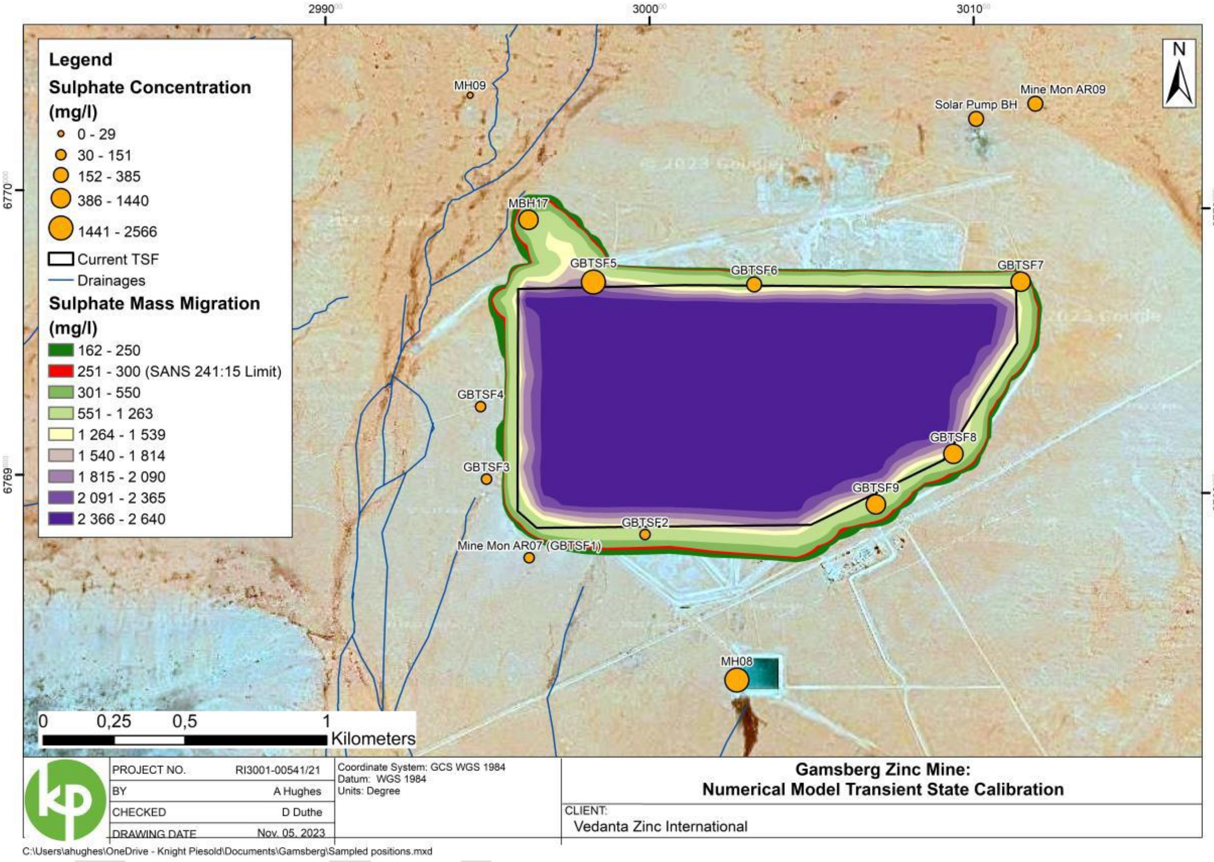


Figure 41. Numerical model Steady State Calibration – Sulphate plume for current TSF (KP, 2024).

Two scenarios were included in the contaminant transport model:

The first scenario is representative of the life of design for the Phase 2 TSF extesnion at Gamsberg Zinc Mine.

The second transient simulation includes a 30 year period that represents the post operational period at Gamsberg Zinc mine. For this scenario the TSF at Gamsberg Zinc mine is no longer in operation, with no new deposition occurring.

Overall, the spatial extent of the modelled plumes is within a 250 m radius of the TSF, both the current and phase 2 extension. The vertical extent of the plume for the TSF could reach a 65 mbgl, indicating the potential to impact the shallow and deep aquifers local to the area. The current simulations show that the risk of the potential contaminant plume from the TSF impacting any groundwater users is low (KP, 2023b).

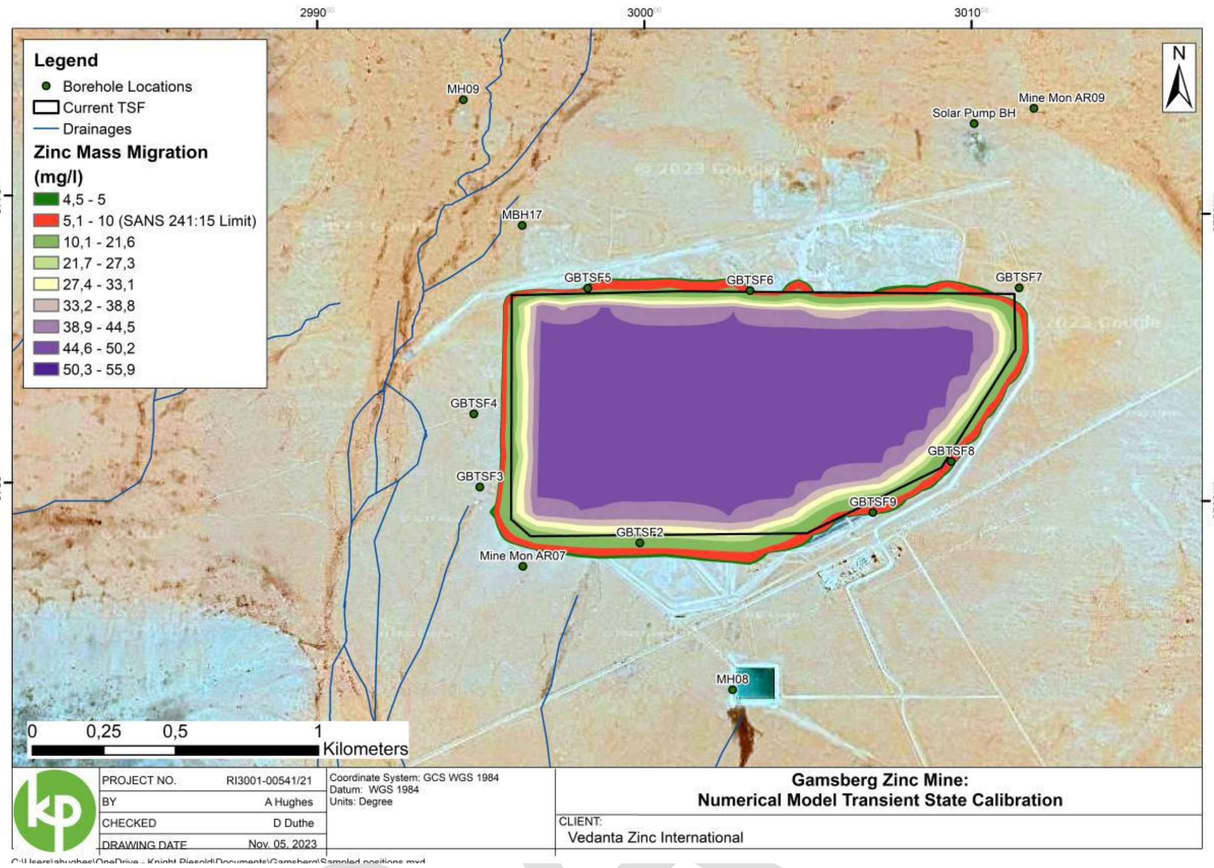


Figure 42. Numerical model Steady State Calibration – Sulphate plume for current TSF (KP, 2024).

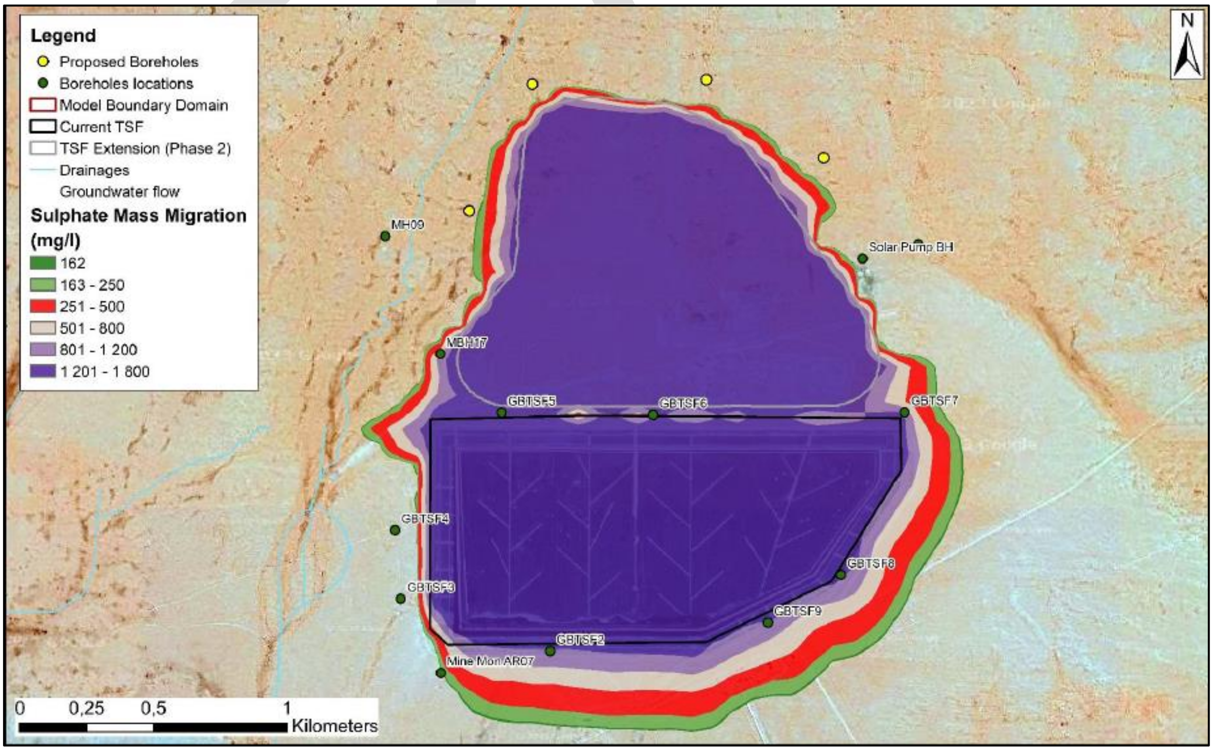


Figure 43. Scenario 1- Sulphate plume for TSF Extension Phase 2 operations (KP, 2024)

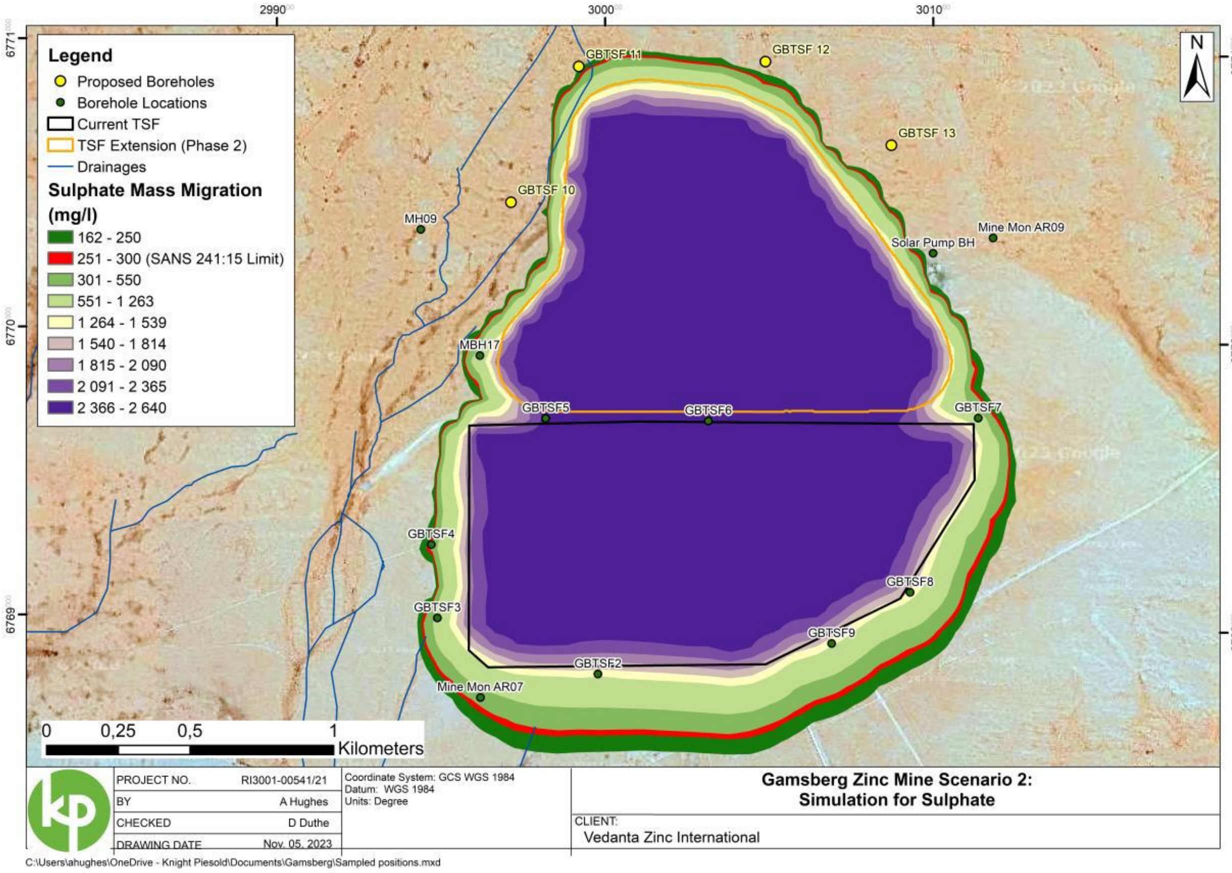


Figure 44. Scenario 2- Sulphate plume for TSF Extension Phase 2 operations (KP, 2024)

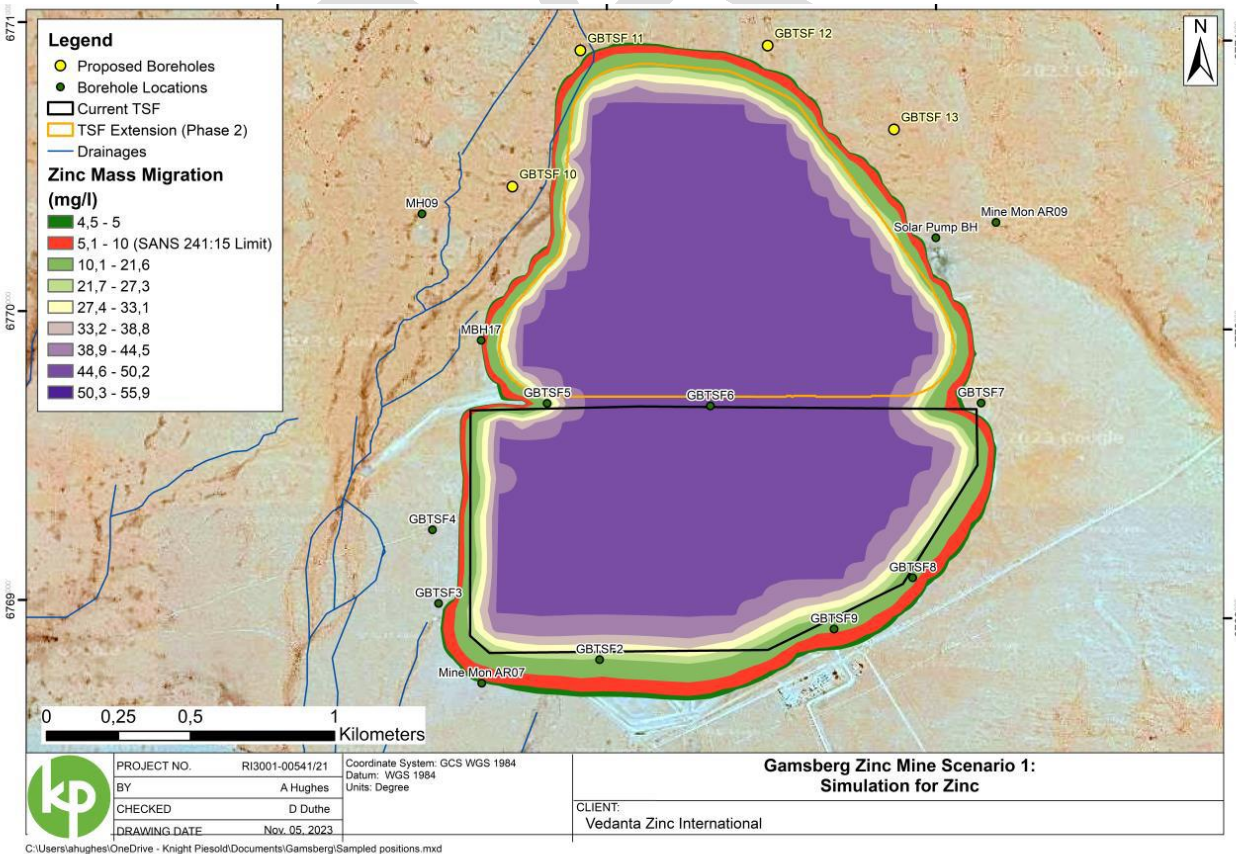


Figure 45. Scenario 1-Zinc plume for TSF Extension Phase 2 operations (KP, 2024)

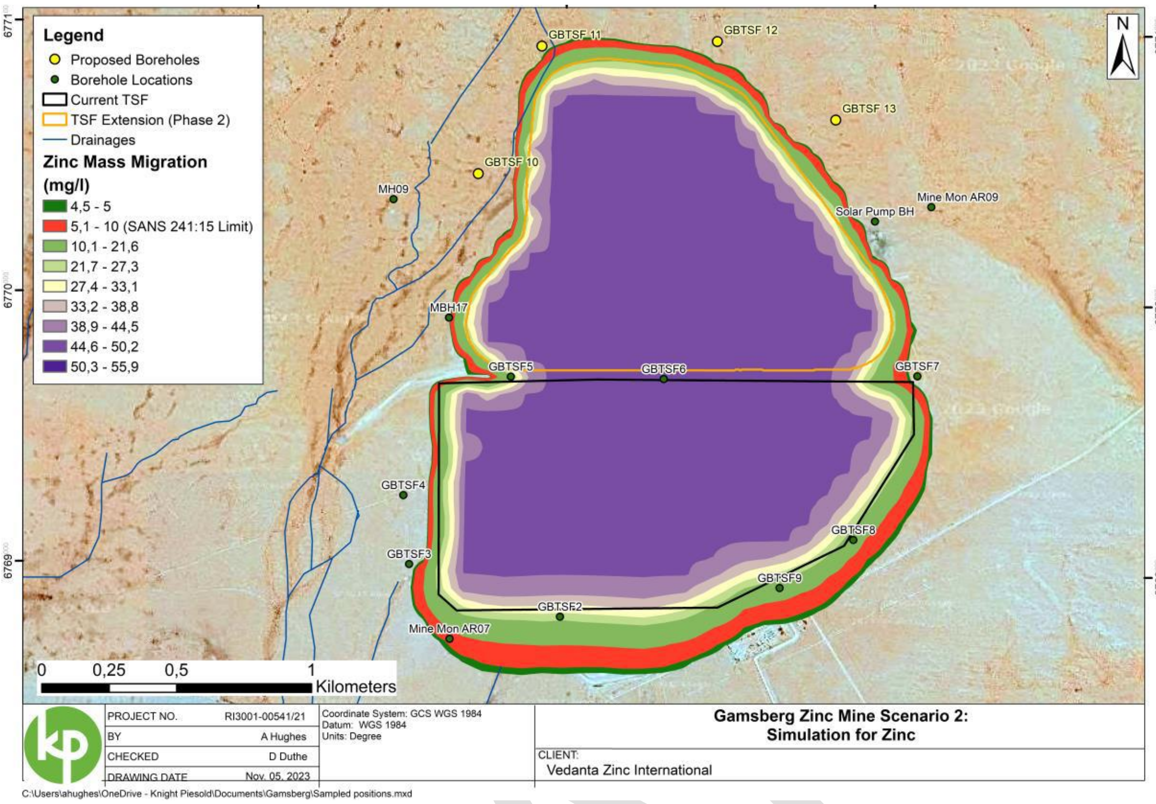


Figure 46. Scenario 2-Zinc plume for TSF Extension Phase 2 post operations (KP, 2024)

4.18 Socio-economic environment

Black Mountain Mining (Pty) Ltd's current contribution to the local service delivery and infrastructure in the area includes:

- Residential accommodation to the majority of employees. Aggeneys currently houses the existing Black Mountain Mine and Gamsberg Zinc Mine workforce of approximately 837 permanent employees and approximately 830 sub-contractor staff. Additional accommodation is provided and secured in Pofadder and Springbok.
- Basic service delivery to the town of Aggeneys. This includes monitoring of resources such as water, energy as well as waste and waste recycling takes place continually to enable sustainable management of resources by all the users.
- Water infrastructure developed to provide potable water to Pofadder, Pella, Aggeneys and surrounding farmers (approximately 1 200 people).
- Directly and indirectly supporting businesses and clubs by providing additional employment and non-mine skills development and economic benefit to the area.

In addition to the above, the Black Mountain Mine Social and Labour Plan (SLP) currently implement four projects, affecting approximately 9 000 persons positively with a total spend of approximately R 16.5 million over five years. This SLP will shortly reach the end of its 5-year period. BMM intends to implement another SLP, similar to the current, which will also include a total spend on R 19.5 million over a 5-year period. This SLP will continue to focus on primary health care, education and small, medium and micro enterprise (SMME) development (Golder, 2022b).

Information in this section was sourced from Social Impact Assessment Report undertaken by Nic Boersema (independent social specialist) (2020) for the Gamsberg Smelter Project.

The regional study area is broadly defined as the Northern Cape Province and specifically the Namakwa District municipal area. The social baseline for the Northern Cape and Namakwa District Municipality is described in Table 38 and Table 39 respectively. The Namakwa District Municipality is one of five district municipalities in the Northern Cape Province.

Table 38. Northern Cape Social Baseline (SLR, 2021).

Aspect	Description
Population	Notwithstanding its large geographical area (the biggest province by land mass), the Northern cape Province has the lowest population of all provinces (1.2 million residents), representing about 2% of the national population in 2014/2015. The age category 0-4 years constituted the largest proportion of the population, while the age cohort 70-74 had the lowest population. The total fertility rate for the province was 2.85 births per woman between 2011 and 2016. The average life expectancy rate at birth was 59 years for males and 65 years for females. Population density was 3.26 persons per square km in 2016. Since 2006, the population has marginally increased year to year. The province had a positive net migration of 3 311 people in the same years. Its urbanisation rate was 79.9% in 2016.
Economy	In 2016, the province was the smallest contributor to the national GDP (2.1%). The Namakwa District Municipality, in turn, was the smallest contributor to the provincial GDB (11%). The largest industries were community services (22.5%) and mining (17.5%). The Province's economic growth rate was -2.7% in 2016. This negative

	economic growth can largely be attributed to contractions in the agriculture, mining, transport and electricity sectors. However, by 2018, the Northern Cape's GDP had expanded by 2.8%, the highest of all provinces. Mining and agriculture were major contributors to the expansion. In 2014, the economy (represented by agriculture, mining, manufacturing and construction) made up 34% of the Northern cape's output. The largest economic sector was mining, at 22% of the provincial economy, followed by agriculture (7%), manufacturing (3%), and construction (2%). The Northern Cape contributed 6% of national mining.
Employment	Approximately 40% of the working age population was employed in 2015. 64 % of total employment was in the formal sector, compared to the national average of 69%. In 2014, the median formal monthly wage was R2 600 and the median wage for domestic, informal, and agricultural workers was R1400. BMM is one the largest private sector employers in the Northern Cape, employing around 1692 people at the BBM mine, and 1171 people at the Gamsberg Zinc Mine Project (employees and business partner employees). Around 80% of BMM's employees are from the Northern Cape, including 60% from the Namakwa district (mainly Khai-Ma and Nama Khoi municipal areas).

Table 39. Namakwa District Municipality Social Baseline (SLR, 2021).

Aspect	Description
Administration	The Khâi-Ma municipality is a low capacity municipality (Category B), divided into four wards. The Project is located in Ward 4 of the Municipality. Pofadder, Pella, Aggeneys, Witbank and Onseepkans are all located within the municipal area. Farming settlements include Dwagga, Soutpan, Vrugbaar, Raap-en-Skraap and Klein Pella. The administrative headquarters of the municipality is located in Pofadder. The Khâi-Ma municipality provides basic services to Onseepkans, Blyvooruitsig, Pofadder and Witbank. Aggeneys is a mining town where the residents are mainly employed by BMM and Gamsberg Zinc Mines and the supporting Business Partners. Vedanta/ Black Mountain Mining provides basic services to the residents of Aggeneys.
Population	The Khâi-Ma Municipality had a population of 12 333 people in 2016.Population density is around one person per square kilometre, with the majority of the population living in the rural areas (4 035 people). Aggeneys has a population of 2 053 people (845 households) and Pofadder 2 919 people (733 households). More than 71% of the population falls within the 15-64age cohort, while 22.2%are under 15 years old. About 6% of the population is older than 64 years. The population growth rate in 2016 was 0.21% per year. The current growth rate is estimated to be 0.83%. The dependency ratio is 39.6 per 100 people within the 15-64 age cohort. The median age was 28 years in 2011. There are 4079 households in the Khai-Ma municipal area, with an average household size of three persons per household. Almost 34% of households are

Aspect	Description
	female-headed households. More than 92% of households live in formal dwellings, while 6.4% live in informal dwellings. The language most spoken at home is Afrikaans (95%), while 75% of the population is considered Coloured." The poverty headcount was 5.9% in 2016.
Education	Almost 3% of the population has no schooling, 22.2% has Matric and 5.2% has higher education.
Services	About 90% of households have piped water and 84% have flush or chemical toilets. Weekly refuse removal is available to 94% of households, and 87.6% has electricity. In 2016, the Khâi-Ma local municipality was the local municipality within its district which had the most access to basic services (Stats SA, 2018). However, the municipality still has trouble in delivering satisfactory services to its communities due to lack of capacity and an influx of people. The high levels of water consumption is also a big concern in this water stressed region.
Economy	The main economic sectors in the municipality are agriculture, mining, tourism, community services, and renewable energy.
Employment	Close to 55% of the working age population are employed. The average annual income was R29 400 per household in 2011, but 34% earned R20 000 or less. The annual income for individuals was R15 000, with 41% earning between R10 000 and R20 000 per annum. As was mentioned, around 80% of BMM's employees are from the Northern Cape, including 60% from the Namakwa district (mainly Khâi-Ma and Nama Khoi municipal areas).
Health care	Provincial hospitals are located in Pofadder, Springbok and Upington and well as a private hospital in Upington. The various towns in the municipal areas have functional government primary health care clinics.
Ward4	Afrikaans is spoken most often at home. Less than 4% are living in informal dwellings. 35.7% have completed matric or higher. Aggeneys is the main town in Ward 4. Approximately 85% of the households have access to piped water,85.2% have refuse removal and 85.9 have flush toilets. More than 90% of households have access to electricity.
Nama Khoi Local Municipality	The Nama Khoi Local Municipality is briefly discussed as it forms an important labour sending area for Black Mountain Mine and Gamsberg Zinc Mine activities. It is anticipated that the smelter project will also use this local municipality as one of its labour sending area. The Nama Khoi Local Municipality is a Category B municipality. The town of Springbok is the administrative centre and the most densely populated area, as it is the economic hub of the Namakwa District with the highest population. It is also the largest contributor to the District's GDP (41%), and made the largest contribution to employment in the District. Mining used to form the backbone of the economy.

Aspect	Description
	According to the 2016 Community Survey, the Khâi-Ma Municipality had a population of 46 513 people, with a population density of 2.6 people per square kilometre. For approximately 97% of the population, Afrikaans is the language most spoken at home.

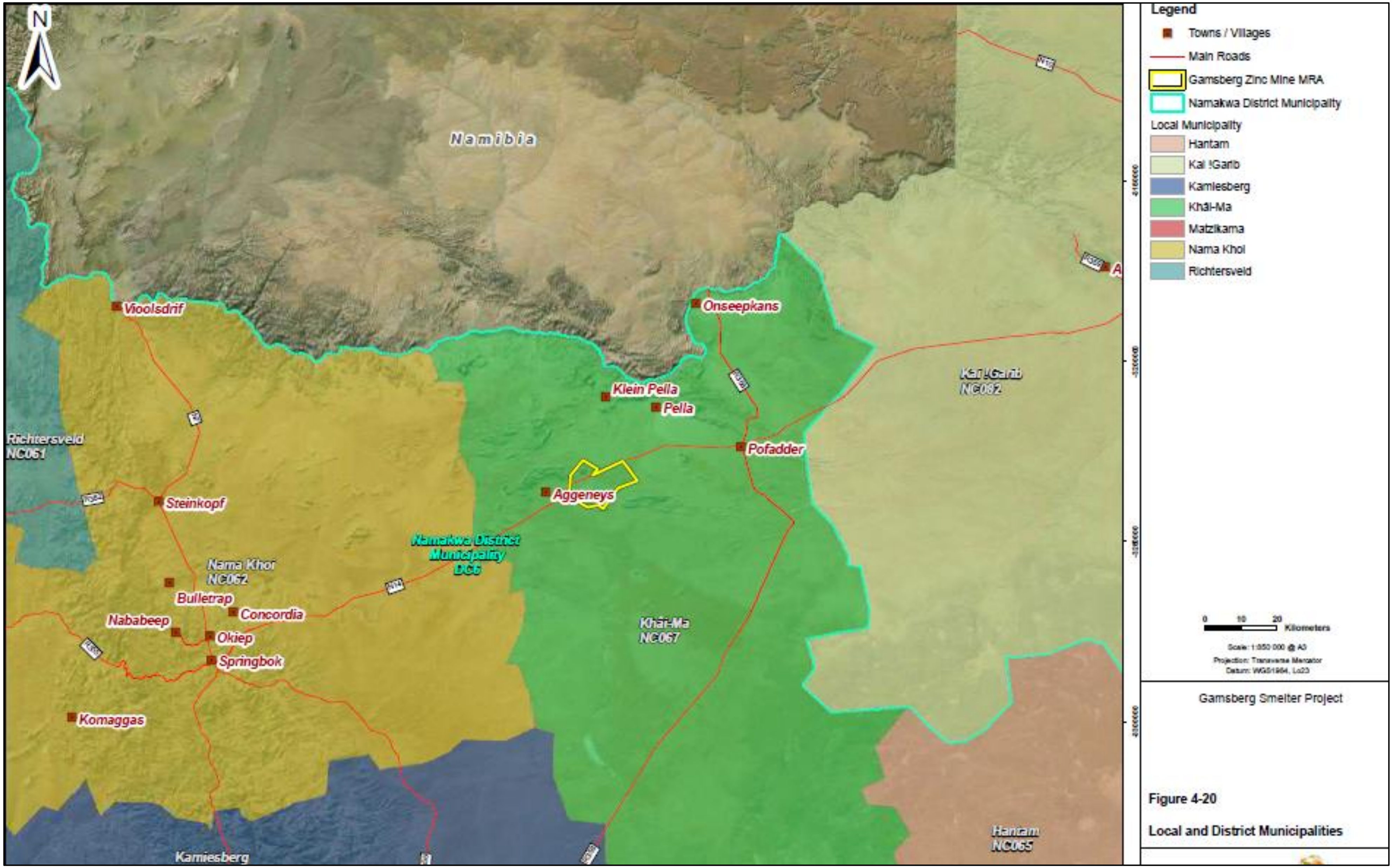


Figure 47. Local and District Municipalities (SLR, 2021).

The Gamsberg Smelter Project is situated in the Khâi-Ma-Ma Local Municipality, which is one of six local municipalities within the Namakwa District Municipality (Figure 47).

A basic socio-economic profile of the population residing in the local study area is presented in Table 40.The information was mainly sourced from the 2011 Census Survey, the 2016 StatsSA Community Survey, the Khai-Ma IDP review (2019), Media Monitoring Africa (2018) (via Wazimap) and the Municipalities of South Africa website (municipalities.co.za).

Table 40. Khâi-Ma Municipality Social Baseline (SLR, 2021).

Aspect	Description
Administration	The Khai-Ma municipality is a low-capacity municipality (Category B), divided into four wards. The Project is located in Ward 4 of the Municipality. Pofadder, Pella, Aggeneys, Witbank and Onseepkans are all located within the municipal area. Farming settlements include Dwagga, Soutpan, Vrugbaar, Raap-en-Skraap and Klein Pella. The administrative headquarters of the municipality is located in Pofadder. The Khai-Ma municipality provides basic services to Onseepkans, Blyvooruitsig, Pofadder and Witbank. Aggeneys is a mining town where the residents are mainly employed by BMM and Gamsberg Zinc Mines and the supporting Business Partners. Vedanta/Black Mountain Mining provides basic services to the residents of Aggeneys.
Population	The Khai-Ma Municipality had a population of 12 333 people in 2016.Population density is around one person per square kilometre, with the majority of the population living in the rural areas (4 035 people). Aggeneys has a population of 2 053 people (845 households) and Pofadder 2 919 people (733 households). More than 71% of the population falls within the 15-64age cohort, while 22.2%are under 15 years old. About 6% of the population is older than 64 years. The population growth rate in 2016 was 0.21% per year. The current growth rate is estimated to be 0.83%. The dependency ratio is 39.6 per 100 people within the 15-64 age cohort. The median age was 28 years in 2011. There are 4079 households in the Khâi-Ma municipal area, with an average household size of three persons per household. Almost 34% of households are female-headed households. More than 92% of households live in formal dwellings, while 6.4% live in informal dwellings. The language most spoken at home is Afrikaans (95%), while 75% of the population is considered "Coloured." The poverty headcount was 5.9% in 2016.
Education	Almost 3% of the population has no schooling, 22.2% has Matric and 5.2% has higher education.
Services	About 90% of households have piped water and 84% have flush or chemical toilets. Weekly refuse removal is available to 94% of households, and 87.6% has electricity. In 2016, the Khai-Ma local municipality was the local municipality within its district which had the most access to basic services (Stats SA, 2018). However, the

Aspect	Description
	municipality still has trouble in delivering satisfactory services to its communities due to lack of capacity and an influx of people. The high levels of water consumption is also a big concern in this water stressed region.
Economy	The main economic sectors in the municipality are agriculture, mining, tourism, community services, and renewable energy.
Employment	Close to 55% of the working age population are employed. The average annual income was R29 400 per household in 2011, but 34% earned R20 000 or less. The annual income for individuals was R15 000, with 41% earning between R10 000 and R20 000 per annum. As was mentioned, around 80% of BMM's employees are from the Northern cape, including 60% from the Namakwa district (mainly Khâi-Ma and Nama Khoi municipal areas).
Health care	Provincial hospitals are in Pofadder, Springbok and Upington and well as a private hospital in Upington. The various towns in the municipal areas have functional government primary health care clinics.
Ward 4	According to the 2011Census, the Ward had a population 3 638 people. The median age in Ward 4 was 31, while 66% of the population was between 18 and 64. Around 20% of the households were female-headed households. Employment was around 57%. For almost 80% of the population, Afrikaans is spoken most often at home. Less than 4% are living in informal dwellings. 35.7% have completed matric or higher. Aggeneys is the main town in Ward 4. Approximately 85% of the households have access to piped water,85.2% have refuse removal and 85.9 have flush toilets. More than 90% of households have access to electricity.
Nama Khoi Local Municipality	The Nama Khoi Local Municipality is briefly discussed as it forms an important labour sending area for Black Mountain Mine and Gamsberg Zinc Mine activities. It is anticipated that the smelter project will also use this local municipality as one of its labour sending area. The Nama Khoi Local Municipality is a Category B municipality. The town of Springbok is the administrative centre and the most densely populated area, as it is the economic hub of the Namakwa District with the highest population. It is also the largest contributor to the District's GOP (41%) and made the largest contribution to employment in the District. Mining used to form the backbone of the economy. According to the 2016 Community Survey, the Khai-Ma Municipality had a population of 46 513 people, with a population density of 2.6 people per square kilometre. For approximately 97% of the population, Afrikaans is the language most spoken at home.

5 Chapter 5: Analysis and characterization of the water use activity

5.1 Site Delineation for Characterisation

The site covers a total surface area of approximately Black Mountain Mining (Pty) Ltd is proposing the construction and operation of the TSF Phase 2 with associated RWD, silt trap, pipelines and stormwater diversion channel within the Gamsberg Zine Mine mining right area. The development footprint for the TSF Phase 2 Project and the associated infrastructure would have an extent of approximately 120 ha within the approved mining right area which is a total extent of 9 505.73 ha.

The mining activities commenced in June 2016 when overburden stripping for the open pit commenced. The mining plan for Phase 1consisted of three smaller open pits in the footprint of the 10 million tonne per annum (mtpa) footprint. Development of the opencast mine and concentrator plant has been done in phases. The construction of the concentrator plant commenced in 2017 with the official opening in February 2019. Phase 2 will expand the mining capacity to the approved 10 mtp). The Gamsberg Zinc Mine is currently mining up to 4 mtpa and producing up to 250 000 tonnes per annum (tpa) of zinc concentrate for export (SLR, 2021).

Black Mountain Mining (Pty) Ltd was issued with a Water Use License, WUL No 14/D82C/ABCGIJ/2654, in 2014, and an amendment was issued in April 2016. A more detailed explanation of the water uses is provided in Section 2.1.

Refer to

Figure 11 for the layout showing the overall water uses of the site, which includes the water uses authorized by the 2014 WUL, the 2016 WUL Amendment, the 2020 WUL Amendment application and the 2023 TSF Phase 2 Amendment application.

Refer to Table 8 for the key infrastructural and activity description, which includes the infrastructure associated with the 2014 WUL, the 2016 WUL Amendment, the 2020 WUL Amendment application and the 2023 TSF Phase 2 Amendment application.

5.2 Water and Waste Management

Water Management:

- Supply of consumptive, sanitation and process water uses: Water is abstracted from the Orange River by the Sedibeng water board and fed into the Pella pipeline system, after being clarified and chlorinated. Feeding two circuits, namely the Black Mountain Mine circuit and the Gamsberg Zinc Mine circuit
- Current water demand, with the Black Mountain Mine operation and Phase 1 concentrator plant at Gamsberg, is 28 ML/day, the existing intake water pumping system has been designed for 40.8 ML/day. Raw water storage dam at the concentrator plant has a total capacity of 6 800 m^3 and provides water to the plant, mine and fire hydrant systems.
- Process water dam with 25,000 m^3 capacity receives treated and raw (make-up) water with recycled plant water (adapted from Golder, 2018 as updated from ERM, 2013b).
- Process Water Use (based on 2022 data):

•

Table 41. Process Water Use of Gamsberg Zinc Mine (as per 2022 Water Balance provided by BMM)

Facility	Water use volume
Equipment Wash Area	45 ML/a
Crusher	0.057 ML/a
Mining	0.25 ML/a
Plant	298 ML/a
Fire water	6.5 ML/a
Gland seal	143 ML/a
Potable	61 ML/a
Total	553.8 ML/a

- Storm Water Management:

Table 42. Storm Water Management structures of the Gamsberg Zinc Mine

Facility	Size
Salvage Yard Stormwater Dam (existing)	1 800m^3
Plant Storm Water Dam (existing)	5 000m^3
Jarosite Storm Water Dam (proposed 2020)	15 000m^3
Refinery Storm Water Dam (proposed 2020)	18 000m^3
PCD 1 (existing)	1 825m^3
PCD 2 (proposed 2020)	1 825m^3
Dirty & clean stormwater channels	various
Flood protection berm at SLF (proposed 2020)	0.8m high

- TSF 1 stormwater berm will be decommissioned and a new berm will be constructed north of TSF 2 for the diversion and slow release of clean stormwater.

Waste Management:

Refer to Section 2.6.2 of this report.

5.3 Process water

Water balance:

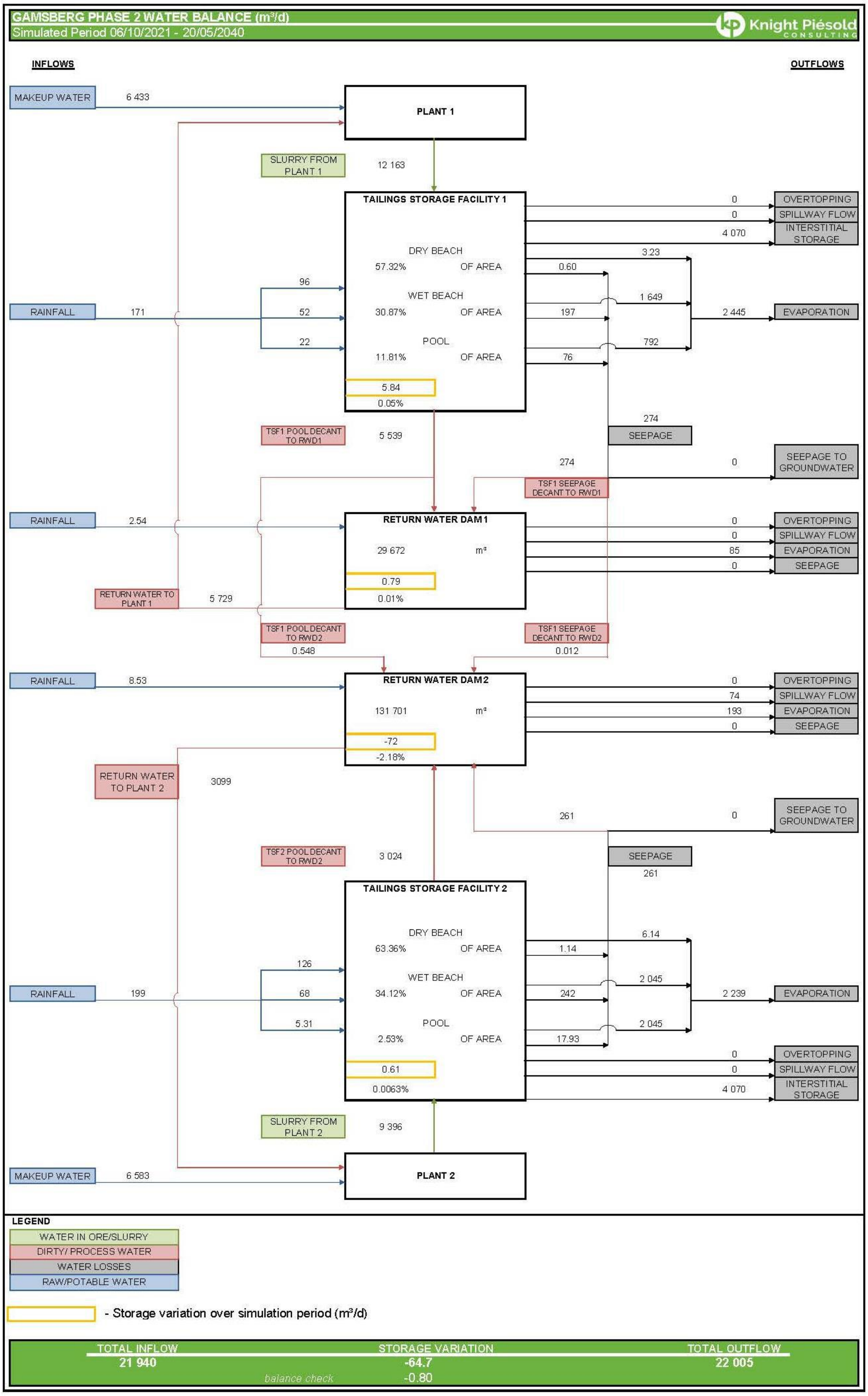
Table 43. Annual Average Water balance (Phase 2) as calculated in 2021 (SLR, 2021).

Gamsberg Zinc Mine	Water Circuit/Stream	Quantity (m^3/year)	Water Circuit/Stream	Quantity (m^3/year)	Balance
Opencast Pit	Rainfall	155 350	Evaporation	259 313	
	Stormwater	204 528	Dust Suppression	100 565	
	Total	**359 878**		**359 878**	**Balanced**
Potable Water Tank	Raw Water Dam	54 919	Losses	5 492	
	Make-Up Water	0	Consumption	49 427	
	Total	**54 919**		**54 919**	**Balanced**
Raw Water Dam	Horseshoe Reservoir	6 296 487	Fire Network	219 002	
			Process Water	3 102 534	
			Smelter Complex	2 920 032	
			Potable Water Network	54 919	
	Total	**6 296 487**		**6 296 487**	**Balanced**
Concentrator Plant	Raw Water Dam	3 102 534	Tailings Water	3 724 866	
	Recovery	1 384 117	Zinc Concentrate	823 905	
	Make-Up Water	62 120			
	Total	**4 548 771**		**4 548 771**	**Balanced**
Smelter Complex	Raw Water	2 920 032	ETP	8 805 912	
	Zinc Concentrate	823 905	Losses	2 201 478	
	RO Plant	7 263 453			
	Total	**11 007 390**		**11 007 390**	**Balanced**
Effluent Treatment Plant	Rainfall	12 783	Losses	443 845	
	Raw Water	1 035 619			
	Smelter Plant	8 805 912	Dust Suppression	219 000	
	SLF SWD	83 904	Evaporation	502 573	
	Smelter SWD	54 363	Return Osmosis	7 113 476	
	STP	111 334	ETP Cake	1 825 020	
	Total	**10 103 915**		**10 103 915**	**Balanced**
Sewage Treatment Plant	Rainfall	12 783	ETP	111 334	
	Amenities	98 551			
	Total	**111 334**		**111 334**	**Balanced**
TSF	Rainfall	64 460	RWD Decant	1 408 237	
	Stormwater	107 093	Interstitial Lock	1 117 478	
			Evaporation	719 265	
	Thickener Inflow	3 724 866	Seepage Loss	651 440	
	Total	**3 896 419**		**3 896 419**	**Balanced**
Return Water Dam	Rainfall	629	Evaporation	24 749	
	TSF Decant	1 408 237	Returned to Plant	1 384 117	
	TSF Seepage	651 440			
	Total	**1 408 866**		**1 408 866**	**Balanced**
SLF	Rainfall	11 931	Evaporation	503 500	
	Runoff	3 579	Interstitial Lock	578 259	
	Jarofix Moisture	87 000	Toe Seepage	749 395	
	ETP Cake	1 825 020	Seepage	96 377	
	Total	**1 927 530**		**1 927 530**	**Balanced**
Smelter SWD	Rainfall	341	Evaporation	62 029	
	Runoff	116 051	ETP	54 363	
	Total	**116 392**		**116 392**	**Balanced**
Jarosite SWD	Rainfall	284	Evaporation	11 168	
	Runoff	90 616	ETP	83 904	
	SLF Toe Seepage	749 395	Available in PCD	745 223	
	Total	**840 295**		**840 295**	**Balanced**
WRDs	Rainfall	147 817	Seepage	1 825	
	Runoff	335 767	Evaporation	481 759	
	Total	**483 584**		**483 584**	**Balanced**
Evaporation Ponds	Rainfall	10 795	Evaporation	6 310	
	Seepage from WRDs	1 825	Plant Return	6 310	
	Total	**12 620**		**12 620**	**Balanced**
Total Water Balance		**41 168 398**		**41 168 398**	

Water balance of TSF 2 (Knight Piésold, 2023b)**:**

The inflows consist of the slurry water (production) and rain, while the outflows are entrainment, decant, evaporation and a small volume to the drains and seepage into the base (the geomembrane liner system is assumed to have some seepage).

Table 44. Water Balance of the TSF 2 (Knight Piésold, 2023b).



The important findings are summarised here:

1. The main conclusion from the water balance update is that the TSF pool volume is highly dependent on the RWD pump rate to the plant. As noted in the December 2021 report, the water balance is further dependent on the density of the slurry feed, but for this analysis, it was assumed to be at 47% solids.
2. The Return Water rate should be set as high as possible, with a minimum of 340m^3/h to reduce the pools on the TSF's, increase stability and reduce water losses.
3. The RWD size should be set at 120 000m^3, to assist with reduction of the pool on TSF1 and provision of storm capacity for both TSF's.
4. The required decant rate is 500m^3/h, but either variable speed pumps will be required or the pumps will run intermittently.
5. If operated at low pool volumes, the TSF should be able to cater for the 1:100 rain event and the excess can be decanted within a month or two (KP, 2023e).

Reuse and Recycling:

Direct runoff from the slopes of the TSF is to be drained towards a storm water dam which will lead to the RWD. This together with the return water will be reused in the processing plant.

Reuse and recycling of contaminated storm water as process water is part of the action plan (Golder, 2019).

Water conservation and demand management: Water conservation is achieved by recycling of water as described above. Water demand is managed by metering of use and comparing to production volumes to identify wasteful use. All relevant staff members attend training relating to water use.

Point source discharges: There are no discharges of dirty stormwater or waste water from the site, and all dirty stormwater is stored and reused.

5.4 Stormwater

Smelter complex:

Clean water catchment areas include the areas upstream and to the northeast of the smelter complex and secured landfill facility including the connecting road.

Dirty water catchment areas include the smelter complex and the secured landfill facility, most of the dirty water catchment within the smelter complex areas would be paved.

The key features of the proposed conceptual storm water management layout plan include:

- Clean storm water will be prevented from entering dirty water catchments by creating perimeter berms around the Smelter and the secured landfill facility footprints (channels and berms);
- Storm water generated from the upstream areas of the Smelter and SLF will be considered clean and managed by clean water diversion berms or unlined clean water channels, and diverted around dirty areas;
- Dirty water generating areas within the Smelter will be on hardstanding cover and the runoff generated will be collected in the dirty water channels;
- Dirty storm water will be collected by concrete lined open channels and circular culverts and conveyed to the SWDs. Open channels are preferred for ease of maintenance and to minimise the depth of the excavation below ground level to accommodate the infrastructure design capacity, whilst maintaining suitable drainage gradients;

- Some smaller storm water structures are also required in selected places in the form of berms (speed bumps) and small concrete walls to redirect storm water into the desired collection channels;
- Collected storm water in the channels is passed through one silt trap before being conveyed into the storm water dams. The sediment being transported in the storm water (likely to include zinc waste residue can then be recovered from the silt traps. The silt traps are sized to accommodate runoff.

All the proposed infrastructure associated with the smelter complex is located outside of any of the calculated 1:100-year flood lines except for the proposed secured landfill facility. a flood protection berm has been proposed that partitions the slope from the level space around the secured landfill facility. This flood protection berm will need to be 0.8 m high along its full alignment.

The channel inlet to the SWD will need to have its own silt trap and the silt trap will be concrete lined to allow for ease of maintenance, i.e. removal of material and cleaning. The silt trap will have two separate equally sized compartments, an operational and a standby compartment. This will allow one compartment to be cleaned whilst the other is in operation. The depth of both the Smelter and SLF silt traps are proposed to be 2m, and design capacity of the Smelter silt trap is 218m^3 and SLF silt trap is 486m^3. The site will be covered with hardstanding surfaces engineered to slope towards the channels at recommended minimum gradients of 1:200. At certain locations, ground levels will need to be raised to allow the storm water to flow away from these areas and to ensure that the drainage direction is towards the channels.

The dirty water channels will be lined to prevent any seepage of dirty water to the underlying groundwater environment. While from a pollutant point of view, it is not required that the clean water channels be lined, due to installation of velocity abatement structures. It is recommended that all the channels are concreted.

Culverts such as the crossing on the road between the smelter complex and the secured landfill facility are recommended for conveying flows beneath major road crossings, whilst grated steel covers installed over open channels are recommended for minor road/ pedestrian crossings.

Kerbing is recommended on the road edges to influence drainage towards channels (SLR, 2020b).

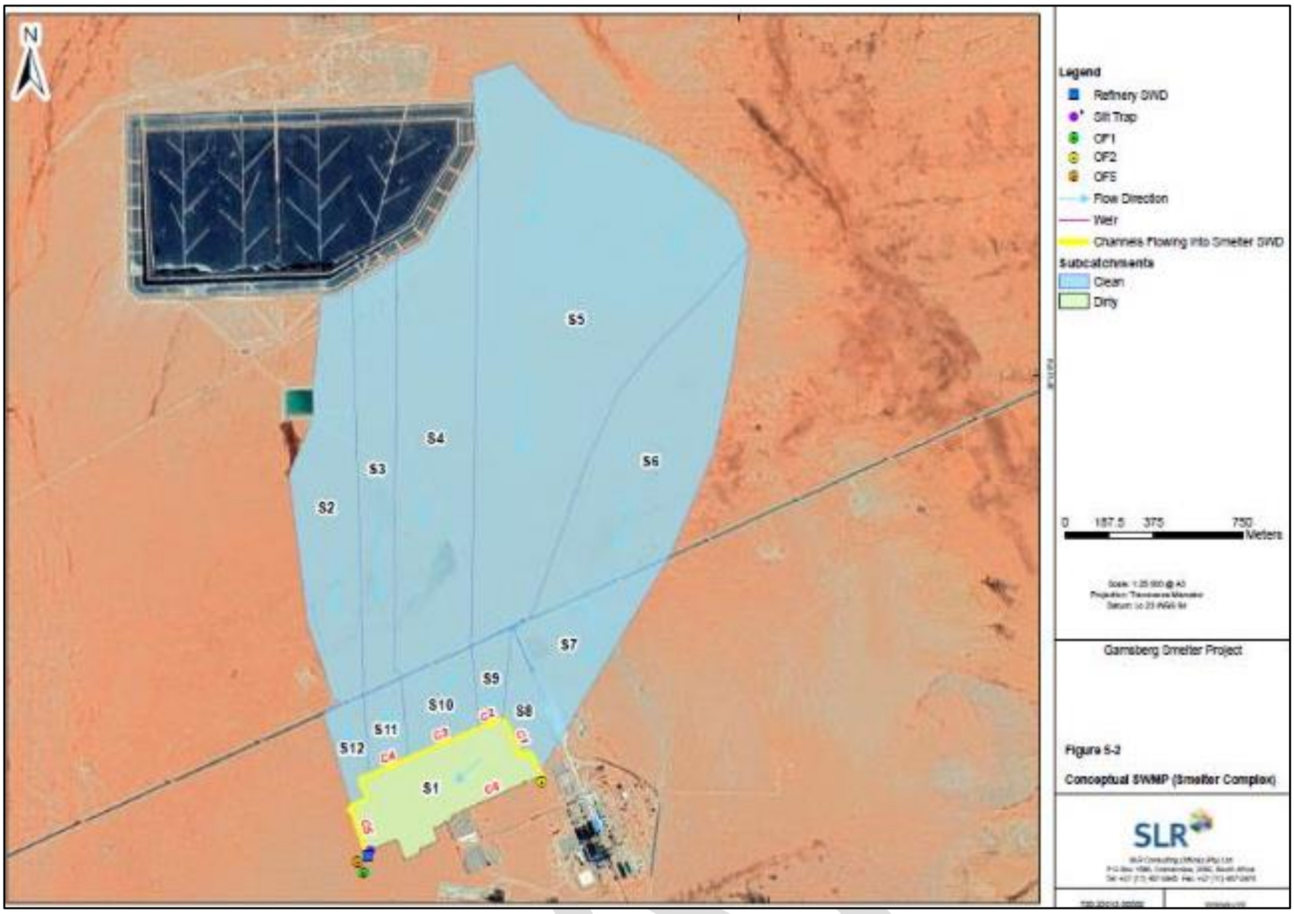


Figure 48. Conceptual SWMP for the Smelter Complex (SLR, 2020b)

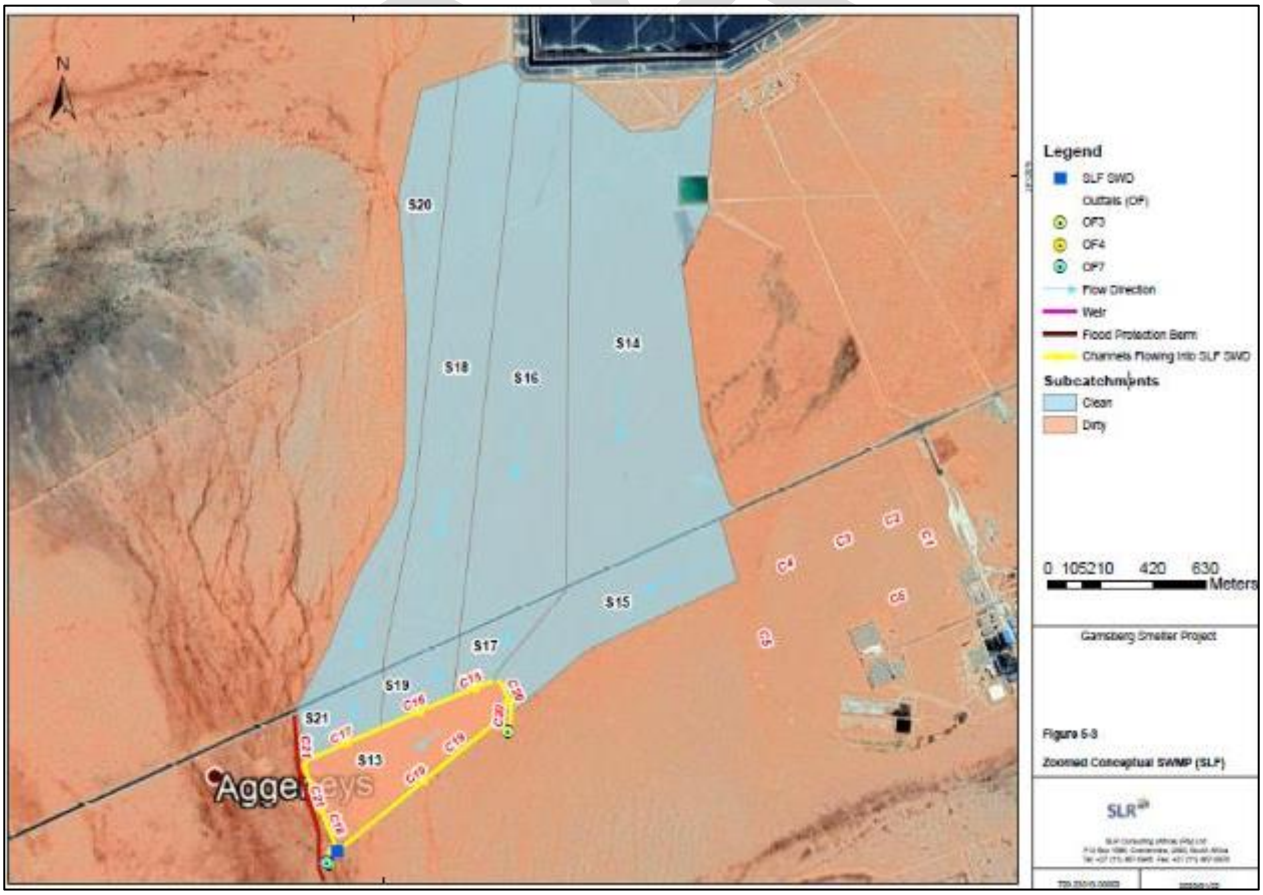


Figure 49. Conceptual SWMP for the SLF (SLR, 2020b)

TSF 2

A new clean water diversion channel is required in to divert clean water runoff coming from the north around the TSFs (KP, 2023b) (Figure 50).

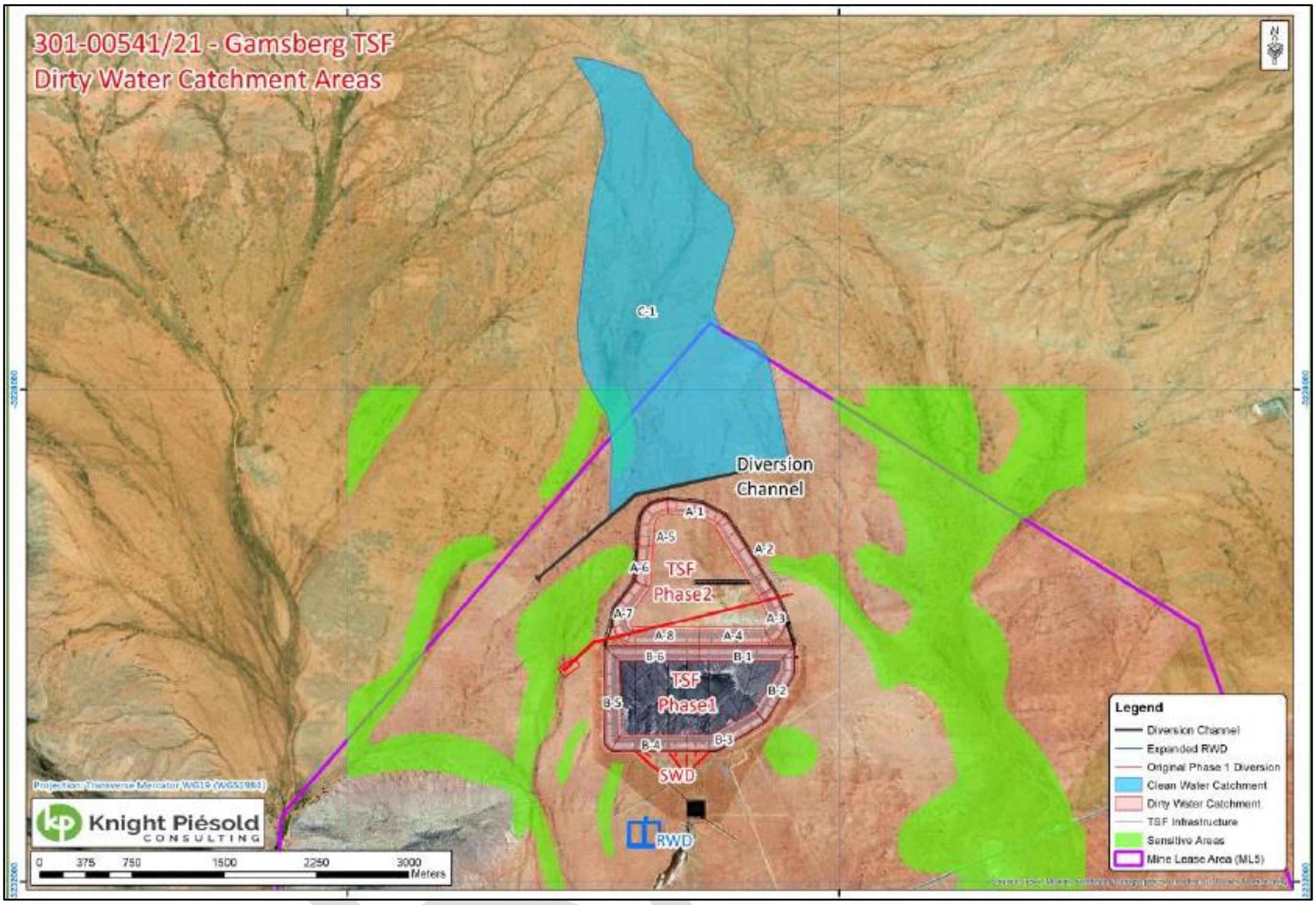


Figure 50. Location and catchment of new clean diversion channel (KP, 2023b).

5.5 Groundwater

TSF Phase 2: Class C, 1080 GSM geotextile, overlayed by 1.5mm HDPE geomembrane underdrains with leak detection

SLF: As the secured landfill facility will be constructed with a Class A liner, the volume of seepage into groundwater is likely to be very low. In addition, the presence of cement in the Jarofix is likely to cause it to solidify with time, significantly reducing the potential for infiltration into the secured landfill facility (SLR, 2021).

Refer to 4.12 to 4.17 for the groundwater baseline description and 5.15 for updated groundwater monitoring results. Also refer to 6.6 for the relevant Action Plan items, and to Table 54 for the recommended TSF monitoring.

5.6 Waste

Refer to 5.2 above.

5.7 Operational Management

The overall responsibility to ensure the implementation of the IWWMP (and all authorisations) lies with the Environmental Manager.

Table 45. Operational management of Gamsberg Zinc Mine

Employee name	Role	Contact No	Email address
Pieter Venter	Gamsberg Zinc Environmental Manager	+27 54 983 8520	pventer@vedantaresources.co.za
Pieter van Greunen	General Manager	+27 54 983 8520	PVanGreunen@vedantaresources.co.za

5.8 Organisational Structure

The Gamsberg Zinc Mine has an integrated structure. The roles and responsibilities of personnel at Black Mountain Mining (Pty) Ltd are allocated to facilitate effective environmental management. The figure below illustrates an overview of the Executive Council along with their qualifications and years of experience.

5.9 Resources and competence

Resources and competencies at the Gamsberg operations are reflected as part of the larger BMC group. During the 2014-2015 financial year, BMC had a total of 1 491 employees spread across various workforce levels at the larger BMC operation. This included permanent employees, fixed term employees and contractors (see Table 46).

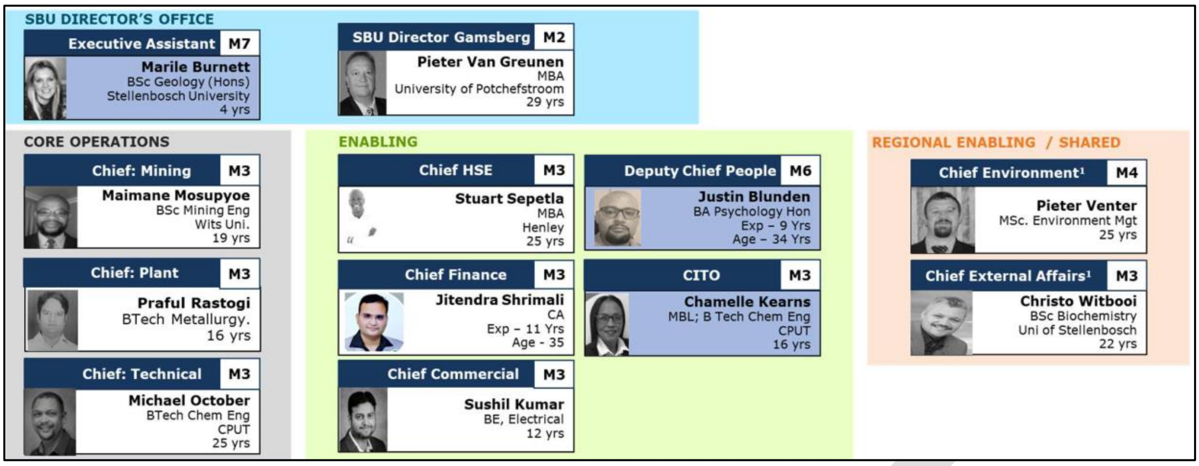


Figure 51. Overview of the Gamsberg Executive Council (SLR, 2021).

Table 46. Workforce Categorisation (SLR, 2021).

Workforce Categorisation	2014 – 2015		
	Male	Female	Total
By Employee Category			
Corporate	0	0	0
M1 – M3L Exco and Senior Management	9	1	10
M4 – M7: Functional Managers, Engineers, Mine Overseers	38	12	50
M8 & 9: Supervisors and Management Trainees	17	16	33
Below M9: Bargaining Unit, Operators, Artisans, Clerks	7	8	15
Fixed-Term Employees	12	5	17
By Employee Type			
Permanent	71	37	108
Contract	12	5	17
Total	**83**	**42**	**125**
By Age (only permanent employees)			
<30	21	20	41
<30 -50	51	22	73
>50	11	0	11

Workforce Categorisation	2014 – 2015		
Total	83	42	125
Black Mountain Mining (Pty) Ltd Total Employees	**83**	**42**	**125**

Specialists and consultants were appointed to assist with the relevant authorisations and specialist studies that have been undertaken as part of these authorisation applications. As well as on-going monitoring.

Table 47. Professional Registration / Qualifications of personnel involved with DRAFT reports compiled for, and relevant to, the Gamsberg Zinc Mine TSF Phase 2 project.

#	Specialist report	Specialist	Qualifications and Professional Registration
1	Design Report	301-00541-21 Gamsberg Mine Phase 2 TSF Design	Justin Teixeira Pr.Eng. No 20190614 Knight Piésold
2	Geotechnical Investigation Interpretive Report	3010054121 Gamsberg TSF GIR Interpretive Rev 1 ed DJM	Bronwen Klaas, Pr.Sci.Nat. No 400515 Knight Piésold
3	Waste Classification Assessment 1	301-00541-21 Gamsberg TSF Waste Classification Assessment 1 Draft 1	Aidan Hughes Pri.Sci. No 127912 Knight Piésold
4	Waste Classification Assessment 2	RI301-00541-12-Gamsberg Waste Assessment 2-Draft	Aidan Hughes Pri.Sci. No 127912 Knight Piésold
5	Technical specifications	RI301-00541-21_Technical Specification_DRAFT 20240112 LM	Francois Du Toit, Pr.Eng. No 202201992 Knight Piésold
6	Construction Quality Assurance	RI301-00541-21_CQA_DRAFT	Francois Du Toit, Pr.Eng. No 202201992 Knight Piésold
7	Hydrogeology	Numerical Groundwater Model Report-Draft-061123	Aidan Hughes Pri.Sci. No 127912 Knight Piésold
8	Silt Trap Design and Hydrailics	301-00541-21 Gamsberg Silt Trap Design and Hydraulics_LDK_20230907	Leon De Kooker Pr.Eng.Cand. No 2023205892 Knight Piésold
9	Slurry RWD Pipeline System	301-00541-21 Gamsberg Ph 2 - Slurry RWD Pipeline syst - Design Criteria Rev A JT	Kobus van Rooyen Pr.Eng.No 20090276 Knight Piésold
10	Gamsberg IWWMP 2023	Gamsberg IWWMP 2023: TSF Phase 2 Project and Annual Update	Marli Burger M.Sc. (Aquatic Health) Pr.Sci.Nat.115534 EAPASA 220/2019 AquaStrat Solutions
11	Hydrological Impact Assessment of HHO Africa. 2013	Fred de Villiers,	Pr Eng, ECSA Reg 20040009
12	Vegetation Baseline and Impact Assessment Report, 2013.	Dr Phillip Desmet	BSc (Wits), MSc & PhD (UCT)

#	Specialist report	Specialist	Qualifications and Professional Registration
13	Quarterly Groundwater Monitoring Report Phase 20: 3rd Quarter 2023.	J.J.H. Hough	GHT Consulting Senior Hydrogeologist M.Sc. Pr. Sci. Nat
14	Terrestrial Fauna and Aquatic Biodiversity Report for proposed Zinc Mine on Gamsberg, Northern Cape, 2013.	Philip Mark Graham	GroundTruth Pr.Sci.Nat.400099/96
15	Groundwater Assessment for the Gamsberg Zinc Mine, 2013.	Helen Seyler	Pr.Sci.Nat. 400042/12
16	Preliminary Geohydrology and Groundwater Quality Baseline, 2010.	Des Visser	SRK Consulting BSc Geology Pr.Sci.Nat. Geological Science

5.10 Education and Training

Black Mountain Mining (Pty) Ltd has a commitment to employee development which is built on inclusive culture of collaboration, experiential learning and meritocracy. Black Mountain Mining (Pty) Ltd endeavours to encourage employees to realise and develop their full potential through a continuous learning environment.

Effective training and development benefit the individual and organisation as a whole and contributes to the achievement of the objectives of the company.

Black Mountain Mining (Pty) Ltd has a number of training programmes which are implemented onsite:

- Frontline Leadership Programme, which aims at training employees to be leaders;
- Graduate Development Programme, which is an in-house two-year programme which aims to enable employees to grow in leadership roles;
- Learnerships/Apprenticeships, through which 10 engineering learnerships are provided for as well as trade candidates (i.e., Fitting, plater/welder, electrical, instrumentation, diesel mechanic and auto electrical); and
- Rock breaking certificates in mining, which aims to provide accredited Mining Qualifications Authority (MQA) training for onsite rock breaking.

As per the Golder IWWMP (2019), Black Mountain Mining (Pty) Ltd recognises the importance of employees in the achievement of its business objectives and that ongoing skills development is the foundation for developing competent and productive employees who will be able to participate in meeting the mine’s business objectives.

As such, there is a commitment to skills development that has an impact beyond the organisation and provides a basis for sustained employability through portable skills and developmental plans, aligned to the National Qualifications Framework (NQF). Black Mountain Mining (Pty) Ltd has registered the mining operation with the relevant Sector Education and Training Authority (SETA) like the MQA and undertakes to pay skills development levies. Table 48 represents the compliance with skills development legislation.

Table 48. Compliance with Skills Development Legislation (SLR, 2021).

Name of SETA	MQA
Registration number at SETA	L800769616
Name of Skills Development Facilitator	Position Yet to be Filled
Name of institution to which the WSP was submitted	MQA

Black Mountain Mining (Pty) Ltd skills development plan and programmes are underpinned by the following principles (Golder, 2019):

- The provision of training and development initiatives will be in line with the principles of the NQF and unit standards (where these exist) and is, thus, outcome-based;
- The secondary focus is the improvement of competency levels that facilitate career progression and support the acquisition of skills that can be transferred and used in other environments;
- A mind-set is established that underpins development which improves the performance of employees/ teams/ organisations;
- Employees are encouraged to take ownership of their own development;
- Mentoring and coaching of learners is incorporated to support their development where appropriate;
- Training facilities and trainers utilised are appropriately accredited and such accreditation maintained; and
- Quality control mechanisms are in place to ensure appropriate assessment and moderation.

Black Mountain Mining (Pty) Ltd, as one of its projects, contained within the Black Mountain Operation SLP (FY1 to FY5) committed to the upgrading of the O'Kiep FET College. The objective of this project was to provide funding support to O'Kiep FET College to ensure sufficient supply of skilled employees for future operations at the Black Mountain Mining (Pty) Ltd operations. This will potentially create a greater alignment between the training offered by the college and operational requirements. There is potential, to incorporate training to students, in other critical transformation (SLR, 2021).

Full details provided in the Social and Labour Plan (provided on request).

5.11 Internal and External Communication

Gamsberg Zinc Mine along with Black Mountain Mining (Pty) Ltd endeavour to develop an inclusive culture through which they interact more often with their employees. Continuous communication with employees aims to align employees with the company's goals and targets (Golder, 2019). The current communication channels employed within the larger Black Mountain Mining (Pty) Ltd include:

- Monthly EXCO meetings – Business level operations review;
- Quarterly General Manager (GM) roadshows and Chief Executive Officer (CEO) roadshows;
- Weekly Safety/Operational Review & Asset Optimisation (OR/AO)/Cost review meetings by General Manager to drive unit specific challenges & opportunities;
- Daily site-wide communication, newsletters, CEO and GM communications;
- Systematic dialogue process in performance management and production incentive scheme;
- Celebrate success: functional, unit team get-together to celebrate target achievements; and
- Unit EXCO team off-site workshops and Zinc International (ZI) annual leadership conference, alignment sessions.

Further to the above-mentioned communication channels, environmental communication is also an important aspect of the internal communication taking place onsite. Environmental communication and awareness are a mine wide responsibility that is facilitated by the environmental unit and line managers.

The environmental unit compiles and ensures distribution of the following communications:

- Daily environmental communication on the toolbox talk;
- Monthly discussion topics;
- Monthly joint Safety, Health and Environment (SHE) presentations;
- Environmental Management Systems (EMS) presentations every month;
- SHE representative training; and
- Electronic correspondence to EMS members of specific issues.

Line management further facilitate knowledge transfer of the above communications to all employees by means of daily toolbox meetings, communication meetings or any other suitable means. Communication and awareness also take place through the display of environmental topics and issues on display notice boards. Further to the above-mentioned communication structures, Black Mountain Mining (Pty) Ltd has several communication structures for external purposes, these include:

- Stakeholder engagement:
- Posters in towns, i.e. Aggeneys, Pella, Pofadder and Onseepkans that may be directly or indirectly impacted on by the mines;
- Adverts in local newspapers;
- Personal correspondence with relevant stakeholders;
- Annual reports which are available online for any interested stakeholders;
- Public Meetings are also held as required, with
  - Local communities;
  - Regional stakeholders (towns and other I and AP's), on project to project basis;
  - Regulators; and
  - NGO's (SLR, 2021).

5.12 Awareness raising

Awareness of the WUL and environmental matters in general is achieve through the following media:

- **Annual Induction** – All full-time staff, and any person performing long-term work, or any person who works unaccompanied on site, are required to attend an annual induction session conducted by the mine internally.
- Annual induction includes the following topics which relate to aspects applicable to the WUL:
  - Environmental Rules (which include waste management and water saving)
  - Management of hazardous chemicals (including management of spillages),
  - Littering
  - Waste management
  - Saving water
  - Water pollution
  - Ground pollution
  - Alien and invasive species (and protected species)
  - Rehabilitation

- **Monthly Safety Meetings** – for Management and Team Leaders
- The following topics were covered in the monthly safety meetings during the past year:
  - Environmental Law – NEMA, NEM:AQA, NWA, NEM:BA, NEM:WA
  - Environmental Impact Assessment Regulations
  - Environmental Management Programs
  - Why is knowledge of the law important
  - Environmental Policy
  - Lender Agreement
- **Daily green are meetings / Tool box talks** – Team Leader share applicable information with members of their team.

5.13 Monitoring and control

As a general approach, Black Mountain Mining (Pty) Ltd would ensure that the monitoring programmes comprise the following (SLR, 2021):

- A formal procedure;
- Appropriately calibrated equipment;
- Where samples require analysis, they would be preserved according to laboratory specifications;
- An accredited, independent, commercial laboratory would undertake the sample analyses;
- Parameters to be monitored would be identified in consultation with a specialist in the field and/or the relevant authority;
- If necessary, following the initial monitoring results, certain parameters may be removed from the monitoring programme in consultation with a specialist and/or the relevant authority;
- Monitoring data would be stored in a structured database;
- Data would be interpreted and reports on trends in the data would be compiled by an appropriately qualified person on a quarterly basis; and
- Both the data and the reports would be kept on record for the LOM.

Table 49. Gamsberg Zinc Mine existing monitoring type and frequency

Monitoring	Sampling localities & Impact monitored	Frequency	Parameters	Reporting & Standards
Water received from Sedibeng Water	Monitoring of intake volume Water Demand Management	Daily	Volume	Water balance: update annually Standard: WCWDM measures
Holding dams	Monitoring of levels and drainage Impact: Raw water, process water, dirty water containment	Daily Annually	Levels & Drainage	Internal reporting: monthly report External reporting: Annual Reporting of spills to authorities
Surface Water Quality	Proposed up- and downstream monitoring of the Kloof after rainfall events	Annual	pH Nitrate Electrical conductivity	Annual in rainy season Standard: SANS 241:2015 and DWAF

Monitoring	Sampling localities & Impact monitored	Frequency	Parameters	Reporting & Standards
	Impact: Smelter Complex and SLF		Ammonia TDS Potassium TSS Nickel Aluminium Manganese Fluoride Iron Total alkalinity Copper Chloride Lead Sulphate Sodium Uranium *E.coli*	Livestock watering guideline (1996) Internal reporting: monthly report External reporting: Annual WQ and spills register
Ground Water Levels	Farming boreholes: AR12, DMBH06, KGT78, KGT3, KMBH01, KGT1, KMBH04, NAm3, NAm2, NAM1, NMBH02, WIT1, KOMBH03, AROAMS01, AROAMS02, AMBH05, ACH2, ACH4, ACH3, ACH1 Impact: potential spills or seepage from SLF and TSF	Quarterly	Levels	Internal reporting: monthly report External reporting: Annual
	Mine boreholes: BLH3, GAMS1, MH01, MH02, MH03, MH10, GAMS2, GAMB1, GAMS3, GAMS8, MH04, MH05, MH06, MH07, AR11, AR10, AR09, AR07, MBH17, SOLAR PUMP BH, MH08, MH09, GBTSF2, GBTSF3, GBTSF4, GBTSF5, GBTSF6, GBTSF7, GBTSF8, GBTSF9 Proposed additions to monitoring network: GB_SLF_01, GB_SLF_02, GB_SMT_01			

Monitoring	Sampling localities & Impact monitored	Frequency	Parameters	Reporting & Standards
Ground Water Quality	Farm boreholes AR11, AR12, KGT78, KGT3, KGT1, NAm3, NAm2, NAM1, WIT1, AROAMS01, AROAMS02, ACH2, ACH4, ACH3, ACH1 Impact: potential spills or seepage from SLF and TSF	Quarterly	Na, Ca, Mg, K, Cl, SO4, F, nitrate (NO3-N), Fe, Zn, Pb, Al, Cd, Cu, Mn, and U WUL: pH, EC Proposed: Colour/ clarity, temperature, oxidation-reduction potential (ORP) and odour; Sb, Hg, As, Se, PO4, Total Cr and Cr (VI), nitrite, and Ba; Petroleum hydrocarbons contaminants *E.coli*, faecal coliforms	Standard: SANS 241:2015 and DWAF Livestock watering and domestic use guideline (1996) Internal reporting: monthly report External reporting: Annual
	Mine Monitoring Boreholes BLH3, GAMS1, MH01, MH02, MH03, MH10, GAMS2, GAMB1, GAMS3, GAMS8, MH04, MH05, MH06, MH07, AR11, AR10, AR09, AR07, MBH17, SOLAR PUMP BH, MH08, MH09, GBTSF2, GBTSF3, GBTSF4, GBTSF5, GBTSF6, GBTSF7, GBTSF8, GBTSF9 Proposed additions to monitoring network: GB_SLF_01, GB_SLF_02, GB_SMT_01			
Bio-Monitoring	Aquatic monitoring at Kloof Spring at top of Gamsberg Inselberg	Quarterly	IHASS	Annual reporting
Waste disposal	Waste inventory	Monthly	Types of waste produced, the volumes, and management measure (i.e. recycled or disposal	Internal reporting (not required to be submitted to DWS)
	Jarofix and ETP cake disposal		5 Samples: - Chemical composition - Mineralogical analysis (as Jarofix ages) - acid-base accounting (ABA) and net acid generation (NAG) - water extraction tests	Update geochemical model: annual

Monitoring	Sampling localities & Impact monitored	Frequency	Parameters	Reporting & Standards
			- kinetic leach tests of at least two representative Jarofix disposal samples	

5.14 Surface Water Monitoring

The last surface water survey was conducted in 2010 and no monitoring is currently taking place.

5.15 Ground Water Monitoring

The monitoring network for Gamsberg) includes the following two areas:

- The farms adjacent to the Gamsberg Operations.
    - Twenty two hydro census / farms boreholes are currently being monitored on the farms Dabie Poort, Kykgate, Skietpoort, Namies, Koups Leegte, Aroams and Achab.
- The monitoring network of the mine itself and the mining area was subdivided into four areas of possible impact namely:
    - Mining operations on top of Gamsberg,
    - Waste Rock Area,
    - Plant and Workshop Area,
    - Tailings Dam Facility (TSF),

Refer to 8 for the Groundwater monitoring network map.

Groundwater Quality 2021 – 2023

The section below summarizes the general findings for the last quarter of 2021 and 2022, and the third quarter of 2023, including:

- Water quality comparison with SANS 241:2015 Drinking Water standards, DWAF (1996) Water Quality Guidelines for livestock watering, as well as with the variables specified in the WUL (14/D82C/ABCGIJ/2654);
- Pollution indices for water quality of each of the 7 mine monitoring areas;
- Key Performance Indicator assessment for water quality monitoring

2021

Comparison with guidelines

The groundwater of the monitoring boreholes of Black Mountain Mining (BMM) are classified as “ARS” (inorganic water quality). According to SANS241-1:2015 the water quality of the boreholes is unsuitable for consumption in general due to Electrical Conductivity (EC), Total Dissolved Solids (TDS), Sodium (Na), Calcium (Ca), Magnesium (Mg), Potassium (K), Chloride (Cl), Sulphate (SO4), Fluoride (F), Nitrate (NO3-N, lesser extent), Aluminium (Al, lesser extent), Lead (Pb, lesser extent) and Manganese (Mn, lesser extent). No presence of Total Petroleum Hydrocarbon (Total TPH) is found in the receiving site aquifer of Black Mountain Mining (below detection limit, <382.0 μg/L).

The groundwater livestock quality of the Black Mountain Mining monitoring boreholes is mostly classified as unsuitable for livestock watering due to elevated concentrations of Total Dissolved Solids (TDS), Sodium (Na, lesser extent), Calcium (Ca, lesser extent), Magnesium (Mg, lesser extent), Chloride (Cl, lesser extent), Sulphate (SO4), Fluoride (F, lesser extent) and Nitrate (NO3-N, lesser extent).

In general, the groundwater monitoring sites concentrations for Electrical Conductivity (EC), Sodium (Na), Calcium (Ca), Chloride (Cl), Sulphate (SO4) and to a lesser extent Magnesium (Mg), Fluoride (F) and Nitrate (NO3-N) are above the water resource quality objectives for catchment D82C as determined by DWS.

Pollution Indices

- A-1 - Deeps Shaft Operations: The monitoring boreholes of the area do display groundwater contamination impacts from mining activities. Therefore, mining activities has impacted the groundwater of the local aquifer system negatively due to salt loading to the aquifer by means of seepage from point pollution sources such as the waste rock discards in the vicinity of the shaft area. Typical chemical parameters that are elevated by the seepage loads to the aquifer for area are EC, TDS, Ca, Mg, K, Cl, F, NO3-N, Zn and Mn. The additional Ca and Mg salts that added to aquifer by means of seepage increases the hardness of the groundwater drastically.
- A-2 - Old Shaft Area, Reed Beds Canal & Waste Rock Stockpile: The monitoring boreholes of the area do display groundwater contamination impacts from mining activities. Therefore, mining activities has impacted the groundwater of the local aquifer system negatively due to salt loading to the aquifer by means of seepage from point pollution sources such as the contaminate mine wastewater flowing in the reed beds and waste rock discards. Typical chemical parameters that are elevated by the seepage loads to the aquifer for area are pH, EC, TDS, Na, Ca, Mg, K, Cl, SO4, NO3-N, Fe and Mn. The additional Ca and Mg salts that added to aquifer by means of seepage increases the hardness of the groundwater drastically.
- A-3 - Plaatjies Vlei Area: The monitoring boreholes of the area do display groundwater contamination impacts from mining activities. Therefore, mining activities has impacted the groundwater of the local aquifer system negatively due to salt loading to the aquifer by means of seepage from the unlined dirty water evaporation dams known as Plaatjies Vlei. Typical chemical parameters that are elevated by the seepage loads to the aquifer for area are pH, EC, TDS, Na, Ca, Mg, K, Cl, SO4 and NO3-N. The additional Ca and Mg salts that added to aquifer by means of seepage increases the hardness of the groundwater drastically.
- A-4 - Swartberg Operations: The monitoring boreholes closer to the Swartberg Mine operations do display groundwater contamination impacts from mining activities. Boreholes AD14 and AD15 that were drilled to measure the outer edges of the groundwater dewatering cone at Swartberg displays background water qualities and are located approximately 3.0 km from the Swartberg Mine decline. Typical chemical parameters that are elevated by the seepage loads to the aquifer for area are pH, EC, TDS, Na, Ca, Mg, Cl, SO4, F, NO3-N and Mn. The additional Ca and Mg salts that added to aquifer by means of seepage increases the hardness of the groundwater drastically.
- A-5 - Tailings Dam Facility (TSF) & Plume Area: The monitoring boreholes of the area do display groundwater contamination impacts from mining activities. Therefore, mining activities has impacted the groundwater of the local aquifer system negatively due to salt loading to the aquifer by means of seepage from the unlined Tailings Dam Facility (TSF). The boreholes to the south-west of the tailings dam also indicate groundwater contamination plume stretching from the tailings dam to at least monitoring boreholes AD9, which is situated 2.0 km for the TSF. Seepage from the reed beds canal and the Plaatjies Vlei evaporation dam has also contributed to the extent of the contamination plume. Typical chemical parameters that are elevated by the seepage loads to the aquifer for area are pH, EC, TDS, Na, Ca, Mg, K, Cl, SO4, F, NO3-N, Fe and Mn. The additional Ca and Mg salts that added to aquifer by means of seepage increases the hardness of the groundwater drastically.
- A-6 - Aggeneys Town Sewage Ponds: The monitoring boreholes of the area do display groundwater contamination impacts. Typical chemical parameters that are elevated by the seepage loads to the aquifer for area are EC, TDS, Na, Ca, Mg, K, Cl and SO4. The additional Ca and Mg salts that added to aquifer by means of seepage increases the hardness of the groundwater drastically.

- A-7 - General Waste Site: The monitoring boreholes of the area do display groundwater contamination impacts from mining activities rather than impacts directly associated with seepage from a general waste site. The seepage from a general waste site is associated with elevated chloride concentrations in the underlying aquifer. Typical chemical parameters that are elevated by the seepage loads to the aquifer for area are EC, TDS, Ca, Mg, Cl, Mg, K, SO4 and Fe. The additional Ca and Mg salts that added to aquifer by means of seepage increases the hardness of the groundwater drastically.

KPI Assessment

- KPI Objective: Management of Potential Groundwater Pollution to Minimise Groundwater Resource Impacts:
  - Indicators: Groundwater seepage from point pollution sources such as the Reed Beds Canal, Waste Rock Stockpiles, Plaatjies Vlei Dirty Water Evaporation Dam, Tailings Dam (TSF) and General Waste Site - Groundwater pollution plume(s) emanating for groundwater point pollution sources such as the Reed Beds Canal, Waste Rock Stockpiles, Plaatjies Vlei Dirty Water Evaporation Dam, Tailings Dam (TSF) and the General Waste Site.
  - Current State: Currently the groundwater chemistry due indicate pollution effected groundwaters due to elevated concentrations of chemical parameters, which includes pH, EC, TDS, Na, Ca, Mg, K, Cl, SO4, NO3-N, Fe, Zn, Fe and Mn. A groundwater contamination plume is observed at the down gradient monitoring boreholes at the Reed Beds Canal, Waste Rock Stockpiles, Plaatjies Vlei Dirty Water Evaporation Dam and Tailings Dam (TSF). The pollution plumes of the point pollution sources are currently confined to the mining lease in general.
  - Verdict: As a legacy mining site, seepage from unlined point pollution sources such as the Reed Beds Canal, Waste Rock Stockpiles, Plaatjies Vlei Dirty Water Evaporation Dam and Tailings Dam (TSF) has significantly impacted the underlying aquifer and degraded the groundwater quality at these sites.
  - Recommendations: Although the groundwater elevations are currently stable it is always best practice to minimise seepage of dirty water into the aquifer on an ongoing basis by reviewing of operational practices. Re-cycling and re-use of dirty water also plays an important role as this area is water scarce. By limiting the seepage volume to the underlying aquifer, the pollution loads can be minimised. It is also recommended that a numerical groundwater model be constructed to predict the impact of the mining activities in terms groundwater elevations (artificial recharge and dewatering) and groundwater quality / contamination plumes (point pollution sources), which has been implemented. It is recommended that the model be updated on a regular basis to incorporated new monitoring data.

2022

Comparison with guidelines

The groundwater of the monitoring boreholes of Black Mountain Mining (BMM) are classified as “ARS” (inorganic water quality). According to SANS241-1:2015 the water quality of the boreholes is unsuitable for consumption in general due to Electrical Conductivity (EC), Total Dissolved Solids (TDS), Sodium (Na), Calcium (Ca), Magnesium (Mg), Potassium (K), Chloride (Cl), Sulphate (SO4), Nitrate (NO3-N, lesser extent), Zink (Zn, lesser extent), Lead (Pb) and Manganese (Mn, lesser extent), (refer to Table 18 below). No presence of Total Petroleum Hydrocarbon (Total TPH) is observed in the receiving site aquifer of Black Mountain Mining (below detection limit, <382 µg/L), except for borehole N4 (Aggeneys sewage ponds monitoring borehole) where the presence of Total Petroleum Hydrocarbon (Total TPH) was detected at a concentration of 510 µg/L.

The Black Mountain Mining monitoring boreholes results according to the South African Water Quality Guidelines, Volume 5 - Agricultural Use: Livestock Watering Standards can be viewed in Table 19 below. The groundwater livestock quality of the Black Mountain Mining monitoring boreholes is mostly classified as unsuitable for livestock watering due to elevated concentrations of Total Dissolved Solids (TDS), Sodium (Na, lesser extent), Calcium (Ca, lesser extent), Magnesium (Mg, lesser extent), Chloride (Cl, lesser extent), Sulphate (SO4) and Nitrate (NO3-N, lesser extent), and Lead (Pb).

In general, the groundwater monitoring sites concentrations for Electrical Conductivity (EC), Sodium (Na), Calcium (Ca), Chloride (Cl), Sulphate (SO4) and to a lesser extent Nitrate (NO3-N) and Lead (Pb) are above the water resource quality objectives for catchment D82C as determined by DWS.

Pollution Indices

- A-1 - Deeps Shaft Operations: The monitoring boreholes of the area do display groundwater contamination impacts from mining activities. Therefore, mining activities has impacted the groundwater of the local aquifer system negatively due to salt loading to the aquifer by means of seepage from point pollution sources such as the waste rock discards in the vicinity of the shaft area. Typical chemical parameters that are elevated by the seepage loads to the aquifer for area are EC, TDS, Ca, Mg, K, SO4, F, NO3-N, Zn and Mn. The additional Ca and Mg salts were that added to aquifer by means of seepage increases the hardness of the groundwater drastically.
- A-2 - Old Shaft Area, Reed Beds Canal & Waste Rock Stockpile: The monitoring boreholes of the area do display groundwater contamination impacts from mining activities. Therefore, mining activities has impacted the groundwater of the local aquifer system negatively due to salt loading to the aquifer by means of seepage from point pollution sources such as the contaminate mine wastewater flowing in the reed beds and waste rock discards. Typical chemical parameters that are elevated by the seepage loads to the aquifer for area are pH, EC, TDS, Na, Ca, Mg, K, Cl, SO4, NO3-N and Fe. The additional Ca and Mg salts that were added to aquifer by means of seepage increases the hardness of the groundwater drastically.
- A-3 - Plaatjies Vlei Area: The monitoring boreholes of the area do display groundwater contamination impacts from mining activities. Therefore, mining activities has impacted the groundwater of the local aquifer system negatively due to salt loading to the aquifer by means of seepage from the unlined dirty water evaporation dams known as Plaatjies Vlei. Typical chemical parameters that are elevated by the seepage loads to the aquifer for area are EC, TDS, Na, Ca, Mg, K, Cl, SO4, NO3-N, Fe and Mn. The additional Ca and Mg salts that were added to aquifer by means of seepage increases the hardness of the groundwater drastically.
- A-4 - Swartberg Operations: The monitoring boreholes closer to the Swartberg Mine operations do display groundwater contamination impacts from mining activities. Boreholes AD14 and AD15 that were drilled to measure the outer edges of the groundwater dewatering cone at Swartberg displays background water qualities and are located approximately 3.0 km from the Swartberg Mine decline. Typical chemical parameters that are elevated by the seepage loads to the aquifer for area are pH, EC, TDS, Na, Ca, Mg, K, Cl, SO4 and NO3-N. The additional Ca and Mg salts that were added to aquifer by means of seepage increases the hardness of the groundwater drastically.
- A-5 - Tailings Dam Facility (TSF) & Plume Area: The monitoring boreholes of the area do display groundwater contamination impacts from mining activities. Therefore, mining activities has impacted the groundwater of the local aquifer system negatively due to salt loading to the aquifer by means of seepage from the unlined Tailings Dam Facility (TSF). The boreholes to the south-west of the tailings dam also indicate groundwater contamination plume stretching from the tailings dam to at least monitoring boreholes AD9, which is situated 2.0 km for the TSF. Seepage from the reed beds canal and the Plaatjies Vlei evaporation dam has also contributed to the extent of the contamination plume. Typical chemical parameters that are elevated by the seepage loads to the aquifer for area are pH, EC, TDS, Na, Ca, Mg, K, Cl, SO4, NO3-N, Fe and Mn. The additional Ca and Mg salts that were added to aquifer by means of seepage increases the hardness of the groundwater drastically.
- A-6 - Aggeneys Town Sewage Ponds: The monitoring boreholes of the area do display groundwater contamination impacts. Typical chemical parameters that are elevated by the seepage loads to the aquifer for area are pH, EC, TDS, Na, Ca, Mg, K, Cl and SO4. The additional Ca and Mg salts that were added to aquifer by means of seepage increases the hardness of the groundwater drastically.
- A-7 - General Waste Site: The monitoring boreholes of the area do display groundwater contamination impacts from mining activities rather than impacts directly associated with seepage from a general waste

site. The seepage from a general waste site is associated with elevated chloride concentrations in the underlying aquifer. Typical chemical parameters that are elevated by the seepage loads to the aquifer for area are EC, TDS, Na, Ca, Mg, K, Cl and SO4. The additional Ca and Mg salts that were added to aquifer by means of seepage increases the hardness of the groundwater drastically.

KPI Assessment

- KPI Objective: Management of Potential Groundwater Pollution to Minimise Groundwater Resource Impacts:
  - Indicators: Groundwater seepage from point pollution sources such as the Reed Beds Canal, Waste Rock Stockpiles, Plaatjies Vlei Dirty Water Evaporation Dam, Tailings Dam (TSF) and General Waste Site - Groundwater pollution plume(s) emanating for groundwater point pollution sources such as the Reed Beds Canal, Waste Rock Stockpiles, Plaatjies Vlei Dirty Water Evaporation Dam, Tailings Dam (TSF) and the General Waste Site.
  - Current State: Currently the groundwater chemistry due indicate pollution effected groundwaters due to elevated concentrations of chemical parameters, which includes pH, EC, TDS, Na, Ca, Mg, K, Cl, SO4, NO3-N, Fe, Zn, Fe and Mn. A groundwater contamination plume is observed at the down gradient monitoring boreholes at the Reed Beds Canal, Waste Rock Stockpiles, Plaatjies Vlei Dirty Water Evaporation Dam and Tailings Dam (TSF). The pollution plumes of the point pollution sources are currently confined to the mining lease in general.
  - Verdict: As a legacy mining site, seepage from unlined point pollution sources such as the Reed Beds Canal, Waste Rock Stockpiles, Plaatjies Vlei Dirty Water Evaporation Dam and Tailings Dam (TSF) has significantly impacted the underlying aquifer and degraded the groundwater quality at these sites.
  - Recommendations: Although the groundwater elevations are currently mostly stable it is always best practice to minimise seepage of dirty water into the aquifer on an ongoing basis by reviewing of operational practices. Re-cycling and re-use of dirty water also plays an important role as this area is water scarce. By limiting the seepage volume to the underlying aquifer, the pollution loads can be minimised. It is also recommended that a numerical groundwater model be constructed to predict the impact of the mining activities in terms groundwater elevations (artificial recharge and dewatering) and groundwater quality / contamination plumes (point pollution sources), which has been implemented. It is recommended that the current numerical groundwater model be updated to incorporated new monitoring data.

2023

Comparison with guidelines

The groundwater of the monitoring boreholes of Black Mountain Mining (BMM) are classified as “ARS” (inorganic water quality). According to SANS241-1:2015 the water quality of the boreholes is unsuitable for consumption in general due to Electrical Conductivity (EC), Total Dissolved Solids (TDS), Sodium (Na), Calcium (Ca), Magnesium (Mg), Potassium (K), Chloride (Cl), Sulphate (SO4), Fluoride (F), Nitrate (NO3-N, lesser extent), Iron (Fe, lesser extent), Aluminium (Al, lesser extent), Zink (Zn, lesser extent) and Manganese (Mn, lesser extent). No presence of Total Petroleum Hydrocarbon (Total TPH) is observed in the receiving site aquifer of Black Mountain Mining (below detection limit, <382 µg/L) (Table 51, Table 52, Table 53).

Table 50. Groundwater quality monitoring results compared to SANS 241:2015 (GHT, Sept 2023).

Area	Site Name	Date	SANS Class	pH	EC	TDS	Na	Ca	Mg	K	Cl	SO_4	F	NO_3-N	NH_3-N	NH_4-N	T.ALK	Fe	Al	Zn	Pb	Mn	COD	Total TPH	IonBalError
				units	mS/m	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	µg/L	%
A-1	N14	2023/08/01	"ARS"	6.51	531.00	3 925.50	457.00	483.00	162.00	81.90	905.10	759.00	2.81	229.97	~	~	66.50	0.01	0.01	15.33	0.01	0.67	~	<0.382	0.44
A-2	AD24	2023/08/01	"ARS"	6.75	2 017.00	14 064.87	2 899.00	1 109.00	539.00	202.63	6 291.22	2 943.00	1.73	6.18	~	~	85.40	0.01	0.01	0.25	0.01	0.41	~	<0.382	-2.46
	M8	2023/08/01	"ARS"	7.54	233.00	1 664.52	326.00	104.00	59.30	39.70	210.07	840.09	2.45	2.58	~	~	119.00	0.01	0.01	0.02	0.01	0.06	~	<0.382	-1.67
	N6	2023/08/01	"ARS"	7.11	403.30	4 134.10	331.00	729.00	132.00	123.00	367.74	2 318.00	0.91	0.47	~	~	217.00	0.01	0.01	0.01	0.01	0.17	~	<0.382	1.39
	M3B (Alt. M3)	2023/08/01	"ARS"	8.43	280.00	2 160.97	230.00	229.81	142.00	45.90	332.74	1 165.09	1.17	0.35	~	~	23.60	0.02	0.01	0.01	0.01	0.08	~	<0.382	0.28
A-3	M5	2023/08/01	"ARS"	6.75	1 653.70	11 856.24	2 592.00	742.00	627.00	217.59	5 224.19	2 395.14	1.92	3.18	~	~	70.10	0.01	0.01	0.01	0.01	0.25	~	<0.382	1.65
	M9	2023/08/01	"ARS"	7.48	194.00	1 071.48	151.00	136.00	62.70	12.10	404.58	167.51	2.06	12.56	~	~	133.00	0.06	0.01	0.01	0.01	0.02	~	<0.382	0.50
	N8	2023/08/01	"ARS"	7.21	1 048.00	9 680.60	1 956.00	638.00	273.00	323.00	1 077.66	4 586.31	1.82	179.41	~	~	49.70	0.17	0.01	0.01	0.01	0.02	~	<0.382	2.68
A-4	AD14	2023/08/01	"ARS"	7.80	67.60	394.12	58.30	49.30	17.10	3.41	70.46	85.15	2.31	8.00	~	~	121.00	0.01	0.01	0.02	0.01	0.02	~	<0.382	-2.88
	AD15	2023/08/01	"ARS"	7.40	117.00	677.63	126.00	77.10	27.20	3.55	210.56	104.65	2.97	2.04	~	~	194.20	0.01	0.01	0.01	0.01	0.02	~	<0.382	-2.87
	AD21	2023/08/01	"ARS"	7.35	193.00	1 119.21	268.00	88.00	31.10	18.60	366.71	146.99	2.88	0.35	~	~	327.00	0.17	0.01	0.01	0.01	0.56	~	<0.382	-2.74
	AD19	2023/08/01	"ARS"	9.02	594.00	3 698.07	809.00	341.00	139.00	24.90	1 849.61	492.65	1.33	0.35	~	~	67.30	0.12	0.01	0.01	0.01	0.08	~	<0.382	-0.05
A-5	AD10	2023/08/01	"ARS"	7.27	581.00	5 540.26	700.00	495.00	312.00	105.00	448.91	3 452.91	0.95	0.35	~	~	39.30	0.32	0.01	0.01	0.01	1.59	~	<0.382	-0.97
	AD9	2023/08/01	"ARS"	7.36	782.00	5 579.88	600.00	901.00	273.00	138.00	2 329.78	1 085.23	0.91	0.35	~	~	418.18	0.02	0.01	0.01	0.01	1.04	~	<0.382	-0.06
	BH2	2023/08/01	"ARS"	7.84	1 274.00	12 392.91	3 099.00	521.40	302.00	245.00	1 270.54	6 810.00	2.09	10.02	~	~	164.00	0.01	0.01	0.01	0.01	0.09	~	<0.382	2.66
	BH4	2023/08/01	"ARS"	7.85	1 217.00	11 682.68	2 871.00	474.45	215.00	305.00	910.78	6 821.00	2.48	1.39	~	~	128.00	0.01	0.01	0.01	0.01	0.03	~	<0.382	0.98
	BH5	2023/08/01	"ARS"	7.85	1 097.00	10 428.95	2 398.00	529.00	210.00	291.00	617.73	6 296.25	2.55	0.63	~	~	136.00	0.01	0.01	0.01	0.01	0.02	~	<0.382	1.29
	M6	2023/08/01	"ARS"	7.82	840.00	7 340.37	1 415.00	489.00	174.00	261.00	536.18	4 376.00	2.40	1.71	~	~	132.00	0.03	0.01	0.01	0.01	0.01	~	<0.382	-1.02
	M7	2023/08/01	"ARS"	7.44	562.00	4 563.46	1 028.00	210.00	84.90	92.20	223.67	2 858.00	2.90	0.35	~	~	96.60	4.56	0.01	0.05	0.01	1.22	~	<0.382	-2.33
	N10	2023/08/01	"ARS"	7.49	811.00	6 966.57	1 400.00	508.00	202.00	194.00	564.13	3 981.78	1.88	1.64	~	~	179.00	0.05	0.01	0.01	0.01	0.08	~	<0.382	2.47
	M18	2023/08/01	"ARS"	7.94	471.00	4 141.51	518.00	549.00	150.00	76.00	452.68	2 304.80	1.50	0.70	~	~	144.00	0.01	0.01	0.01	0.01	0.04	~	<0.382	0.36
	M19	2023/08/01	"ARS"	7.92	890.00	7 852.93	1 564.00	483.33	288.84	226.12	732.70	4 103.15	1.00	2.81	~	~	730.00	0.16	0.01	0.17	0.01	3.01	~	<0.382	0.36
	M20	2023/08/01	"ARS"	7.80	1 641.00	16 343.63	3 673.00	734.00	548.00	635.00	2 220.04	8 292.00	1.82	1.40	~	~	385.00	0.01	0.01	0.08	0.01	2.51	~	<0.382	2.86
	M21	2023/08/01	"ARS"	7.86	640.00	5 924.28	702.00	606.24	252.16	282.00	639.81	3 317.43	1.57	7.04	~	~	118.00	0.06	0.01	0.04	0.01	21.00	~	<0.382	-0.27
A-6	N12	2023/08/01	"ARS"	7.61	701.00	5 485.71	1 306.00	277.60	196.00	108.00	1 073.99	2 290.40	1.86	3.07	~	~	362.00	0.01	0.01	0.02	0.01	1.05	~	<0.382	2.19
A-7	N4	2023/08/01	"ARS"	7.63	536.00	3 651.84	429.00	418.41	250.31	46.90	1 207.22	1 206.46	1.52	4.21	0.45	0.45	113.00	0.02	5.50	0.02	0.01	0.04	97.00	<0.382	-0.01
Geometric Mean (Groundwater Mine)				7.56	568.54	4461	762.12	359.77	160.31	88.41	702.67	1609.37	1.80	2.29	–	–	133.23	0.030	0.013	0.02	0.010	0.170	–	–	–
Average (Groundwater Mine)				7.58	745.18	6244	1227.17	458.56	218.06	157.75	1174.57	2815.35	1.92	18.50	–	–	177.65	0.227	0.221	0.62	0.010	1.311	–	–	–

The groundwater **livestock quality** of the Black Mountain Mining monitoring boreholes is mostly classified as unsuitable for livestock watering due to elevated concentrations of Total Dissolved Solids (TDS), Sodium (Na, lesser extent), Calcium (Ca, lesser extent), Magnesium (Mg, lesser extent), Chloride (Cl, lesser extent), Sulphate (SO4) and Nitrate (NO3-N, lesser extent).

Table 51. Groundwater quality monitoring results compared to SAWQG for livestock watering (GHT, Sept 2023).

Area	Site Name	Date	SAWQG (Livestock)	pH	EC	TDS (Sheep)	Na	Ca	Mg	K	Cl (Sheep)	SO_4	F (Ruminants)	NO_3-N	T.ALK	Fe	T. Hard	Zn	Pb
				units	mS/m	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
A-1	N14	2023/08/01	"AMA"	6.51	531.00	3 925.50	457.00	483.00	162.00	81.90	905.10	759.00	2.81	229.97	66.50	0.010	1 873	15.333	0.010
A-2	AD24	2023/08/01	"AMA"	6.75	2 017.00	14 064.87	2 899.00	1 109.00	539.00	202.63	6 291.22	2 943.00	1.73	6.18	85.40	0.010	4 989	0.250	0.010
	M8	2023/08/01	"Class 1"	7.54	233.00	1 664.52	326.00	104.00	59.30	39.70	210.07	840.09	2.45	2.58	119.00	0.010	504	0.020	0.010
	N6	2023/08/01	"Class 1"	7.11	403.30	4 134.10	331.00	729.00	132.00	123.00	367.74	2 318.00	0.91	0.47	217.00	0.010	2 364	0.010	0.010
	M3B (Alt. M3)	2023/08/01	"Class 1"	8.43	280.00	2 160.97	230.00	229.81	142.00	45.90	332.74	1 165.09	1.17	0.35	23.60	0.020	1 159	0.010	0.010
A-3	M5	2023/08/01	"AMA"	6.75	1 653.70	11 856.24	2 592.00	742.00	627.00	217.59	5 224.19	2 395.14	1.92	3.18	70.10	0.010	4 435	0.010	0.010
	M9	2023/08/01	"Class 1"	7.48	194.00	1 071.48	151.00	136.00	62.70	12.10	404.58	167.51	2.06	12.56	133.00	0.060	598	0.010	0.010
	N8	2023/08/01	"AMA"	7.21	1 048.00	9 680.60	1 956.00	638.00	273.00	323.00	1 077.66	4 586.31	1.82	179.41	49.70	0.170	2 717	0.010	0.010
A-4	AD14	2023/08/01	"Class 1"	7.80	67.60	394.12	58.30	49.30	17.10	3.41	70.46	85.15	2.31	8.00	121.00	0.010	194	0.020	0.010
	AD15	2023/08/01	"Class 1"	7.40	117.00	677.63	126.00	77.10	27.20	3.55	210.56	104.65	2.97	2.04	194.20	0.010	305	0.010	0.010
	AD21	2023/08/01	"Class 1"	7.35	193.00	1 119.21	268.00	88.00	31.10	18.60	366.71	146.99	2.88	0.35	327.00	0.170	348	0.010	0.010
	AD19	2023/08/01	"AMA"	9.02	594.00	3 698.07	809.00	341.00	139.00	24.90	1 849.61	492.65	1.33	0.35	67.30	0.120	1 424	0.010	0.010
A-5	AD10	2023/08/01	"AMA"	7.27	581.00	5 540.26	700.00	495.00	312.00	105.00	448.91	3 452.91	0.95	0.35	39.30	0.320	2 521	0.010	0.010
	AD9	2023/08/01	"AMA"	7.36	782.00	5 579.88	600.00	901.00	273.00	138.00	2 329.78	1 085.23	0.91	0.35	418.18	0.020	3 374	0.010	0.010
	BH2	2023/08/01	"AMA"	7.84	1 274.00	12 392.91	3 099.00	521.40	302.00	245.00	1 270.54	6 810.00	2.09	10.02	164.00	0.010	2 546	0.010	0.010
	BH4	2023/08/01	"AMA"	7.85	1 217.00	11 682.68	2 871.00	474.45	215.00	305.00	910.78	6 821.00	2.48	1.39	128.00	0.010	2 070	0.010	0.010
	BH5	2023/08/01	"AMA"	7.85	1 097.00	10 428.95	2 398.00	529.00	210.00	291.00	617.73	6 296.25	2.55	0.63	136.00	0.010	2 186	0.010	0.010
	M6	2023/08/01	"AMA"	7.82	840.00	7 340.37	1 415.00	489.00	174.00	261.00	536.18	4 376.00	2.40	1.71	132.00	0.030	1 938	0.010	0.010
	M7	2023/08/01	"AMA"	7.44	562.00	4 563.46	1 028.00	210.00	84.90	92.20	223.67	2 858.00	2.90	0.35	96.60	4.560	874	0.050	0.010
	N10	2023/08/01	"AMA"	7.49	811.00	6 966.57	1 400.00	508.00	202.00	194.00	564.13	3 981.78	1.88	1.64	179.00	0.050	2 100	0.010	0.010
	M18	2023/08/01	"AMA"	7.94	471.00	4 141.51	518.00	549.00	150.00	76.00	452.68	2 304.80	1.50	0.70	144.00	0.010	1 989	0.010	0.010
	M19	2023/08/01	"AMA"	7.92	890.00	7 852.93	1 564.00	483.33	288.84	226.12	732.70	4 103.15	1.00	2.81	730.00	0.160	2 396	0.170	0.010
	M20	2023/08/01	"AMA"	7.80	1 641.00	16 343.63	3 673.00	734.00	548.00	635.00	2 220.04	8 292.00	1.82	1.40	385.00	0.010	4 089	0.080	0.010
	M21	2023/08/01	"AMA"	7.86	640.00	5 924.28	702.00	606.24	252.16	282.00	639.81	3 317.43	1.57	7.04	118.00	0.060	2 552	0.040	0.010
A-6	N12	2023/08/01	"AMA"	7.61	701.00	5 485.71	1 306.00	277.60	196.00	108.00	1 073.99	2 290.40	1.86	3.07	362.00	0.010	1 500	0.020	0.010
A-7	N4	2023/08/01	"AMA"	7.63	536.00	3 651.84	429.00	418.41	250.31	46.90	1 207.22	1 206.46	1.52	4.21	113.00	0.020	2 076	0.020	0.010
Geometric Mean (Groundwater Farms)				7.56	568.54	4461	762.12	359.77	160.31	88.41	702.67	1609.37	1.80	2.29	133.23	0.030	1580.02	0.023	0.010
Average (Groundwater Farms)				7.58	745.18	6244	1227.17	458.56	218.06	157.75	1174.57	2815.35	1.92	18.50	177.65	0.227	2043.01	0.622	0.010

In general, the groundwater monitoring sites concentrations for Electrical Conductivity (EC), Sodium (Na), Calcium (Ca), Chloride (Cl), Sulphate (SO4) and to a lesser extent Nitrate (NO3-N) are above the water resource quality objectives for catchment D82C as determined by DWS.

Table 52. Comparison of the latest water sample results with the DWS Water Resource Quality Objectives for D82C (WUL 14/D82C/EGJ/1717) (GHT, Sept 2023).

Area	Site Name	Date	pH	EC	Na	Ca	Mg	Cl	SO_4	F	NO_3-N	Zn	Fe	Pb
			units	mS/m	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
A-1	N14	2023/08/01	6.51	531.00	457.00	483.00	162.00	905.10	759.00	2.81	229.97	15.333	0.010	0.010
A-2	AD24	2023/08/01	6.75	2 017.00	2 899.00	1 109.00	539.00	6 291.22	2 943.00	1.73	6.18	0.250	0.010	0.010
	M8	2023/08/01	7.54	233.00	326.00	104.00	59.30	210.07	840.09	2.45	2.58	0.020	0.010	0.010
	N6	2023/08/01	7.11	403.30	331.00	729.00	132.00	367.74	2 318.00	0.91	0.47	0.010	0.010	0.010
	M3B (Alt. M3)	2023/08/01	8.43	280.00	230.00	229.81	142.00	332.74	1 165.09	1.17	0.35	0.010	0.020	0.010
A-3	M5	2023/08/01	6.75	1 653.70	2 592.00	742.00	627.00	5 224.19	2 395.14	1.92	3.18	0.010	0.010	0.010
	M9	2023/08/01	7.48	194.00	151.00	136.00	62.70	404.58	167.51	2.06	12.56	0.010	0.060	0.010
	N8	2023/08/01	7.21	1 048.00	1 956.00	638.00	273.00	1 077.66	4 586.31	1.82	179.41	0.010	0.170	0.010
A-4	AD14	2023/08/01	7.80	67.60	58.30	49.30	17.10	70.46	85.15	2.31	8.00	0.020	0.010	0.010
	AD15	2023/08/01	7.40	117.00	126.00	77.10	27.20	210.56	104.65	2.97	2.04	0.010	0.010	0.010
	AD21	2023/08/01	7.35	193.00	268.00	88.00	31.10	366.71	146.99	2.88	0.35	0.010	0.170	0.010
	AD19	2023/08/01	9.02	594.00	809.00	341.00	139.00	1 849.61	492.65	1.33	0.35	0.010	0.120	0.010
A-5	AD10	2023/08/01	7.27	581.00	700.00	495.00	312.00	448.91	3 452.91	0.95	0.35	0.010	0.320	0.010
	AD9	2023/08/01	7.36	782.00	600.00	901.00	273.00	2 329.78	1 085.23	0.91	0.35	0.010	0.020	0.010
	BH2	2023/08/01	7.84	1 274.00	3 099.00	521.40	302.00	1 270.54	6 810.00	2.09	10.02	0.010	0.010	0.010
	BH4	2023/08/01	7.85	1 217.00	2 871.00	474.45	215.00	910.78	6 821.00	2.48	1.39	0.010	0.010	0.010
	BH5	2023/08/01	7.85	1 097.00	2 398.00	529.00	210.00	617.73	6 296.25	2.55	0.63	0.010	0.010	0.010
	M6	2023/08/01	7.82	840.00	1 415.00	489.00	174.00	536.18	4 376.00	2.40	1.71	0.010	0.030	0.010
	M7	2023/08/01	7.44	562.00	1 028.00	210.00	84.90	223.67	2 858.00	2.90	0.35	0.050	4.560	0.010
	N10	2023/08/01	7.49	811.00	1 400.00	508.00	202.00	564.13	3 981.78	1.88	1.64	0.010	0.050	0.010
	M18	2023/08/01	7.94	471.00	518.00	549.00	150.00	452.68	2 304.80	1.50	0.70	0.010	0.010	0.010
	M19	2023/08/01	7.92	890.00	1 564.00	483.33	288.84	732.70	4 103.15	1.00	2.81	0.170	0.160	0.010
	M20	2023/08/01	7.80	1 641.00	3 673.00	734.00	548.00	2 220.04	8 292.00	1.82	1.40	0.080	0.010	0.010
	M21	2023/08/01	7.86	640.00	702.00	606.24	252.16	639.81	3 317.43	1.57	7.04	0.040	0.060	0.010
A-6	N12	2023/08/01	7.61	701.00	1 306.00	277.60	196.00	1 073.99	2 290.40	1.86	3.07	0.020	0.010	0.010
A-7	N4	2023/08/01	7.63	536.00	429.00	418.41	250.31	1 207.22	1 206.46	1.52	4.21	0.020	0.020	0.010

Pollution Indices

The following observations are made regarding the **Pollution Indexes** of the monitoring boreholes of Black Mountain Mining: (BMM):

- A-1 - Deeps Shaft Operations: The monitoring boreholes of the area do display groundwater contamination impacts from mining activities. Therefore, mining activities has impacted the groundwater of the local aquifer system negatively due to salt loading to the aquifer by means of seepage from point pollution sources such as the waste rock discards in the vicinity of the shaft area. Typical chemical parameters that are elevated by the seepage loads to the aquifer for area are EC, TDS, Ca, Mg, K, SO4, F, NO3-N and Mn. The additional Ca and Mg salts were that added to aquifer by means of seepage increases the hardness of the groundwater drastically.

- A-2 - Old Shaft Area, Reed Beds Canal & Waste Rock Stockpile: The monitoring boreholes of the area do display groundwater contamination impacts from mining activities. Therefore, mining activities has impacted the groundwater of the local aquifer system negatively due to salt loading to the aquifer by means of seepage from point pollution sources such as the contaminate mine wastewater flowing in the reed beds and waste rock discards. Typical chemical parameters that are elevated by the seepage loads to the aquifer for area are pH, EC, TDS, Na, Ca, Mg, K, Cl, SO4, Fe and Mn. The additional Ca and Mg salts that were added to aquifer by means of seepage increases the hardness of the groundwater drastically.
- A-3 - Plaatjies Vlei Area: The monitoring boreholes of the area do display groundwater contamination impacts from mining activities. Therefore, mining activities has impacted the groundwater of the local aquifer system negatively due to salt loading to the aquifer by means of seepage from the unlined dirty water evaporation dams known as Plaatjies Vlei. Typical chemical parameters that are elevated by the seepage loads to the aquifer for area are EC, TDS, Na, Ca, Mg, K, Cl, SO4, NO3-N, Fe and Mn. The additional Ca and Mg salts that were added to aquifer by means of seepage increases the hardness of the groundwater drastically.
- A-4 - Swartberg Operations: The monitoring boreholes closer to the Swartberg Mine operations do display groundwater contamination impacts from mining activities. Boreholes AD14 and AD15 that were drilled to measure the outer edges of the groundwater dewatering cone at Swartberg displays background water qualities and are located approximately 3.0 km from the Swartberg Mine decline. Typical chemical parameters that are elevated by the seepage loads to the aquifer for area are pH, EC, TDS, Na, Ca, Mg, Cl, F, Fe and Mn. The additional Ca and Mg salts that were added to aquifer by means of seepage increases the hardness of the groundwater drastically.
- A-5 - Tailings Dam Facility (TSF) & Plume Area: The monitoring boreholes of the area do display groundwater contamination impacts from mining activities. Therefore, mining activities has impacted the groundwater of the local aquifer system negatively due to salt loading to the aquifer by means of seepage from the unlined Tailings Dam Facility (TSF). The boreholes to the south-west of the tailings dam also indicate groundwater contamination plume stretching from the tailings dam to at least monitoring boreholes AD9, which is situated 2.0 km for the TSF. Seepage from the reed beds canal and the Plaatjies Vlei evaporation dam has also contributed to the extent of the contamination plume. Typical chemical parameters that are elevated by the seepage loads to the aquifer for area are pH, EC, TDS, Na, Ca, Mg, K, Cl, SO4, F, NO3-N, Fe and Mn. The additional Ca and Mg salts that were added to aquifer by means of seepage increases the hardness of the groundwater drastically.
- A-6 - Aggeneys Town Sewage Ponds: The monitoring boreholes of the area do display groundwater contamination impacts. Typical chemical parameters that are elevated by the seepage loads to the aquifer for area are EC, TDS, Na, Ca, Mg, K, Cl and SO4. The additional Ca and Mg salts that were added to aquifer by means of seepage increases the hardness of the groundwater drastically.
- A-7 - General Waste Site: The monitoring boreholes of the area do display groundwater contamination impacts from mining activities rather than impacts directly associated with seepage from a general waste site. The seepage from a general waste site is associated with elevated chloride concentrations in the underlying aquifer. Typical chemical parameters that are elevated by the seepage loads to the aquifer for area are EC, TDS, Na, Ca, Mg, K, Cl and SO4. The additional Ca and Mg salts that were added to aquifer by means of seepage increases the hardness of the groundwater drastically (GHT Consulting, Aug 2023).

KPI Assessment

The **groundwater quality KPI's** for Black Mountain Mining (BMM) are as follows:

- KPI Objective: Management of Potential Groundwater Pollution to Minimise Groundwater Resource Impacts:
    - Indicators: Groundwater seepage from point pollution sources such as the Reed Beds Canal, Waste Rock Stockpiles, Plaatjies Vlei Dirty Water Evaporation Dam, Tailings Dam (TSF) and General Waste Site - Groundwater pollution plume(s) emanating for groundwater point pollution sources such as the

Reed Beds Canal, Waste Rock Stockpiles, Plaatjies Vlei Dirty Water Evaporation Dam, Tailings Dam (TSF) and the General Waste Site.
  - Current State: Currently the groundwater chemistry due indicate pollution effected groundwaters due to elevated concentrations of chemical parameters, which includes pH, EC, TDS, Na, Ca, Mg, K, Cl, SO4, NO3-N, Fe, Zn, Fe and Mn. A groundwater contamination plume is observed at the down gradient monitoring boreholes at the Reed Beds Canal, Waste Rock Stockpiles, Plaatjies Vlei Dirty Water Evaporation Dam and Tailings Dam (TSF). The pollution plumes of the point pollution sources are currently confined to the mining lease in general.
  - Verdict: As a legacy mining site, seepage from unlined point pollution sources such as the Reed Beds Canal, Waste Rock Stockpiles, Plaatjies Vlei Dirty Water Evaporation Dam and Tailings Dam (TSF) has significantly impacted the underlying aquifer and degraded the groundwater quality at these sites.
  - Recommendations: Although the groundwater elevations are currently mostly stable it is always best practice to minimise seepage of dirty water into the aquifer on an ongoing basis by reviewing of operational practices. Re-cycling and re-use of dirty water also plays an important role as this area is water scarce. By limiting the seepage volume to the underlying aquifer, the pollution loads can be minimised. It is also recommended that a numerical groundwater model be constructed to predict the impact of the mining activities in terms groundwater elevations (artificial recharge and dewatering) and groundwater quality / contamination plumes (point pollution sources), which has been implemented. It is recommended that the current numerical groundwater model be updated to incorporated new monitoring data.

Groundwater levels 2021 – 2023

2021

The monitoring borehole of Black Mountain Mining (BMM) indicates mostly stable to increasing groundwater level trends except for the Swartberg U/G area where decreasing groundwater levels are predominant due to the U/G dewatering. In general, the BMM monitoring boreholes indicates stable groundwater level trends with slight decreasing trends at some boreholes.

The groundwater elevations of BMM have been disturbed by mining activities, which includes artificial recharge to the local groundwater aquifer (TSF) as well as dewatering (Shafts and Declines) as can be seen in low correlation (R-Squared values) between topographical elevations and groundwater elevations. Note that the R-Squared value is 0.69 for the Swartberg Mine area is indicative of that groundwater elevations are not mimicking the topographical elevations as dewatering has taken place around the decline. Also note that the R-Squared value is 0.52 for the Tailings Dam and associate plume area, which is also indicative of that groundwater elevations are not mimicking the topographical elevations as artificial recharge from the TSF to the upper quaternary aquifer has taken place and to a lesser extend at Plaatjies Vlei due to the unlined evaporation dam (R-Squared value = 0.74). The Old Shaft / Reed Beds Areas as artificial recharge has taken place from the unlined trench areas (R-Squared value = 0.92).

In terms of groundwater depth and elevation in general the water table is shallowest in the vicinity of the Tailings Dam, Reed Beds / Deeps Dewatering Trench and Old Evaporation Dam due to artificial recharge and deepest to the east of the Swartberg due to dewatering effects of the Swartberg Mine U/G Workings

The **groundwater elevation KPI objectives** for 2021 are as follows:

- Dewatering Influences of the Black Mountain Mining (BMM) Shafts:
  - Indicators: Prolonged downwards trends (not seasonal trends) of groundwater elevations of mine monitoring boreholes affected by a potential dewatering cone caused by the Old Shaft and Deeps Shaft.
  - Current State: Currently the groundwater elevations observed at the monitoring boreholes of the Old Shaft indicate no observable dewatering at Old Shaft and limited local dewatering at Deeps Shaft. The

groundwater level depths of the monitoring boreholes in the vicinity of the shafts have depths of 4.8 m (Old Shaft) to 56.9 m (Deeps Shaft).

- Verdict: No shaft dewatering influences are observed in the groundwater level data of the monitoring boreholes in the vicinity of Old Shaft. Limited local dewatering effects is observed at Deeps Shaft.
- Recommendations: Monitoring of groundwater level elevations in the vicinity of the shafts to determine the extent of possible dewatering effects and associated risk to the groundwater resource. It is also suggested to include the potential shaft dewatering at Deeps that was modelled numerically be updated yearly to reflect the changes in groundwater elevation more accurately.

- Dewatering Influences of the Black Mountain Mining, Swartberg Mine Decline:
  - Indicators: Prolonged downwards trends (not seasonal trends) of groundwater elevations of mine monitoring boreholes affected by a potential dewatering cone caused by the Swartberg Decline.
  - Current State (Swartberg Mine Decline): Currently the groundwater elevations observed at the monitoring boreholes of the Swartberg Mine decline indicates a dewatering cone as numerous of the closest monitoring boreholes are dry as the groundwater table has receded to depths below the borehole depths. The water table near the decline is estimated as deeper than >100 m. Numerical modelling of the dewatering cone has been performed to model the lateral extend and cone of influence of the dewatering in 2018 /2019 (refer to Figure 19 on page 40). The dewatering is a known impact and is being monitored. Additional monitoring boreholes were drilled in 2017 for observation purposes. The drilling of additional boreholes is in planning stage as well.
  - Verdict: The groundwater elevations of the monitoring boreholes of the Swartberg Mine operations confirm the presence of a well-developed cone of groundwater dewatering situated to the east of Swartberg (refer to Figure 19 on page 40). Currently the dewatering cone of Swartberg Mine impacts potentially only on the eastern part Witputs Farm and possibly the northern border of Koeris Farm. The Witputs Farm is currently being supplied with water by the BMM.
  - Recommendations: Monitoring of groundwater level elevations in the vicinity of the decline and in selected hydro census or farm boreholes to determine the extent of the dewatering effects and associated risk to the groundwater resource. It is also recommended although no further impacts are expected on farm boreholes that should other farm boreholes be affected that water be supplied by the mine to the affected parties. It is recommended that the current BMM numerical groundwater model be updated yearly, which also include aspects of the other BMM operations [evaporation pan (Plaatjies Vlei), Tailings Dam (TSF) and Shafts as features in the numerical model as dewatering and artificial recharge elements].

- Artificial Recharge from Tailings Dam (TSF), Reed Beds, Salvage Yard Area and Evaporation Dam (Plaatjies Vlei):
  - Indicators: Prolonged upwards trends (not seasonal trends) of groundwater elevations of mine monitoring boreholes situated in the vicinity of the Tailings Dam. The upwards trends in these monitoring boreholes will be due to potential dirty water seepage from the Tailings Dam, Reed beds and Evaporation Dam, which is also associated with increased groundwater contamination or pollution loads.
  - Current State: Groundwater levels of monitoring boreholes at these sites indicate mostly stable groundwater elevations, which is indicative of equilibrium being achieved between seepage water and the local underlying aquifer. Shallow / perched or elevated groundwater levels are observed in the vicinity of the Tailings Dam, Reed Beds / canals to Plaatjies Dam, Salvage Yard Area and Evaporation Dam, which is indicative of historical high volumes of seepage or spillage of waste / process water entering the aquifer as artificial recharge. Currently the dewatering water from Deeps is channelled to the Reed Beds via an unlined trench. Monitoring boreholes m^3 and m^3B (Alt. m^3) in the vicinity of the trench indicated a decrease in groundwater level. Although a decrease is measured in groundwater elevations artificial recharge will be taking place due to the unlined nature of the trench.

- Verdict: The seepage volumes to the aquifer have currently decreased from historical highs as indicated by the stable groundwater elevations from 2016 to 2021.
- Most of the affected shallow aquifer was created by surface spillage rather than just the seepage volumes from the TSF.
- Recommendations: Although the groundwater elevations are currently stable it is always best practice to minimise seepage of dirty water into the aquifer on an ongoing basis by reviewing of operational practices as well as to prevent further surface spillages from the reed beds canal. Re-cycling and re-use of dirty water also plays an important role as this area is water scarce.

2022

The monitoring borehole of Black Mountain Mining (BMM) indicates mostly stable to increasing groundwater level trends except for the Swartberg U/G area where decreasing groundwater levels are predominant due to the U/G dewatering. In general, the BMM monitoring boreholes indicates mostly stable groundwater level trends with slight increasing and decreasing trends.

The groundwater elevations of BMM have been disturbed unnaturally by mining activities, which includes artificial recharge to the local groundwater aquifer as well as dewatering (Shafts and Declines) as can be seen in low correlation (R-Squared values) between topographical elevations and groundwater elevations. Note that the R-Squared value is 0.68 for the Swartberg Mine area is indicative of that groundwater elevations are not mimicking the topographical elevations as dewatering has taken place around the decline. Also note that the R-Squared value is 0.57 for the Tailings Dam and associate plume area, which is also indicative of that groundwater elevations are not mimicking the topographical elevations as artificial recharge from the TSF to the upper quaternary aquifer has taken place and to a lesser extend at Plaatjies Vlei due to the unlined evaporation dam (R-Squared value = 0.71). The Old Shaft / Reed Beds Areas as artificial recharge has taken place from the unlined trench areas (R-Squared value = 0.92).

In terms of groundwater depth and elevation in general the water table is shallowest in the vicinity of the Tailings Dam, Reed Beds / Deeps Dewatering Trench and Old Evaporation Dam due to artificial recharge and deepest to the east of the Swartberg due to dewatering effects of the Swartberg Mine U/G Workings

The **groundwater elevation KPI objectives** for 2022 are as follows:

- Dewatering Influences of the Black Mountain Mining (BMM) Shafts:
  - Indicators: Prolonged downwards trends (not seasonal trends) of groundwater elevations of mine monitoring boreholes affected by a potential dewatering cone caused by the Old Shaft and Deeps Shaft.
  - Current State: Currently the groundwater elevations observed at the monitoring boreholes of the Old Shaft indicate no observable dewatering at Old Shaft and limited local dewatering at Deeps Shaft. The groundwater level depths of the monitoring boreholes in the vicinity of the shafts have depths of 6.73 m (Old Shaft closest borehole) to 54.01 m (Deeps Shaft).
  - Verdict: No shaft dewatering influences are observed in the groundwater level data of the monitoring boreholes in the vicinity of Old Shaft. Limited local dewatering effects is observed at Deeps Shaft.
  - Recommendations: Monitoring of groundwater level elevations in the vicinity of the shafts to determine the extent of possible dewatering effects and associated risk to the groundwater resource. It is also suggested to include the potential shaft dewatering at Deeps that was modelled numerically be updated yearly to reflect the changes in groundwater elevation more accurately.

- Dewatering Influences of the Black Mountain Mining, Swartberg Mine Decline and U/G Sections:
  - Indicators: Prolonged downwards trends (not seasonal trends) of groundwater elevations of mine monitoring boreholes affected by a potential dewatering cone caused by the Swartberg Decline.

- Current State (Swartberg Mine Decline): Currently the groundwater elevations observed at the monitoring boreholes of the Swartberg Mine decline indicates a dewatering cone as numerous of the closest monitoring boreholes are dry as the groundwater table has receded to depths below the borehole depths. The water table near the decline is estimated as deeper than >100 m. Numerical modelling of the dewatering cone has been performed to model the lateral extend and cone of influence of the dewatering in 2018 /2019 (refer to Figure 16 on page 38). The dewatering is a known impact and is being monitored. Additional monitoring boreholes were drilled in 2017 for observation purposes. The drilling of additional boreholes is in planning stage as well.
- Verdict: The groundwater elevations of the monitoring boreholes of the Swartberg Mine operations confirm the presence of a well-developed cone of groundwater dewatering situated to the east of Swartberg (refer to Figure 16 on page 38). Currently the dewatering cone of Swartberg Mine impacts potentially only on the eastern part Witputs Farm and possibly the northern border of Koeris Farm. The Witputs Farm is currently being supplied with water by the BMM.
- Recommendations: Monitoring of groundwater level elevations in the vicinity of the decline and in selected hydrocensus or farm boreholes to determine the extent of the dewatering effects and associated risk to the groundwater resource. It is also recommended although no further impacts are expected on farm boreholes that should other farm boreholes be affected that water be supplied by the mine to the affected parties. It is recommended that the current BMM numerical groundwater model be updated yearly, which also include aspects of the other BMM operations [evaporation pan (Plaatjies Vlei), Tailings Dam (TSF) and Shafts as features in the numerical model as dewatering and artificial recharge elements].

- Artificial Recharge from Tailings Dam (TSF), Reed Beds, Salvage Yard Area and Evaporation Dam (Plaatjies Vlei):
  - Indicators: Prolonged upwards trends (not seasonal trends) of groundwater elevations of mine monitoring boreholes situated in the vicinity of the Tailings Dam. The upwards trends in these monitoring boreholes will be due to potential dirty water seepage from the Tailings Dam, Reed beds and Evaporation Dam, which is also associated with increased groundwater contamination or pollution loads.
  - Current State: Groundwater levels of monitoring boreholes at these sites indicate mostly stable groundwater elevations with slight increases and decreases, which is indicative of equilibrium being achieved between seepage water and the local underlying aquifer. Shallow / perched or elevated groundwater levels are observed in the vicinity of the Tailings Dam, Reed Beds / canals to Plaatjies Dam, Salvage Yard Area and Evaporation Dam, which is indicative of historical high volumes of seepage or spillage of waste / process water entering the aquifer as artificial recharge. Currently the dewatering water from Deeps is channelled to the Reed Beds via an unlined trench. Monitoring boreholes m^3 and m^3B (Alt. m^3) in the vicinity of the trench indicated a decrease in groundwater level. Although a decrease is measured in groundwater elevations artificial recharge will be taking place due to the unlined nature of the trench. The elevated groundwater levels observed in the shallow aquifer in the vicinity of the Reed Beds, Plaatjies Vlei and the TSF was created by a combination surface spillage and seepage from the TSF.
  - Verdict: The seepage volumes to the aquifer have currently decreased from historical highs as indicated by the stable groundwater elevations from 2016 to 2022.
  - Recommendations: Although the groundwater elevations are currently mostly stable it is always best practice to minimise seepage of dirty water into the aquifer on an ongoing basis by reviewing of operational practices as well as to prevent further surface spillages from the reed beds canal. Re-cycling and re-use of dirty water also plays an important role as this area is water scarce.

2023

The monitoring borehole of Black Mountain Mining (BMM) indicates mostly stable to increasing groundwater level trends except for the Swartberg U/G area where decreasing groundwater levels are predominant due to the U/G dewatering. The BMM monitoring boreholes indicates mostly stable groundwater level trends with slight increasing and decreasing trends. The groundwater elevations of BMM have been disturbed unnaturally by mining activities, which includes artificial recharge to the local groundwater aquifer as well as dewatering (Shafts and Declines) as can be seen in low correlation (R-Squared values) between topographical elevations and groundwater elevations. Note that the R-Squared value is 0.68 for the Swartberg Mine area is indicative of that groundwater elevations are not mimicking the topographical elevations as dewatering has taken place around the decline. Also note that the R-Squared value is 0.55 for the Tailings Dam and associate plume area, which is also indicative of that groundwater elevations are not mimicking the topographical elevations as artificial recharge from the TSF to the upper quaternary aquifer has taken place and to a lesser extend at Plaatjies Vlei due to the unlined evaporation dam (R-Squared value = 0.70). The Old Shaft / Reed Beds Areas as artificial recharge has taken place from the unlined trench areas (R-Squared value = 0.95). In terms of groundwater depth and elevation in general the water table is shallowest in the vicinity of the Tailings Dam, Reed Beds / Deeps Dewatering Trench and Old Evaporation Dam due to artificial recharge and deepest to the east of the Swartberg due to dewatering effects of the Swartberg Mine U/G Workings (Figure 52).

Table 53. Groundwater level monitoring results (GHT, Sept 2023).

	Borehole Name	Quaternary Sub-Catchment	Owner	Date	Time	Elevation (mamsl)	Datum Level (m)	Aquifer Monitored	Water Level Type	Static Water Level (mbgl)	Static Water Level Elevation (mamsl)	Groundwater Level Trend	Comments
1	HC-BH01 / WIT05	D82C	Mr. Jasper Mosterd	2023/08/01	10:00	800.35	0.500	Gneiss Aquifer	Static Water Level	116.58	684.27	Stable, with a slight increase in May 2023.	The groundwater level of HC-BH01 / WIT05 indicate dewatering although it is unclear if it is due to localised pumping or due to the Swartberg U/G Workings. The farm is supplied with water by BMM.
2	HC-BH08 / HBHDoA5615	D82C	Koeris Trust (KaiMa Municipality)	2023/08/04	16:15	907.25	0.330	Gneiss Aquifer	Static Water Level	25.83	881.75	Stable, with a slight increase in May 2023	Borehole groundwater levels indicate no signs of dewatering ($R^2 = 0.95$).
3	HC-BH11 / HBHWild1	D82C	Vendanta Plc	2023/08/03	15:40	858.98	0.000	Gneiss Aquifer	Static Water Level	57.23	801.75	Stable.	Borehole groundwater levels indicate no signs of dewatering ($R^2 = 0.95$).
4	HC-BH12 / T05	D82C	Vendanta Plc	2023/08/03	16:38	850.00	0.340	Gneiss Aquifer / Trust Fault Zone	Static Water Level	33.21	817.13	Decreasing.	Borehole groundwater levels indicate no signs of mine dewatering (R2 = 0.95). The borehole is utilised as a production borehole.

BMM Farm Hydrocensus Area

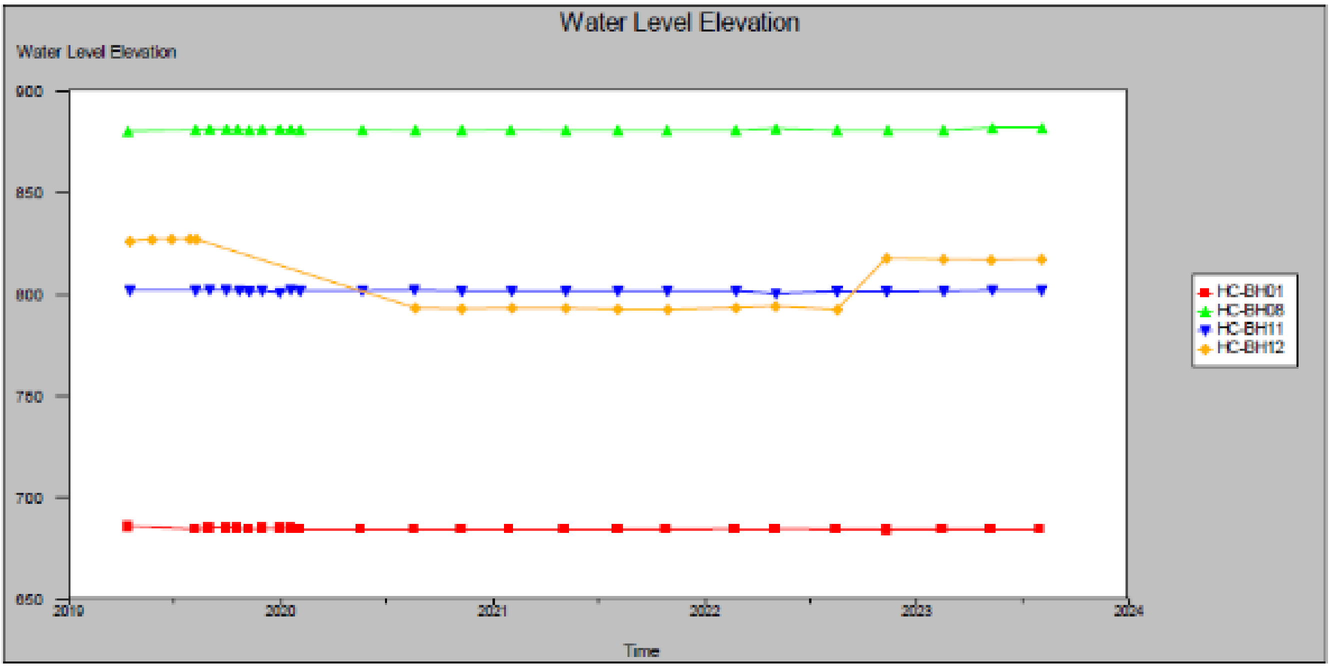


Figure 52. Groundwater elevations for the farm boreholes adjacent to Gamsberg mine.

BH12 is a production borehole hence the fluctuations in groundwater elevations.

The **groundwater elevation KPI objectives** for 2023 are as follows:

- Dewatering Influences of the Black Mountain Mining (BMM) Shafts:
  - Indicators: Prolonged downwards trends (not seasonal trends) of groundwater elevations of mine monitoring boreholes affected by a potential dewatering cone caused by the Old Shaft and Deeps Shaft.
  - Current State: Currently the groundwater elevations observed at the monitoring boreholes of the Old Shaft indicate no observable dewatering at Old Shaft and limited local dewatering at Deeps Shaft. The groundwater level depths of the monitoring boreholes in the vicinity of the shafts have depths of 6.48 m (Old Shaft closest borehole) to 56.59 m (Deeps Shaft).
  - Verdict: No shaft dewatering influences are observed in the groundwater level data of the monitoring boreholes in the vicinity of Old Shaft. Limited local dewatering effects is observed at Deeps Shaft.
  - Recommendations: Monitoring of groundwater level elevations in the vicinity of the shafts to determine the extent of possible dewatering effects and associated risk to the groundwater resource. It is also suggested to include the potential shaft dewatering at Deeps that was modelled numerically be updated yearly to reflect the changes in groundwater elevation more accurately.

- Dewatering Influences of the Black Mountain Mining, Swartberg Mine Decline and U/G Sections:
  - Indicators: Prolonged downwards trends (not seasonal trends) of groundwater elevations of mine monitoring boreholes affected by a potential dewatering cone caused by the Swartberg Decline.
  - Current State (Swartberg Mine Decline): Currently the groundwater elevations observed at the monitoring boreholes of the Swartberg Mine decline indicates a dewatering cone as numerous of the closest monitoring boreholes are dry as the groundwater table has receded to depths below the borehole depths. The water table near the decline is estimated as deeper than >100 m. Numerical modelling of the dewatering cone has been performed to model the lateral extend and cone of influence of the dewatering in 2018 / 2019. The dewatering is a known impact and is being monitored. Additional

monitoring boreholes were drilled in 2017 for observation purposes. The drilling of additional boreholes is in planning stage as well.

- Verdict: The groundwater elevations of the monitoring boreholes of the Swartberg Mine operations confirm the presence of a well-developed cone of groundwater dewatering situated to the east of Swartberg. Currently the dewatering cone of Swartberg Mine impacts potentially only on the eastern part Witputs Farm and possibly the northern border of Koeris Farm. The Witputs Farm is currently being supplied with water by the BMM.
- Recommendations: Monitoring of groundwater level elevations in the vicinity of the decline and in selected hydrocensus or farm boreholes to determine the extent of the dewatering effects and associated risk to the groundwater resource. It is also recommended although no further impacts are expected on farm boreholes that should other farm boreholes be affected that water be supplied by the mine to the affected parties. It is recommended that the current BMM numerical groundwater model be updated yearly, which also include aspects of the other BMM operations [evaporation pan (Plaatjies Vlei), Tailings Dam (TSF) and Shafts as features in the numerical model as dewatering and artificial recharge elements].

- Artificial Recharge from Tailings Dam (TSF), Reed Beds, Salvage Yard Area and Evaporation Dam (Plaatjies Vlei):
  - Indicators: Prolonged upwards trends (not seasonal trends) of groundwater elevations of mine monitoring boreholes situated in the vicinity of the Tailings Dam. The upwards trends in these monitoring boreholes will be due to potential dirty water seepage from the Tailings Dam, Reed beds and Evaporation Dam, which is also associated with increased groundwater contamination or pollution loads.
  - Current State: Groundwater levels of monitoring boreholes at these sites indicate mostly stable groundwater elevations with slight increases and decreases, which is indicative of equilibrium being achieved between seepage water and the local underlying aquifer. Shallow / perched or elevated groundwater levels are observed in the vicinity of the Tailings Dam, Reed Beds / canals to Plaatjies Dam, Salvage Yard Area and Evaporation Dam, which is indicative of historical high volumes of seepage or spillage of waste / process water entering the aquifer as artificial recharge. Currently the dewatering water from Deeps is channelled to the Reed Beds via an unlined trench. Monitoring boreholes m^3 and m^3B (Alt. m^3) in the vicinity of the trench indicated a decrease in groundwater level. Although a decrease is measured in groundwater elevations artificial recharge will be taking place due to the unlined nature of the trench. The elevated groundwater levels observed in the shallow aquifer in the vicinity of the Reed Beds, Plaatjies Vlei and the TSF was created by a combination surface spillage and seepage from the TSF.
  - Verdict: The seepage volumes to the aquifer have currently decreased from historical highs as indicated by the stable groundwater elevations from 2016 to 2023.
  - Recommendations: Although the groundwater elevations are currently mostly stable it is always best practice to minimise seepage of dirty water into the aquifer on an ongoing basis by reviewing of operational practices as well as to prevent further surface spillages from the reed beds canal. Re-cycling and re-use of dirty water also plays an important role as this area is water scarce.

5.16 Bio monitoring

The watercourses identified as habitats of conservation concern (Desmet, 2013) include drainage lines (washes), Seeps, Springs and Temporary Rock Pools. These are further discussed in detail in the section below. Although saline pans are a feature of the Bushmanland plains landscape none occurs in the study area.

The Faunal Biodiversity report (GroundTruth, 2013) indicates the aquatic ecosystems, consisting of ephemeral streams, springs and rock pools, as part of the overall faunal sensitive habitat, shown in the figure below.

The Aquatic Biodiversity Compliance Statement (Golder, 2022c) indicates that no wetlands were identified in the area mapped as ‘channelled valley bottom wetland habitat’ by the NWM5 database.

Ongoing monitoring includes:

- Quarterly aquatic monitoring (in the Kloof Spring located at the top of the Gamsberg Inselberg) (SLR, 2021).
- Annual plant biodiversity monitoring (Golder, 2019).

5.17 Waste monitoring

Monthly waste inventory: types of waste produced, the volumes, and management measure (i.e. recycled or disposal).

As per SANS 10286 only suitably qualified personnel are to operate the tailings dam complex. In addition, a suitably qualified and certified engineer named the Engineer of Record (EoR) should inspect the facility at the required interval as per the hazard rating on the SANS 10286 or the CCS type for GISTM compliance based. The monitoring procedures are reiterated within the operation manual (Knight Piésold, 2023b).

Table 54. TSF monitoring recommended by Knight Piésold (2023b):

Type of Monitoring	Responsible person	Frequency
Rainfall & evaporation (from rain gauge and evaporation pan on or near TSF)	Mine management	Daily recording, monthly reporting
Decant system: hours and clarity	Operator	Daily recording, monthly reporting
Underdrains flow: solids during initial operation; initial deposition over the drains	Experienced person	Reported monthly (daily upon initial operation)
Tailings Properties & quantity	Experienced person	Monthly for 6 months; solids content daily (Marcy scale) Quantity monthly as tonnage. Annual in-situ density test and calculation
Dust: buckets	Suitably qualified personnel	To be determined by the relevant personnel
Surface monuments: 4 on each new bench	Experienced person	Annually
Liner temperature	Mine management	Monthly; preferably automatically logged (trigger temp at 28°C)
Inspection	Senior mine management	Monthly
Vibrating wire piezometer data	Senior mine management	Monthly
Freeboard of 2m (from Georeferenced freeboard poles) and spacing around perimeter wall of 100m	Operator	Monthly
Review meeting	All responsible personnel	Quarterly
Dam report	EoR	Annual
External audit	Independent Tailings Review Board	Annual

5.18 Risk assessment/Best Practice Assessment

Risks of the TSF Phase 2 include the following aspects that are addressed in the strategies and objectives in Section 6 of this report:

- Stormwater separation & containment
- Surface water pollution prevention/minimization
- Groundwater pollution prevention/minimization

The risks of the Gamsberg Zinc Mine were collectively determined in 2017 by the Gamsberg and Golder personnel and were included in the 2018 IWWMP and are set out in Table 55 and

Table 56.

Table 55. Gamsberg risk matrix (Golder, 2018)

Table 24: Gamsberg risk matrix

Risk Matrix		Hazard Effect / Consequence (where an event has more than one "Loss Type", choose the "Consequence" with the highest rating)				
Loss Type (Additional "Loss Type" may exist for an event: identify and rate accordingly)		**1 Insignificant**	**2 Minor**	**3 Moderate**	**4 High**	**5 Major**
(S / H) Harm to people (Safety / Health)		First aid case / Exposure to minor health risk	Medical Treatment case / Exposure to major health risk	Lost time injury / Reversible impact on health	Single fatality or loss of quality of life / Irreversible impact on health	Multiple fatalities / Impact on health ultimately fatal
(EI) Environmental Impact		Minimal environmental harm L1 incident	Material environmental harm – L2 incident remediable short term	Serious environmental harm – L2 incident remediable within LOM	Major environmental harm – L2 incident remediable post LOM	Extreme environmental harm – L3 incident irreversible
(BI /MD) Business Interruption / Material Damage & Other Consequential Losses		No disruption to operation 5% loss of budgeted operating profit / listed assets	Brief disruption to operation 10% loss of budgeted operating profit / listed assets	Partial shutdown / 15% loss of budgeted operating profit / listed assets	Partial loss of operation / 20% loss of budgeted profit / listed assets	Substantial or total loss of operation 25% loss of budgeted profit / listed assets
(L & R) Legal & Regulatory		Low level legal issue	Minor legal issue: non-compliance and breaches of the law	Serious breach of law: investigation / report to authority, prosecution and/or moderate penalty possible	Major breach of the law: considerable prosecution and penalties	Very considerable penalties & prosecutions. Multiple law suits & jail terms
(R / S / C) Impact on Reputation / Social / Community		Slight impact – public awareness may exist but no public concern	Limited impact – local public concern	Considerable impact – regional public concern	National impact – national public concern	International impact - international public attention
Likelihood	**Examples** Consider near-hits as well as actual events	**Risk Rating**				
5 (Almost Certain)	The unwanted event has occurred frequently: occurs in order of one or more times per year & is likely to reoccur within1 year	11 (M)	16 (S)	20 (S)	23 (H)	25 (H)
4 (Likely)	The unwanted event has occurred infrequently: occurs in order of less than once per year & is likely to reoccur within 5 years	7 (M)	12 (M)	17 (S)	21 (H)	24 (H)
3 (Possible)	The unwanted event has happened in the business at some time: or could happen within 10 years	4 (L)	8 (M)	13 (S)	15 (S)	22 (H)
2 (Unlikely)	The unwanted event has happened in the business at some time: or could happen within 20 years	2 (L)	5 (L)	9 (M)	14 (S)	19 (S)
1 (Rare)	The unwanted event has never been known to occur in the business: or it is highly unlikely that it will occur within 20 years	1 (L)	3 (L)	6 (M)	10 (M)	15 (S)
Risk Rating	**Risk Level**	**Guidelines for Risk Matrix**				
21 to 25	(H) – High	Eliminate, avoid, implement specific action plans / procedures to manage & monitor				
13 to 20	(S) – Significant	Proactively manage				
6 to 12	(M) – Medium	Actively manage				
1 to 5	(L) – Low	Monitor & manage as appropriate				

Table 56. Gamsberg Risk Assessment

	Aspect	Risk Event and Cause	Risk Consequence	Existing Controls	Consequence Type	Consequence Rating	Probability Rating	Risk Score	Risk Rank	Mitigation
1	Ground Water	Dewatering of mountain aquifer	Reduction in catchment yield. Destruction of groundwater springs. Removal of headwaters.	Groundwater level monitoring. Preservation of natural springs on offset property.	Environmental	4 - High	4 - Likely	21	High	Establishment of headwater augmentation borehole. Continuation of level monitoring.
2	Storm water management system	High rainfall event during construction	Contamination of clean storm water runoff through runoff through dirty areas. Sedimentation of surface water course	Execution of construction plan.	Environmental	2 - Minor	2 - Unlikely	5	Low	Proper implementation of construction plan. Timeous construction and commissioning of planned storm water containment facilities.
3	Water supply	Treatment works failure (including pipeline). Loss of supply from the Orange River.	Loss of production	Buffer capacity of 2 days. Attendance of Orange River forum meetings. Engagement with DWS. Treatment works and pipeline maintenance.	Business Interruption / Material Damage	5 - Major	2 - Unlikely	19	Significant	Buffer capacity of 2 days. Attendance of Orange River forum meetings. Engagement with DWS. Treatment works and pipeline maintenance.
4	Waste Management	Lack of available air space for waste disposal at BMC landfill area, which will receive waste from Gamsberg	Necessity for the establishment of a new landfill site.	Incineration of waste to reduce volumes.	Business Interruption / Material Damage	1 - Insignificant	4 - Likely	7	Medium	Improved waste recycling at mine and town. Implementation of zero waste initiative.
5	Hydrocarbon Management	Accidental spillage of hydrocarbons as part of operations	Contamination of soil	Implementation of waste control measures. Distribution of spill kits at key areas. Bioremediation of contaminated soils at Gamsberg facilities.	Environmental	1 - Insignificant	3 - Possible	4	Low	Maintenance of awareness with regards to waste control measures. Continued implementation of waste control measures.
6	Water Use Authorisation	Change in interpretation of water uses.	Un-authorised water uses taking place on site.	Engagement with DWS	Legal & Regulatory	2 - Minor	3 - Possible	8	Medium	Clarification of current WUL through amendment. Application for Water Use Licence for un-authorised

	Aspect	Risk Event and Cause	Risk Consequence	Existing Controls	Consequence Type	Consequence Rating	Probability Rating	Risk Score	Risk Rank	Mitigation
										water uses.
7	Waste Management	Failure to effectively separate waste at source	Double handling of waste resulting in additional costs being incurred	Waste management measures, training, awareness, procedures etc.	Cost	2 - Minor	3 - Possible	8	Medium	Continued training and awareness raising to ensure proper implementation of waste control measures.
8	Groundwater	Liner failure at containment/conveyance facilities	Contamination of groundwater resource	Quality inspection on liner systems. Temperature sensors on TSF liner.	Environmental	3 - Moderate	2 - Unlikely	9	Medium	Groundwater monitoring. Continued inspection on facilities at commissioned facilities. Leakage detection at TSF.

5.19 Issues and Responses from Public Consultation Process

The Public Participation (PP) process for the TSF 2 project commences in April 2024 and provides a 60-day commenting period until 6 February 2024. The PP report will be appended to the final IWWMP report as Appendix B.

5.20 Matters Requiring Attention/Problem Statement

- Stormwater:
  - Consolidated Stormwater Management Plan is required with additional controls required at the crushed ore stockpile and ROM stockpile extension (SRK, 2022).
  - Waste rock dump slope stability
- Surface water:
  - TSF failure resulting in contamination of watercourses
- Groundwater:
  - Dewatering of mountain aquifer
  - Liner failure
- Process water:
  - Water balance: install flow meters on key water circuits
  - Water conservation and demand management
- Waste:
  - Separation and recycling

5.21 Assessment of Level and Confidence of Information

The information in this report is the findings and recommendations of specialists involved.

Refer to **Table 47** in this report for Professional registration of specialists who compiled the reports for the WULA or that have compiled reports for other purposes and have been referred to in the IWWMP.

6 Chapter 6: Water and Waste Management

6.1 Water and Waste Management Philosophy (Process water, Stormwater, Groundwater and Waste)

Gamsberg Zinc Mine recognizes that water is a scarce resource and should be protected as set out by the relevant legislations. Therefore, all management and maintenance actions aim to:

- Philosophy 1: Use water sustainably
- Philosophy 2: Prevent pollution to and degradation of the environment

The water quality management hierarchy of DWS (Figure 53below is applied to process, storm and groundwater.

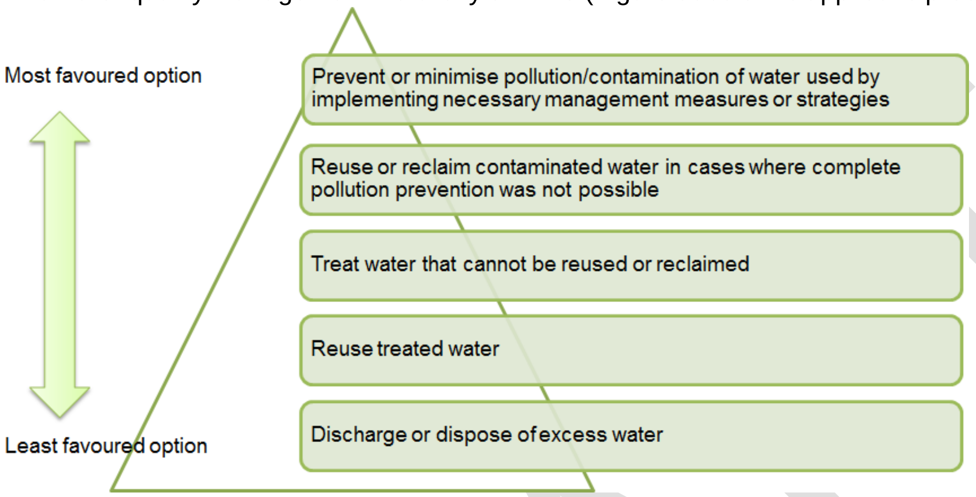


Figure 53. Water quality management hierarchy (Golder, 2018).

6.2 Strategies (Process Water, Stormwater, Groundwater and Waste)

Water strategies are as follows:

Strategy A: Soil, surface and groundwater pollution prevention
Strategy B: Erosion prevention
Strategy C: Adaptive management
Strategy D: Re-use and conservation of water

6.3 Performance Objectives /Goals

Goals are related to each strategy under the two main philosophies and are included in the table below in Section 6.8 of this report.

6.4 Measures to Achieve and Sustain Performance Objectives

Gamsberg Zinc Mine sustainability objectives are set through their Environmental Policy (Appendix C) and managed through the monthly Sustainability Reporting.

6.5 Option Analyses and Motivation for Implementation of Preferred Options (optional)

Three liner options were considered for the expansion of the TSF:

- Alternative 1: GMB over a GCL - *252 l/ha/d at 5m and 504 l/ha//d at 10m water depth*
- Alternative 2: Low permeability layer over a GMB (inverted barrier) - *Low permeability layer over a GMB (Inverted barrier): between 1.3 – 16.6 l/ha/d at 5m depth with hole diameter of 0.01 – 0.1m; and between 2.5 – 33.3 l/ha/d at 10m depth with hole diameter of 0.01 – 0.1m*

- Alternative 3: Inverted, Calcrete over GMB - *7.1 – 286.2 l/ha/d at 5m; and 14.2 – 572.5 l/ha/d at 10m water depth.*
- Alternative 2 is the preferred alternative based on the leakage rates and the estimated cost (Knight Piésold, 2023a).

6.6 IWWMP Action Plan

The table in 6.8 below outlines actions to be undertaken, with these being ranked in terms of implementation time frames (defined below) under the heading of "Action Plan".

Priority actions (P) – actions that must be consistently implemented without failure / actions to be implemented within six months and must take precedence over operational activities when required to prevent pollution or degradation of the environment and natural resources.

Short-term actions (S) – include the actions to be implemented in response to an incident on site or to a rainfall event, where remediation can be completed in a short time period, such as spills on site, monitoring of waste management actions and damage to stormwater structures.

Medium-term actions (M) – include actions undertaken periodically, but repeatedly over the life-of-mine following routine inspection of structures and activities.

Long term actions (L) – include planned actions to be implemented consistently for the life-of-mine, applicable to a specific season or financial year, i.e. alien vegetation eradication.

6.7 Control and Monitoring

Tasks undertaken to ensure that the Actions described are implemented.

6.8 Monitoring of Change in Baseline (Environment) Information (Surface water, Groundwater and Bio-monitoring)

Means of determining if there is a change in conditions over time. At Gamsberg this is achieved through routine evaluation of information collected as described in the table below, under Control and Monitoring.

Table 57. Performance objectives of Gamsberg Zinc Mine

6.1 Philosophy / 6.2 Strategy	6.3 Performance objectives / goals	6.4 Measures to achieve and sustain performance objectives	6.6 Action Plan #	6.7 Control and Monitoring	6.8 Monitoring of Change in Baseline
Philosophy 2: Prevent pollution **Strategy C:** Adaptive management	Separate "clean" and "dirty" water And / or Contain "dirty water" on-site	Implement SWMP Maintain separation, attenuation and conveyance structures and berms	P	Inspect and repair after every medium – large rainfall event. If damage is noted, repair work to be implemented within a week.	Visual observations. Environmental Planning Meeting (EPM) minutes
		Amend / update SWM structures as mining progresses	M	Visual inspection of SWM structures during internal inspection walk-abouts.	Visual observations. EPM minutes SWMP (record major changes)
		Evaluate SWMP and SWM structures	P	Annual WUL audit to note erosion, sedimentation and integrity of SWM structures.	Comparison of WUL Audit scores year on year – specifically the sections relating to SWM control
		Repair infrastructure damaged by rainfall events	P	Visual inspection after rainfall event. Groundwater quality monitoring.	EPM minutes Monitoring reports: comparison with WUL and DWS parameters.
Philosophy 1: Sustainability **Strategy D:**	Maintain water use volumes (per ton produced) in line with authorised use	Minimise waste from leaks by means of weekly visual inspections along pipes and reporting of leaks on the day they are identified, and repairing of leaks within as short a time period as possible	S/M	Monthly water consumption figures (flow meter readings)	Resource Consumption reporting / Water Balance Orange River Forum attendance
				Report leaks in Environmental Management System (EMS)	Biannual evaluation of EMS incidents relating to frequency of water leaks.

6.1 Philosophy / 6.2 Strategy	6.3 Performance objectives / goals	6.4 Measures to achieve and sustain performance objectives	6.6 Action Plan #	6.7 Control and Monitoring	6.8 Monitoring of Change in Baseline
Re-use and conservation of water	Promote re-use on site	WC/WDM strategy to be developed. Reuse includes: - Percolating water at TSF via RWD - ETP water from Smelter complex	S/M	Water balance to reflect source of water used Monthly water consumption figures (flow readings)	Resource Consumption reporting (Monthly Sustainability Reporting) Water Balance (comparison year on year) WC/WDM report
	Monitor and address dewatering of mountain aquifer	- Collection of data for groundwater model and impacts - Augmentation borehole/scheme	S/M	Quarterly monitoring of groundwater levels.	Groundwater model updating from monitoring reports.
Philosophy 2: Pollution Prevention **Strategy A:** Soil, surface and groundwater pollution prevention	No hydrocarbon spills to reach a water resource or pollute soil or groundwater resources	Hazardous materials are in bunded storage	S/M	Monthly bund condition monitoring.	Biannual evaluation of EMS incidents – determine frequency of problems (if any).
		Spill kits to be kept in all areas where there is the potential for a hydrocarbon spill (excluding haul vehicles)	S/M	Monthly kit maintenance (inspection of content and ensuring replacement of used stock).	Biannual evaluation of frequency of replacement of stock – used to determine frequency of spill clean ups required – compared with EMS incident records.
				Reporting incidents on EMS.	Biannual evaluation of EMS incidents – determine frequency of spills. (Also compare frequency changes with replacement of stock.)
		Drains around workshop to be free flowing (i.e. free of debris and sediments)	S/M	Weekly inspection of drains – implementing cleaning if necessary. (Sediments to be disposed with hazardous waste.)	Frequency of removal of sludge from oil separator. (Increased frequency may be due to

6.1 Philosophy / 6.2 Strategy	6.3 Performance objectives / goals	6.4 Measures to achieve and sustain performance objectives	6.6 Action Plan #		6.7 Control and Monitoring	6.8 Monitoring of Change in Baseline
		Manage levels of sludge in oil trap to prevent overflow to the receiving environment	S/M		Monthly visual inspection of levels of sludge in first chamber.	sediments flowing into separator.)
		Hazardous waste, specifically hydrocarbons, to be stored in designated areas	S/M		Visual inspection of hazardous waste storage areas – report incident of incorrect storage / storage capacity exceeded on EMS	Visual observations Biannual evaluation of EMS incidents – determine frequency of incorrect storage / storage capacity exceeded.
			S/M		Removal of hydrocarbon waste before the capacity of the waste area is exceeded.	Monthly evaluation of waste volumes – reporting for the Sustainability Report.
		Slope stability and integrity of Waste Rock Dump: implement controls	S/M		Visual inspection of stability	Visual observations
	No deterioration of ground water quality	Waste facilities (TSF, RWD) liner must be intact and repaired if damaged	S/M	L	Visual inspection of structures during internal inspection walk-abouts. Quarterly monitoring of groundwater quality.	Monitoring reports: Comparison of recent and historic/baseline data.
		Waste separation at source to reduce handling; implement control measures			Visual inspection	
Philosophy 2: Pollution Prevention **Strategy B:** Erosion prevention	Reduced sediment load into water reticulation system	Maintenance of the SWM structures	S/M		Inspect and repair after every medium – large rainfall event. If damage is noted, repair work to be implemented within a week.	Visual observations. EPM minutes

Notes: # P = Priority Actions S/M = Short- and Medium-term Actions L = Long-term Actions

6.9 Audit and Report on Performance Measures

The applicant must appoint an independent, duly qualified and competent professional to conduct Environmental Audits and Water monitoring assessments as prescribed in the conditions of the EMPR and WUL.

6.10 Audit and Report on Relevance of IWWMP Action Plan

To be captured in annual WUL audit report.

7 Chapter 7: Conclusion

7.1 Regulatory Status of Activity

Black Mountain Mining (Pty) Ltd was issued with a Water Use License, WUL No 14/D82C/ABCGIJ/2654, in 2014, and an amendment was issued in April 2016.

The following is a summary of the Water uses **authorized by the 2014 WUL** (refer to Table 13 for details):

- S.21(b): Storage of water from Pella Drift Water Board in Raw Water Storage Dam and Process Water Dam.
- S.21(c) & (i): Pipeline, open cast pit, tailings facility and demarcation fence in the regulated area of drainage lines.
- S.21(g): Disposal of waste and/or wastewater into TSF 1, PCDs, Wast Rock Dump Facility, Sewage Sludge Collection Sump, Treated Sewage Effluent Dam, Salvage Yard Stormwater Dam, Wash Bay Collection Sump; and dust suppression around plant area and on haul road
- 21.(j): Pit dewatering

Water uses **authorized by the 2016 WUL** (amended; refer to Table 13 for details):

- S.21(c) & (i): Pipeline, Magazine Area, Plant Area.
- S.21(g): Disposal of waste and/or wastewater into Plant Storm Water Dam and into Process Water Dam.

7.2 Statement of Water Uses Requiring Authorisation, Dispensing with Licencing Requirement and Possible Exemption from Regulation

Water uses (WUL Amendment) **submitted in 2020**, not included in WUL (refer to Table 14 for details):

- S.21(b): Storage of water from Pella Drift Water Board in 10ML reservoir for Smelter
- S.21(b): Storage of water in Firewater Tank for Smelter
- S.21(c) & (i): Pipelines for Smelter; TSF and Seepage Collection Pond; Magazine Area, Plant Area, demarcation fence; Secured Landfill Facility and protection berm, Business Partner Camp and Laydown area, and Smelter Complex (SLR, 2021) in 1:100 year flood line of a drainage line.
- S.21(g): Secured Landfill Facility for Jarofix and ETP cake disposal; Jarosite Storm Water Dam; Refinery Storm Water Dam; Sewage Treatment Plant capacity increase (SLR, 2021). Disposal of dirty stormwater into PCD 2; disposal of waste water into Plant Storm Water Dam, Process Water Dam and Pit Area.

Proposed Water Uses

The proposed water uses are summarized in the table below.

Water use	Facility/Activity	Capacity, Dimensions, Volume, Area/length	Property
21 (c) & (i)	Removal of diversion channel north of TSF 1	2 022m	RE of Aroams 57
21 (g)	TSF 2*	6 183 412 m³/a slurry (333 333t/month at 1.61t/ m³) 116 ha 32 000 000 m³	
	RWD with silt trap for TSF 2	Capacity below spillway invert 96 706 m³ RWD: 120 000 m³ Spillway: 10 x 2 x 0.8m depth Double silt trap measuring 25 m x 15 m x 1.5 m deep with a drying bed measuring 25 m x 4.7 m wide	
	Disposal of tailings slurry into TSF 2	770m³/hr or 548 tph	
	Disposal of wastewater into RWD	800 m³/hr	
	Pipelines for disposal into TSF 2 and RWD	7 500m 3 155m	

8 Chapter 8: References

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9 Chapter 9: Appendices

A: WUL No 14/D82C/ABCGIJ/2654 (2014 & 2016)

B: Public Participation Report (to be included in Final IWWMP)

C: Gamsberg Zinc Mine Environmental Policy