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WATER QUALITY REPORT AS PART OF THE ENVIRONMENTAL ASSESSMENT AND AUTHORISATION PROCESS FOR THE PROPOSED RIETKOL SILICA MINE NEAR DELMAS, MPUMALANGA PROVINCE

Prepared for

JACANA ENVIRONMENTALS CC

May 2018 (Revised May 2021)

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Report reference:	**SAS 215333**

SAS Environmental Group of Companies

EXECUTIVE SUMMARY

Scientific Aquatic Services was appointed to develop a water quality baseline assessment as part of the Environmental Assessment and Authorisation process required in terms of the National Environmental Management Act (NEMA) (Act 107 of 1998) for authorisation of the proposed Rietkol Mining Operation (Rietkol Project), where mining of silica through opencast methods will occur. The proposed Rietkol Project is situated within Wards 8 and 9 of the Victor Khanye Local Municipality and the Nkangala District Municipality. The Mining Right Application (MRA) area is situated approximately 6km west of the town of Delmas/ Botleng. The MRA area is further situated approximately 900m southeast of the N12, 2.1 km southwest of the R50, and 2.7 km north of the R555 (Figure 1 & 2). During the initial baseline assessment performed in 2016 and with the final report completed in April 2018, four water resources were identified within a 500m boundary of the MRA area of the proposed Rietkol silica mine:

- An artificial impoundment associated within the hillslope seep wetland located within the MRA area (RK01). However, note that the currently proposed layout area position now makes provision for infrastructure to fall outside of the 100 m Zone of Regulation (of the Hillslope Seep in which RK01 is located) as per GN 704;
- A natural depression wetland (RK02) and associated artificial impoundment (RK03) within the MRA area; and
- A depression wetland, which has an open water body associated with it (RK04) and is dammed as a result of road crossings.

RK04 is located outside of, but adjacent to, the MRA area. Although the MRA area will encompass RK01, RK02 and RK03, the planned open cast pit will not intersect the freshwater features.

During the 2016 baseline assessment water quality data were garnered from RK01 – RK03 during three sampling runs spanning different seasons, and RK04 was sampled during a single sampling run. During the current May 2021 baseline assessment water quality data were garnered from sites RK01 and RK04 while the remaining two sites were dry at the time of assessment. This data should be used to supplement the 2016 baseline data and will allow an accurate update to reflect the most current water quality baseline status. The data on selected water quality variables were then assessed, tabulated and compared to the following guidelines:

- South African Water Quality Guidelines for aquatic ecosystems, recreation, agricultural use and drinking water (DWAF 1996);
- The General and Special Limits for the discharge of wastewater into a watercourse (DWAF 1999), and;
- The resource quality objectives for the Upper Olifants River catchment (General Notice 466 of 2016). It is noted that as none of the aquatic resources assessed have riverine characteristics, and that the most proximally linked OREWA resource unit was located ~28km to the north of the study area, OREWA was only considered as a tentative guideline for management of resources within the greater catchment.

The following conclusions and recommendations were made:

- The water quality at RK01-03 is in line with the water quality standards recommended for the Upper Olifants Catchment. However, the water quality standards for the Upper Olifants Catchment only encompass basic water quality parameters, whereas the DWAF (1996) guidelines for aquatic ecosystems are more comprehensive. The water at the monitoring points complied with between 46% (RK03 in 2016) and 77% (2016) and 86% (2021) (both RK04) of the TWQR for aquatic ecosystems. Thus, the environmental state of the system prior to the development of the proposed Rietkol silica mine cannot be considered as pristine;
- The only water application for which RK01, 03 and 04 were suited for is full contact recreational use. Full contact recreational use includes fully submersive activities such as swimming. However, no other monitoring point was considered 100% suitable for any other use, and;
- The visual assessment identified that RK01 and RK04 are likely being utilised for irrigation, and RK04 is likely also being utilised for informal domestic use. The water quality at these resources is not considered suitable for this use, which should cease. The continuation of irrigation may be justifiable if cautious monitoring of crops is undertaken in order to determine bioaccumulation – but this would be done at risk and should only be undertaken in consultation with the appropriate specialist.

Additionally, these constituents may accumulate in irrigated soils over time increasing the toxicological risk and this aspect should also be monitored if use continues. However, in its current state, it is recommended that all use of water from RK01-04 for irrigation cease permanently;

- Trends in percentage of parameters that complies with the TWQR at sites RK01 and RK04 that was also assessed in May 2021, remained largely the same compared to the 2016 baseline data.
- Regarding temporal changes in individual parameter values, temporal variability [comparing May 2021 data to 2016 data], was evident at both sites RK01 (more pronounced) and RK04 prior to any potential impact from the proposed mining activity. Parameters for which concentrations increased at both sites were boron, EC, pH, potassium, sodium and zinc, and;
- The quantified water quality baseline data, and particularly those data that exceeded the various guidelines (described in section 4.2), should be considered by the regulating authority when authorising and setting licensed limits for the mine.

An impact assessment was conducted considering both the 2016 and current May 2021 baseline results, and it was determined that with the implementation of mitigation measures as is planned, the significance of the impacts upon the water quality of all resources and during all phases will be low. Thus, from a water quality point of view, the project cannot be considered to be fatally flawed. A detailed list of mitigation measures is presented in section 5.3.

Impact	Impact 1: Impact upon the water quality associated with RK01 – RK03	Impact 2: Impact upon the water quality associated with RK04
Without Management		
Clearing/Construction Phase	Low (5)	Low (4)
Operational/mining phase	Low to Medium (39)	Low (9)
Closure Phase	Low to Medium (36)	Low (18)
Care and Maintenance Phase	Low (9)	Low (8)
With Management		
Clearing/Construction Phase	Low (3)	Low (3.2)
Operational/mining phase	Low (15.6)	Low (7.2)
Closure Phase	Low (14.4)	Low (14.4)
Care and Maintenance Phase	Low (9)	Low (8)

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A summary and copies if any comments that were received during any consultation process	N/A
Any other information requested by the competent authority.	N/A

1 INTRODUCTION

1.1 Project objectives and scope

Scientific Aquatic Services was appointed to develop a baseline water quality assessment as part of the Environmental Assessment and Authorisation process required in terms of the Minerals and Petroleum Resource Development Act (MPRDA) (Act 28 of 2002) and the National Water Act (NWA) (Act 36 of 1998) for authorisation of the proposed Rietkol mining operation, where mining of silica through opencast methods will occur. The proposed Rietkol Mining Operations is situated within Wards 8 and 9 of the Victor Khanye Local Municipality and the Nkangala District Municipality. The Mining Right Application (MRA) area is situated approximately 6km west of the town of Delmas/ Botleng. The MRA area is further situated approximately 900m southeast of the N12, 2.1 km southwest of the R50, and 2.7 km north of the R555.

The MRA area covers an area of 221 ha, and consists of

- 16 Modder East Agricultural Holdings on the farm Olifantsfontein 196IR;
- Portion 71 of the farm Rietkol 237 IR; and
- A portion of the remaining extent of Portion 31 of the farm Rietkol 237 IR.

Silica is planned to be mined by means of conventional opencast methods to a depth of between 30 and 50 meters below surface (mbs). The proposed Rietkol Project estimated life of mine (LOM) is 20 years, although further exploration drilling to be conducted during the operational phase, may increase the LOM and the depth of mining if resources proof viable (Jacana, 2021).

The following infrastructure is associated with the proposed project:

- Opencast pits;
- Processing plant (i.e. crushing, wash plant, screening etc.);
- Product Stockpiles;
- Administration office facilities (i.e. security building, administration and staff offices, reception area, ablution facilities, etc);
- Access Roads; and
- Clean and dirty water management infrastructure

This report presents:

A) the results of an EIA phase initial baseline assessment (performed in 2016 and reported April 2018) in which the concentrations of constituents associated with silica mining operations were quantified in the aquatic resources within, and directly adjacent to, the Rietkol Mining Right (MRA) area;

B) the results of additional baseline sampling performed in May 2021 to determine if any significant changes in water quality baseline conditions occurred since 2016.

The data on selected water quality variables were then assessed, tabulated and compared to the following guidelines:

- South African Water Quality Guidelines for aquatic ecosystems, recreation, agricultural use and drinking water (DWAF 1996);
- The General and Special Limits for the discharge of wastewater into a watercourse (DWAF 1999), and;
- The resource quality objectives for the Upper Olifants River catchment (General Notice 466 of 2016). Please note as none of the aquatic resources assessed had riverine characteristics, and that the most proximally linked OREWA resource unit was located ~28km to the north of the study area, OREWA was only considered as a tentative guideline for management of resources within the greater catchment.

The objective of the initial baseline assessment (performed 2016 with final reporting in April 2018) was to define the reference water quality conditions of the aquatic resources that may be affected by the proposed mining operations as part of the final phase of the Environmental Authorisation Application. This served to define the baseline condition and sensitivity of the systems as well as potential future impacts and mitigatory measures associated with the proposed operations. The objective of the current (May 2021) additional baseline assessment was to report on water quality and compare to the initial data and to determine if any significant changes in the baseline water quality status were evident. These objectives were reached through:

- Desktop assessment of the study area in order to inform site selection and gather background information;
- *In situ* and laboratory analysis of water samples from aquatic resources that may be affected by the proposed operations. Baseline data constituted three different spanning from 4 February 2016 to 6 December 2016. For the current assessment sampling was performed in May 2021;

- Reporting the data to establish baseline conditions considering both the 2016 and May 2021 results;
- Comparing the gathered data to the water quality guidelines described above in order to further inform the baseline condition of the aquatic resources considering both the 2016 and May 2021 results.

Four aquatic resources were assessed on the 7th of February, 13 June, 6 December 2016, namely:

- An artificial impoundment associated within the hillslope seep wetland located within the Rietkol MRA area (RK01);
- A natural depression wetland (RK02) and associated artificial impoundment (RK03), and
- A depression wetland, which has an open water body associated with it (RK04) and is dammed as a result of road crossings.

RK04 is located outside of, but adjacent to, the Rietkol MRA area. Although the MRA area will encompass RK01, RK02 and RK03, the planned open cast pit will not intersect the freshwater features.

During the May 2021 assessment only two of the four sites were assessed, namely RK01 and RK04 while RK03 and RK02 were dry at the time of assessment.

Please refer to Figure 1 overleaf for an indication of the position of the monitoring points within the MRA area indicated on a digital satellite image, as well as on a map also detailing the location of the monitoring points relative to freshwater resources in the investigation area (Figure 2). Figure 3 provides a comparison of the proposed original (as assessed 2016) and current (as assessed 2021) layout area (now proposed to be located outside of the 100 m Zone of Regulation as per GN 704) within the MRA area, and Figure 4 provides details on infrastructure layout within the proposed layout area.

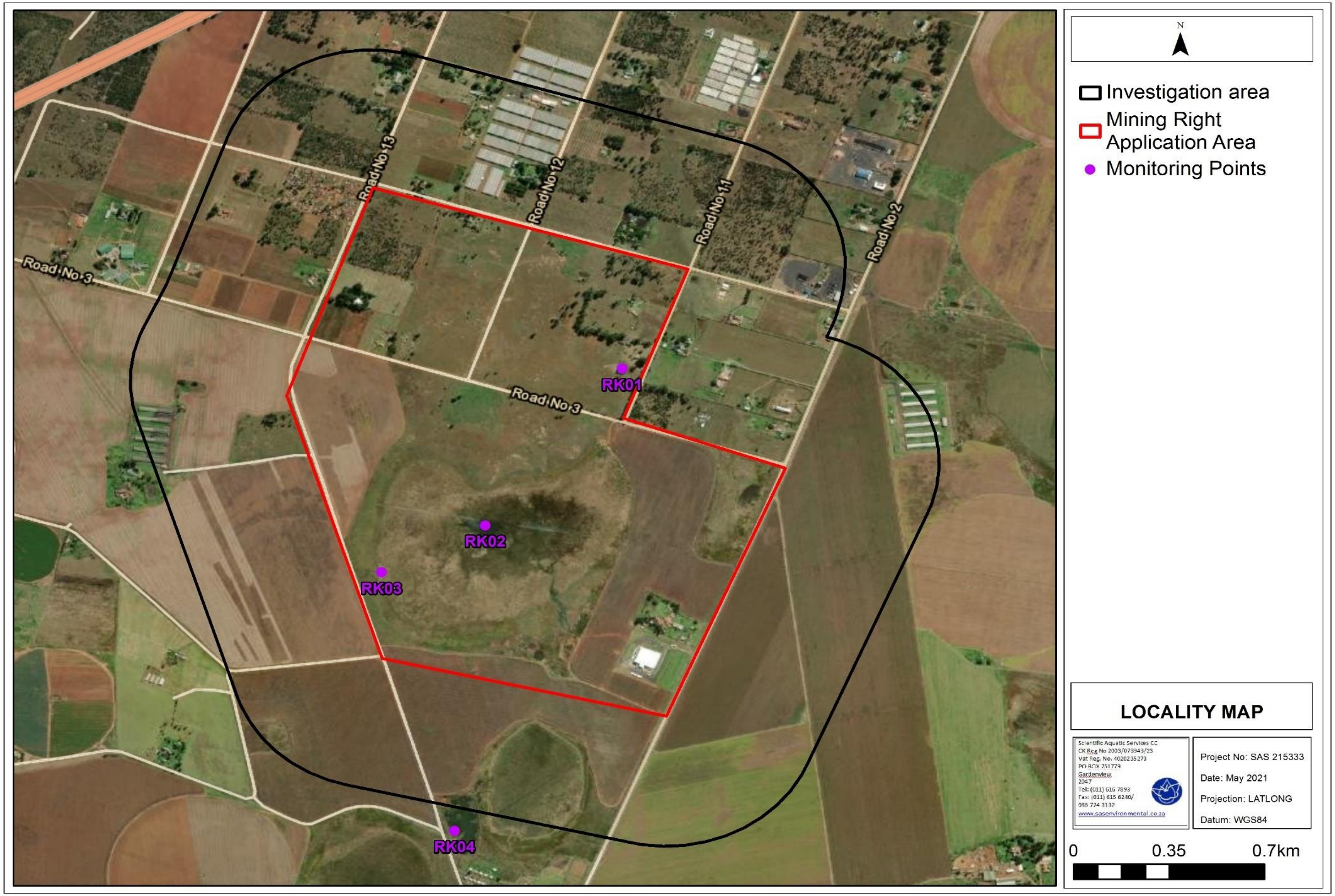

Figure 1: A digital satellite image of the water quality monitoring points.

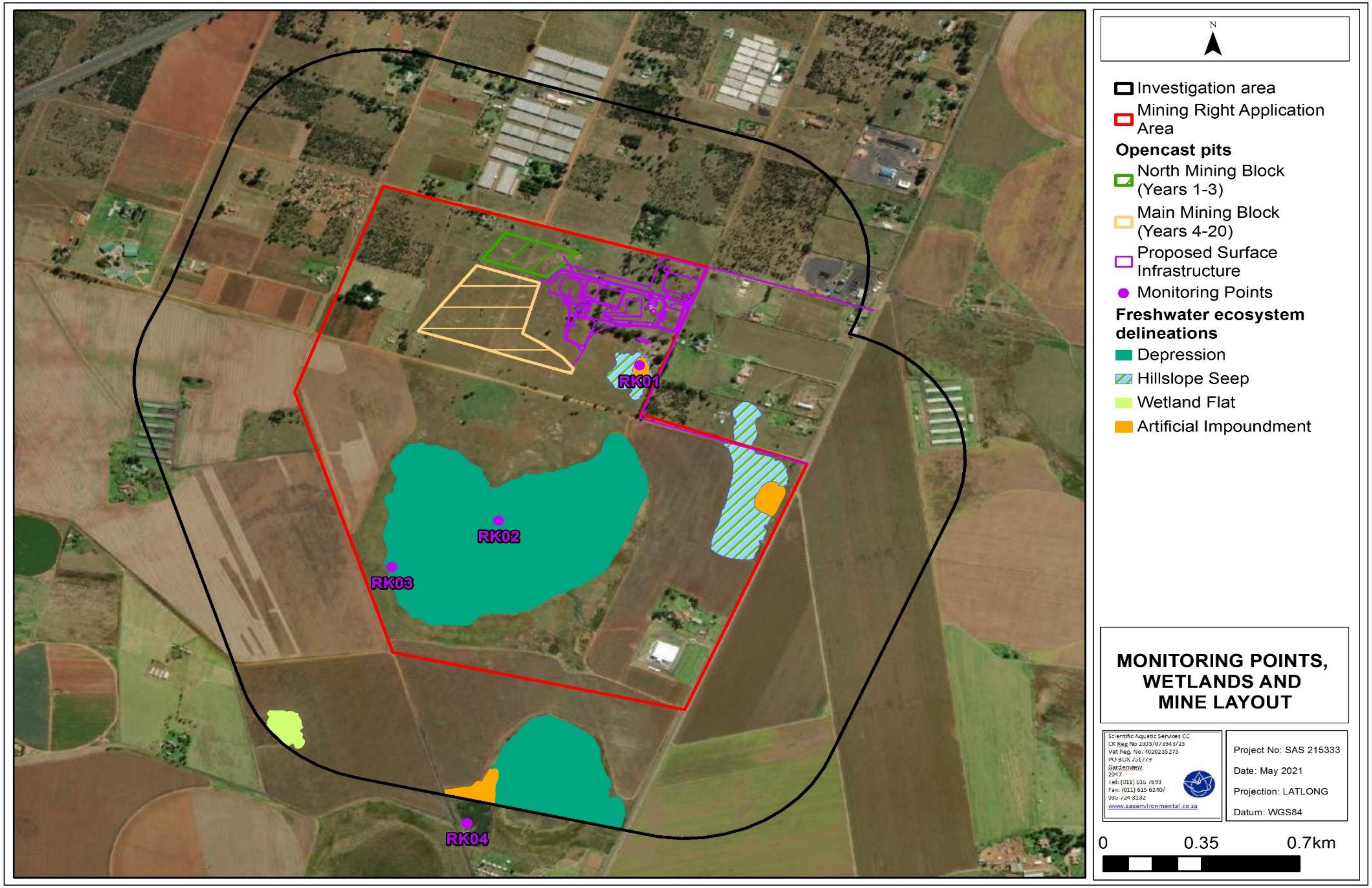

Figure 2: Location of freshwater resources within the investigation area and in relation to the sampling points and Mining Rights Application (MRA) area.

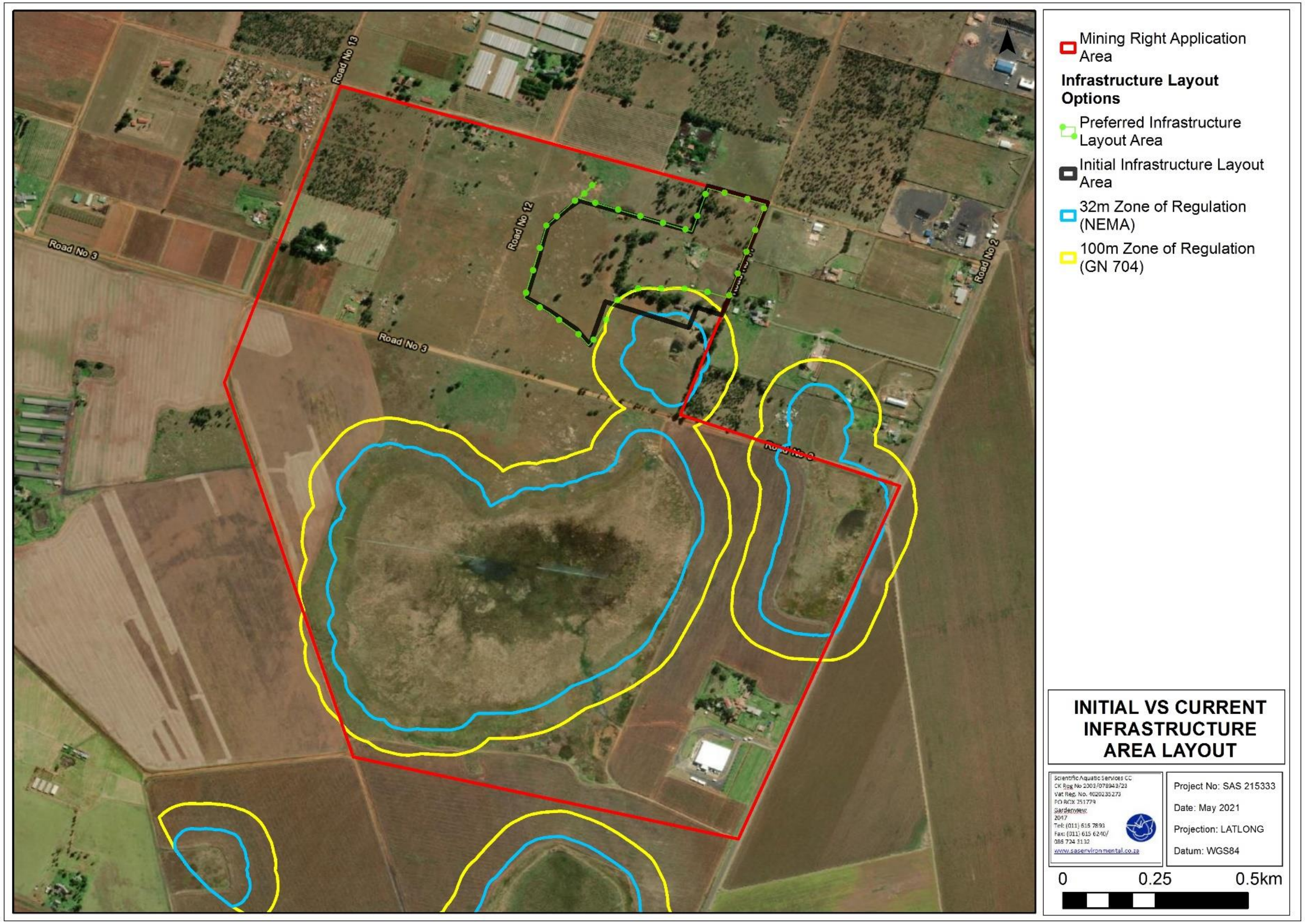

Figure 3: Comparison of the initial proposed open cast mining area layout (2016) position to the current (2021) proposed layout within the Mining Rights Application(MRA) area.

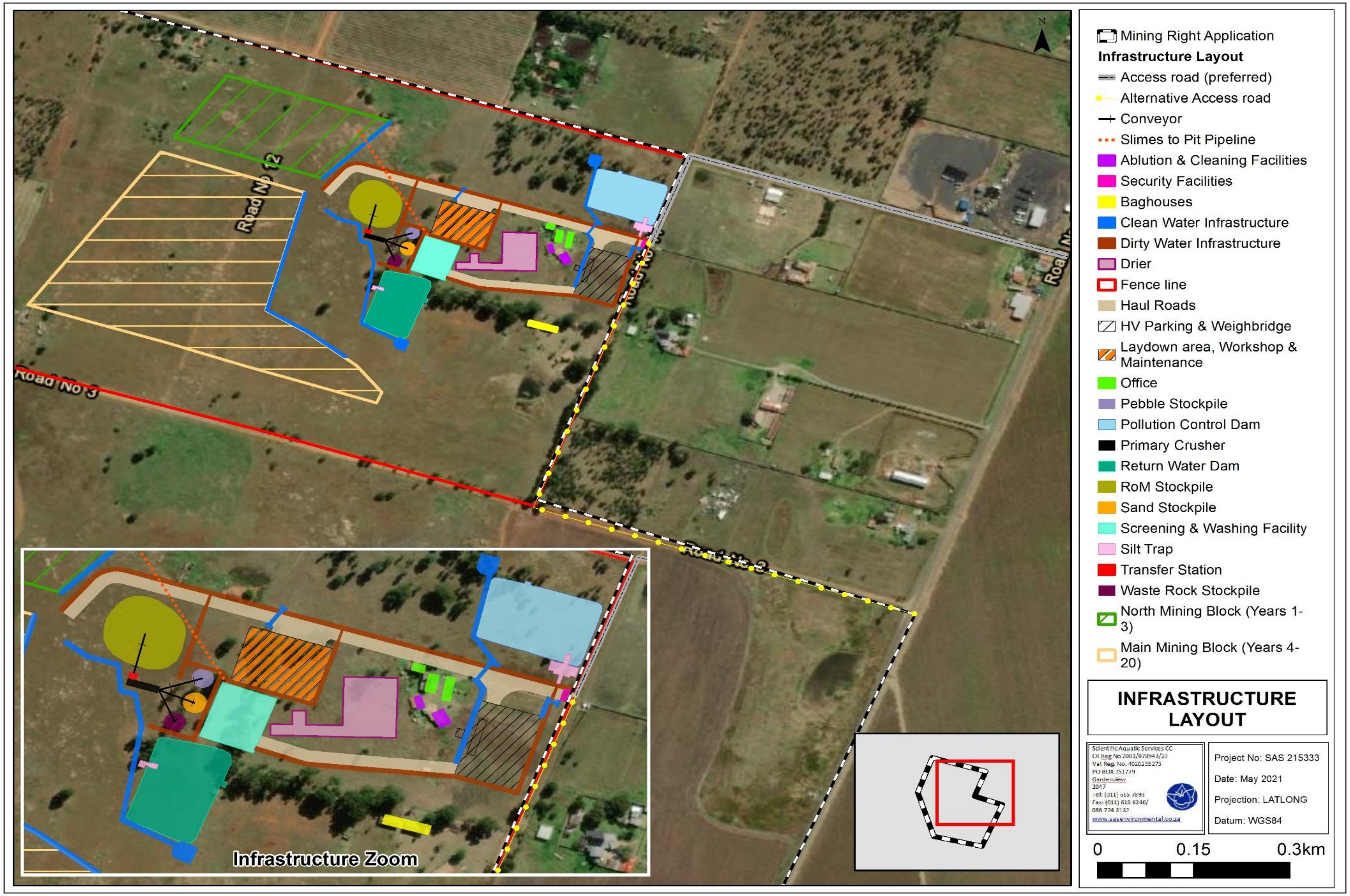

Figure 4: Proposed open cast mining area infrastructure within the preferred layout are (as per Figure 2).

1.2 Site Sensitivity Verification Statement

Nhlabathi applied for a Mining Right to mine silica in February 2018 and commenced with the Environmental Impact Assessment (EIA) process as contemplated in the National Environmental Management Act 107 of 1998 (NEMA) and Government Notice (GN) No. R. 982-986 of 4 December 2014: NEMA: Environmental Impact Assessment Regulations, as amended (2014 EIA Regulations), for the Rietkol Project.

Several specialist studies were conducted within the Mining Right Application (MRA) area in support of the EIA process, and a comprehensive Public Participation process was initiated. The Final Scoping Report was submitted on 3 April 2018 and accepted by the Department of Mineral Resources and Energy (DMRE) on 26 April 2018. However, the MRA was rejected by the DMRE Mpumalanga Mine Economics Directorate on the basis that the MRA formed part of another right granted in terms of the MPRDA. This decision resulted in a delay in the EIA process, ultimately causing the application for Environmental Authorisation to lapse.

Nhlabathi has recently re-initiated the MRA process and applied for a Mining Right over the same farm portions in early 2020. The MRA was accepted by the DMRE on 21 January 2021 and Nhlabathi has since re-initiated the EIA process with Jacana Environmentals cc (Jacana) appointed as the independent Environmental Assessment Practitioner (EAP).

Several additional requirements when applying for Environmental Authorisation (EA) have emerged since the 2018 EIA process, including but not limited to:

1. Notice was given in Government Notice No. 960 (GN 960) dated 5 July 2019 of the requirement to submit a report generated by the National Web Based Environmental Screening Tool in terms of section 24(5)(h) of the NEMA and regulation 16(1)(b)(v) of the 2014 EIA Regulations. Such a Screening Rreport became compulsory when applying for an EA 90 days from publication of GN 960 (5 October 2019). The purpose of the Screening Report is to identify the list of specialist assessments that needs to be conducted in support of the EA application, based on the selected classification, and the environmental sensitivities of the proposed development footprint.
2. Government Notice No. 320 (GN 320) dated 20 March 2020 prescribes general requirements for undertaking site sensitivity verification and for protocols for the assessment and minimum report content requirements of environmental impacts for environmental themes for activities requiring EA in terms of sections 24(5)(a), (h) and 44 of NEMA. These procedures and requirements came into effect 50 days after publication of GN 320 (15 May 2020). The purpose of the site sensitivity verification is to verify (confirm or dispute) the current use of the land and the environmental

sensitivity of the site under consideration as identified in the Screening Report. This will determine the level of assessment required for each environmental theme, i.e. Specialist Assessment or Compliance Statement.

As indicated above, several specialist studies were commissioned for the Rietkol Project during 2016-2018 in support of the previous application, including:

- Soils, land use and capability, Hydropedology;
- Terrestrial / Aquatic Biodiversity;
- Groundwater;
- Air Quality;
- Ambient Noise;
- Blasting & Vibration;
- Traffic;
- Heritage and Cultural Resources;
- Palaeontology;
- Visual and Aesthetics;
- Social;
- Hazard Identification and Risk Assessment (HIRA); and
- Land Trade-off & Macro-Economic Analysis.

Comprehensive specialist assessments were conducted for all the environmental and social themes listed above, irrespective of the sensitivity identified by the specialist assessment (2018) or the Screening Report. Therefore, no site sensitivity verification has been done for this EA application as all themes have been considered to have a **high to very high sensitivity**, requiring a full Specialist Assessment.

The list of specialist assessments listed in the Screening Report and the extent to which it has been addressed in the re-application for EA for the Rietkol Project is indicated below. Where applicable, motivation is provided for the exclusion of certain specialist assessments.

GN 960 requirement	Extent to which it is included in the Plan of Study
Agricultural Impact Assessment	Soil and Land Capability Assessment by Scientific Aquatic Services.
Landscape/Visual Impact Assessment	Visual Impact Assessment by Scientific Aquatic Services.
Archaeological and Cultural Heritage Impact Assessment	Phase 1 Heritage Impact Assessment by R&R Cultural Resource Consultants.
Palaeontology Impact Assessment	Palaeontology Impact Assessment by ASG Geo Consultants (Pty) Ltd {Dr Gideon Groenewald}.

GN 960 requirement	Extent to which it is included in the Plan of Study
Terrestrial Biodiversity Impact Assessment	Faunal, Floral and Freshwater Assessment by Scientific Terrestrial Services.
Aquatic Biodiversity Impact Assessment	Faunal, Floral and Freshwater Assessment by Scientific Terrestrial Services.
Hydrology Assessment	Baseline Water Quality Assessment by Scientific Aquatic Services. Water Management Plan – Preliminary Design Report by Onno Fortuin Consulting.
Noise Impact Assessment	Environmental Noise Impact Assessment by Enviro Acoustic Research.
Radioactivity Impact Assessment	Waste Classification by Groundwater Complete. Analysis will include Uranium and Thorium to determine potential for radioactivity within the resource.
Traffic Impact Assessment	Traffic Impact Assessment by Avzcons Civil Engineering Consultant.
Geotechnical Assessment	A geotechnical assessment will be undertaken as part of the engineering package for the project, if required. This is not included in the application for EA.
Climate Impact Assessment	A greenhouse gas emissions statement is included in the Air Quality Impact Assessment by EBS Advisory.
Health Impact Assessment	Hazard Identification and Risk Assessment by AirCheck Occupational Health, Environmental & Training Services.
Socio-Economic Assessment	Socio-Economic Impact Assessment by Diphororo Development.
Ambient Air Quality Impact Assessment	Air Quality Impact Assessment by EBS Advisory.
Seismicity Assessment	A Blasting Impact Assessment is included and has been conducted by Blast Management Consulting. It deals extensively with the potential impact in respect of air blast and vibration from blasting operations.
Plant Species Assessment	Part of Terrestrial Biodiversity Impact Assessment.
Animal Species Assessment	Part of Terrestrial Biodiversity Impact Assessment.

Further studies that are not included in the GN 960 requirements, but were commissioned for the Rietkol Project, are:

- Hydropedological Assessment by Scientific Aquatic Services.

- Geohydrological Investigation by Groundwater Complete.
- Blasting Impact Assessment by Blast Management Consulting.
- Land Trade-off Study and Macro-Economic Impact Analysis by Mosaka Economic Consultants.
- Rehabilitation, Decommissioning and Closure Plan by Jacana Environmentals.

Where a specific environmental theme protocol has been prescribed by GN 320, the specialist assessment will adhere to such protocol. Where no protocol has been prescribed, the report will comply with Appendix 6 of the EIA Regulations.

1.3 *Project key staff*

Stephen van Staden [2016 (reported 2018) and 2021 assessments]

SACNASP REG.NO: **400134/05**

Stephen van Staden completed an undergraduate degree in Zoology, Geography and Environmental Management. He then undertook an honours course in Aquatic health. In 2002, he began a Master's degree in environmental management, including his mini dissertation in the field of aquatic resource management. Stephen began building a career at a firm specialising in town planning developments, after which he moved to a larger firm in late 2002 where he managed the monitoring division and acted as a specialist consultant on water resource management issues and other environmental processes and applications. In 2003, Stephen started consulting independently specialising in water resource management. In addition to aquatic ecological assessments, clients enquired about terrestrial ecological assessments and biodiversity assessments, which developed into a very significant part of the business. Stephen started working in the wetland consulting arena and has become recognised as a national expert in this regard combining science (ecology and hydrology), engineering principles and an in-depth understanding of the legislative framework to provide turnkey advisory services. Stephen has launched soil and land capability assessment and visual impact assessment services with other specifically qualified specialists. Stephen is registered by the SA RHP as an accredited aquatic biomonitoring specialist and is also registered as a Professional Natural Scientist with SACNASP in the field of ecology. Stephen is also a member of the Gauteng Wetland Forum, the South African Soil Surveyors Organisation (SASSO) and IAIA.

Kirstin Olsen [2016 (reported 2018) assessment]

In 2015 Kirstin joined the SAS Environmental Group as a specialist water quality consultant and has completed over thirty water quality assessments, reported on over ten biomonitoring and toxicological assessments, and undertaken over ten freshwater ecological assessments thus far in Gauteng, Limpopo, Mpumalanga, Free State, KwaZulu-Natal, the North-West Province, the Northern Cape and the Western Cape. Her environmental experience includes wetlands, rivers, lakes, dams, and stormwater runoff and groundwater environments. While Kirstin's situational experience includes residential developments, infrastructure development including transit, and sanitation (from small scale septic systems to municipal treatment plants), industrial activities (including paint manufacturing and galvanising plants), and mining operations (platinum, gold, coal, silica, gabbro-norite and diamond mining).

In terms of reporting Kirstin has experience in water use authorisations (General Authorisations, Water Use Licensing, and Emergency Authorisations), temporal and spatial analysis, impact assessments (including emergency spills, construction, rehabilitation and maintenance), hydrocensus, environmental reserve determination (PAI water quality analysis only), digital fingerprinting, and rehabilitation, maintenance and management.

Dionne Crafford (2021 assessment)

SACNASP REG.NO: **400146/14**

Dionne Crafford completed an undergraduate degree in Zoology in 1996 and his Honours degree in the same field in 1997. His subsequent MSc degree (completed 2000) was focussed on using fish health and parasite fauna as indicators of water quality. Following this he worked as a parasitologist in the Animal Health industry during which he completed his part-time PhD (again Zoology with specialization in Monogenean parasites of fish from the Vaal Dam) in 2013. From this time, he also started performing work for the SAS Environmental group, reporting mostly on biomonitoring and toxicity testing studies. Dionne is registered as a Professional Natural Scientist with SACNASP in the field of Biological Science.

1.4 Indemnity and Terms of Use of this Report

The findings, results, observations, conclusions and recommendations presented in this report are based on the author’s best scientific and professional knowledge as well as available information. The report is based on survey and assessment techniques which are limited by time and budgetary constraints relevant to the type and level of investigation undertaken.

SAS cc and its staff reserve the right to modify aspects of the report including the recommendations if and when new information may become available from ongoing research or further work in this field, or pertaining to this investigation.

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1.4 Legislative Requirements

Minerals and petroleum Resource Development Act (MPRDA) (Act 28 of 2002) and National Environmental Management Act (Act 107 of 1998)

The obtaining of a New Order Mining Right (NOMR) is governed by the MPRDA. The MPRDA requires the applicant to apply to the Department of Mineral Resources (DMR) for a NOMR which triggers a process of compliance with the 2014 regulations in terms of NEMA (Act 107 of 1998) as amended in 2017. This could follow either the Basic Assessment process or the S&EIR process depending on the nature of the activity and scale of the impact.

National Water Act (NWA; Act 36 of 1998)

- The NWA; Act 36 of 1998 recognises that the entire ecosystem and not just the water itself in any given water resource, constitutes the resource and as such needs to be conserved. No activity may therefore take place within a watercourse unless it is authorised by the Department of Water and Sanitation (DWS).
- Any area within a wetland or riparian zone is therefore excluded from development unless authorisation is obtained from DWS in terms of Section 21 of the NWA.

GN 704 – Regulations on use of water for mining and related activities aimed at the protection of water resources, 1999

These Regulations, forming part of the NWA, were put in place in order to prevent the pollution of water resources and protect water resources in areas where mining activity is taking place from impacts generally associated with mining. It is recommended that the proposed project complies with Regulation GN 704 of the NWA, 1998 (act no. 36 of 1998) which contains regulations on use of water for mining and related activities aimed at the protection of water resources. GN 704 states that:

No person in control of a mine or activity may:

(a) locate or place any residue deposit, dam, reservoir, together with any associated structure or any other facility within the 1:100 year floodline or within a horizontal distance of 100 metres from any watercourse or estuary, borehole or well, excluding boreholes or wells drilled specifically to monitor the pollution of groundwater, or on waterlogged ground, or on ground likely to become waterlogged, undermined, unstable or cracked;

According to the above, the activity footprint must fall outside of the 1:100 year floodline of the aquatic resource or 100m from the edge of the resource, whichever distance is the greatest, unless authorised in terms of the NWA (Act 36 of 1998).

1.5 Assumptions and Limitations

Aquatic, wetland and riparian ecosystems are dynamic and complex. Some aspects of the ecology of these systems, some of which may be important, may have been overlooked. For instance, findings relating to RK04 were largely based on a single site visit during the initial 2016 baseline assessment. A more reliable assessment would have required that seasonal assessments take place with at least one assessment in the low flow season also undertaken. Only a single assessment was initially conducted taken at RK04, as RK04 was only included in the monitoring program when the extent of the MRA area was revised (which took place after the second 2016) site visit. Findings relating to RK01 to RK03 do not have this seasonal limitation, as three replicates were taken during the initial 2016 baseline assessment, with means calculated to provide a more accurate reflection. However, with a subsequent baseline visit again performed in 2021 at sites RK01 and RK04, additional data has been generated that allows for further temporal comparison.

The precise concentration of several parameters could not be quantified and were recorded as being below the detection limit (e.g. <0.01 mg/l). In some cases, the detection limit (as specified for each element/compound by the analysing laboratory and dependent on instrument specifications) was above the guidelines which they were being compared to, meaning that it was not possible to determine compliance. In such cases the precautionary principle was applied, and it was assumed that the value exceeded the guideline. These instances are, however, specifically identified in the data and in the text.

Given that the proposed open cast mine will descend to a depth of 30-50m, and is located outside the 100m zone of regulation of wetland resources, it was confirmed that de-watering of the pit will be required.

2 METHOD OF ASSESSMENT

In order to contextualise the baseline water quality assessment and consider pertinent background information, a desktop assessment was conducted.
The results of the desktop assessment assisted in informing the selection of the monitoring points, and in developing the applicable sampling technique, laboratory and data analyses. The aforementioned aspects of the method used are detailed further in Appendix 1.

3 SYSTEM CHARACTERISATION

In order to contextualise the study, the National Freshwater Ecosystem Priority (NFEPA) (2011) database and Present Ecological State/Ecological Importance and Sensitivity (PES/EIS) database, developed by the DWS, were utilised to obtain additional background information on the project area. The information therein is summarized in Table 1 below.

Table 1: Summary of desktop information pertaining to the proposed Rietkol silica mine (NFEPA 2011; DWS, 2012).

Ecoregion	**Highveld**
Catchment	**Olifants North**
Water Management Area (WMA)	**Olifants**
SubWMA	**Upper Olifants**
Quaternary Catchment	**B20B**
Most proximal sub-quaternary reach	**B20B-01285**
Proximity	**~2.5 km north west of proposed Rietkol silica mine**
Sub-quaternary reach name	Koffiespruit
Expert Present Ecological State (PES) assessment	Y
PES category median	D (Largely Modified)
Mean Ecological Importance Class	Moderate
Mean Ecological Sensitivity Class	Moderate
Stream Order	1
Default Ecological Class	C (Moderately Modified)

Additionally, the NFEPA database identified the following in respect of the proposed Rietkol silica mine:

- Not an important FEPA;
- Not important in terms of cranes, frogs, or water birds;
- The NFEPA database identified the natural depressions, in which RK02, RK03 and RK04 are located, as natural features that are in a moderately modified condition (Figure 2);
- The Koffiespruit was identified as an NFEPA River, however it is located 2.5 km North West of the proposed Rietkol silica mine.

Figure 5: The natural wetland features present within the MRA area (NFEPA, 2011).

4 ACTIVITY DESCRIPTION

The following activities and aspects may lead to one or more impacts upon the water quality:

Clearing/Construction Phase

- Clearing of vegetation for infrastructure, and security, and;
- Establishment of roads, buildings, washing plant, stockpile areas, ablutions, etc.

Operational/Mining Phase

- Potential poor separation of clean and dirty stormwater runoff leading to contaminated runoff entering water resources, potentially altering the chemical character of the system and potentially leading to anoxic and/or oleaginous conditions. Except for limited chemicals used in the thickener plant, no further chemicals are added during the beneficiation process. The material mined is also inert and poses a low risk of impact on water quality (Jacana, 2021);
- Uncontrolled release of stormwater from the open cast pit, sand/pebble/waste rock stockpile and associated infrastructure, potentially leading to the erosion of resources and water quality impairment, as well as alterations to aquatic habitat and communities through changes in flow characteristics. Alteration to the ecology of the wetland may have a feedback effect on water quality due to less filtration and assimilation capacity. The tailings storage facility will be located within the northern portion of the proposed pit, which will be mined first;
- Dust transport into water resources which may potentially increase the TSS and decrease clarity, leading to anoxic conditions. Dust has also been known to pollute water bodies;
- Sand/pebble/waste rock and slimes (purportedly inert in this case) or residue from explosives (which may contain contaminants such as nitrates) can affect water quality in the receiving environment;
- The revised proposed layout the open cast pit will not be located within 100m of the wetland depression associated with RK02. Ground water is not anticipated to have a significant direct interaction with the surface and shallow sub-surface hydrogeological processes. Furthermore, groundwater influx into the proposed open pits will be from the intermediate, deeper aquifer and not from the shallow subsoil aquifer. Dewatering and resulting drying out of the wetland features within 500m of the proposed mine is thus considered unlikely as the wetlands are not considered to be driven by groundwater recharge. Any potential impact is considered to be largely insignificant provided that good design and development of clean and dirty water separation

structures takes place, and that clean water is directed in a manner that allows recharge of the wetlands in as natural a way as possible;

- With reference to the geohydrological environment (Groundwater Complete 2021) it must be noted that the sensitive dolomitic aquifer will not be intersected by the proposed opencast pits. The quartzite deposit in its entirety is expected to act as a buffer between the proposed mining activities and the surrounding and underlying dolomite.
- Please refer to Figure 4 for details on infrastructure layout, including the position of process water infrastructure. It is noted that:
  - Process water will not be discharged, but will be recycled for re-use in the plant;
  - Whilst there is no consumption during processing, approximately 20% will be lost through moisture in the product and evaporation (Jacana, 2021);
  - A process water dam will be associated with the plant in order to collect the water from the drying beds that will be re-used, and;
  - Water utilised for ablution will either be collected and removed from the site by an independent contractor, or will be processed via a package sewage treatment plan or French drains (see location of "Ablution and Cleaning Facilities" on Figure 4).
- Edge effects, the proliferation of alien and invasive species in the disturbed mining areas which may migrate into the water resources.

Closure Phase

- The north pit will be filled with material and rehabilitated accordingly, however, the main pit will only be partially filled with tailings material from year 13/14 onwards, as most of the mined material will be sold as product. As such, the main pit is likely to remain as an open void within the MRA area. Although no formal rehabilitation report has been formulated, it can be assumed rehabilitation activities, where feasible, will require significant earthworks and landscaping. These activities may result in the discharge of stormwater high in TSS and turbidity entering adjacent water resources.

Care and Maintenance Phase

- This phase will consist of low impact activities such as maintenance of stormwater and rehabilitation structures, as well as environmental monitoring. Unlikely to impact upon the water quality of the resources. No post closure decant is expected to occur.

5 RESULTS

5.1 Visual assessment of each monitoring point selected

A photographic record of each site was made during the baseline assessment to provide visual record of the characteristics of each monitoring point, as observed during the field assessment. The photographs taken at each site, during each site visit, are presented in the tables that follow.

For the May 2021 assessment no additional photographs were taken and only water quality results are reported on (where applicable as not all sites were again sampled with some sites being dry at the time of assessment).

The tables also summarise the observations for the various criteria made during the visual assessment undertaken on the respective sites over time.

Table 2: Location of the water quality monitoring points with co-ordinates thereof (baseline assessment reported April 2018).

Description	Photograph (02.04.2016)	Photograph (13.06.2016)	Photograph (06.12.2016)
Site: RK01 Description: Artificial impoundment associated with a hillslope seep wetland within the proposed Rietkol silica mine, and within the MRA area. GPS: 26° 7'43.47"S 28°36'41.88"E			
Site: RK02 Description: Natural depression located directly to the south of the proposed Rietkol silica mine, and within the MRA area. GPS 26° 8'1.33"S 28°36'22.95"E			

Site: RK03 Description: Artificial impoundment associated with the natural depression located directly south of the proposed Rietkol silica mine, and within the MRA area. GPS 26° 8'9.42"S 28°36'13.45"E			
Site: RK04 Description: Natural depression located 560m to the south of the MRA area boundary. GPS 26° 8'40.96"S 28°36'21.83"E	N/A - A revision of the proposed MRA area was published following the first two site visits, and a further natural depression wetland was identified as a monitoring point (RK04). Thus RK04 was only sampled once.		

Table 3: Description of the location of the aquatic monitoring points associated with the proposed Rietkol silica mine.

Monitoring point	RK01	RK02	RK03	RK04
Hydrological linkages	This system is linked to a hillslope seepage wetland. The property owner indicated that the artificial feature was excavated from the wetland in 2006, and drainage from the wetland was directed into and accrued within the impoundment associated with RK01 for agricultural irrigation.	RK02 is a monitoring point within a natural depression and is inherently linked to an artificial impoundment that is located within the depression.	RK03 is a monitoring point within an artificial impoundment. The impoundment is associated with a natural depression. The water quality in the natural depression is being monitored by RK02.	RK04 is a depression wetland, which has an open water body associated with it as a result of road crossings. On the surface it does not appear to be connected to any other freshwater feature, but due to its proximity to RK02 and RK03, groundwater linkage may occur. However, no direct groundwater linkage to the surface water resources was mentioned in the geohydrological report and hydropedological studies. As the system is not groundwater driven nor hydrologically connected to the wetland systems in the north, any potential impact via groundwater on the assessed sites will likely be insignificant.
Anthropogenic applications	Crop irrigation by the neighboring farmstead	None	The artificial nature of the feature implies that the water might have been used for an anthropogenic purpose, but present uses are unknown.	Rosgro islocated directly next to the wetland and has large agricultural fields surrounding the wetland. Additionally, evidence of water being extracted from and discharged into the wetland was observed.
Algal presence	Only evident during the June 2016 baseline inspection – indigenous *Marsilea* sp. observed at a moderately high cover.	Not evident.	Not evident.	Not evident.
Visual indication of an impact on aquatic fauna	Not evident.	Not evident.	Trampling by cows was observed during both the June 2016 and December 2016 baseline assessments. Overgrazing was also observed in June 2016.	Not evident.
Water clarity	Clear to moderately turbid.	Clear to moderately turbid.	Slightly to highly turbid with a low amount of suspended organic matter.	Slightly turbid.

Monitoring point	RK01	RK02	RK03	RK04
Depth characteristics	The low gradient of the bed appeared to be largely moderate and uniform.	The low gradient of the bed appeared to be largely moderate and uniform.	The low gradient of the bed appeared to be largely moderate and uniform.	Moderate depth characteristics, but mostly uniform gradients across the feature.
Flow condition	The resource had limited flow diversity and consisted of a pool with very slow flow characteristics driven by the wind.	The flow condition was still and stagnant.	The resource had limited flow diversity and consisted of a pool with very slow flow characteristics driven by the wind.	The resource had limited flow diversity and consisted of a pool with very slow flow characteristics driven by the wind.
Water odor	Not evident.	Not evident.	Strong anoxic smell evident during the June 2016 and December 2016 site visits.	Strong smell of fertilizer.
Erosion potential	Unlikely – no erosion was evident.	Very low.	A high degree of erosion was observed on the edge of the feature during the June 2016 assessment.	High potential – steep banks with little vegetation. However, whilst potential was high, little erosion was observed.
Aquatic Biota	The biota associated with this feature are common tolerant species known to occur in still water environments. Species with an affinity for vegetation biotopes are dominant.	Limited surface water present. Only more tolerant taxa present, including tadpoles (observed in December 2016).	The biota associated with this feature are common tolerant species known to occur in still water environments. Species with an affinity for vegetation biotopes are dominant.	The biota associated with this feature are common tolerant species known to occur in still water environments. Species with an affinity for vegetation biotopes are dominant.

5.2 Analysis and comparison of water quality with established guidelines

Each quantified parameter was compared to the following guidelines:

- South African Water Quality Guidelines for aquatic ecosystems, recreation, agricultural use and drinking water (DWAF 1996);
- The General and Special Limits for the discharge of wastewater into a watercourse (DWAF 1999), and;
- The resource quality objectives for the Upper Olifants River catchment (DWS 2016). Please note as none of the aquatic resources assessed have riverine characteristics OREWA was only considered as a tentative guideline.

The method of comparison is further specified in Appendix 1. The results of the *in situ* and laboratory analyses are presented in Appendix 2 and 3. Appendix 2 details the data obtained, Appendix 3 presents the compliance of each measurement with the guidelines listed above in a tabular format and also presents temporal comparisons for sites RK01 and RK04. A discussion on the suitability of the water at each of the monitoring points to the applicable water uses assessed is presented below.

RK02 and RK04 both represent a natural depression and should therefore be considered as the monitoring points in the most natural condition. However, the nature of each of the monitoring points is highly variable such that it is challenging to compare the water quality of the monitoring points to each other – for instance RK04 has likely been influenced by a road crossing through it whereas RK02 has no such crossing. Thus, any comparisons made were done so with caution.

It is also important to note, that standards were not presented in the guideline documents for thirty-nine parameters, and therefore only the baseline result is presented together with updates from the May 2021 results (latter for sites RK01 and RK04 only, see Appendix 2). This may be due to the rarity of the parameters in the environment, and in South Africa, or else a reflection of the significance (or un-importance thereof) of each element. Future assessments once mining commenced will allow for these parameters to be assessed relative to the reference state (baseline considering both the 2016 and May 2021 results) to determine changes over time that might be associated with the proposed Rietkol silica mine. Results are presented for the parameters listed in Table 4 below.

Table 4: Quantified chemical parameters for which no water use standard was available from the selected water quality guidelines.

Caesium (mg/l)	Gold (mg/l)	Neodymium (mg/l)	Scandium (mg/l)	Thorium (mg/l)
Cerium (mg/l)	Hafnium (mg/l)	Niobium (mg/l)	Silicon (mg/l)	Thullium (mg/l)
Dysprosium (mg/l)	Holmium (mg/l)	Osmium (mg/l)	Silver (mg/l)	Tin (mg/l)
Erbium (mg/l)	Indium (mg/l)	Palladium (mg/l)	Strontium (mg/l)	Titanium (mg/l)
Europium (mg/l)	Iridium (mg/l)	Platinum (mg/l)	Tantalum (mg/l)	Tungsten (mg/l)
Gadolinium (mg/l)	Lanthanum (mg/l)	Rhodium (mg/l)	Tellurium (mg/l)	Ytterbium (mg/l)
Gallium (mg/l)	Lead (mg/l)	Rubidium (mg/l)	Terbium (mg/l)	Yttrium (mg/l)
Germanium (mg/l)	Lutetium (mg/l)	Samarium (mg/l)	Thallium (mg/l)	Thorium (mg/l)

Thirty-six of the parameters quantified had a recommended standard or guideline for at least one water use. The suitability of water at each of the monitoring points was calculated based upon the degree of compliant vs. non-compliant parameters with each of the standards stipulated for the water application. The results of this assessment are presented in Figures 6 to 8 that follow.

The compliance of several of the quantified parameters with the various applicable guidelines could not be determined as the stipulated standard was below the detection limit. For example, at baseline (04 February 2016 assessment) the ammonia concentration at RK01 was <0.1 mg/l, and the DWAF 1996 guideline for the concentration in aquatic ecosystems is <0.0007 mg/l. It was considered best practice to approach this issue by applying the precautionary principle and assuming that the parameter was non-compliant with the standard. Therefore, the water at each of the monitoring points might be more suitable for each of the water uses. In cases where less than three data values were above the detection limit at a site, the values above the detection limit were utilised alone in order to determine compliance (i.e. the value below the detection limit was excluded from the statistical analysis).

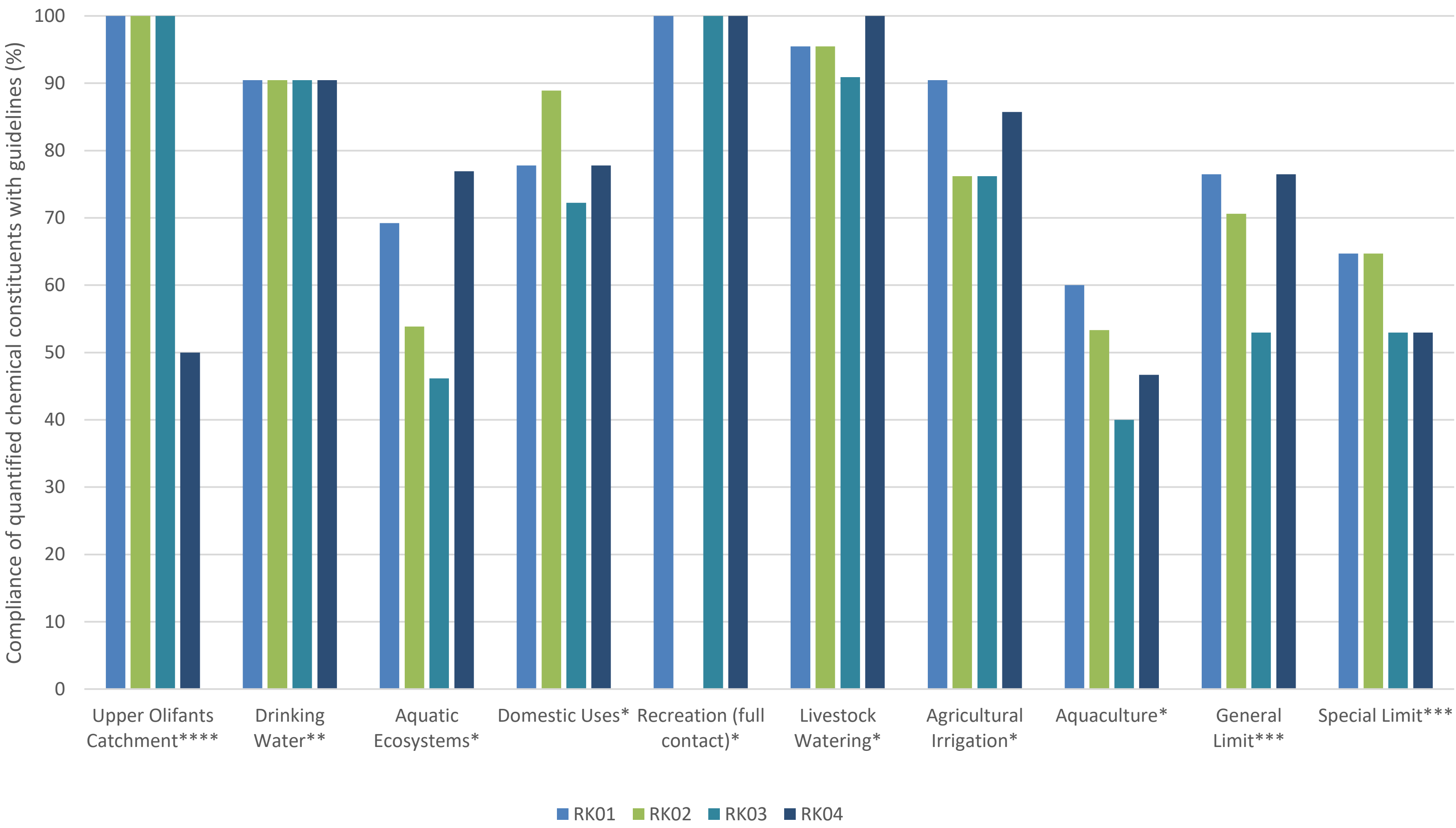
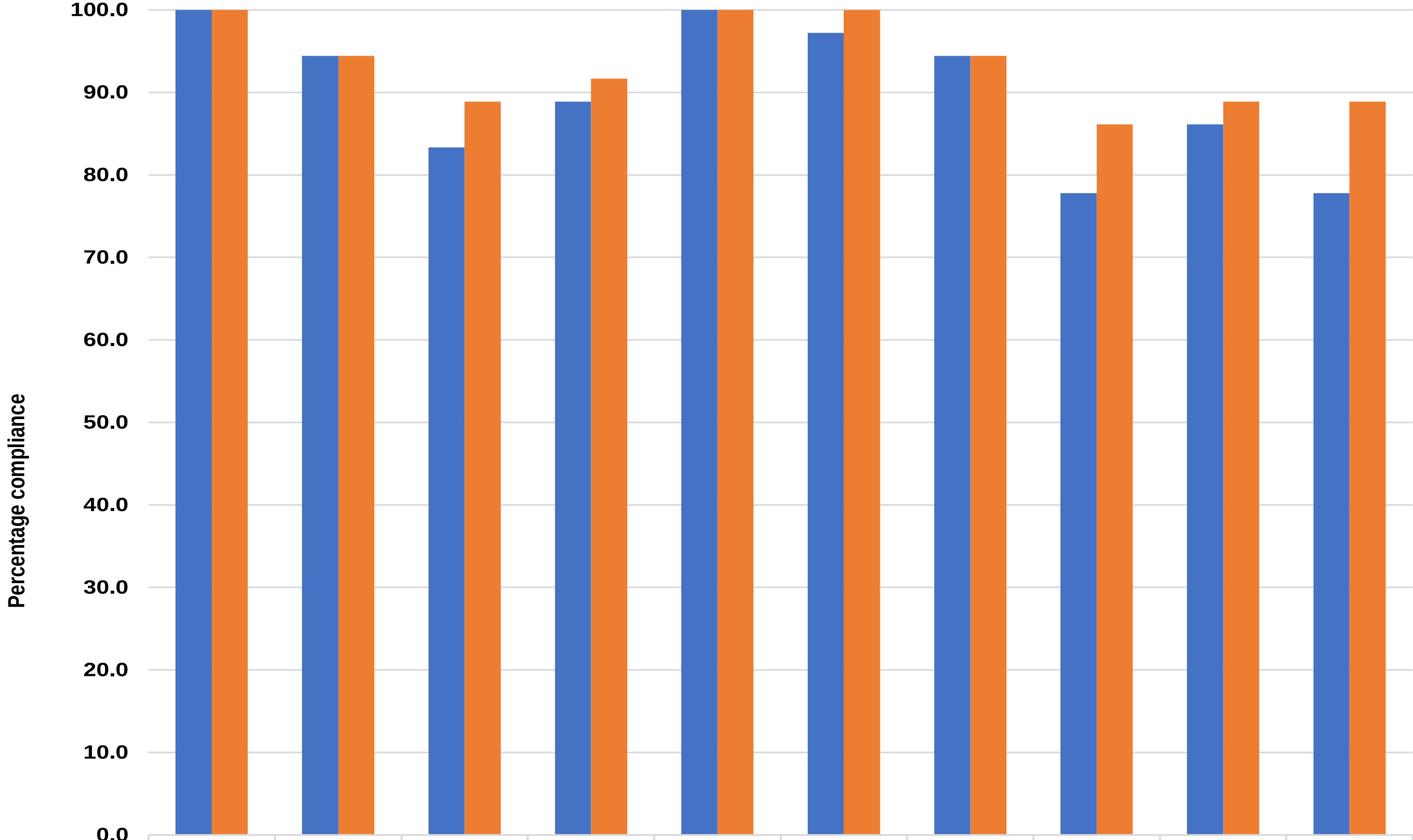


Figure 6: Compliance of the quantified parameters for each monitoring point with the stipulated guidelines at for initial 2016 baseline data.

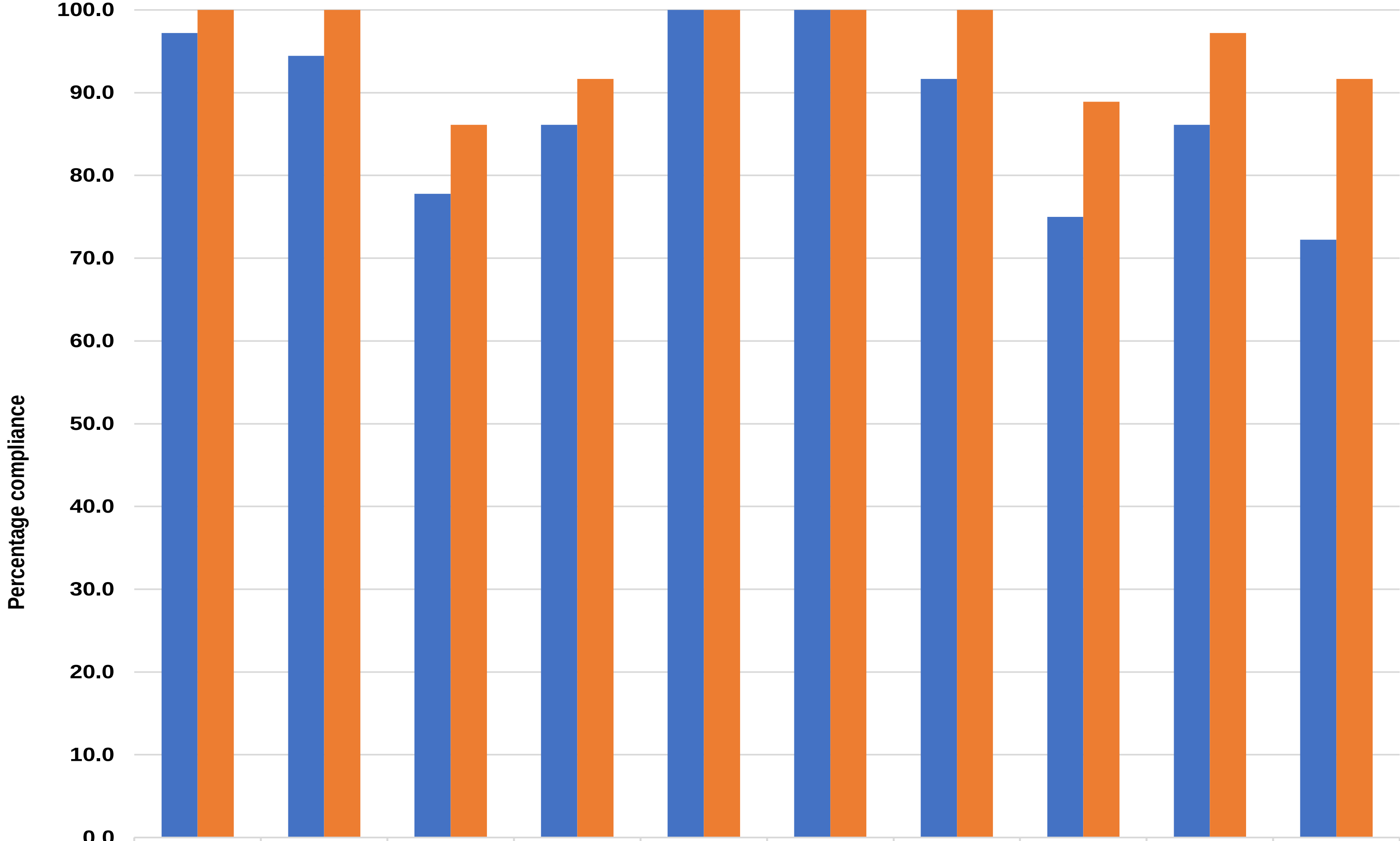
*DWAF 1996
**SANS 241 (2015)
*** DWAF 1999
****DWS 2016
^It is noted that no value is shown pertaining to the compliance of RK02 with the DWAF (1996) TWQR for recreation as a 0% compliance value was determined.



	Upper Olifants Catchment****	Drinking Water**	Aquatic Ecosystems*	Domestic Uses*	Recreation (Full Contact)*	Livestock Watering*	Agricultural Irrigation*	Aquaculture*	General Limit**	Special Limit***
RK01 2016 % compliance	100.0	94.4	83.3	88.9	100.0	97.2	94.4	77.8	86.1	77.8
RK01 2021 % compliance	100.0	94.4	88.9	91.7	100.0	100.0	94.4	86.1	88.9	88.9

*DWAF 1996
**SANS 241 (2015)
*** DWAF 1999
****DWS 2016

Figure 7: Compliance of the quantified parameters for each monitoring point with the stipulated guidelines in the May 2021 baseline assessment (compared to that in 2016 for site RK01 to update baseline condition status).



	Upper Olifants Catchment****	Drinking Water**	Aquatic Ecosystems*	Domestic Uses*	Recreation (Full Contact)*	Livestock Watering*	Agricultural Irrigation*	Aquaculture*	General Limit**	Special Limit***
RK04 2016 % compliance	97.2	94.4	77.8	86.1	100.0	100.0	91.7	75.0	86.1	72.2
RK04 2021 % compliance	100.0	100.0	86.1	91.7	100.0	100.0	100.0	88.9	97.2	91.7

*DWAF 1996
**SANS 241 (2015)
*** DWAF 1999
****DWS 2016

Figure 8: Compliance of the quantified parameters for each monitoring point with the stipulated guidelines in the May 2021 baseline assessment (compared to that in 2016 for site RK04 to update baseline condition status).

5.2.1 Water quality with reference to aquatic ecosystem integrity

Initial baseline assessment performed 2016:

Figure 6 indicates that the baseline water quality at RK01-03 is in line with the water quality standards recommended for the Upper Olifants Catchment. The TDS at RK04 exceeded this guideline by 1.1X. However, the water quality standards for the Upper Olifants Catchment only encompass basic water quality parameters, whereas the DWAF 1996 guidelines for aquatic ecosystems is more comprehensive. The water at the monitoring points complied with between 46% (RK03) and 77% (RK04) of the TWQR for aquatic ecosystems. The parameters which exceeded the TWQR in 2016 (see comparison with 2021 results in section to follow: "Additional May 2021 baseline analysis results compared to 2016 data to update baseline water quality status") are identified below, with the maximum level of exceedance presented as well:

- At all monitoring points the average 2016 baseline mean concentrations of ammonia (819X), copper (566X), lead (1 100X) and zinc (100X) exceeded the TWQR. [It is noted that the detection limit was not above the guideline in all instances [e.g. in February 2016 the value was below the detection limit (<0.1) whilst the guideline recommendation for aquatic ecosystems are ≤ 0.007 – due to the precautionary approach followed these were then considered as potentially exceeding the guideline and processed as such, hence any interpretations from these calculations should be interpreted with caution). This potentially indicates significant heavy metal contamination as well as contamination from nitrogen rich substances prior to any mining activity taking place;
- The concentration of arsenic exceeded the TWQR at RK01, 03, and 04, by a maximum of 2.4X;
- The concentration of manganese exceeded the TWQR at RK02, 03, and 04 by a maximum of 12.5X;
- The concentration of dissolved oxygen exceeded the TWQR at RK02 by a maximum of 1.08X; and
- The concentration of selenium and TDS exceeded the TWQR at RK04, respectively by a maximum of 1.5X and 1.1X.

Therefore, it is shown that the environmental state of the system prior to the development of the proposed Rietkol silica mine cannot be considered as pristine.

The recommended standards for the non-compliant constituents within aquatic ecosystems are all significantly low relative to other constituents (Appendix 3) i.e. trace metals versus nonmetals. This is due to the high toxicological risk each of the non-compliant constituent poses to the receiving environment.

The toxicity of ammonia is related to its potential to transform into ammonium. The occurrence and concentration of ammonium in aquatic ecosystems significantly increases the probability of eutrophication, which can result in an anoxic environment and severely reduce the biodiversity of the ecosystem.

The transformation of ammonia into ammonium is triggered by changes in the pH, whereby an increase in the pH results in a concomitant increase in ammonium. Thus, by extension, the concentrations of ammonia can be toxic to aquatic biota.

Furthermore, the bioavailability and toxicity of chromium, lead, zinc and copper are inversely related to changes in pH and water hardness. Manganese, lead, zinc and copper are only soluble in high concentrations at low pH levels (less than 6.5). These metals are not inherently toxic (some of them are considered essential metals for metabolic health). However, the metals become toxic at high concentrations by disrupting protein synthesis through diluting other constituents in the cells and binding to the protein themselves (thus resulting in malformations which can result in cellular malfunctions). Thus, decreases in pH increase the metals' solubility, bioavailability and toxicological potential, and vice versa for ammonia. Therefore, the risk posed by these potential toxicants to the receiving environment is highly sensitive to any alterations in the pH.

The average pH range at RK01-4 lies between 6.4 pH at RK02 and 7.7 pH at RK04. The pH continuum reflected at RK01-04 means that only a relatively small degree of buffering from influxes of hydrogen ions (or hydroxide ions) is present. Therefore, the system can be considered to be moderately sensitive to changes in pH.

The TDS and selenium were only quantified as exceeding the TWQR only at RK04, however this may have been a result of existing water uses – where water is abstracted from and discharged into RK04 in order to support the agricultural activities by Rosgro. Therefore, the system should not be considered naturally turbid or high in selenium.

The average EC across all of the monitoring points ranged from 5.37mS/m, 11mS/m, 23mS/m and 33mS/m respectively at RK01 – 4. Indicating that all of the features can be described as having a relatively medium salinity in this environment, and that the salinity across the features is highly variable. These data indicate that the features can be considered to have a low sensitivity to changes in salinity, as the features currently had moderate levels of salinity with high variability, as described above.

Clear separation of clean and dirty water associated with the proposed Rietkol silica mine is thus deemed essential as is strict planning in line with the requirements of Regulation GN704 in order to minimise any potential changes in pH, and other water quality variables as well.

Additional May 2021 baseline analysis results compared to 2016 data to update baseline water quality status:

From Figures 7 and 8 it is clear that trends in percentage of parameters that complies with the TWQR in May 2021 remained largely the same compared to the 2016 baseline data.

Percentage compliance was in fact generally higher during the May 2021 baseline assessment compared to the 2016 baseline assessment. However, this needs to be interpreted with caution as the results were affective by increased sensitivity of the analyses (i.e. decreased detection limits in 2021 compared to 2016). For example, for several parameters the detection limit for 2016 analyses was <0.010 mg/l, but was < 0.001 mg/l in 2021.

Using total copper (Cu) at site RK04 as an example, the detection limits was as described above. As precautionary approach, for any TWQR that exceeds the detection limit, it was assumed that the actual value exceeded the guideline recommendation. The DWAF (1996) TWQR for aquaculture for copper is stated as <0.005 mg/l. For 2016 (initial baseline results) with a detection limit of <0.010 mg/l the precautionary principle would dictate that the actual value is scored as exceeding the guideline requirement (which may not necessarily be the case). For the May 2021 baseline assessment where the detection limit was <0.001 mg/l, which is lower than 0.005 mg/l, the parameter is scored as meeting the guideline recommendation, hence resulting in a generally higher compliance percentage for the May 2021 assessment. Considering the precautionary approach applied, actual values and resulting percentage compliance results are in reality likely more similar than that reported in Figures 7 and 8, suggesting that there was likely no significant change in baseline water quality status.

Regarding parameters for which the aquatic ecosystem TWQR were exceeded at sites RK01 and RK04 compared to that in 2016, the following is evident:

- As for the mean 2016 assessment values, May 2021 results indicate that concentrations of ammonia (20% increase from baseline at site RK01 and unchanged at site RK04), zinc (84% increase from baseline at site RK01 and 40% increase from baseline at site RK04), copper and lead (for both these parameters below detection at both RK01 and RK04 but still considered not compliant as per precautionary measure, as TWQR are lower than the detection limit) exceeded the TWQR. Results for these parameters thus largely remained unchanged between the 2016 and 2021 results, apart from the increase in zinc evident at both sites in May 2021;

- Whilst the concentration of arsenic exceeded the TWQR at RK01 and 04 in 2016, the parameter was below detection (and compliant with TWQR) at RK01 in May 2021. However, this parameter was also not compliant with the TWQR at RK04 in May 2021 and increased by 15% compared to the mean value in 2016;
- The concentration of manganese exceeded the TWQR at RK04 in 2016, but in 2021 complied with the TWQR (67% reduction compared to 2016);
- The concentration of selenium and TDS exceeded the TWQR at RK04, but in 2021 complied with the TWQR (compared to 2016 there was a 96.7% reduction in selenium and 11.3% reduction in TDS).

5.2.2 Water quality with reference to identified and potential water applications

Initial baseline assessment performed 2016:

Figure 6 indicates that the only water application for which RK01, 03 and 04 were suited for is full contact recreational use. Full contact recreational use includes fully submersive activities such as swimming. However, no other monitoring point was considered 100% suitable for any other use.

- The water at all of the monitoring points complied with 90% of the SANS 241 (2015) drinking water standards. This was due to the concentration of iron and manganese which were above the recommended guideline at all monitoring points, and respectively by a maximum of 64X and 23X. At these concentrations the metals can be considered potentially toxic to humans and thus the water should not be utilised for consumption without treatment. High concentrations of manganese are toxic and can cause the disruption of metabolic pathways in the central nervous system in particular (DWAF 1996). The effects of toxic doses of iron include depression, rapid and shallow respiration, coma, convulsions, respiratory failure and cardiac arrest (WHO 1996);
- The water at the monitoring points complied with between 72% (RK03) and 89% (RK02) of the DWAF (1996) TWQR for domestic uses. Similar to the above, the concentration of iron and manganese exceeded the TWQR, and also the concentration of mercury at all monitoring points. However, it is noted that the quantified concentration of mercury (2016 baseline detection limit value of <0.010 mg/l) was above the TWQR guideline (0 mg/l), thus compliance could not be determined, and employing the precautionary approach it was thus assumed that the actual values exceeded the guideline recommendation. The concentration of lead and ammonia exceeded the TWQR for domestic use at RK03, and the concentration of selenium exceeded the TWQR at RK04. As discussed above, and in section 4.2.1, these

constituents have significant potential toxicological risk at these concentrations, and this water is not deemed fit for domestic uses or full contact recreational use;

- The water at the monitoring points complied with between 91% (RK03) and 100% (RK04) of the TWQR for livestock watering. Specifically, the concentration of molybdenum at RK01 and RK02 exceeded the TWQR by 13X and 3X. The concentration of iron and boron at RK03 were respectively above the TWQR by 2X each. Molybdenum is considered highly toxic to organisms and may potentially also have bioaccumulation implications for humans. On this basis, and in comparison with the DWAF (1996) TWQR, RK01, 02, and 03 resources should not be utilised for livestock watering. RK04 may be utilised on the basis that the DWAF (1996) guidelines determine it to be suitable for such use; and
- The water at the monitoring points complied with between 76% (RK02 and RK03) and 90% (RK01) of the TWQR for irrigation. The concentration of manganese was above the TWQR at all of the monitoring points, and by a maximum of 113X at RK03. The concentration of boron, and cobalt at RK03 exceeded the TWQR by 18X and 1.2X. The concentration of molybdenum exceeded the TWQR at RK01 and RK02 by 3X and 13X. Additionally, the concentration of suspended solids exceeded the TWQR of 50 mg/l at RK02-04, and by a maximum of 128X at RK03. The TSS concentration is not considered to be of a high concern for irrigation, however due to potential bioaccumulation the concentration of boron, cobalt, manganese and molybdenum are. Water from these resources should not be considered fit for irrigation, unless cautious monitoring is undertaken.

The visual assessment identified that RK01 and RK04 are likely being utilised for irrigation, and RK04 is likely also being utilised for informal domestic use. The water quality at these resources is not considered suitable for these uses. The continuation of irrigation may be justifiable if cautious monitoring of crops is undertaken in order to determine bioaccumulation. Additionally, these constituents may accumulate in irrigated soils over time increasing the toxicological risk and this aspect should also be monitored if use continues.

Additional May 2021 baseline analysis results compared to 2016 data to update baseline water quality status:

The percentage change in parameter values for sites RK01 and RK04, comparing May 2021 baseline results to that of the 2016 baseline value, is tabulated in Table 3a and Table 3d, respectively. Please note that, to allow calculations to be performed in cases where values were below detection, the detection limit value was used in the calculation. Using total copper (Cu) at site RK04 as an example, the detection limit at baseline (2016) was <0.010 mg/l but was < 0.001 mg/l in May 2021. As a result, the respective values used in the calculation was

0.010 and 0.001, resulting in a percentage reduction of 90%. Such results must be interpreted with caution and is indicative that values at the least remained the same, but potentially decreased (improved).

At site RK01, the following parameters presented with a temporal increase: ammonia (20.0%), boron (150.0%), calcium (389.5%), EC (337.6%), iron (15.9%), magnesium (809.1%), manganese (100%), pH (7.1%), potassium (148.6%), sodium (900.0%), suspended solids (285.2%), total dissolved solids (238.3%) and zinc (84.5%).

At site RK04, the following parameters presented with a temporal increase: arsenic (15.0%), boron (47.5%), EC (3.9%), pH (2.6%), potassium (62.8%), sodium (1.9%), sulphate (63.6%) and zinc (40.0%).

Temporal variability, comparing May 2021 baseline data to 2016 baseline data, is thus evident at both sites RK01 (more pronounced) and RK04 prior to any potential impact from the proposed mining activity. Parameters for which concentrations increased at both sites were boron, EC, pH, potassium, sodium and zinc.

5.2.3 Baseline water quality with reference to potential anthropogenic pollutant fluxes

It should be noted that the baseline water quality at RK01-04 was not fully compliant with the General or Special Limit for the discharge of wastewater into a watercourse.
This included the concentrations of copper, iron, lead, manganese, mercury, TSS and zinc at all of the monitoring points. Therefore, it is shown that the environmental state of the system prior to the development of the proposed Rietkol silica mine is impacted. Thus, it is recommended that all possible pollution prevention measures be implemented within the mining operations of the proposed Rietkol silica mine to minimise cumulative impacts on the water sources.

5.3 IMPACT ASSESSMENT

This baseline assessment forms part of the EIA phase of an Environmental Authorisation Application for the proposed Rietkol silica mine, as stipulated in the National Environmental Management Act (NEMA) (Act 107 of 1998). As part of the Environmental Authorisation an S&EIR must be conducted.

It should also be noted that should any infrastructure be located within 100m of a wetland feature this will trigger water use activities as defined in the National Water Act (Act 36 of

1998), General Notices 704 and 509, and potentially require authorisation in the form of a Water Use Licence Application. It must be noted that the revised layout proposal from 2021 now reflects the layout area to be outside of the 100 m Zone of Regulation as per GN 704.

As part of the EIA phase, the baseline water quality data were used in conjunction with the proposed mine plan to assess the potential impacts that the proposed silica mine might have upon the water quality of the aquatic resources identified. Also, mitigatory actions were developed in order to prevent, or lessen the severity of each potential impact. The activities and aspects which may lead to these impacts are described in detail in section 4 above.

The method used to determine the potential impacts associated with the proposed silica mine, and to develop the mitigatory actions, are described in detail in Appendix 1, and the section below presents the results of that assessment.

Factors Considered In the Impact Assessment:

The following considerations, summarised and based on the data presented in sections 4, 5.1 and 5.2 above, were included in the assessment of the impact:

- The baseline water quality (considering both the 2016 and 2021 assessments) indicates that the freshwater resources cannot be considered to be in a pristine condition. More specifically, it is considered unlikely that they are sensitive to changes in salinity (specifically a moderate input of salts) as the waters are already considered to have moderate levels of salinity. However, the water resources only have a small pH buffering capacity, and thus would be sensitive to any acidic waters that are discharged into them (where the pH is less than 5). However, inputs of acid generating substances are not anticipated with the proposed activities;
- The baseline water quality investigation determined that the water at all of the resources was unfit for any water use without treatment, with the potential exception of irrigation (only conducted under specific monitoring protocols and with permission from the Department of Agriculture, Fisheries, and Forestry);
- Few water uses were potentially associated with the water resources. Furthermore, all of the water resources can be considered as endorheic systems and do not appear to have any strong linkages to the wider water network. These considerations imply that from a water use point of view, their ecoservices value can be viewed as relatively limited, and their ecological value in the context of the wider catchment can also be viewed as relatively limited. (The formal ecosystem services provided by these features was quantified by a qualified Wetland Ecologist in a specialist report (SAS 2021), kindly refer should additional information be required);

- Conversely, the ecology of endorheic systems is more vulnerable to potential contaminants as the residence time and potential accumulation of contaminants is significantly higher compared to an exoreic system. Because of this potential exposure time and accumulation, the ecology of endorheic systems are particularly vulnerable to metal contamination as these constituents can have toxicological impacts at low concentrations;
- All of the monitoring points are located at varying distances from the proposed mine, which also influences the potential significance of the impacts. RK01 is located most proximally to the proposed mine (within ~20m based on the initial infrastructure layout area). However, the currently proposed layout area position makes provision for infrastructure to fall outside of the 100 m Zone of Regulation (of the Hillslope Seep in which RK01 is located) as per GN 704. The next point closest to the proposed mine is RK02 (> 200m from the first 20 year mining blocks), RK03 (within ~600m) and RK04 (within ~970m). Although RK03 is significantly further from the proposed mine than RK02, the hydrology of the two resources is strongly connected, and impacts upon RK02 are likely to also affect RK03. RK04 however, is the most hydrologically isolated monitoring point because:
  - RK04 is the furthest water resource from the mine;
  - A depression wetland associated with RK02, and several croplands, are located between the proposed mine and the water resource associated with RK04;
  - Due to site RK04 relative proximity to RK02 and RK03, groundwater linkage may in theory potentially occur. However, no direct groundwater linkage to the surface water resources was identified in the geohydrological and hydropedological reports. Any potential impact via groundwater on the assessed sites will likely be insignificant.

  Based upon the above, the potential risks to RK04 have a lower probability of occurring because of its location relative to the other monitoring points on this basis, the water quality impact assessment must be divided into two sections – the first pertaining to potential impacts upon the water quality at RK01-03, and the second pertaining to impacts upon RK04, and;

- In addition to the above considerations, it should also be noted that the topography appears to indicate that drainage from both the proposed open cast pit, and infrastructure area is towards the south – i.e. towards the depression wetland associated with RK02 (Figure 2). This suggests that uncontrolled dirty stormwater from the proposed mine does have the potential to affect RK01, RK02, and RK03. Based upon the elevation, and because the wetland associated with RK02 is a depression, surface drainage between RK02 and RK04 is limited.

- The geohydrological report concluded that no decant from the open pits is expected to occur (Groundwater Complete 2021).

Latent impacts as a result of the proposed mine include disturbance of soils, changes in topography and drainage (although these should be minimised through post closure rehabilitation and placement of mining infrastructure outside of the 100m wetland buffer), infrastructure (buildings and roads) and also the potential proliferation of alien and invasive vegetation (if this is not effectively controlled). Unintended edge effects, such as the establishment of an illegal township, may also contribute to the latent impacts.

In terms of cumulative impacts, little mining in the region occurs and the predominant land use is agricultural (medium to high density use). However, should the proposed mine contribute to the impairment of the water resources then this will place additional cumulative pressure on these endorheic resources.

Mitigation and Management Recommendations:

To reduce the impacts upon water quality and aquatic biota associated with the proposed mine it is recommended that the following mitigation measures be implemented:

Stormwater Management

- Given that water will be re-used within the mining process, with 20% evaporation during each cycle, there is a high probability that contaminants of potential concern will concentrate over time. Thus, the process water dam should be lined with an appropriate impermeable liner system, and it should be assured that the liner remains intact for the life of mine, including post closure, should the closed water system still be necessary. Additionally, the capacity of the dam should be designed and operated to ensure capacity for a 1:50 year flood event at all times;
- A professional engineer should be engaged, with input from an environmental specialist, to develop a comprehensive stormwater management plan for the proposed mine. The plan must include proven effective measures for the separation and control of clean and dirty stormwater runoff. All dirty stormwater runoff should be contained and not allowed to pollute the surrounding freshwater resources – this includes runoff potentially contaminated by activities associated with stockpile areas, service yards, parking and loading bays, as well as the crusher, screening and washing facility, and

drier. Dirty runoff also includes areas where soils have only been bared – although no mining may have taken place in these areas, they may still contribute to increases in TSS and deterioration of water quality if released. Additionally, clean water must be discharged into the natural environment in a non-erosive and controlled manner, and not allowed to form concentrated channels;

- Ensure that as far as possible all infrastructure and roads are placed outside of the freshwater resources – maintaining at least a 32m buffer. Failure to do so may result in increased TSS, oil and grease and other constituents in the water quality;
- During the operational phase of the proposed mining project, erosion berms should be installed on roadways to prevent gully formation and cumulative siltation of the aquatic resources leading to impaired water quality. The following points should serve to guide the placement of erosion berms:
  - Where the track has slope of less than 2%, berms every 50m should be installed;
  - Where the track slopes between 2% and 10%, berms every 25m should be installed;
  - Where the track slopes between 10%-15%, berms every 20m should be installed;
  - Where the track has slope greater than 15%, berms every 10m should be installed, and;
- All erosion noted within the MRA area should be remedied immediately and included as part of an ongoing rehabilitation plan in order to further minimise potential increases in TSS in the water resources.

Storage, Handling and Spills

- Proactive prevention of leakages from storage areas will decrease the probability of surface water contamination as well as the loss of costly materials. Thus, all chemicals and explosives must be stored in appropriately bunded and covered areas (if applicable). The appropriate Material Safety Datasheets, or Safety Data Sheets (as per the updated 2015 Globally Harmonised System of Classifying and Labelling Chemicals), should be utilised to guide any special instructions (such as types of container, instructions for use, transport, etc.). Liquids – such as diesel – should be stored within a bunded area capable of containing 110% volume of the container/s in case of leakages. It is recommended that chemical storage areas be inspected for leaks or drainage on at least a weekly basis. In cases where rainfall into the bunded area may be confused with a leak, it is recommended that management consider covering the area in order to allow for accurate leak detection, and;

- No dumping of waste should take place within the freshwater features. If any spills occur, they should be immediately cleaned up.

Stockpiling

- No material may be deposited or stockpiled within any of the freshwater resources in the vicinity of the proposed mining project, and;
- Ensure that all stockpiles are well managed and have measures such as berms and – in the case of stockpiles that are not going to be continuously utilised – are protected with hessian sheets to prevent erosion and sedimentation, which may lead to lead to impaired water quality in the resources. The need and application of these recommendations should be determined *in situ* by the site environmental officer. As stated above, these measures should be implemented into the stormwater management plan.

Protect and retain the filtration and assimilation capability of the water resources

- All areas of increased ecological sensitivity (i.e. the freshwater resources and areas which are important in terms of recharge) should be designated as “No-Go” areas and be off limits to all unauthorised vehicles and personnel during all phases of the proposed mining project. Disturbance of soils in recharge areas and wetland vegetation can affect the water quality of these resources and may lead to anoxic conditions in particular;
- Due to the proximity of the proposed mine to the wetland resources (which can become dry in winter), no smoking should be allowed outside of authorised smoking areas in order to reduce the risk of fire. These areas should be determined *in situ* by the site safety and environmental officer. Should a fire occur the water filtering capability of the wetland may be severely limited, and ash may lead to anoxic conditions;
- Limit the footprint area of the mining and associated activities to what is absolutely essential in order to minimise the loss of clean water runoff areas and catchment yield and the concomitant recharge of water resources in the area;
- Mining must be planned to ensure that the impact on downstream wetlands due to potential dewatering/drying out of the wetland features is minimised as far as possible in order to minimise potential impacts upon the water quality within these resources. This must be informed by a detailed hydrogeological assessment and hydropedological study;
- Given that the potential dewatering and abstraction of groundwater may lead to drying out of the freshwater resources and concentration of constituents in the water, it is also

optionally recommended that the resources be monitored for this via soil moisture content and changes in vegetation structure over time. This is deemed particularly important as the proposed pit might create a cone of depression once dewatering has ceased, if mining has commenced below the water table (to be determined by a hydrogeological study). This impact should be monitored so as to inform the development and need for adaptations to a wetland rehabilitation plan in order to minimise impacts upon water quality. This monitoring will also contribute towards a potential due diligence defence and liability in the event of legal ramifications;

- Very strict control of water consumption must take place. Detailed monitoring must be implemented and maintained to ensure that all water usage is continuously optimised.
- Tailings material from the plant will be dumped into the North Block during the operational phase of mining. This fine material will effectively "plug" the mine void, allowing for very little water infiltration and no decant is therefore envisaged. Mining and related infrastructure will be demolished during the decommissioning phase and the resulting building rubble is planned to be disposed of into the South Block and the remainder of the void filled with water (Groundwater Complete 2021). Backfilling is thus envisioned for the North Block and partial backfilling for the South Block. For the latter, drainage patterns in the landscape are unlikely to be fully restored, impacting upon the hydrology of the water resources which has bearing upon the water quality. Should lower volumes of water enter these endorheic systems then constituents may concentrate leading to impaired water quality;
- Disturbed areas or exposed soils not earmarked for use must be rehabilitated to minimise canalisation, sedimentation and erosion during all phases – should stormwater runoff from these areas enter the water resources they may impair water quality;
- All topsoil should be stored in specifically identified stockpiles for rehabilitation purposes, and not mixed with tailings. This stockpile must be covered with an impermeable material in order to prevent seepage. This will lessen the likelihood of topsoil having to be imported (which may contain alien and invasive species), and also assist in preserving the fertility of the topsoil to be utilised for rehabilitation purposes. Effective rehabilitation of the landscape will minimise potential siltation of the water resources, and impairment of the water quality, and;
- As an example of good corporate governance, it is mine must advise personnel of the importance of not impacting upon the wetland associated with RK02 (as part of the induction training). However, as this will be privately owned land and not purchased by the mine, potential activities such as grazing of cattle, subsistence farming, or the establishment of informal settlements will be outside of the direct control of the mine.

Although the mine would not likely be strictly liable for these impacts, these activities have the potential to impair the quality of water associated with the freshwater resources.

Table 5: Risk assessment for the operational/mining, closure, care and maintenance phases of the proposed Rietkol Silica Mine.

ID	Environmental Aspect	Potential Impact	Nature of Impact	Duration	Extent	Probability	Intensity	Weighting factor	Impact Significance	Significant Points	Proposed Mitigation measures	Mitigation Efficiency	Impact Significance
Construction Phase													
1	Water Quality Impact	Impact upon the water quality associated with RK01 - RK03	Negative	Temporary	Site specific	Improbable	Insignificant	Low	Low	5	Numerous, detailed measures are proposed. Kindly see text.	Medium	3 (Low)
2	Water Quality Impact	Impact upon the water quality associated with RK04	Negative	Temporary	Site specific	Rare	Insignificant	Low	Low	4	Numerous, detailed measures are proposed. Kindly see text.	Medium	2,4 (Low)
Operational Phase													
3	Water Quality Impact	Impact upon the water quality associated with RK01 - RK03	Negative	Long Term	Site specific	Definite	Medium	Medium	Low to Medium	39	Numerous, detailed measures are proposed. Kindly see text.	High	7.8 (Low)
4	Water Quality Impact	Impact upon the water quality associated with RK04	Negative	Long Term	Site specific	Improbable	Low	Low	Low	9	Numerous, detailed measures are proposed. Kindly see text.	Medium to High	4,6 (Low)
Closure Phase													
5	Water Quality Impact	Impact upon the water quality associated with RK01 - RK03	Negative	Long Term	Site specific	Highly Probable	Medium	Medium	Low to Medium	36	Numerous, detailed measures are proposed. Kindly see text.	Medium to High	14,4 (Low)
6	Water Quality Impact	Impact upon the water quality associated with RK04	Negative	Long Term	Site specific	Improbable	Low	Low to Medium	Low	18	Numerous, detailed measures are proposed. Kindly see text.	Medium to High	7,2 (Low)

ID	Environmental Aspect	Potential Impact	Nature of Impact	Duration	Extent	Probability	Intensity	Weighting factor	Impact Significance	Significant Points	Proposed Mitigation measures	Mitigation Efficiency	Impact Significance
Care & Maintenance Phase													
7	Water Quality Impact	Impact upon the water quality associated with RK01 - RK03	Negative	Permanent	Site specific	Rare	Low	Low	Low	9	Numerous, detailed measures are proposed. Kindly see text.	Not Efficient	9 (Low)
8	Water Quality Impact	Impact upon the water quality associated with RK04	Negative	Permanent	Site specific	Rare	Insignificant	Low	Low	8	Numerous, detailed measures are proposed. Kindly see text.	Not Efficient	8 (Low)

From the results of the table above, it can be seen that:

- The water quality impacts associated with RK01 – 03 during all phases, and with or without management measures in place, will be higher than that of RK04;
- Without management the highest impacts are associated with the operational phase for monitoring points RK01 – 03, and the closure phase for RK04 (the reasons for this are detailed in the point below). However, with the implementation of appropriate stormwater and other management controls these impacts can be reduced at RK01 – 03 (from medium-low to low) and at RK04 (by 11 points within the low category), and;
- With the implementation of monitoring measures, the most significant impacts would likely occur during the operational phase due to edge effects associated with mining. Any potential impact would be of low significance for all resources.

In summary, it was determined that with the implementation of the readily practicable mitigation measures during the clearing/construction phase, operational/mining and the closure phase the impact upon RK01-RK03 could be reduced to low. With mitigation the potential impact upon RK04 during the operational/mining phase and the closure phase can be reduced to low. With, and without implementation, the impacts upon water quality associated with the care and maintenance phase upon all of the monitored resources was low. Based upon the above, with the implementation of mitigation measures as is planned, the significance of the impacts upon the water quality of all resources and during all phases is anticipated to be low. Thus, from a water quality and water resource management point of view, the project can be considered favourably, however consideration must be given to the findings of the Freshwater ecological assessment.

6 CONCLUSION AND RECOMMENDATIONS

Four water resources were identified within a 500m boundary of the MRA area of the proposed Rietkol silica mine:

- An artificial impoundment associated within the hillslope seep wetland located within the MRA area (RK01);
- A natural depression wetland (RK02) and associated artificial impoundment (RK03), and
- A depression wetland, which has an open water body associated with it (RK04) and is dammed as a result of road crossings.

RK04 is located outside of, but adjacent to, the MRA area. Although the MRA area will encompass RK01, RK02 and RK03, the planned open cast pit and infrastructure area will not intersect the freshwater features.

Water quality data in 2016 were garnered from RK01 – RK03 during three sampling runs spanning different seasons, and RK04 was sampled during a single sampling run. A second baseline assessment was conducted in May 2021, and was considered supplementary to that performed in 2016, to more accurately assess current baseline water quality status. The data on selected water quality variables were then assessed, tabulated and compared to the following guidelines:

- South African Water Quality Guidelines for aquatic ecosystems, recreation, agricultural use and drinking water (DWAF 1996);
- The General and Special Limits for the discharge of wastewater into a watercourse (DWAF 1999), and;
- The resource quality objectives for the Upper Olifants River catchment (General Notice 466 of 2016). Please note as none of the aquatic resources assessed had riverine characteristics, and that the most proximally linked OREWA resource unit was located ~28km to the north of the study area, OREWA was only considered as a tentative guideline for management of resources within the greater catchment.

The following conclusions and recommendations were made:

- The water quality at RK01-03 is in line with the water quality standards recommended for the Upper Olifants Catchment. However, the water quality standards for the Upper Olifants Catchment only encompass basic water quality parameters, whereas the DWAF 1996 guidelines for aquatic ecosystems is more comprehensive. The water at the monitoring points complied with between 46% (RK03) and 77% (RK04) of the

TWQR for aquatic ecosystems. Thus, the environmental state of the system prior to the development of the proposed Rietkol silica mine cannot be considered as pristine;

- The only water application for which RK01, 03 and 04 were suited for is full contact recreational use. Full contact recreational use includes fully submersive activities such as swimming. However, no other monitoring point was considered 100% suitable for any other use.
- The visual assessment identified that RK01 and RK04 are likely being utilised for irrigation, and RK04 is likely also being utilised for informal domestic use. The water quality at these resources is not considered suitable for this use, which should cease. The continuation of irrigation may be justifiable if cautious monitoring of crops is undertaken in order to determine bioaccumulation. Additionally, these constituents may accumulate in irrigated soils over time increasing the toxicological risk and this aspect should also be monitored if use continues. However, in its current state, it is recommended that all use of water from RK01-04 for irrigation cease permanently.
- Trends in percentage of parameters that complies with the TWQR at sites RK01 and RK04 that was also assessed in May 2021, remained largely the same compared to the 2016 baseline data.
- Regarding temporal changes in individual parameter values, temporal variability [comparing May 2021 baseline data to baseline (2016) data], was evident at both sites RK01 (more pronounced) and RK04 prior to any potential impact from the proposed mining activity. Parameters for which concentrations increased at both sites were boron, EC, pH, potassium, sodium and zinc. Ongoing monitoring of these trends should continue.

The quantified water quality baseline data, and particularly those data that exceeded the various guidelines, should be considered by the regulating authority when setting licensed limits for the mine.

Lastly, an impact assessment was conducted, and it was determined that with the implementation of mitigation measures as is planned, the significance of the impacts upon the water quality of all resources and during all phases will be low. Thus, the project cannot be considered as fatally flawed from a surface water resource and water quality perspective. A detailed list of mitigation measures is presented in section 5.3.

7 REFERENCES

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APPENDIX 1: METHOD OF ASSESSMENT

Desktop assessments undertaken

A desktop study was compiled with all relevant information as presented by the South African National Biodiversity Institute's (SANBI's) Biodiversity Geographic Information Systems (BGIS) website (http://bgis.sanbi.org). Wetland specific information resources taken into consideration during the desktop assessment of the study area included:

- National Freshwater Ecosystem Priority Areas (NFEPAs, 2011);
  - NFEPA water management area (WMA);
  - FEPA (sub)WMA % area;
  - Sub water catchment area FEPAs;
  - Water management area FEPAs, and;
- Threatened Terrestrial Ecosystems for South Africa, 2009.

Additionally, studies undertaken by the Institute for Water Quality Studies assessed all quaternary catchments as part of the Resource Directed Measures for Protection of Water Resources. This database was consulted in order to inform the characterisation of the system. In these assessments, the Ecological Importance and Sensitivity (EIS), Present Ecological Management Class (PEMC) and Desired Ecological Management Class (DEMC) were defined, and serve as a useful guideline in determining the importance and sensitivity of aquatic ecosystems.

The aquatic resources identified will be generally classified according to the degree of modification or level of impairment. The classes used by the South African River Health Program (RHP) are presented in the table below and will be used as the basis of classification of the systems in the study area.

Table 1aClassification of river health assessment classes in line with the RHP

Class	Description
A	Unmodified, natural.
B	Largely natural, with few modifications.
C	Moderately modified.
D	Largely modified.
E	Extensively modified.
F	Critically modified.

In addition, the ecological category (EC) classification will be employed using the eco-status A to F continuum approach (Kleynhans and Louw 2007). This approach allows for boundary categories denoted as B/C, C/D etc., as illustrated in Figure 1a.

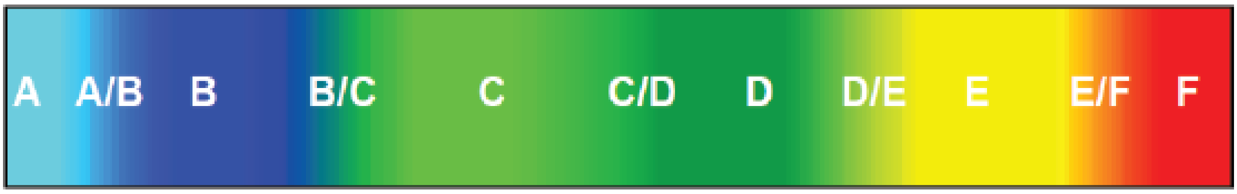

Figure 1a: Ecological categories (EC) eco-status A to F continuum approach employed (Kleynhans and Louw 2007)

Site selection process

Sites were selected based on their locality to the mining right area and the results of the desktop assessment. Four aquatic resources were identified within close proximity to the proposed Rietkol silica mine.

The desktop assessment clearly indicated an artificial impoundment located within the south eastern corner of the proposed Rietkol silica mine. This site (RK01) was selected for further investigation, as were two others. A wetland feature was identified 80 meters to the south of the proposed Rietkol silica mine (RK02), and an artificial impoundment was identified within the south-western boundary of the wetland (RK03) and 900m south of the proposed Rietkol silica mine. A revision of the proposed MRA area was published following the first two site visits, and a further natural depression wetland that has been dammed by a road was identified as a monitoring point (RK04).

Sampling technique

A field assessment was carried out on the 4th of February, the 12th of June, and the 6th of December 2016, whereby each site was investigated in order to identify visible impacts on the site, with specific reference to impacts from surrounding activities and specifically the proximity of intensive agriculture to each of the monitoring points. Both natural constraints placed on ecosystem structure and function, as well as anthropogenic alterations to the system, were identified by observing conditions and relating them to professional experience. Photographs of each site were taken to provide visual indications of the conditions at the time of assessment. Factors which were noted in the site specific visual assessments included the following:

- Salt build-up around the aquatic resources;
- Erosion potential (of the depression wetlands specifically);
- Depth flow and substrate characteristics;
- Signs of physical disturbance of the area, and;
- Other life forms reliant on aquatic ecosystems.

Following this *in situ* water sampling and water analysis was conducted at each of the selected monitoring points.

In situ sampling and water analysis

The water quality at RK01-4 were quantified through the use of both *in situ* measurements and laboratory analyses.

A Hanna Combo pH & EC tester were used *in situ* to quantify:

- pH;
- Electrical conductivity;
- Total dissolved solid concentration, and;
- Temperature.

Water samples were taken at each site, stored in an insulated environment, and transported directly to a SANAS accredited laboratory for analysis following their extraction. The following parameters were quantified:

- Suspended solid concentration;
- Sulphate concentration;
- Nitrate concentration;
- Silica concentration;
- Ortho-phosphate;
- Free and saline ammonia concentration;
- Ammonium concentration, and;
- Mass spectroscopy of all metal constituents.

Chain of custody and cold chain management

Immediately following the extraction of water from the aquatic resources each sample was stored in an icebox and following the completion of sampling at all of the selected monitoring sites the water samples were transported directly to a SANAS accredited laboratory for storage and analysis and arrived at the laboratory within 12 hours of sampling.

Data analysis

The baseline water quality chemical analyses quantified seventy five chemical constituents at each of the four monitoring points. Data were analysed as per the directions specified in the DWAF (1996) Guideline for aquatic ecosystems, whereby the recommended statistic for eacfh parameter was calculated and compared to each of the appropriate guideline. In this case, for all parameters this recommended statistic was the average of the dataset. The data on selected water quality variables were then tabulated and compared to the following guidelines:

- South African Water Quality Guidelines for aquatic ecosystems, recreation, agricultural use and drinking water (DWAF 1996);
- The General and Special Limits for the discharge of wastewater into a watercourse (DWAF 1999), and;

- The resource quality objectives for the Upper Olifants River catchment (OREWA) (DWS 2016). Please note as none of the aquatic resources assessed had riverine characteristics OREWA was only considered as a tentative guideline.

The outcomes of these comparisons indicate the current compliance of the aquatic resources with the established guidelines. Any non-compliance of water quality to the established guidelines was noted and may be compared with subsequent assessments in order to determine any impacts the proposed development might pose.

Spatial variation and probably hydrological linkages between each of the monitoring points, and RK02-4 in particular, were considered in order to contextualise the possible impacts upon the receiving catchment. Linkages or common water quality impacts between the aquatic resources that might be indicate catchment wide impacts occurring prior to the assessment were also considered.

Impact Assessment Methodology

Impact Significance

Nature and Status

The ‘nature’ of the impact describes what is being affected and how. The ‘status’ is based on whether the impact is positive, negative or neutral.

Spatial Extent

'Spatial Extent' defines the spatial or geographical scale of the impact.

Category	Rate	Descriptor
Site	1	Site of the proposed development
Local	2	Limited to site and/or immediate surrounds
District	3	Victor Khanye Local Municipal Area
Region	4	Nkangalai District Municipal Area
Provincial	5	Mpumalanga Province
National	6	South Africa
International	7	Beyond South African borders

Duration

'Duration' gives the temporal scale of the impact.

Category	Rate	Descriptor
Temporary	1	0 – 1 years
Short term	2	1 – 5 years
Medium term	3	5 – 15 years
Long term	4	Where the impact will cease after the operational life of the activity either because of natural process or by human intervention
Permanent	5	Where mitigation either by natural processes or by human intervention will not occur in such a way or in such a time span that the impact can be considered as transient

Probability

The 'probability' describes the likelihood of the impact actually occurring.

Category	Rate	Descriptor
Rare	1	Where the impact may occur in exceptional circumstances only
Improbable	2	Where the possibility of the impact materialising is very low either because of design or historic experience
Probable	3	Where there is a distinct possibility that the impact will occur
Highly probable	4	Where it is most likely that the impact will occur
Definite	5	Where the impact will occur regardless of any prevention measures

Intensity

'Intensity' defines whether the impact is destructive or benign, in other words the level of impact on the environment.

Category	Rate	Descriptor
Insignificant	1	Where the impact affects the environment is such a way that natural, cultural and social functions and processes are not affected. Localised impact and a small percentage of the population is affected
Low	2	Where the impact affects the environment is such a way that natural, cultural and social functions and processes are affected to a limited extent
Medium	3	Where the affected environment is altered in terms of natural, cultural and social functions and processes continue albeit in a modified way
High	4	Where natural, cultural or social functions or processes are altered to the extent that they will temporarily or permanently cease
Very High	5	Where natural, cultural or social functions or processes are altered to the extent that they will permanently cease and it is not possible to mitigate or remedy the impact

Ranking, Weighting and Scaling

The weight of significance defines the level or limit at which point an impact changes from low to medium significance, or medium to high significance. The purpose of assigning such weights serves to highlight those aspects that are considered the most critical to the various stakeholders and ensure that the element of bias is taken into account. These weights are often determined by current societal values or alternatively by scientific evidence (norms, etc.) that define what would be acceptable or unacceptable to society and may be expressed in the form of legislated standards, guidelines or objectives.

The weighting factor provides a means whereby the impact assessor can successfully deal with the complexities that exist between the different impacts and associated aspect criteria.

Spatial Extent	Duration	Intensity / Severity	Probability	Weighting factor	Significance Rating (SR - WOM) Premitigation	Mitigation Efficiency (ME)	Significance Rating (SRWM) Post Mitigation
Site (1)	Short term (1)	Insignificant (1)	Rare (1)	Low (1)	Low (0 – 19)	High (0.2)	Low (0 – 19)
Local (2)	Short to Medium term (2)	Minor (2)	Unlikely (2)	Low to Medium (2)	Low to Medium (20 – 39)	Medium to High (0.4)	Low to Medium (20 – 39)
District (3)							
Regional (4)	Medium term (3)	Medium (3)	Possible (3)	Medium (3)	Medium (40 – 59)	Medium (0.6)	Medium (40 – 59)
Provincial (5)	Long term (4)	High (4)	Likely (4)	Medium to High (4)	Medium to High (60 – 79)	Low to Medium (0.8)	Medium to High (60 – 79)
National (6)							
International (7)	Permanent (5)	Very high (5)	Almost certain (5)	High (5)	High (80 – 110)	Low (1.0)	High (80 – 110)

Impact significance without mitigation (WOM)

Following the assignment of the necessary weights to the respective aspects, criteria are summed and multiplied by their assigned weightings, resulting in a value for each impact (prior to the implementation of mitigation measures).

Equation 1:

Significance Rating (WOM) = (Extent + Intensity + Duration + Probability) x Weighting Factor

Effect of Significance on Decision-makings

Significance is determined through a synthesis of impact characteristics as described in the above paragraphs. It provides an indication of the importance of the impact in terms of both tangible and intangible characteristics. The significance of the impact "without mitigation" is the prime determinant of the nature and degree of mitigation required.

Rating	Rate	Descriptor
Negligible	0	The impact is non-existent or insignificant, is of no or little importance to decision making.
Low	1-19	The impact is limited in extent, even if the intensity is major; the probability of occurrence is low and the impact will not have a significant influence on decision-making and is unlikely to require management intervention bearing significant costs.
Low to Medium	20 – 39	The impact is of importance, however, through the implementation of the correct mitigation measures such potential impacts can be reduced to acceptable levels. The impact and proposed mitigation measures can be considered in the decision-making process
Medium	40 – 59	The impact is significant to one or more affected stakeholder, and its intensity will be medium or high; but can be avoided or mitigated and therefore reduced to acceptable levels. The impact and mitigation proposed should have an influence on the decision.

Medium to High	60 -79	The impact is of major importance but through the implementation of the correct mitigation measures, the negative impacts will be reduced to acceptable levels.
High	80 – 110	The impact could render development options controversial or the entire project unacceptable if it cannot be reduced to acceptable levels; and/or the cost of management intervention will be a significant factor and must influence decision making.

Mitigation

“Mitigation” is a broad term that covers all components of the ‘mitigation hierarchy’ defined hereunder. It involves selecting and implementing measures, amongst others, to conserve biodiversity and to protect, the users of biodiversity and other affected stakeholders from potentially adverse impacts because of mining or any other land use. The aim is to prevent adverse impacts from occurring or, where this is unavoidable, to limit their significance to an acceptable level. Offsetting of impacts is considered the last option in the mitigation hierarchy for any project.

The mitigation hierarchy in general consists of the following in order of which impacts should be mitigated:

- Avoid/prevent impact: can be done through utilising alternative sites, technology and scale of projects to prevent impacts. In some cases, if impacts are expected to be too high, the “no project” option should also be considered, especially where it is expected that the lower levels of mitigation will not be adequate to limit environmental damage and eco-service provision to suitable levels.
- Minimise (reduce) impact: can be done through utilisation of alternatives that will ensure that impacts on biodiversity and eco-services provision are reduced. Impact minimisation is considered an essential part of any development project.
- Rehabilitate (restore) impact is applicable to areas where impact avoidance and minimisation are unavoidable where an attempt to re-instate impacted areas and return them to conditions which are ecologically similar to the pre-project condition or an agreed post project land use, for example arable land. Rehabilitation can however not be considered as the primary mitigation toll as even with significant resources and effort rehabilitation that usually does not lead to adequate replication of the diversity and complexity of the natural system. Rehabilitation often only restores ecological function to some degree to avoid ongoing negative impacts and to minimise aesthetic damage to the setting of a project. Practical rehabilitation should consist of the following phases in best practice:
  - Structural rehabilitation which includes physical rehabilitation of areas by means of earthworks, potential stabilisation of areas as well as any other activities required to develop a long terms sustainable ecological structure;
  - Functional rehabilitation, which focuses on ensuring that the ecological functionality of the ecological resources on the subject property supports the intended post-closure land use. In this regard, special mention is made of the need to ensure the continued functioning and integrity of wetland and riverine areas throughout and after the rehabilitation phase;
  - Biodiversity reinstatement that focuses on ensuring that a reasonable level of biodiversity is re-instated to a level that supports the local post-closure land uses. In this regard, special mention is made of re-instating vegetation to levels which will allow the natural climax vegetation community of community suitable for supporting the intended postclosure land use; and
  - Species reinstatement that focuses on the re-introduction of any ecologically important species, which may be important for socio-cultural reasons, ecosystem functioning reasons and for conservation reasons. Species re-instatement need only occur if deemed necessary.
- Offset impact: refers to compensating for latent or unavoidable negative impacts on biodiversity. Offsetting should take place to address any impacts deemed unacceptable which cannot be mitigated through the other mechanisms in the mitigation hierarchy. The objective of biodiversity offsets should be to ensure no net loss of biodiversity. Biodiversity offsets can be considered a last resort to compensate for residual negative impacts on biodiversity.

According to the DMR (2013) "Closure" refers to the process for ensuring that mining operations are closed in an environmentally responsible manner, usually with the dual objectives of ensuring sustainable post-mining land uses and remedying negative impacts on biodiversity and ecosystem services.

The significance of residual impacts should be identified on a regional as well as national scale when considering biodiversity conservation initiatives. If the residual impacts lead to irreversible loss or irreplaceable biodiversity, the residual impacts should be considered to be of very high significance and when residual impacts are considered to be of very high significance, offset initiatives are not considered an appropriate way to deal with the magnitude and/or significance of the biodiversity loss. In the case of residual impacts determined to have medium to high significance, an offset initiative may be investigated. If the residual biodiversity impacts are considered of low significance, no biodiversity offset is required.

Impact significance with mitigation measures (WM)

In order to gain a comprehensive understanding of the overall significance of the impact, after implementation of the mitigation measures, it is necessary to re-evaluate the impact.

Mitigation Efficiency (ME)

The most effective means of deriving a quantitative value of mitigated impacts is to assign each significance rating value (WOM) a mitigation effectiveness (ME) rating. The allocation of such a rating is a measure of the efficiency and effectiveness, as identified through professional experience and empirical evidence of how effectively the proposed mitigation measures will manage the impact. Thus, the lower the assigned value the greater the effectiveness of the proposed mitigation measures and subsequently, the lower the impacts with mitigation.

Equation 2: Significance Rating (WM) = Significance Rating (WOM) x Mitigation Efficiency (ME)

Mitigation Efficiency is rated out of 1 as follows:

Category	Rate	Descriptor
Not Efficient (Low)	1	Mitigation cannot make a difference to the impact
Low to Medium	0.8	Mitigation will minimize impact slightly
Medium	0.6	Mitigation will minimize impact to such an extent that it becomes within acceptable standards
Medium to High	0.4	Mitigation will minimize impact to such an extent that it is below acceptable standards
High	0.2	Mitigation will minimize impact to such an extent that it becomes insignificant

Significance Following Mitigation (SFM)

The significance of the impact after the mitigation measures are taken into consideration. The efficiency of the mitigation measure determines the significance of the impact. The level of impact is therefore seen in its entirety with all considerations taken into account.

APPENDIX 2: WATER QUALITY RESULTS AS ASSESSED BY A SANAS ACCREDITED LABORATORY AND *IN SITU* MEASUREMENTS.

Table 2a: Baseline water quality results (recorded as mg/l) quantified at monitoring points (RK01-03) associated with the proposed Rietkol silica mine, near Delmas, Mpumalanga Province on the 4th of February 2016.

Origin	Ag	Al	As	Au	B	Ba	Be	Bi	Ca	Cd	Ce	Co
RK01	<0.010	0.317	0.018	<0.010	0.050	0.066	<0.010	<0.010	4	<0.010	<0.010	<0.010
RK02	<0.010	4.11	<0.010	<0.010	0.049	0.039	<0.010	<0.010	2	<0.010	<0.010	<0.010
RK03	<0.010	1.59	<0.010	<0.010	0.027	0.058	<0.010	<0.010	5	<0.010	<0.010	<0.010

Origin	Cr	Cs	Cu	Dy	Er	Eu	Fe	Ga	Gd	Ge	Hf	Hg
RK01	<0.010	<0.010	0.165	<0.010	<0.010	<0.010	3.34	0.012	<0.010	<0.010	<0.010	<0.010
RK02	<0.010	<0.010	0.047	<0.010	<0.010	<0.010	4.33	<0.010	<0.010	<0.010	<0.010	<0.010
RK03	<0.010	<0.010	0.014	<0.010	<0.010	<0.010	8.78	0.013	<0.010	<0.010	<0.010	<0.010

Origin	Ho	In	Ir	K	La	Li	Lu	Mg	Mn	Mo	Na	Nb
RK01	<0.010	<0.010	<0.010	3.7	<0.010	0.033	<0.010	1	0.294	0.132	1	<0.010
RK02	<0.010	<0.010	<0.010	7.2	<0.010	0.011	<0.010	2	0.524	0.026	14	<0.010
RK03	<0.010	<0.010	<0.010	7.3	<0.010	<0.010	<0.010	3	0.070	<0.010	1	<0.010

Origin	Nd	Ni	Os	P	Pb	Pd	Pt	Rb	Rh	Ru	Sb	Sc
RK01	<0.010	0.027	<0.010	0.407	<0.010	<0.010	<0.010	0.013	<0.010	<0.010	<0.010	<0.010
RK02	<0.010	0.026	<0.010	0.541	<0.010	<0.010	<0.010	0.008	<0.010	<0.010	<0.010	<0.010
RK03	<0.010	0.053	<0.010	0.180	<0.010	<0.010	<0.010	0.014	<0.010	<0.010	<0.010	<0.010

Origin	Se	Si	Sm	Sn	Sr	Ta	Tb	Te	Th	Ti	Tl	Tm
RK01	<0.010	3.3	<0.010	<0.010	0.215	<0.010	<0.010	<0.010	<0.010	0.093	<0.010	<0.010
RK02	<0.010	16.7	<0.010	<0.010	0.054	<0.010	<0.010	<0.010	<0.010	0.158	<0.010	<0.010
RK03	<0.010	5.4	<0.010	<0.010	0.081	<0.010	<0.010	<0.010	<0.010	0.073	<0.010	<0.010

Origin	U	V	W	Y	Yb	Zn	Zr					
RK01	<0.010	<0.010	<0.010	<0.010	<0.010	0.126	<0.010					
RK02	<0.010	0.012	<0.010	<0.010	<0.010	0.085	<0.010					
RK03	<0.010	<0.010	<0.010	<0.010	<0.010	0.028	<0.010					

Table 2b: Baseline water quality results (recorded as mg/l) quantified at monitoring points (RK01 and RK03) associated with the proposed Rietkol silica mine, near Delmas, Mpumalanga Province on the 12th of June 2016.

Origin	Ag	Al	As	Au	B	Ba	Be	Bi	Ca	Cd	Ce	Co
RK01	< 0.010	< 0.100	< 0.010	< 0.010	0.011	0.070	< 0.010	< 0.010	4	< 0.010	< 0.010	< 0.010
RK03	< 0.010	7.69	0.024	< 0.010	0.022	0.448	< 0.010	< 0.010	20	< 0.010	0.110	0.060
Origin	**Cr**	**Cs**	**Cu**	**Dy**	**Er**	**Eu**	**Fe**	**Ga**	**Gd**	**Ge**	**Hf**	**Hg**
RK01	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0.297	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
RK03	0.016	< 0.010	0.017	< 0.010	< 0.010	< 0.010	37	0.026	< 0.010	< 0.010	< 0.010	< 0.010
Origin	**Ho**	**In**	**Ir**	**K**	**La**	**Li**	**Lu**	**Mg**	**Mn**	**Mo**	**Na**	**Nb**
RK01	< 0.010	< 0.010	< 0.010	4.6	< 0.010	< 0.010	< 0.010	1	0.061	< 0.010	1	< 0.010
RK03	< 0.010	< 0.010	< 0.010	45	0.036	< 0.010	< 0.010	8	6.46	< 0.010	19	< 0.010
Origin	**Nd**	**Ni**	**Os**	**P**	**Pb**	**Pd**	**Pr**	**Pt**	**Rb**	**Rh**	**Ru**	**S**
RK01	< 0.010	< 0.010	< 0.010	0.056	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	379
RK03	< 0.010	0.202	< 0.010	1.543	0.022	< 0.010	0.010	< 0.010	0.050	< 0.010	< 0.010	3918
Origin	**Sb**	**Sc**	**Se**	**Si**	**Sm**	**Sn**	**Sr**	**Ta**	**Tb**	**Te**	**Th**	**Ti**
RK01	< 0.010	< 0.010	< 0.010	0.4	< 0.010	< 0.010	0.021	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
RK03	< 0.010	< 0.010	0.015	15.9	< 0.010	< 0.010	0.208	< 0.010	< 0.010	< 0.010	< 0.010	0.109
Origin	**Tl**	**Tm**	**U**	**V**	**W**	**Y**	**Yb**	**Zn)**	**Zr**			
RK01	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010			
RK03	< 0.010	< 0.010	< 0.010	0.046	< 0.010	0.022	< 0.010	0.065	< 0.010			

Table 2c: Baseline water quality results (recorded as mg/l) quantified at monitoring points (RK01-04) associated with the proposed Rietkol silica mine, near Delmas, Mpumalanga Province on the 6th of December 2016.

Origin	Ag	Al	As	Au	B	Ba	Be	Bi)	Ca	Cd	Ce)	Co
RK01	< 0.010	1.07	< 0.010	< 0.010	0.015	0.073	< 0.010	< 0.010	4	< 0.010	< 0.010	< 0.010
RK02	< 0.010	1.91	< 0.010	< 0.010	0.046	0.140	< 0.010	< 0.010	4	< 0.010	0.010	< 0.010
RK03	< 0.010	3.70	< 0.010	< 0.010	0.039	0.073	< 0.010	< 0.010	5	< 0.010	< 0.010	< 0.010
RK04	< 0.010	0.280	0.022	< 0.010	0.040	0.093	< 0.010	< 0.010	31	< 0.010	< 0.010	< 0.010
Origin	**Cr**	**Cs**	**Cu**	**Dy**	**Er**	**Eu**	**Fe**	**Ga**	**Gd**	**Ge**	**Hf**	**Hg**
RK01	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	1.65	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
RK02	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	5.84	0.016	< 0.010	< 0.010	< 0.010	< 0.010
RK03	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	11	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
RK04	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	2.44	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Origin	**Ho**	**In**	**Ir**	**K**	**La**	**Li**	**Lu**	**Mg**	**Mn**	**Mo**	**Na**	**Nb**
RK01	< 0.010	< 0.010	< 0.010	2.7	< 0.010	< 0.010	< 0.010	1	0.170	< 0.010	< 1	< 0.010
RK02	< 0.010	< 0.010	< 0.010	4.1	< 0.010	0.010	< 0.010	2	3.44	< 0.010	14	< 0.010
RK03	< 0.010	< 0.010	< 0.010	9.3	< 0.010	< 0.010	< 0.010	2	0.235	< 0.010	2	< 0.010
RK04	< 0.010	< 0.010	< 0.010	1.3	< 0.010	< 0.010	< 0.010	21	0.229	< 0.010	11	< 0.010
Origin	**Nd**	**Ni**	**Os)**	**P**	**Pb**	**Pd**	**Pr)**	**Pt**	**Rb**	**Rh**	**Ru**	**Sb**
RK01	< 0.010	< 0.010	< 0.010	1.17	< 0.010	< 0.010	< 0.010	< 0.010	0.010	< 0.010	< 0.010	< 0.010
RK02	< 0.010	< 0.010	< 0.010	2.09	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
RK03	< 0.010	< 0.010	< 0.010	2.09	< 0.010	< 0.010	< 0.010	< 0.010	0.018	< 0.010	< 0.010	< 0.010
RK04	< 0.010	< 0.010	< 0.010	1.04	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Origin	**Sc**	**Se**	**Si**	**Sm**	**Sn**	**Sr**	**Ta**	**Tb**	**Te**	**Th**	**Ti**	**Tl**
RK01	< 0.010	0.024	2.5	< 0.010	< 0.010	0.020	< 0.010	< 0.010	< 0.010	< 0.010	0.033	< 0.010
RK02	< 0.010	0.017	5.4	< 0.010	< 0.010	0.024	< 0.010	< 0.010	< 0.010	< 0.010	0.059	< 0.010
RK03	< 0.010	0.023	9.0	< 0.010	< 0.010	0.051	< 0.010	< 0.010	< 0.010	< 0.010	0.126	< 0.010
RK04	< 0.010	0.031	1.7	< 0.010	< 0.010	0.078	< 0.010	< 0.010	< 0.010	< 0.010	0.048	< 0.010
Origin	**Tm**	**U**	**V**	**W**	**Y**	**Yb**	**Zn**	**Zr**				
RK01	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0.272	< 0.010				
RK02	< 0.010	< 0.010	0.011	< 0.010	< 0.010	< 0.010	0.397	< 0.010				
RK03	< 0.010	< 0.010	0.015	< 0.010	< 0.010	< 0.010	0.067	< 0.010				
RK04	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0.058	< 0.010				

Table 2d: May 2021 water quality results (recorded as mg/l unless otherwise indicated) quantified at monitoring points RK01 and RK04, associated with the proposed Rietkol silica mine, near Delmas, Mpumalanga Province as analysed on the 24th of May 2021.

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CERTIFICATE OF ANALYSES

GENERAL WATER QUALITY PARAMETERS

Date received: 2021-05-14 **Date completed:** 2021-05-24
Project number: 244 **Report number:** 100400 **Order number:**

Client name: Scientific Aquatic Services **Contact person:** Stephen van Staden
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Telephone: 011 616 7893 **Facsimile:** 011 615 4106 **Mobile:** 0834152356

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification: Rietkol	
			RK01	RK04
Sample Number			127793	127794
Date/Time Sampled			N/A	N/A
pH - Value @ 25 °C	A	WLAB065	7.5	7.9
Electrical Conductivity in mS/m @ 25°C	A	WLAB002	23.5	34.6
Total Dissolved Solids @ 180°C	A	WLAB003	118	192
Suspended Solids at 105°C	A	WLAB004	80	6.0
Sulphate as SO_4	A	WLAB046	<2	18
Nitrate as N	A	WLAB046	<0.1	<0.1
Nitrite as N	A	WLAB046	<0.05	<0.05
Ortho Phosphate as P	A	WLAB046	<0.1	<0.1
Dissolved Oxygen as O_2	N	WLAB040	7.0	8.0
Gold as Au	N	WLAB050	<0.001	<0.001
Cerium as Ce	N	WLAB050	0.003	<0.001
Caeslum as Cs	N	WLAB050	<0.001	<0.001
Dysprosium as Dy	N	WLAB050	<0.001	<0.001
Erbium as Er	N	WLAB050	<0.001	<0.001
Europium as Eu	N	WLAB050	<0.001	<0.001
Gadolinium as Gd	N	WLAB050	<0.001	<0.001
Germanium as Ge	N	WLAB050	<0.001	<0.001
Hafnium as Hf	N	WLAB050	0.001	<0.001
Holmium as Ho	N	WLAB050	<0.001	<0.001
Iridium as Ir	N	WLAB050	<0.001	<0.001
Lanthanum as La	N	WLAB050	0.001	<0.001
Lutetium as Lu	N	WLAB050	<0.001	<0.001
Niobium as Nb	N	WLAB050	<0.001	<0.001
Neodymium as Nd	N	WLAB050	0.001	<0.001
Osmium as Os	N	WLAB050	<0.001	<0.001
Praseodymium as Pr	N	WLAB050	<0.001	<0.001
Platinum as Pt	N	WLAB050	<0.001	<0.001
Ruthenium Ru	N	WLAB050	<0.001	<0.001
Scandium as Sc	N	WLAB050	0.002	0.001

J. Ngobeza - Chemical Technical Signatory

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Contact person: Stephen van Staden
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Mobile: 0834152356

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification: Rietkol	
			RK01	RK04
Sample Number			127793	127794
Date/Time Sampled			N/A	N/A
Samarium as Sm	N	WLAB050	<0.001	<0.001
Tantalum as Ta	N	WLAB050	<0.001	<0.001
Terbium as Tb	N	WLAB050	<0.001	<0.001
Thulium as Tm	N	WLAB050	<0.001	<0.001
Yttrium as Y	N	WLAB050	<0.001	<0.001
Ytterbium as Yb	N	WLAB050	<0.001	<0.001
Free and Saline Ammonia as N	A	WLAB046	0.3	0.1
Sodium as Na	A	WLAB015	6	11
Potassium as K	A	WLAB015	9.1	2.1
Calcium as Ca	A	WLAB015	21	27
Magnesium as Mg	A	WLAB015	10	20
Aluminium as Al	A	WLAB015	0.172	<0.100
Antimony as Sb	A	WLAB050	<0.001	0.001
Arsenic as As	A	WLAB050	<0.001	0.023
Arsenic as As (µg/ℓ)	A	WLAB050	<1	23
Barium as Ba	N	WLAB050	0.088	0.042
Beryllium as Be	N	WLAB050	<0.001	<0.001
Bismuth as Bi	N	WLAB050	<0.001	<0.001
Boron as B	N	WLAB050	0.050	0.059
Cadmium as Cd	A	WLAB050	<0.001	<0.001
Chromium as Cr	N	WLAB050	<0.001	<0.001
Indium as In	N	WLB050	<0.001	<0.001
Cobalt as Co	N	WLAB050	0.001	<0.001
Copper as Cu	N	WLAB050	<0.001	<0.001
Gallium as Ga	N	WLAB050	0.012	0.006
Iron as Fe	A	WLAB015	2.04	0.182
Lead as Pb	A	WLAB050	0.003	<0.001
Palladium as Pd	N	WLAB050	0.001	<0.001
Lithium as Li	N	WLAB050	<0.001	0.003
Manganese as Mn	A	WLAB015	0.360	0.075
Mercury as Hg	A	WLAB047	<0.001	<0.001
Molybdenum as Mo	N	WLAB050	<0.001	0.002

J. Ngobeza - Chemical Technical Signatory

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sanas Testing Laboratory T0391

CERTIFICATE OF ANALYSES

GENERAL WATER QUALITY PARAMETERS

Date received: 2021-05-14 **Date completed:** 2021-05-24
Project number: 244 **Report number:** 100400 **Order number:**

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			Sample Identification: Rietkol	
			RK01	RK04
			127793	127794
			N/A	N/A
Nickel as Ni	N	WLAB050	0.001	0.003
Rubidium as Rb	N	WLAB050	0.009	0.002
Rhodium as Rh	N	WLAB050	<0.001	<0.001
Phosphorus as P	N	WLAB050	0.090	0.044
Selenium as Se	A	WLAB050	<0.001	<0.001
Silicon as Si	N	WLAB015	0.2	3.3
Silver as Ag	N	WLAB050	<0.001	<0.001
Strontium as Sr	N	WLAB050	0.050	0.047
Tellurium as Te	N	WLAB050	<0.001	<0.001
Thallium as Tl	N	WLAB050	<0.001	<0.001
Thorium as Th	N	WLAB050	<0.001	<0.001
Tin as Sn	N	WLAB050	<0.001	<0.001
Titanium as Ti	N	WLAB050	0.011	0.014
Tungsten as W	N	WLAB050	<0.001	<0.001
Uranium as U	A	WLAB050	<0.001	<0.001
Vanadium as V	N	WLAB050	0.001	0.001
Zinc as Zn	N	WLAB050	0.369	0.084
Zirconium as Zr	N	WLAB050	<0.001	<0.001

J. Ngobeza - Chemical Technical Signatory

A = Accredited N = Not Accredited S = Subcontracted
Tests marked "Not SANAS Accredited" in this report are not included in the SANAS Schedule of Accreditation for this Laboratory.

Results marked "Subcontracted Test" in this report are not included in the SANAS Schedule of accreditation for this Laboratory.

Sample condition acceptable unless specified on the report.

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APPENDIX 3: COMPARISON OF WATER QUALITY RESULTS FOR RK01 to RK04 WITH STIPULATED GUIDELINES

Table 3a: Quantified water quality at RK01 (2016 baseline and May 2021), and compliance with the DWS (2016), SANS 241 (2015), DWAF (1996) and DWAF (1999) water quality guidelines.

Parameter	RK01 baseline a	RK01 baseline b	RK01 baseline c	RK01 baseline mean	RK01 (May 2021)	Current vs baseline (%)	DWS 2016	SANS 241 (2015)	DWAF 1996						DWAF 1999	
	04.02.2016	12.06.2016	06.12.2016	Mean (baseline)	14.05.2021	% variation: 14.05.2021 vs mean	Upper Olifants Catchment	Drinking Water	Aquatic Ecosystems	Domestic Uses	Recreation (Full Contact)	Livestock Watering	Agricultural Irrigation	Aquaculture	General Limit	Special Limit
Aluminium (ug/l)	0.317	< 0.100	1.07	0.7	0.172	-75.4		≤ 300								
Ammonia as N (mg/l)	<0.1	0.3	0.2	0.25	0.3	20.0			≤ 0.007	≤ 1				≤ 0.025	≤ 3	≤ 2
Ammonium as N (mg/l)	<0.1	0.3	0.2	0.25	-	-										
Antimony (ug/l)	<0.010	< 0.010	< 0.010	< 0.010	<0.001	-90.0		≤ 20								
Arsenic, total (mg/l)	0.0182389	< 0.010	< 0.010	0.02	<0.001	-95.0		≤ 10	≤ 0.01	≤ 0.01		≤ 1	≤ 0.1	≤ 0.05	≤ 0.02	≤ 0.01
Barium (ug/l)	66.158328	0.07	0.07	22.1	0.088	-99.6		≤ 700								
Beryllium (mg/l)	<0.010	< 0.010	< 0.010	< 0.010	<0.001	-90.0							≤ 0.1			
Boron (mg/l)	0.0496791	0.01	0.01	0.02	0.05	150.0		≤ 2 400				≤ 5	≤ 0.5		≤ 1	≤ 0.5
Cadmium (ug/l)	<10	< 0.010	< 0.010	< 0.010	<0.001	-90.0		≤ 3	≤ 5			≤ 10	≤ 10	≤ 0.2	≤ 5	≤ 1
Calcium (mg/l)	4.24	4.3	4.34	4.29	21	389.5			≤ 32			≤ 1000				
Chromium (mg/l)	<0.010	< 0.010	< 0.010	< 0.010	<0.001	-90.0			≤ 0.007[B]	≤ 0.05		≤ 1	≤ 0.1	≤ 0.002[B]	≤ 0.05	≤ 0.02
Cobalt (mg/l)	<0.010	< 0.010	< 0.010	< 0.010	0.001	-90.0						≤ 1	≤ 0.05			
Copper (mg/l)	0.1654812	< 0.010	< 0.010	0.17	<0.001	-99.4		≤ 2	≤ 0.0003	≤ 1		≤ 0.5	≤ 0.2	≤ 0.005	≤ 0.01	≤ 0.002
DO (mg/l)	-	-	-	-	7	-										
DO (%)	98.8	110.8	113.4	107.67	-	-			> 80%							

Parameter	RK01 baseline a	RK01 baseline b	RK01 baseline c	RK01 baseline mean	RK01 (May 2021)	Current vs baseline (%)	DWS 2016	SANS 241 (2015)	DWAF 1996						DWAF 1999	
	04.02.2016	12.06.2016	06.12.2016	Mean (baseline)	14.05.2021	% variation: 14.05.2021 vs mean	Upper Olifants Catchment	Drinking Water	Aquatic Ecosystems	Domestic Uses	Recreation (Full Contact)	Livestock Watering	Agricultural Irrigation	Aquaculture	General Limit	Special Limit
EC (mS/m)	6	6	4.1	5.37	23.5	337.6		≤ 170		≤ 69		≤ 1000	≤ 40			
Iron (mg/l)	3.335	0.3	1.65	1.76	2.04	15.9		≤ 0.3		≤ 0.3		≤ 10	≤ 5	≤ 0.01	≤ 0.3	≤ 0.3
Lead (mg/l)	<0.010	< 0.010	< 0.010	< 0.010	0.003	-70.0			≤ 0.0002[AB]	≤ 0.01		≤ 0.1	≤ 0.2	≤ 0.01	≤ 0.01	≤ 0.006[B]
Lithium (mg/l)	0.0325081	< 0.010	< 0.010	0.03	<0.001	-96.7							≤ 2.5			
Magnesium (mg/l)	1.276	1.1	0.91	1.1	10	809.1				≤ 30		≤ 500				
Manganese (mg/l)	0.294	0.06	0.17	0.18	0.36	100.0		≤ 0.1	≤ 0.18	≤ 0.05		≤ 10	≤ 0.02	≤0.1	≤0.1	≤0.1
Mercury (mg/l)	<0.010	< 0.010	< 0.010	< 0.010	<0.001	-90.0			≤0.04	0[AB]		≤1		≤0.001[B]	≤0.005[B]	≤0.001[B]
Molybdenum (mg/l)	0.1322897	< 0.010	< 0.010	0.13	<0.001	-99.2						≤0.01	≤0.01			
Nickel (ug/l)	27	< 0.010	< 0.010	27	0.001	-100.0		≤ 70				≤1000	≤200			
Nitrate as N (mg/l)	<0.1	0.2	0.1	0.15	<0.1	-33.3		≤ 11		≤6		≤100		≤0.05	≤15	≤1.5
Nitrite as N (mg/l)	<0.05	<0.05	<0.05	<0.05	<0.05	0.0		≤ 0.9		≤6		≤10			≤15	≤1.5
Orthophosphate as P (mg/l)	<0.1	<0.1	0.1	0.1	<0.1	0.0								≤0.1	≤10	≤2.5
pH	6.61	7.9	6.5	7	7.5	7.1		≥ 5 to ≤ 9.7		09-Jun	6.5-8.5		6.5-8.4	6.5-9	5.5-9.5	5.5-7.5
Potassium (mg/l)	3.667	4.61	2.7	3.66	9.1	148.6			≤50							
Selenium (mg/l)	<0.010	< 0.010	0.02	0.02	<0.001	-95.0		≤ 40	≤0.02	≤0.02		≤50	≤0.02	≤0.3	≤0.02	≤0.02
Sodium (mg/l)	0.567	0.64	< 1	0.6	6	900.0		≤ 200		≤100		≤2000	≤70			
Sulphate (mg/l)	5	12	9	8.67	<2	-76.9		≤ 250		≤200		≤1000				
Suspended solids (mg/l)	27	13.3	22	20.77	80	285.2							≤50	≤50	≤25	≤10
Total Inorganic Nitrogen (mg/l)	-	-	-		-	-	<1.0									
Total Dissolved Solids (mg/l)	39	39	26.65	34.88	118	238.3	≤195	≤ 1 200								
Uranium (mg/l)	<0.010	< 0.010	< 0.010	< 0.010	< 0.010	0.0		≤0.015					≤0.01			

Parameter	RK01 baseline a	RK01 baseline b	RK01 baseline c	RK01 baseline mean	RK01 (May 2021)	Current vs baseline (%)	DWS 2016	SANS 241 (2015)	DWAF 1996						DWAF 1999	
	04.02.2016	12.06.2016	06.12.2016	Mean (baseline)	14.05.2021	% variation: 14.05.2021 vs mean	Upper Olifants Catchment	Drinking Water	Aquatic Ecosystems	Domestic Uses	Recreation (Full Contact)	Livestock Watering	Agricultural Irrigation	Aquaculture	General Limit	Special Limit
Vanadium (mg/l)	<0.010	< 0.010	< 0.010	< 0.010	0.001	-90.0		≤0.2		≤0.1		≤1	≤0.1			
Zinc (mg/l)	0.1264323	< 0.010	0.27	0.2	0.369	84.5		≤ 5	≤0.002	≤3		≤20	≤1	≤0.03	≤0.1	≤0.04

*Mean was calculated based on numbers that were above the detection limit.

*Both average 2016 baseline value and May 2021 value exceeded the specified guideline.

*Average 2016 baseline value exceeded the specified guideline.

*May 2021 value exceeded the specified guideline.

*Detection limit was below guideline for both baseline and May 2021 assessments, therefore compliance could not be determined. The precautionary principle was utilised, and it was assumed that the value exceeded the guideline (A = May 2021, B = Baseline).

*Data were below the detection limit, thus calculation of the parameter was not possible.

Table 3b: Quantified baseline water quality at RK02 (not assessed in May 2021), and compliance with the DWS (2016), SANS 241 (2015), DWAF (1996) and DWAF (1999) water quality guidelines.

Parameter	RK02	RK02	RK02	RK02	DWS 2016	SANS 241 (2015)	DWAF 1996						DWAF 1999	
	04.02.2016	12.06.2016	06.12.2016	Mean	Upper Olifants Catchment	Drinking Water	Aquatic Ecosystems	Domestic Uses	Recreation (Full Contact)	Livestock Watering	Agricultural Irrigation	Aqua-culture	General Limit	Special Limit
Aluminium (ug/l)	4.11	No Sample	1.91	3.01		≤ 300								
Ammonia as N (mg/l)	1.00		0.50	0.75			≤ 0.007	≤ 1				≤ 0.025	≤ 3	≤ 2
Ammonium as N (mg/l)	1.00		0.50	0.75										
Antimony (ug/l)	<0.010		< 0.010	< 0.010		≤ 20								
Arsenic, total (mg/l)	<0.010		< 0.010	< 0.010		≤ 10	≤ 0.01	≤ 0.01		≤ 1	≤ 0.1	≤ 0.05	≤ 0.02	≤ 0.01
Barium (ug/l)	39.00		0.14	19.57		≤ 700								
Beryllium (mg/l)	<0.010		< 0.010	< 0.010							≤ 0.1			
Boron (mg/l)	0.05		0.05	0.05		≤ 2 400				≤ 5	≤ 0.5		≤ 1	≤ 0.5
Cadmium (ug/l)	<0.010		< 0.010	< 0.010		≤ 3	≤ 5			≤ 10	≤ 10	≤ 0.2	≤ 5	≤ 1
Calcium (mg/l)	2.44		3.68	3.06			≤ 32			≤ 1000				
Chromium (mg/l)	<0.010		< 0.010	< 0.010			≤ 0.007	≤ 0.05		≤ 1	≤ 0.1	≤ 0.002	≤ 0.05	≤ 0.02
Cobalt (mg/l)	<0.010		< 0.010	< 0.010						≤ 1	≤ 0.05			
Copper (mg/l)	0.05		< 0.010	0.05		≤ 2	≤ 0.0003	≤ 1		≤ 0.5	≤ 0.2	≤ 0.005	≤ 0.01	≤ 0.002
DO (%)	49.80		98.30	74.05			> 80%							
EC (mS/m)	14.00		8.30	11.15		≤ 170		≤ 69		≤ 1000	≤ 40			
Iron (mg/l)	4.33		5.84	5.08		≤ 0.3		≤ 0.3		≤ 10	≤ 5	≤ 0.01	≤ 0.3	≤ 0.3
Lead (mg/l)	<0.010		< 0.010	< 0.010			≤ 0.0002	≤ 0.01		≤ 0.1	≤ 0.2	≤ 0.01	≤ 0.01	≤ 0.006
Lithium (mg/l)	0.01		0.01	0.01							≤ 2.5			
Magnesium (mg/l)	2.29		2.43	2.36				≤ 30		≤ 500				
Manganese (mg/l)	0.52		3.44	1.98		≤ 0.1	≤ 0.18	≤ 0.05		≤ 10	≤ 0.02	≤0.1	≤0.1	≤0.1
Mercury (mg/l)	<0.010		< 0.010	< 0.010			≤0.04	0.00		≤1		≤0.001	≤0.005	≤0.001
Molybdenum (mg/l)	0.03		< 0.010	0.03						≤0.01	≤0.01			

Parameter	RK02	RK02	RK02	RK02	DWS 2016	SANS 241 (2015)	DWAF 1996						DWAF 1999	
Nickel (ug/l)	26.00		< 0.010	26.00		≤ 70				≤1000	≤200			
Nitrate as N (mg/l)	<0.1		<0.1	<0.1		≤ 11		≤6		≤100		≤0.05	≤15	≤1.5
Nitrite as N (mg/l)	<0.05		<0.05	<0.05		≤ 0.9		≤6		≤10			≤15	≤1.5
Orthophosphate as P (mg/l)	0.10		<0.1	0.10								≤0.1	≤10	≤2.5
pH	6.31		6.50	6.41		≥ 5 to ≤ 9.7		6-9	6.5-8.5		6.5-8.4	6.5-9	5.5-9.5	5.5-7.5
Potassium (mg/l)	7.19		4.12	5.66			≤50							
Selenium (mg/l)	<0.010		0.02	0.02		≤ 40	≤0.02	≤0.02		≤50	≤0.02	≤0.3	≤0.02	≤0.02
Sodium (mg/l)	13.51		13.62	13.57		≤ 200		≤100		≤2000	≤70			
Sulphate (mg/l)	4.00		<2	4.00		≤ 250		≤200		≤1000				
Suspended solids (mg/l)	107.00		284.00	195.50							≤50	≤50	≤25	≤10
Total Inorganic Nitrogen (mg/l)					<1.0									
Total Dissolved Solids (mg/l)	91.00		53.95	72.48	≤195	≤ 1 200								
Uranium (mg/l)	<0.010		< 0.010	< 0.010		≤0.015					≤0.01			
Vanadium (mg/l)	0.01		0.01	0.01		≤0.2		≤0.1		≤1	≤0.1			
Zinc (mg/l)	0.08		0.40	0.24		≤ 5	≤0.002	≤3		≤20	≤1	≤0.03	≤0.1	≤0.04

*Mean was calculated based on numbers that were above the detection limit.

*Average value exceeded the specified guideline.

*Detection limit was below guideline, therefore compliance could not be determined. The precautionary principle was utilised, and it was assumed that the value exceeded the guideline.

*Data were below the detection limit, thus calculation of the parameter was not possible.

Table 3c: Quantified baseline water quality at RK03 (not assessed in May 2021), and compliance with the DWS (2016), SANS 241 (2015), DWAF (1996) and DWAF (1999) water quality guidelines.

Parameter	RK03	RK03	RK03	RK03	DWS 2016	SANS 241 (2015)	DWAF 1996						DWAF 1999	
	04.02.2016	12.06.2016	06.12.2016	Mean	Upper Olifants Catchment	Drinking Water	Aquatic Ecosystems	Domestic Uses	Recreation (Full Contact)	Livestock Watering	Agricultural Irrigation	Aqua-culture	General Limit	Special Limit
Aluminium (ug/l)	1.59	7.69	3.70	4.327		≤ 300								
Ammonia as N (mg/l)	0.1	17	0.1	5.733			≤ 0.007	≤ 1				≤ 0.025	≤ 3	≤ 2
Ammonium as N (mg/l)	0.1	17	0.1	5.733										
Antimony (ug/l)	<0.010	< 0.010	< 0.010	< 0.010		≤ 20								
Arsenic, total (mg/l)	<0.010	0.024	< 0.010	0.024		≤ 10	≤ 0.01	≤ 0.01		≤ 1	≤ 0.1	≤ 0.05	≤ 0.02	≤ 0.01
Barium (ug/l)	0.058	0.448	0.073	0.193		≤ 700								
Beryllium (mg/l)	<0.010	< 0.010	< 0.010	< 0.010							≤ 0.1			
Boron (mg/l)	27.000	0.022	0.039	9.020		≤ 2 400				≤ 5	≤ 0.5		≤ 1	≤ 0.5
Cadmium (ug/l)	<0.010	< 0.010	< 0.010	< 0.010		≤ 3	≤ 5			≤ 10	≤ 10	≤ 0.2	≤ 5	≤ 1
Calcium (mg/l)	5	20	5	10.047			≤ 32			≤ 1000				
Chromium (mg/l)	<0.010	0.016	< 0.010	0.016			≤ 0.007	≤ 0.05		≤ 1	≤ 0.1	≤ 0.002	≤ 0.05	≤ 0.02
Cobalt (mg/l)	<0.010	0.060	< 0.010	0.060						≤ 1	≤ 0.05			
Copper (mg/l)	0.014	0.017	< 0.010	0.016		≤ 2	≤ 0.0003	≤ 1		≤ 0.5	≤ 0.2	≤ 0.005	≤ 0.01	≤ 0.002
DO (%)	127.8	44.5	103.7	92.000			> 80%							
EC (mS/m)	9.000	52.000	8.100	23.033		≤ 170		≤ 69		≤ 1000	≤ 40			
Iron (mg/l)	8.78	37.23	11.36	19.124		≤ 0.3		≤ 0.3		≤ 10	≤ 5	≤ 0.01	≤ 0.3	≤ 0.3
Lead (mg/l)	<0.010	0.022	< 0.010	0.022			≤ 0.0002	≤ 0.01		≤ 0.1	≤ 0.2	≤ 0.01	≤ 0.01	≤ 0.006
Lithium (mg/l)	<0.010	< 0.010	< 0.010	< 0.010							≤ 2.5			
Magnesium (mg/l)	3	8	2	4.429				≤ 30		≤ 500				
Manganese (mg/l)	0.070	6.456	0.235	2.254		≤ 0.1	≤ 0.18	≤ 0.05		≤ 10	≤ 0.02	≤0.1	≤0.1	≤0.1
Mercury (mg/l)	<0.010	< 0.010	< 0.010	< 0.010			≤0.04	0.00		≤1		≤0.001	≤0.005	≤0.001
Molybdenum (mg/l)	<0.010	< 0.010	< 0.010	< 0.010						≤0.01	≤0.01			
Nickel (ug/l)	53.000	0.202	< 0.010	26.601		≤ 70				≤1000	≤200			

Parameter	RK03	RK03	RK03	RK03	DWS 2016	SANS 241 (2015)	DWAF 1996						DWAF 1999	
Nitrate as N (mg/l)	<0.1	0.1	0.1	0.100		≤ 11		≤6		≤100		≤0.05	≤15	≤1.5
Nitrite as N (mg/l)	<0.05	<0.05	<0.05	<0.05		≤ 0.9		≤6		≤10			≤15	≤1.5
Orthophosphate as P (mg/l)	<0.1	<0.1	<0.1	<0.1								≤0.1	≤10	≤2.5
pH	7.42	6.8	6.5	6.907		≥ 5 to ≤ 9.7		6-9	6.5-8.5		6.5-8.4	6.5-9	5.5-9.5	5.5-7.5
Potassium (mg/l)	7.3	45.4	9.3	20.670			≤50							
Selenium (mg/l)	<0.010	0.015	0.023	0.019		≤ 40	≤0.02	≤0.02		≤50	≤0.02	≤0.3	≤0.02	≤0.02
Sodium (mg/l)	1	19	2	7.363		≤ 200		≤100		≤2000	≤70			
Sulphate (mg/l)	3	104	7	38.000		≤ 250		≤200		≤1000				
Suspended solids (mg/l)	8	19117	67	6397.333							≤50	≤50	≤25	≤10
Total Inorganic Nitrogen (mg/l)					<1.0									
Total Dissolved Solids (mg/l)	58.5	338	52.65	149.717	≤195	≤ 1 200								
Uranium (mg/l)	<0.010	< 0.010	< 0.010	< 0.010		≤0.015					≤0.01			
Vanadium (mg/l)	<0.010	0.046	0.015	0.030		≤0.2		≤0.1		≤1	≤0.1			
Zinc (mg/l)	0.028	0.065	0.067	0.054		≤ 5	≤0.002	≤3		≤20	≤1	≤0.03	≤0.1	≤0.04

*Mean was calculated based on numbers that were above the detection limit.

*Average value exceeded the specified guideline.

*Detection limit was below guideline, therefore compliance could not be determined. The precautionary principle was utilised, and it was assumed that the value exceeded the guideline.

*Data were below the detection limit, thus calculation of the parameter was not possible.

Table3d: Quantified water quality at RK04 (2016 baseline and May 2021), and compliance with the DWS (2016), SANS 241 (2015), DWAF (1996) and DWAF (1999) water quality guidelines.

Parameter	Site			DWS 2016	SANS 241 (2015)	DWAF 1996						DWAF 1999	
	RK04 baseline	RK04 (May 2021)	May 2021 vs baseline (%)	Upper Olifants Catchment	Drinking Water	Aquatic Ecosystems	Domestic Uses	Recreation (Full Contact)	Livestock Watering	Agricultural Irrigation	Aqua-culture	General Limit	Special Limit
Aluminium (ug/l)	0.28	<0.1	-64.3		≤ 300								
Ammonia as N (mg/l)	<0.1	0.1	0.0			≤ 0.007[AB]	≤ 1				≤ 0.025[AB]	≤ 3	≤ 2
Ammonium as N (mg/l)	<0.1	-	-										
Antimony (ug/l)	< 0.010	0.001	-90.0		≤ 20								
Arsenic, total (mg/l)	0.02	0.023	15.0		≤ 10	≤ 0.01	≤ 0.01		≤ 1	≤ 0.1	≤ 0.05	≤ 0.02	≤ 0.01
Barium (ug/l)	0.09	0.042	-53.3		≤ 700								
Beryllium (mg/l)	< 0.010	<0.001	-90.0							≤ 0.1			
Boron (mg/l)	0.04	0.059	47.5		≤ 2 400				≤ 5	≤ 0.5		≤ 1	≤ 0.5
Cadmium (ug/l)	< 0.010	<0.001	-90.0		≤ 3	≤ 5			≤ 10	≤ 10	≤ 0.2	≤ 5	≤ 1
Calcium (mg/l)	31.49	27	-14.3			≤ 32			≤ 1000				
Chromium (mg/l)	< 0.010	<0.001	-90.0			≤ 0.007[B]	≤ 0.05		≤ 1	≤ 0.1	≤ 0.002[B]	≤ 0.05	≤ 0.02
Cobalt (mg/l)	< 0.010	<0.001	-90.0						≤ 1	≤ 0.05			
Copper (mg/l)	< 0.010	<0.001	-90.0		≤ 2	≤ 0.0003[AB]	≤ 1		≤ 0.5	≤ 0.2	≤ 0.005[B]	≤ 0.01	≤ 0.002[B]
DO (mg/l)	-	8	-										
DO (%)	101.19	-	-			> 80%							
EC (mS/m)	33.3	34.6	3.9		≤ 170		≤ 69		≤ 1000	≤ 40			
Iron (mg/l)	2.44	0.182	-92.5		≤ 0.3		≤ 0.3		≤ 10	≤ 5	≤ 0.01	≤ 0.3	≤ 0.3
Lead (mg/l)	< 0.010	<0.001	-90.0			≤ 0.0002[AB]	≤ 0.01		≤ 0.1	≤ 0.2	≤ 0.01	≤ 0.01	≤ 0.006[B]
Lithium (mg/l)	< 0.010	0.003	-70.0							≤ 2.5			
Magnesium (mg/l)	21.45	20	-6.8				≤ 30		≤ 500				
Manganese (mg/l)	0.23	0.075	-67.4		≤ 0.1	≤ 0.18	≤ 0.05		≤ 10	≤ 0.02	≤0.1	≤0.1	≤0.1
Mercury (mg/l)	< 0.010	<0.001	-90.0			≤0.04	0		≤1		≤0.001[B]	≤0.005[B]	≤0.001[B]
Molybdenum (mg/l)	< 0.010	0.002	-80.0						≤0.01	≤0.01			

Parameter	Site			DWS 2016	SANS 241 (2015)	DWAF 1996						DWAF 1999	
	RK04 baseline	RK04 (May 2021)	May 2021 vs baseline (%)	Upper Olifants Catchment	Drinking Water	Aquatic Ecosystems	Domestic Uses	Recreation (Full Contact)	Livestock Watering	Agricultural Irrigation	Aqua-culture	General Limit	Special Limit
Nickel (ug/l)	< 0.010	0.003	-70.0		≤ 70				≤1000	≤200			
Nitrate as N (mg/l)	0.1	<0.1	0.0		≤ 11		≤6		≤100		≤0.05	≤15	≤1.5
Nitrite as N (mg/l)	<0.05	<0.05	0.0		≤ 0.9		≤6		≤10			≤15	≤1.5
Orthophosphate as P (mg/l)	<0.1	<0.1	0.0								≤0.1	≤10	≤2.5
pH	7.7	7.9	2.6		≥ 5 to ≤ 9.7		09-Jun	6.5-8.5		6.5-8.4	6.5-9	5.5-9.5	5.5-7.5
Potassium (mg/l)	1.29	2.1	62.8			≤50							
Selenium (mg/l)	0.03	<0.001	-96.7		≤ 40	≤0.02	≤0.02		≤50	≤0.02	≤0.3	≤0.02	≤0.02
Sodium (mg/l)	10.79	11	1.9		≤ 200		≤100		≤2000	≤70			
Sulphate (mg/l)	11	18	63.6		≤ 250		≤200		≤1000				
Suspended solids (mg/l)	52	6	-88.5							≤50	≤50	≤25	≤10
Total Inorganic Nitrogen (mg/l)		-	-	<1.0									
Total Dissolved Solids (mg/l)	216.45	192	-11.3	≤195	≤ 1 200								
Uranium (mg/l)	< 0.010	<0.001	-90.0		≤0.015					≤0.01			
Vanadium (mg/l)	< 0.010	0.001	-90.0		≤0.2		≤0.1		≤1	≤0.1			
Zinc (mg/l)	0.06	0.084	40.0		≤ 5	≤0.002	≤3		≤20	≤1	≤0.03	≤0.1	≤0.04

[red] *Both 2016 baseline value and May 2021 value exceeded the specified guideline.

[blue] *2016 baseline value exceeded the specified guideline.

[orange] *May 2021 value exceeded the specified guideline.

[yellow] *Detection limit was below guideline, therefore compliance could not be determined. The precautionary principle was utilised, and it was assumed that the value exceeded the guideline (A = May 2021, B = Baseline).

[black] *Data were below the detection limit, thus calculation of the parameter was not possible.

APPENDIX 4: SPECIALISTS RESUMES AND DECLARATION

SCIENTIFIC AQUATIC SERVICES (SAS) – SPECIALIST CONSULTANT INFORMATION

CURRICULUM VITAE OF DIONNE CRAFFORD

PERSONAL DETAILS

Position in Company	Aquatic Scientist/Scientific Writer
Date of Birth	17 October 1975
Nationality	South African
Languages	Afrikaans, English
Joined SAS Environmental Group	2013

MEMBERSHIP IN PROFESSIONAL SOCIETIES

Registered Professional Scientist at South African Council for Natural Scientific Professions (SACNASP)

EDUCATION

Qualifications	**Year completed**
PhD Zoology (University of Johannesburg)	2013
MSc Zoology (Rand Afrikaans University)	2000
BSc (Hons) Zoology (University of Pretoria)	1997
BSc Ecology (University of Pretoria)	1996

COUNTRIES OF WORK EXPERIENCE

South Africa

PROJECT EXPERIENCE

Water Quality, Freshwater Ecology, Aquatic Biomonitoring and Toxicology Reporting

SCIENTIFIC AQUATIC SERVICES (SAS) – SPECIALIST CONSULTANT INFORMATION

CURRICULUM VITAE OF STEPHEN VAN STADEN

PERSONAL DETAILS

Position in Company	Managing member, Ecologist, Aquatic Ecologist
Date of Birth	13 July 1979
Nationality	South African
Languages	English, Afrikaans
Joined SAS	2003 (year of establishment)
Other Business	Trustee of the Serenity Property Trust

MEMBERSHIP IN PROFESSIONAL SOCIETIES

Registered Professional Scientist at South African Council for Natural Scientific Professions (SACNASP)

Accredited River Health practitioner by the South African River Health Program (RHP)

Member of the South African Soil Surveyors Association (SASSO) Member of the Gauteng Wetland Forum

Member of IAIA South Africa

EDUCATION

Qualifications

MSc (Environmental Management) (University of Johannesburg)	2003
BSc (Hons) Zoology (Aquatic Ecology) (University of Johannesburg)	2001
BSc (Zoology, Geography and Environmental Management) (University of Johannesburg)	2000
Tools for wetland Assessment short course Rhodes University	2016

COUNTRIES OF WORK EXPERIENCE

South Africa – All Provinces

Southern Africa – Lesotho, Botswana, Mozambique, Zimbabwe Zambia

Eastern Africa – Tanzania Mauritius

West Africa – Ghana, Liberia, Angola, Guinea Bissau

Central Africa – Democratic Republic of the Congo

SELECTED PROJECT EXAMPLES OUT OF OVER 2000 PROJECTS WORKED ON

Impoundment studies

- Lalini Dam specialist aquatic ecological assessment with focus on aquatic macro-invertebrate and fish community analysis and fish migration.
- Ntabalenga Dam specialist aquatic ecological assessment with focus on macro-invertebrate fish community analysis and fish migration.
- Donkerhoek Dam specialist aquatic ecological assessment and consideration of fish migration requirements.
- Groot Phisantekraal dam specialist aquatic ecological assessment and Ecological Water Requirements for the Diep River.
- Musami Dam (Zimbabwe) assessment with focus on the FRAI and MIRAI aquatic community assessment indices and the development of the Ecological Water Requirements.
- Mhlabatsane dam Ecological Water specialist aquatic ecological assessment and consideration of fishway needs and macro-invertebrate community sensitivity.

Development compliance studies

- Project co-leader for the development of the EMP for the use of the Wanderers stadium for the Ubuntu village for the World Summit on Sustainable Development (WSSD).
- Environmental Control Officer for Eskom for the construction of an 86Km 400KV power line in the Rustenburg Region.
- Numerous Environmental Impact Assessment (EIA) and EIA exemption applications for township developments and as part of the Development Facilitation Act requirements.
- EIA for the extension of mining rights for a Platinum mine in the Rustenburg area by Lonmin Platinum. EIA Exemption application for a proposed biodiesel refinery in Chamdor.
- Compilation of an EIA as part of the Bankable Feasibility Study process for proposed mining of a gold deposit in the Lofa province, Liberia.
- EIA for the development of a Chrome Recovery Plant at the Two Rivers Platinum Mine in the Limpopo province, South Africa.
- Compilation of an EIA as part of the Bankable Feasibility Study process for the Mooihoek Chrome Mine in the Limpopo province, South Africa.
- Mine Closure Plan for the Vlakfontein Nickel Mine in the North West Province.

Specialist studies and project management

- Development of the Water Resource and biodiversity chapters of the 2015 Limpopo Province Biodiversity outlook.
- Development of a zero discharge strategy and associated risk, gap and cost benefit analyses for the Lonmin Platinum group.
- Development of a computerised water balance monitoring and management tool for the management of Lonmin Platinum process and purchased water.
- The compilation of the annual water monitoring and management program for the Lonmin Platinum group of mines.
- Analyses of ground water for potable use on a small diamond mine in the North West Province.
- Project management and overview of various soil and land capability studies for residential, industrial and mining developments.
- The design of a stream diversion of a tributary of the Olifants River for a proposed opencast coal mine.
- Waste rock dump design for a gold mine in the North West province.
- Numerous wetland delineation and function studies in the North West, Gauteng and Mpumalanga KwaZulu Natal provinces, South Africa.
- Hartebeespoort Dam Littoral and Shoreline PES and rehabilitation plan.
- Development of rehabilitation principles and guidelines for the Crocodile West Marico Catchment, DWAF North West.

Aquatic and water quality monitoring and compliance reporting

- Development of the Resource quality Objective framework for Water Use licensing in the Crocodile West Marico Water management Area.
- Development of the Resource Quality Objectives for the Local Authorities in the Upper Crocodile West Marico Water management Area.
- Development of the 2010 State of the Rivers Report for the City of Johannesburg.

• Management of the water quality reporting programs for several mining projects in the Gold, Chrome and Platinum mining industries. • Initiation and management of a physical, chemical and biological monitoring program, President Steyn Gold Mine Welkom. • Aquatic biomonitoring programs for several Xstrata Alloys Mines and Smelters. • Aquatic biomonitoring programs for several Anglo Platinum Mines. • Aquatic biomonitoring programs for African Rainbow Minerals Mines. • Aquatic biomonitoring programs for several Assore Operations. • Aquatic biomonitoring programs for Petra Diamonds. • Aquatic biomonitoring programs for several Coal mining operations. • Aquatic biomonitoring programs for several Gold mining operations. • Aquatic biomonitoring programs for several mining operations for various minerals including iron ore, and small platinum and chrome mining operations. • Aquatic biomonitoring program for the Valpre bottled water plant (Coca Cola South Africa). • Aquatic biomonitoring program for industrial clients in the paper production and energy generation industries. • Aquatic biomonitoring programs for the City of Tshwane for all their Waste Water Treatment Works. • Baseline aquatic ecological assessments for numerous mining developments. • Baseline Freshwater resource assessments for numerous residential commercial and industrial developments. • Baseline Freshwater resource assessments in southern, central, east and west Africa for gold mining projects, Phosphate mining diamond mining and copper mining.
Wetland delineation and wetland function assessment • Wetland biodiversity studies for three copper mines on the copper belt in the Democratic Republic of the Congo. • Wetland biodiversity studies for proposed mining projects in Guinea Bissau, Liberia and Angola in West Africa. • Numerous terrestrial and wetland biodiversity studies for developments in the mining industry. • Numerous terrestrial and wetland biodiversity studies for developments in the residential commercial and industrial sectors. • Development of wetland riparian resource protection measures for the Hartbeespoort Dam as part of the Harties Metsi A Me integrated biological remediation program. • Priority wetland mammal species studies for numerous residential, commercial, industrial and mining developments throughout South Africa.
Terrestrial ecological studies and biodiversity studies • Development of a biodiversity offset plans for Glencore, ACSA and Canyon coal. • Biodiversity Action plans for numerous mining operations for several Anglo Platinum mining operations throughout South Africa in line with the NEMBA requirements. • Biodiversity Action plans for numerous mining operations of Assmang Chrome throughout South Africa in line with the NEMBA requirements. • Biodiversity Action plans for numerous mining operations of Glencore Mining operations throughout South Africa in line with the NEMBA requirements. • Biodiversity Action plan for the Nkomati Nickel and Chrome Mine Joint Venture. • Terrestrial and wetland biodiversity studies for three copper mines on the copperbelt in the Democratic Republic of the Congo. • Terrestrial and wetland biodiversity studies for proposed mining projects in Guinea Bissau, Liberia and Angola in West Africa. • Numerous terrestrial ecological assessments for proposed platinum and coal mining projects. • Numerous terrestrial ecological assessments for proposed residential and commercial property developments throughout most of South Africa. • Specialist Giant bullfrog (*Pyxicephalus adspersus*) studies for several proposed residential and commercial development projects in Gauteng, South Africa. • Specialist Marsh sylph (*Metisella meninx*) studies for several proposed residential and commercial development projects in Gauteng, South Africa. • Project management of several Red Data Listed (RDL) bird studies with special mention of African grass owl (*Tyto capensis*).

• Project management of several studies for RDL Scorpions, spiders and beetles for proposed residential and commercial development projects in Gauteng, South Africa. • Specialist assessments of terrestrial ecosystems for the potential occurrence of RDL spiders and owls. • Project management and site specific assessment on numerous terrestrial ecological surveys including numerous studies in the Johannesburg-Pretoria area, Witbank area, and the Vredefort dome complex. • Biodiversity assessments of estuarine areas in the Kwa-Zulu Natal and Eastern Cape provinces. • Impact assessment of a spill event on a commercial maize farm including soil impact assessments.
Fisheries management studies • Tamryn Manor (Pty.) Ltd. still water fishery initiation, enhancement and management. • Verlorenkloof Estate fishery management strategising, fishery enhancement, financial planning and stocking strategy. • Mooifontein fishery management strategising, fishery enhancement and stocking programs. • Wickams retreat management strategising. • Gregg Brackenridge management strategising and stream recalibration design and stocking strategy. • Eljira Farm baseline fishery study compared against DWAF 1996 aquaculture and aquatic ecosystem guidelines.

REFERENCES

- Terry Calmeyer
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- Alex Pheiffer
  African Environmental Management Operations Manager
  SLR Consulting
  Tel: +27 11 467 0945
  Email: apheiffer@slrconsulting.com

- Marietjie Eksteen
  Managing Director: Jacana Environmentals
  Tel: 015 291 4015

Yours faithfully

STEPHEN VAN STADEN

Declaration

Declaration that the specialist is independent in a form as may be specified by the competent authority

I, Stephen van Staden, declare that -

- I act as the independent specialist in this application;
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the relevant legislation and any guidelines that have relevance to the proposed activity;
- I will comply with the applicable legislation;
- I have not, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- All the particulars furnished by me in this form are true and correct

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Signature of the Specialist