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Hydrological Assessment & Conceptual Stormwater Management Plan for the Proposed Lion Smelter Energy Conversion Project

Report

Version - Final 1

22 March 2022

Nettzero

GCS Project Number: 21-0939_SW

Client Reference: Lion Smelter Energy Conversion Project

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DECLARATION OF INDEPENDENCE

GCS (Pty) Ltd was appointed to conduct this specialist surface water study and to act as the independent hydrological specialist. GCS objectively performed the work, even if this results in views and findings that are not favourable. GCS has the expertise in conducting the specialist investigation and does not have a conflict of interest in the undertaking of this study. This report presents the findings of the investigations which include the activities set out in the scope of work.

EXECUTIVE SUMMARY

GCS Water and Environment (Pty) Ltd (GCS) was appointed by Nettzero to undertake a hydrological assessment and to develop a conceptual stormwater management plan (CSWMP) for the proposed Lion Smelter Energy Conversion Project, situated in Steelpoort, Mpumalanga Province (refer to Figure 1-2). The project falls within quaternary catchment B41J of the Olifants Water Management Area (WMA) (DWS, 2016).

GCS undertook a pre-screening of the site, in terms of hydrology (GCS, 2022), and as part of the findings, it was determined that a CSWMP is required in a dedicated hydrology assessment report to describe stormwater management and drainage for the site. This document will supplement the BA/EIA for the site.

This study found that two (2) hydrological response units (HRUs) describe the natural drainage for the study area (using an ALOS DTM, with a 1:200 stream count and 15m DTM fill). The HRUs delineated correspond well to known non-perennial drainage lines associated with the site. The origin of the non-perennial stream appears to be near the existing tailings facility (TSF) towards the southwest, and the pollution control dam (PCD) towards the northeast from the position of the proposed site. Hence, and based on available elevation data, the area zoned for the proposed ECF (Energy Conversion Facility) Plant is situated on a sub-catchment water divide. Approximately 90% of the proposed layout falls within HRU1, and 10% in HRU2. Hence, drainage from the position of the proposed Plant will primarily be towards the northeast, with some minor runoff towards the northwest.

Drainage from the Lion Smelter site is towards the north-west, via two (2) non-perennial streams (as identified with HRU1 and HRU2) and flow is towards the Steelpoort River, situated approximately 1.14 km northwest of the site. Distance from the site to the nearest drainage lines is recorded as approx. 160 and 272 m.

Storm peak flows and flooding return periods (1:10, 1:20, 1:50 and 1:100-year events) were calculated for the site, to compile a conceptual stormwater management plan (CSWMP) to manage peak stormwater discharge from the site and prevent/reduce mixing of storm discharge from the site with that of natural runoff from the greater project area. The CSWMP is presented in Section 4.

Several hydrological risks are associated with the site, of which mixing of dirty and clean water on the premises and discharge of the water to the environment via the on-site stormwater system (not part of the CSWMP but will be developed by the site engineer) environment is the greatest risk. The hydrological risk was evaluated (refer to Section 5) and the hydrological risk about the proposed activities is anticipated to be marginal. Mitigation measures were proposed to circumvent potential impacts (refer to Section 5).

- The risk assessment for both construction and post-construction phases of the project is considered marginal, with mostly reversible and manageable impacts.
- Mixing of dirty and clean water on the premises and potential overall runoff and stormwater discharge from the site into the surrounding environment (increased peak flows) may cause erosion of the soils surrounding the development and may impact land capability. This is the largest risk and should be managed with the on-site stormwater management plan (as per the developer designs) and the conceptual stormwater management plan as proposed in this document.
- The risk of flooding, poor quality seepage via the vadose zone, and impacts on surface water quality is predicted to be zero during the construction and operational phase of the project. This is largely due to the proposed concrete barrier to be installed, the absence of any surface water streams, and the fact that the zoned area has already been modified as a result of the existing Lion Smelter activities.
- A stormwater monitoring system was developed (refer to Section 6) to monitor the impact on the surface environment and prevent uncontrolled stormwater discharge to the environment.

This hydrological assessment cannot find any grounds or identify high hydrological risks not proceed with the development. This is grounded on the assumption that the proposed mitigation measures (Section 5), CSWMP, EMPr and EIA recommendations (Section 6.1) are implemented during the construction and operational phase of the development.

No avoidance areas are recommended. This is based on the proposed development area, the site's unique hydrological conditions and drainage conditions, the distance to recognized rivers/streams and flooding areas; and founded on the premise that a proper stormwater system will be implemented. No alternative development sites are proposed.

APPENDIX 6 OF THE EIA REGULATION – CHECKLIST AND REFERENCE FOR THIS REPORT

Table 1 - Requirements from Appendix 6 of GN 326 EIA Regulation 2017

Requirements from Appendix 6 of GN 326 EIA Regulation 2017	Chapter
(a) Details of: (i) The specialist who prepare the reports; and (ii) the expertise of that specialist to compile a specialist report including a curriculum vitae	Document Issue (Page ii) Appendix B.
(b) Declaration that the specialist is independent in a form as may be specialities by the competent authority	Appendix B.
(c) Indication of the scope of, and purpose for which, the report was prepared	Section 1.
(cA) Indication of the quality and age of base data used for the specialist report	Section 1, 2 and 6.
(cB) A description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change	Section 5.1.
(d) Duration, Date and seasons of the site investigation and the relevance of the season to the outcome of the assessment	Section 1.5.
(e) Description of the methodology adopted in preparing the report or carrying out the specialised process include of equipment and modelling used	Section 2.
(f) Details of an assessment of the specifically identified sensitivity of the site related to the proposed activity or activities and its associate’s structures and infrastructure, inclusive of a site plan identifying alternatives	Section 4 and 6.
(g) Identification of any areas to be avoided, including buffers	Section 6.1.
(h) Map superimposing the activity and associated structures and infrastructure on environmental sensitivities of the site including areas to be avoided, including buffers	Section 1, 3.
(i) Description of any assumptions made and uncertainties or gaps in knowledge	Section 2, 4, 5.
(j) A description of the findings and potential implications of such findings on the impact of the proposed activity including identified alternatives on the environment or activities	Executive summary, Section 6.5.
(k) Mitigation measures for inclusion in the EMPr	Section 6.2.
(l) Conditions for inclusion in the environmental authorisation	Refer to recommendations in Section 6.
(m) Monitoring requirements for inclusion in the EMPr or environmental authorisation	Refer to recommendations in Section 6.
(n) Reasoned opinion – (i) as to whether the proposed activity, activities or portions thereof should be authorised; (iA) regarding the acceptability of the proposed activity or activities; and (ii) if the opinion is that the proposed activity, activities or portions thereof should be authorised, and avoidance, management, mitigation measures that should be included in the EMPr, and where applicable, the closure plan	Section 6.4.
(o) Description of any consultation process that was undertaken during preparing the specialist report	*None required.*
(p) A summary and copies of any comments received during any consultation process and where applicable all responses thereto	*None required.*
(q) Any other information requested by the competent authority	*None required.*

CONTENTS PAGE

1 Introduction ... 1
1.1 Project background ... 1
1.2 Existing site conditions & activities to construct the plant ... 2
1.3 The objective of this report ... 4
1.4 Scope of Work ... 4
1.5 Study relevance to the season in which it was undertaken ... 5
2 Methodology ... 7
2.1 Legal considerations ... 7
2.2 Hydrological assessment ... 9
2.2.1 Catchment description and delineation ... 9
2.2.2 Design rainfall and peak flow ... 10
2.3 Conceptual stormwater management plan (CSWMP) ... 11
2.4 Hydrological risk assessment ... 11
2.5 Surface water monitoring plan ... 11
3 Site overview and hydrology ... 12
3.1 Sub-catchments / hydrological response units (HRUs) ... 12
3.2 Land cover and slope ... 12
3.3 Climate ... 15
3.3.1 Temperature ... 15
3.3.2 Wind speed and direction ... 15
3.3.3 Rainfall and evaporation ... 17
3.3.4 Runoff ... 18
3.4 Local geology and soils ... 19
3.5 Floodlines ... 20
3.6 Depth to groundwater ... 21
3.7 Surface water users within the sub-catchment associated with the site ... 21
3.8 Wetland areas ... 21
3.9 Present ecological state (PES) and ecological importance and sensitivity (EIS) ... 22
3.10 Surface water quality ... 22
3.11 Surface water quality objectives ... 23
4 Conceptual stormwater management plan ... 25
4.1 Aim of the stormwater management plan ... 25
4.2 Existing stormwater infrastructure ... 25
4.3 Stormwater drainage and delineation of clean and dirty water areas ... 26
4.4 Assumptions ... 26
4.5 Stormwater peak flows ... 27
4.6 Proposed stormwater management measures ... 28
4.7 Proposed stormwater system sizing ... 29
4.8 Proposed stormwater monitoring requirements ... 30
5 Hydrological Risk Assessment ... 33
5.1 Cumulative impacts ... 34
6 Conclusions ... 36
6.1 Identification of any areas that should be avoided ... 37
6.2 Mitigation measures for inclusion in the EMPr and EIA ... 37
6.3 Monitoring requirements, specifically related to the stormwater management ... 38
6.4 Reasoned opinion whether the activity should be authorized ... 38
6.5 Recommendations ... 38

LIST OF FIGURES

Figure 1-1: Site layout plan (Swedish Stirling, 2021) 2
Figure 1-2: Site locality and drainage 6
Figure 2-1: Monitoring Process 11
Figure 3-1: Landcover 13
Figure 3-2: Sub-catchment slope (%) rise 14
Figure 3-3: Average yearly temperatures (Meteoblue, 2021) 15
Figure 3-4: Wind rose (Meteoblue, 2021) 16
Figure 3-5: Rainfall distribution (station 0593015) (WRC, 2015) 17
Figure 3-6: Simulated runoff for quaternary catchment B41J (WRC, 2015) 18
Figure 3-7: 1:100 year flood line for the Steelpoort River (extracted from Knight Piésold Consulting, 2019) 20
Figure 3-8: Illustration of the riparian zone and applied 32 m buffer (The Biodiversity Company, 2022) 21
Figure 3-9: Positions of monitoring points (JMA, 2021) 24
Figure 4-1: Dirty & clean water areas 31
Figure 4-2: Conceptual stormwater management system 32

LIST OF TABLES

Table 2-1: Summary of peak flow methods 10
Table 3-1: Summary of land cover types 12
Table 3-2: Summary of monitoring points (JMA, 2021) 22
Table 3-3: Summary of hydrochemistry results for March 2021 (JMA, 2019) 22
Table 3-4: Summary of hydrochemistry results for August 2021 (JMA, 2019) 23
Table 3-5: Water Quality limits for the Catchment downstream of De Hoop Dam 23
Table 4-1: Stormwater return period estimates for the proposed parking lots 27
Table 4-2: Proposed stormwater systems 29
Table 5-1: Construction (preparation and development) phase hydrological risk 35
Table 5-2: Operational phase hydrological risk 35
Table 6-1: Proposed Criteria and Rating Scales to be used in the Assessment of the Potential Impacts 40
Table 6-2: Explanation of Assessment Criteria 42

LIST OF APPENDICES

Appendix A: Hydrological risk assessment rating 39
Appendix B: Disclaimer and deceleration of independence 44
Details OF THE SPECIALIST, DECLARATION OF INTEREST AND UNDERTAKING UNDER OATH 45
CV of Specialist 1

LIST OF ACRONYMS

Acronym	Description
ADD	Average Daily Demand
BA	Basic Assessment
BOD	Biological oxygen demand
COD	Chemical oxygen demand
CM	Concentrated Molasses
CSWMP	Conceptual stormwater management plan
DEM	Digital Elevation Model
DWS	Department of Water and Sanitation
GCS	GCS Water and Environment (Pty) Ltd.
GN704	General Notice 704
ha	Hectare
HRU	Hydrological Response Unit
IWULA	Integrated Water Use Licence Application
m^3	Cubic Metres
MAE	Mean annual evaporation
MAR	Mean Annual Runoff
MIPI	Midgley and Pitman
NEMA	National Environmental Management Agency
n-Value	Manning’s Roughness Coefficients
NWA	National Water Act, 1998 (Act No. 36 of 1998)
PCD	Pollution Control Dam
PFD	Process flow diagram
SDF	Standard design flood
SW	Surface Water
TDS	Total dissolved solids
TIN	Triangulated Irregular Network
WMA	Water Management Area
WR2012	Water Resources of South Africa 2012
RLS	Rustenburg Layered Suite
BIC	Bushveld Igneous Complex
Vdr	Dwars River Sub-suite
Vdj	Dsjate Sub-suite

1 INTRODUCTION

GCS Water and Environment (Pty) Ltd (GCS) was appointed by Nettzero to undertake a hydrological assessment and to develop a conceptual stormwater management plan (CSWMP) for the proposed Lion Smelter Energy Conversion Project, situated in Steelpoort, Mpumalanga Province (refer to Figure 1-2). The project falls within quaternary catchment B41J of the Olifants Water Management Area (WMA) (DWS, 2016).

GCS undertook a pre-screening of the site, in terms of hydrology (GCS, 2022), and as part of the findings, it was determined that a CSWMP is required in a dedicated hydrology assessment report to describe stormwater management and drainage for the site. This document will supplement the BA/EIA for the site.

1.1 Project background

The Lion ECF (Energy Conversion Facility) is a standalone plant, presently in development which will use excess furnace gas from the Glencore Lion Smelter complex to generate electricity – refer to Figure 1-1. The Plant is of modular design, with each power generating module (called a PWR BLOK Unit or PBU) being made up of three primary components:

1. The PWR BLOK module (containerised generation plant with 14 engines and all necessary ancillaries)
2. A Containerised Gas Conditioner (CGC), conditions the incoming gas before this is fed to the PWR BLOK.
3. A Cooling Plant interconnected with the PWR BLOK module provides the necessary cooling for the 14 PCU's.
4. The configuration of these components is shown on the PWR BLOK General Arrangement drawing, which is included as Annexure 3.

The ECF consists of 25 PWR BLOK Modules resulting in a total ECF power generation capacity of 10 MW. The plant also includes all necessary civil, electrical, control and general infrastructure required for standalone operations.

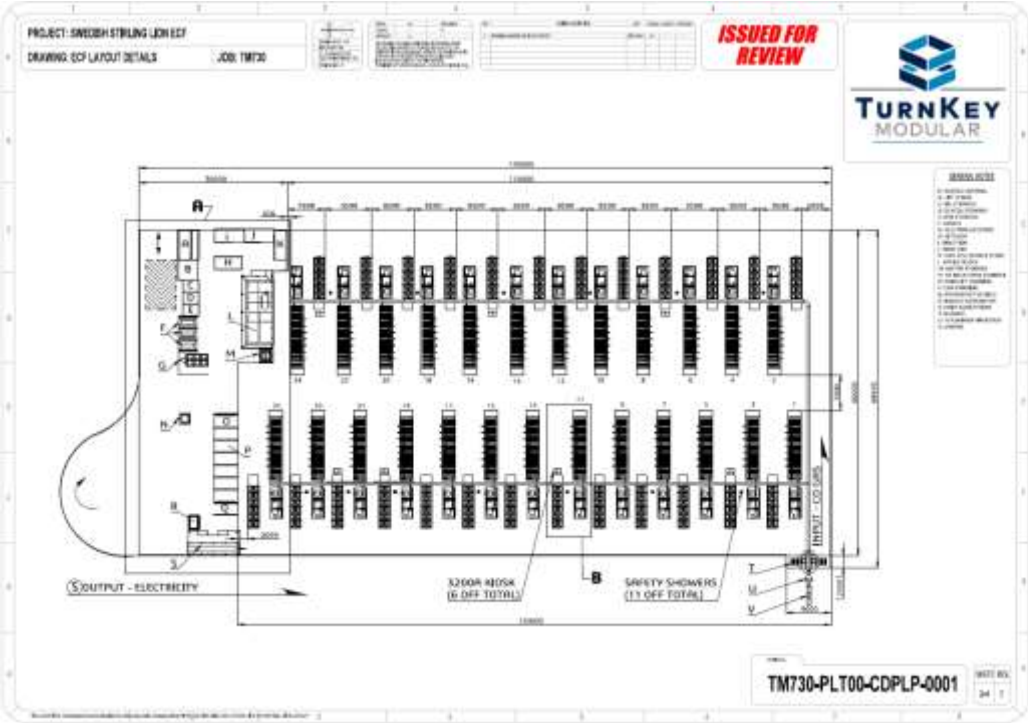


Figure 1-1: Site layout plan (Swedish Stirling, 2021)

1.2 Existing site conditions & activities to construct the plant

The proposed project site appears to have been partially worked in the past while there are small trees, shrubs and grass, no significant surface anomalies are present. No recognized watercourses are associated with the immediate area, and the footprint is zoned at the bottom of an existing TSF. Distance from the site to the nearest drainage lines (non-perennial streams) is recorded as approx. 160 and 272 m, and the distance from the site to the Steelpoort River is approximately 1.14 km. The site falls well away from 1:50 and 1:100-year flood lines of the Steelpoort River (Knight Piésold Consulting, 2019). No surface water users fall in the direct vicinity of the proposed development. Existing geotechnical information suggests moderate to good soils in the region (Swedish Stirling, 2021).

As part of the construction activities, groundworks will thus be limited to:

1. Clearing.
2. Removal and stockpiling of topsoil.
3. Limited excavation to a suitable depth.
4. Re-compaction of existing material; and
5. Importing of upper layers as will be informed by the layer works design.

The modular plant will be constructed on a single concrete slab devoid of complex civil structures. As such the plant footprint is to be covered with concrete. This is thickened underneath high load structures. In areas with moderate traffic, thinner sections may be considered. As there will be a concrete barrier installed, it is highly like that poor quality seepage from the facility into the sub-soils will be marginal to zero.

All dirty water shall be managed with a dedicated secondary catchment under the PBU's (modular trays above the surface are envisaged). As such, all water captured above the slab shall be considered to be clean water. The preliminary civil footprint is indicated on the ECF Layout Detail drawing, this is preliminary and is yet to be refined. A specific objective of the Front End Engineering and Design Phase (FEED) is to reduce this footprint to a total area of less than 10 000 m^2.

All building works for the Lion ECF Project will be modular or containerised re-deployable structures and will consist of the following

1. An access control point.
2. Lift store (containerised).
3. Oil, glycol, and gas storage areas (open bays).
4. Waste area for removable skips (open bays).
5. PCU Trailer store (open bay).
6. Ablution facility (containerised).
7. First aid facility (containerised).
8. A general store (containerised).
9. Parking bays (covered for forklift and cars).
10. Emergency vehicle parking bay (dedicated open parking bay, for use by Emergency Response Vehicles if needed).

Services such as potable water will tie into the existing Lion network, the proposed potable water tie-in position is indicated on the site layout drawing. The blackwater (sewer) tie-in will be resolved pending a suitable site survey, it is however anticipated that this will be near the western corner of the Lion site and is dependent on the invert levels of the existing sewer lines, should a suitable tie-in point not be possible due to the topography, alternatives may be assessed in the detailed.

The site stormwater management strategy (this is the designed on-site stormwater system that will be implemented and not the site-wide CSWMP as per this document) will be developed as part of the detailed engineering design for the facility. Each PWR BLOK will have a dedicated secondary containment receptible underneath it for the capture of potentially contaminated water. The stormwater captured on-site will be conveyed via the designed stormwater system, and tie into the proposed stormwater system developed as part of the hydrology assessment.

As described above, no permanent buildings are present on the site, all infrastructure is considered mobile re-deployable. As such the ECF implementation strategy allows for easy salvage on decommissioning. The most significant building structure is the civil slab, which by its nature is devoid of deep or complex structures (such as piling). The slab can be either repurposed on the closure of the ECF or easily demolished as may be required by LION.

1.3 The objective of this report

The objectives of this study, were as follows:

- Evaluate the site's hydrological setting (i.e., climate, rainfall, drainage, etc.).
- Determine the 1:10, 1:20, 1:50, and 1:100-year peak flows for the drainage streams draining the site; and
- Develop a conceptual stormwater management plan (CSWMP) to provide mitigative steps to circumvent erosion and control stormwater runoff.
- Undertake a hydrological risk assessment and compile mitigation measures; and
- Compile a stormwater monitoring plan to monitor the impact on the receiving environment

1.4 Scope of Work

The scope of work completed, were as follows:

1. **Baseline Hydrology Review:**
    a. Hydro-meteorological data collection and analysis.
    b. Catchment delineation and drainage characteristics.
    c. Determination of catchment hydraulic and geometric parameters.
2. **Conceptual Storm Water Management Plan and Stormwater Monitoring:**
    a. Identification of stormwater sub-catchments (i.e., clean and dirty areas)
    b. Determination of stormwater flows and volumes (1:10, 1:20, 1:50 and 1:100- yr return periods) were undertaken; and

c. Indication and explanations of the placement of stormwater attenuation infrastructure were offered.

d. A stormwater monitoring system plan was drafted, to ensure that the stormwater discharge impact on the environment is managed and controlled.

3. **Risk assessment:**

   a. A hydrological risk assessment was undertaken, to contextualize the potential hydrological risks associated with this project.

4. **Reporting:**

   a. This hydrology assessment report, entailing the above-mentioned components was compiled.

1.5 Study relevance to the season in which it was undertaken

This study was undertaken as a once-off study and relies on historical hydrological and climate data for the site, as well as recognised hydrological and water resource databases for South Africa. Data generated during the time of this study is not seasonally bound as average yearly data was applied where required and as scientifically acceptable.

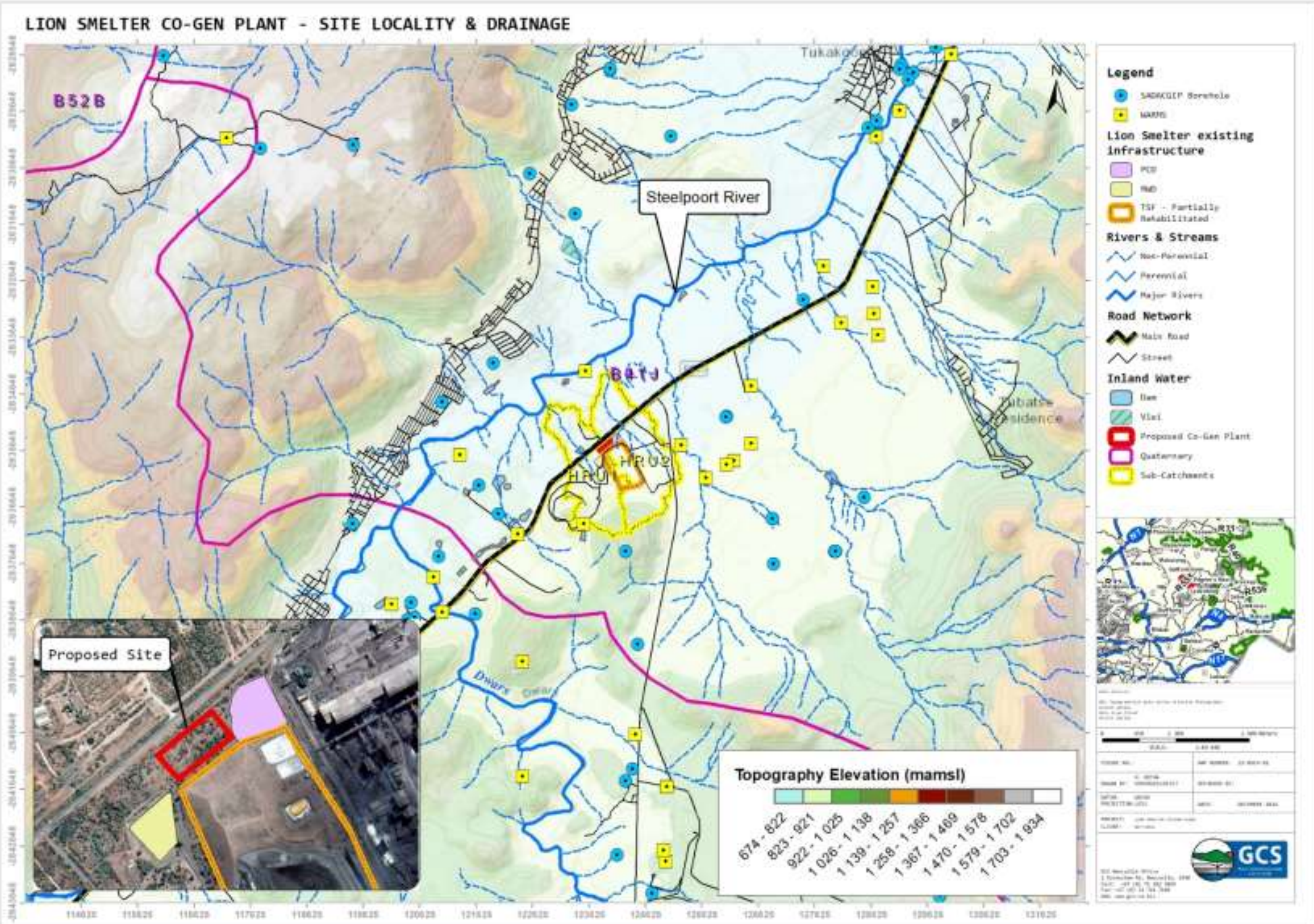


Figure 1-2: **Site locality and drainage**

2 METHODOLOGY

The methodological approach for the study is described in the sub-sections below.

2.1 Legal considerations

The National Water Act, (Act 36 of 1998) (NWA) governs the use of water and protection of water resources in South Africa. There are two sets of regulations on water use thus far:

- Government Notice No. 704, 4 June 1999, National Water Act, 1998 (No. 36 of 1998): Regulations on the use of water for mining and related activities aimed at the protection of water resources (GN704).
- Government Notice No. 1352, 12 November 1999, National Water Act, 1998 (No. 36 of 1998): Regulations requiring that water use be registered.

In terms of Section 144 of the National Water Act of 1998 (Act 36 of 1998), a flood line, representing the highest elevation that would probably be reached during a storm with a return interval of 100 years, must be indicated on all plans for the establishment of townships. The term, "establishment of townships" includes the subdivision of stands or farm portions in existing townships/development, if the 100-year flood lines are not already indicated on these plans, or when the land-use category of a particular portion of land is changed.

The National Environmental Management Act (Act 107 of 1998) (NEMA) stipulates that all relevant factors be considered for proposed developments to ensure that water pollution and environmental degradation is avoided. Section 2 of the Act establishes a set of principles that apply to the activities of all organs of the state that may significantly affect the environment. These include the following:

- Development must be sustainable
- Pollution must be avoided or minimized and remedied
- Waste must be avoided or minimized, reused or recycled
- Negative impacts must be minimized.

The requirements laid down by the National Building Regulations and Building Standards Act (Act 103 of 1977) in terms of development within the 1:50-year flood line area are based only on safety considerations without proper consideration and understanding of the underlying natural streamflow processes. The Town Planning and Townships Ordinance (Ordinance 15 of 1986) also makes provision in Regulation 44(3) for the extension of flood line areas up to 32 m from the centre of a stream in instances where the 1:50-year flood line is less than 62 m wide in total (CSIR, 2005).

Appendix 6 of GN 326 EIA Regulation 2017 regulations further govern hydrology assessments for EIAs. This hydrology report conforms to Appendix 6 of the EIA regulations, which include the following aspects (where applicable to this study) to be addressed:

(a) Details of:

(i) The specialist who prepare the reports; and

(ii) the expertise of that specialist to compile a specialist report including a curriculum vitae

(b) Declaration that the specialist is independent in a form as may be specialities by the competent authority

(c) Indication of the scope of, and purpose for which, the report was prepared

(cA) Indication of the quality and age of base data used for the specialist report

(cB) A description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change

(d) Duration, Date and seasons of the site investigation and the relevance of the season to the outcome of the assessment

(e) Description of the methodology adopted in preparing the report or carrying out the specialised process include of equipment and modelling used

(f) Details of an assessment of the specifically identified sensitivity of the site related to the proposed activity or activities and its associate's structures and infrastructure, inclusive of a site plan identifying alternatives

(g) Identification of any areas to be avoided, including buffers

(h) Map superimposing the activity and associated structures and infrastructure on environmental sensitivities of the site including areas to be avoided, including buffers

(i) Description of any assumptions made and uncertainties or gaps in knowledge

(j) A description of the findings and potential implications of such findings on the impact of the proposed activity including identified alternatives on the environment or activities

(k) Mitigation measures for inclusion in the EMPr

(l) Conditions for inclusion in the environmental authorisation

(m) Monitoring requirements for inclusion in the EMPr or environmental authorisation

(n) Reasoned opinion –

(i) as to whether the proposed activity, activities or portions thereof should be authorised;

(iA) regarding the acceptability of the proposed activity or activities; and

(ii) if the opinion is that the proposed activity, activities or portions thereof should be authorised, and avoidance, management, mitigation measures that should be included in the EMPr, and where applicable, the closure plan

(o) Description of any consultation process that was undertaken during preparing the specialist report

(p) A summary and copies of any comments received during any consultation process and where applicable all responses thereto.

(q) Any other information requested by the competent authority.

2.2 Hydrological assessment

Hydrometeorological data for the study area were obtained from various sources including the South African Water Resources Study WR2012 database (Bailey & Pitman, 2015), South African Atlas of Agrohydrology, and Climatology (Schulze, 1997), and the Daily Rainfall Data Extraction Utility (Lynch, 2004). Moreover, sources such as the Köppen Climate Classification (Kottek, et al., 2006), World Climate Data CMIP6 V2.1 (Eyring, 2016), and Meteoblue (Meteoblue, 2022) were used to refine hydrological data.

These sources provided means of determining the Mean Annual Precipitation (MAP), Mean Annual Runoff (MAR), and Mean Annual Evaporation (MAE) of the study site as well as the design rainfall data. Data was applied to the site water balance calculations, runoff peak flow estimates for flood line modelling and stormwater runoff peak flow estimates for stormwater system sizing (where applicable to this study).

2.2.1 Catchment description and delineation

A 30 m Digital Terrain Model (DTM) data from the Advanced Land Observing Satellite (ALOS) (JAXA, 2022) were used to delineate the area draining to the streams relevant to this study, sub-catchment flow path as well as to derive river geometry characteristics. These characteristics (area, slopes, and hydraulic parameters) are used to parameterize the site hydraulic model for flood line modelling, water balance modelling or stormwater modelling.

2019 South African (SA) National Land Cover data (DEA, 2019) was used to characterize the sub-catchment vegetation and derive manning surface roughness (n-values) coefficients.

2.2.2 Design rainfall and peak flow

The Design Rainfall Estimation Software (Smithers & Schulze, 2002) data from the rainfall stations surrounding the study site were used to calculate the 24-hour design rainfall depths for various return periods. Critical storm durations for Rational Methods Alternative 3 were calculated using the Modified Hershfield Equation (Adamson, 1981).

The streams/drainage sections that were modelled applying the three widely used methods were used to calculate 1:10, 1:20, 1:50, and 1:100-year peak flows. These are the Rational Method, Midgley and Pitman (MIPI), and the Standard Design Flood (SDF) methods. A brief description of each of the peak flow methods can be seen in Table 2-1, below.

Methodologies for using the applied peak flow models are explained broadly in the South African Drainage Manual (SANRAL, 2013). Calibration of the runoff coefficients for the drainage areas was guided by the manual, the understanding of the runoff-generating processes as well as land cover attributes. The resulting peak flows calculated using the selected methods were evaluated and conservative values provided inputs into the stormwater management plan.

Table 2-1: Summary of peak flow methods

Rational Method

The rational method was developed in the mid-19th century and is one of the most widely used methods for the calculation of peak flows for small catchments (< 15 km^2). The formula indicates that Q = CIA, where I is the rainfall intensity, A is the upstream runoff area and C is the runoff coefficient. Q is the peak flow. There are 3 alternatives to the Rational Method which differ on the methodology used to calculate rainfall intensities. The first alternative (RM1) uses the depth-duration frequency relationships approach, the second uses the modified Hershfield equation while the third alternative uses the Design Rainfall software for South Africa (SANRAL, 2013).

Midgley and Pitman

The Midgley and Pitman (MIPI) method is an empirical method that relates peak discharge to catchment size, slope, and distance from the drainage point to the centroid of the catchment (Campbell, 1986). The MIPI method uses 10-unit hydrographs for 10 zones in South Africa. The method does not consider overland flow as a component separate from streamflow but considers only the total longest flow path (Campbell, 1986).

Standard Design Flood Method

The Standard Design Flood (SDF) method was developed specifically to address the uncertainty in flood prediction under South African conditions (Alexander, 2002). The runoff coefficient (C) is replaced by a calibrated value based on the subdivision of the country into 26 regions or Water Management Areas (WMAs). The design methodology is slightly different and looks at the probability of a peak flood event occurring at any one of a series of similarly sized catchments in a wider region, while other methods focus on point probabilities (SANRAL, 2013).

2.3 Conceptual stormwater management plan (CSWMP)

The SWMP was designed in conjunction with the provided existing infrastructure layout plans and available topographical data. The Rational Method was applied to determine stormwater peak flows.

The conceptual SWMP was designed to consider relevant South African legislation – the National Water Act (1998) (NWA, 1998) and the Council for Scientific and Industrial Research (CSIR) Human Settlement Planning and Design guidelines (CSIR, 2005).

2.4 Hydrological risk assessment

As per GNR 982 of the EIA Regulations (2014), the significance of potential hydrological impacts was assessed. The risk assessment methodology and ratings applied to the study area and proposed activities are available in **Appendix A.**

2.5 Surface water monitoring plan

The monitoring network is based on the principles of a monitoring network design as described by the DWAF Best Practice Guidelines: G3 Monitoring (DWAF, 2007). The methodological approach that the monitoring plan follows is represented in Figure 2-1, below.

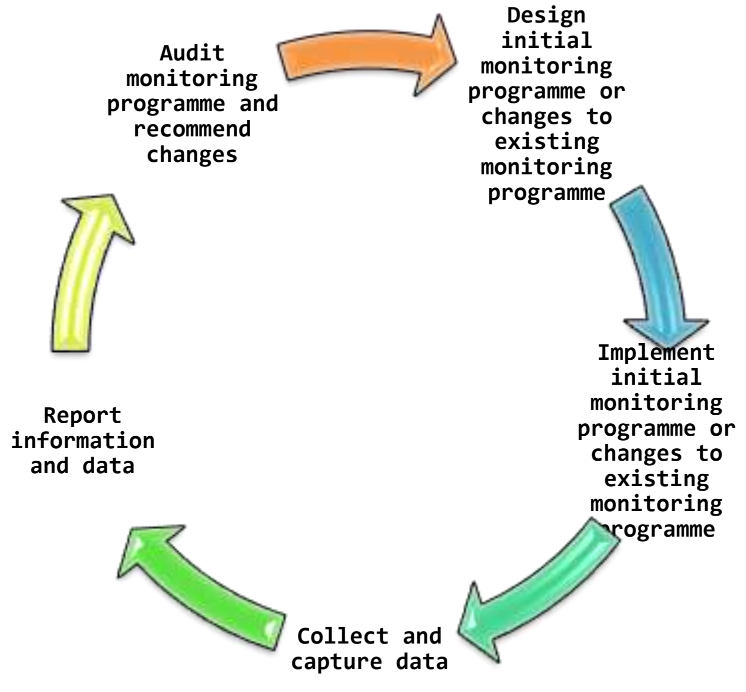


Figure 2-1: Monitoring Process

A surface water monitoring plan was drafted and is based on the hydrological risks identified for the site and stormwater/natural runoff from the site.

3 SITE OVERVIEW AND HYDROLOGY

As mentioned previously, the project falls within the lower reaches of quaternary catchment B41J of the Olifants Water Management Area (WMA) (DWS, 2016). Elevations on the site typically range from 770 to 840 metres above mean sea level (mamsl).

3.1 Sub-catchments / hydrological response units (HRUs)

Two (2) hydrological response units (HRUs) describe the natural drainage for the study area (using an ALOS DTM, with a 1:200 stream count and 15m DTM fill) – refer to Figure 3-1 and Figure 1-2. The HRUs delineated correspond well to known non-perennial drainage lines associated with the site.

The origin of the non-perennial stream appears to be near the existing tailings facility (TSF) towards the southwest, and the pollution control dam (PCD) towards the northeast from the position of the proposed site. Hence, and based on available elevation data, the area zoned for the proposed ECF (Energy Conversion Facility) Plant is situated on a sub-catchment water divide. Approximately 90% of the proposed layout falls within HRU1, and 10% in HRU2. Hence, drainage from the position of the proposed Plant will primarily be towards the northeast, with some minor runoff towards the northwest.

Drainage from the Lion Smelter site is towards the north-west, via two (2) non-perennial streams (as identified with HRU1 and HRU2) and flow is towards the Steelpoort River, situated approximately 1.14 km northwest of the site. Distance from the site to the nearest drainage lines is recorded as approx. 160 and 272 m.

3.2 Land cover and slope

Contiguous (indigenous) forest, low shrubland (fynbos), low shrubland (succulent karoo), natural pans (flooded @ observation times), subsistence / small-scale annual crops, fallow land & old fields (bare), fallow land & old fields (low shrub), residential informal (bush), urban recreational fields (bare), commercial and mine surface infrastructure types dominate the sub-catchment (DEA, 2019) – refer to Figure 3-1. The land cover data were used to classify land types into 4 groups, as presented in Table 3-1. The slope rise (%) for each HRU was determined using an ALOS 30mDTM and can be seen in Figure 3-2.

Table 3-1: Summary of land cover types

Sub-Catchment		HRU1	HRU2
Area (km²)		1.441	1.832
Longest Drainage Line (km)		1.11	0.62
Average Slope (%)		2.65%	2.05%
Land Cover	Thick bush & plantation	0.00%	0.00%
	Light bush & farm-lands	54.05%	32.26%
	Grasslands	0.68%	5.11%
	No Vegetation	45.27%	62.55%

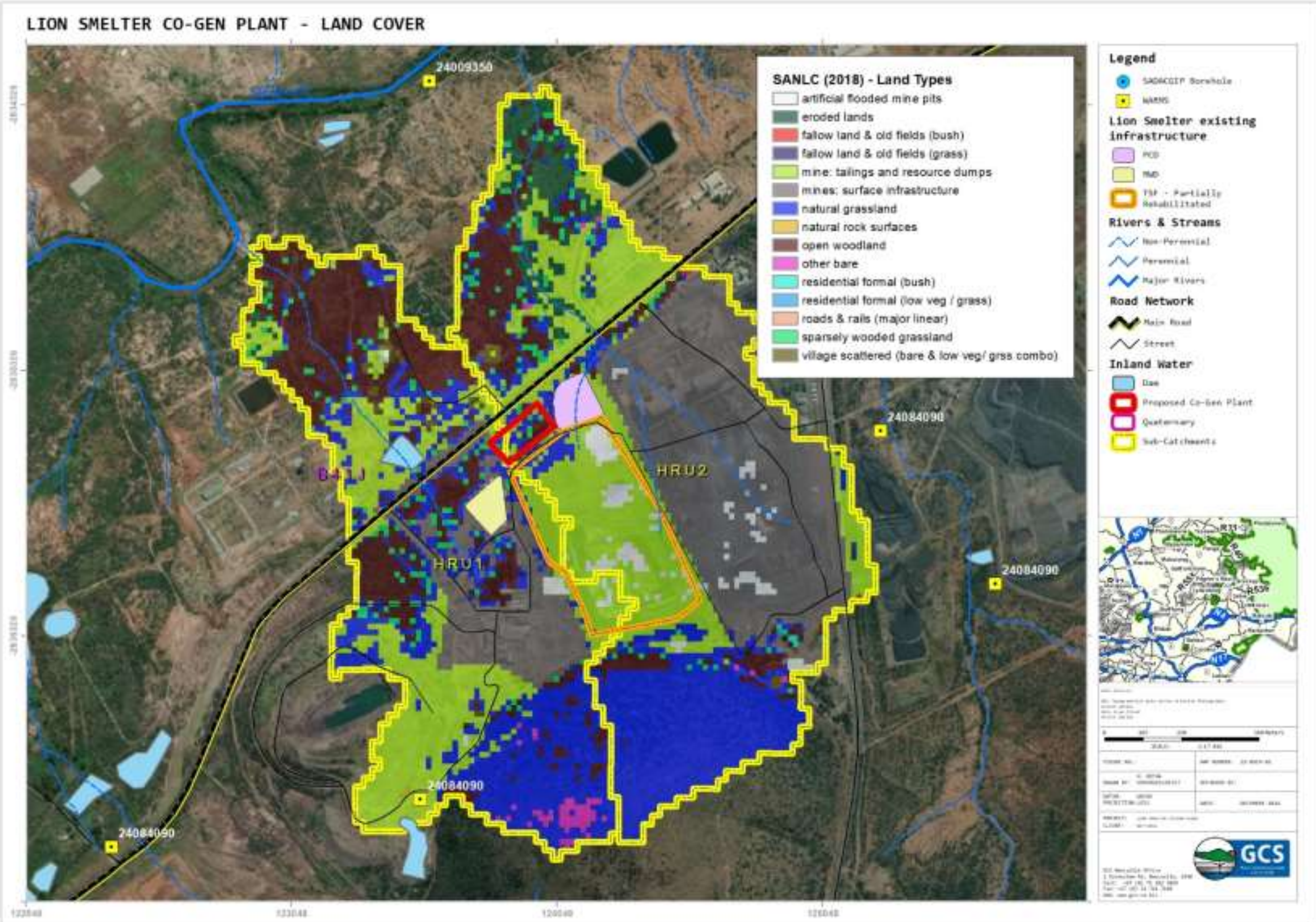


Figure 3-1: Landcover

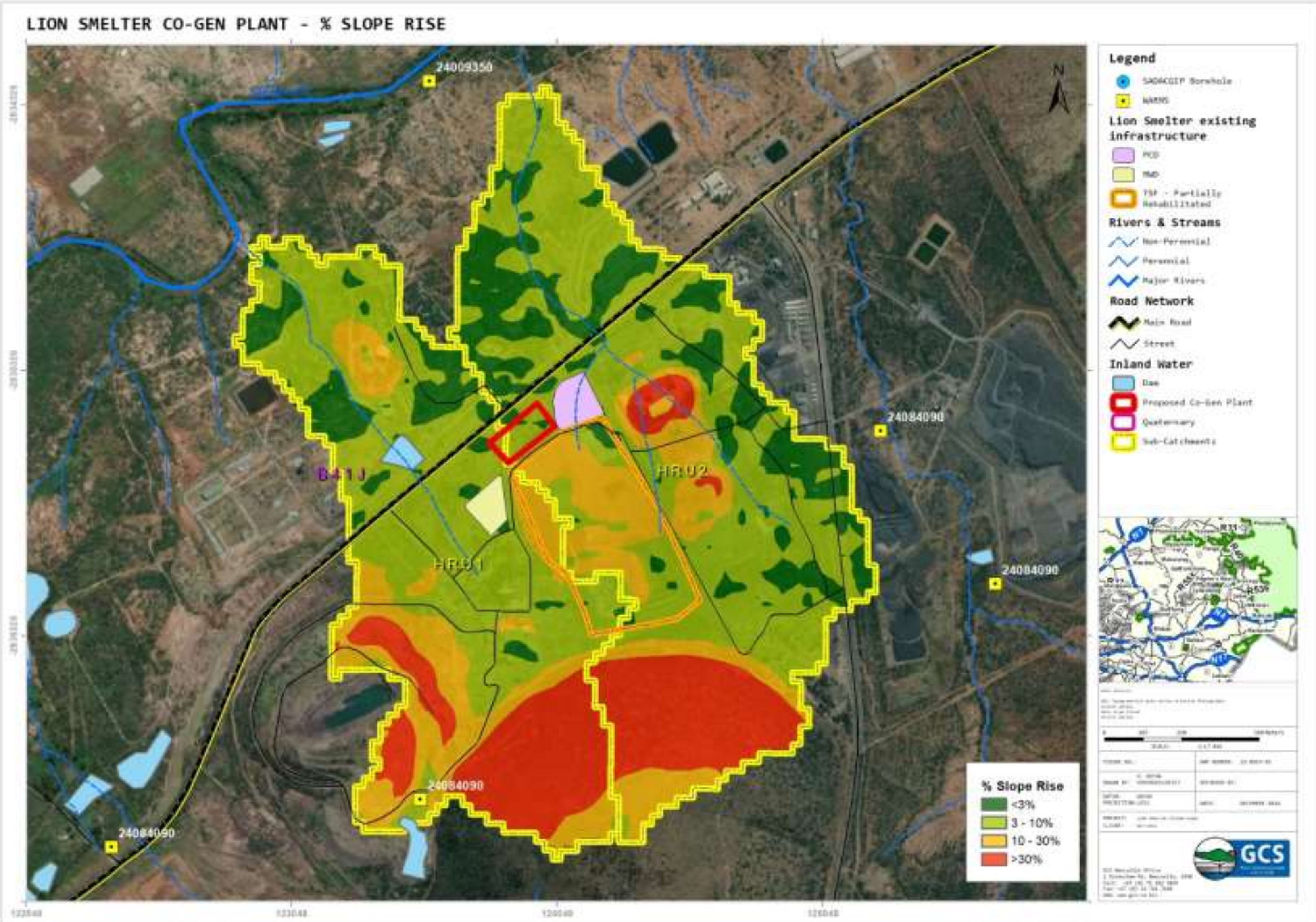


Figure 3-2: Sub-catchment slope (%) rise

3.3 Climate

Climate, amongst other factors, influences soil-water processes and stormwater peak flows. The most influential climatic parameter is rainfall. Rainfall intensity, duration, evaporative demand, and runoff were considered in this study to indicate rainfall partitioning within the project area.

3.3.1 Temperature

The average yearly temperature (refer to Figure 3-3) for the project area ranges from 23 to 37 C (high) and 3 to 8 °C (Low). The study area is situated in a Warm Temperate, Winter Dry, Hot Summer climate (Cwa), as per the Köppen Climate Classification (Kottek, et al., 2006). Hence, the area received summer rainfall.

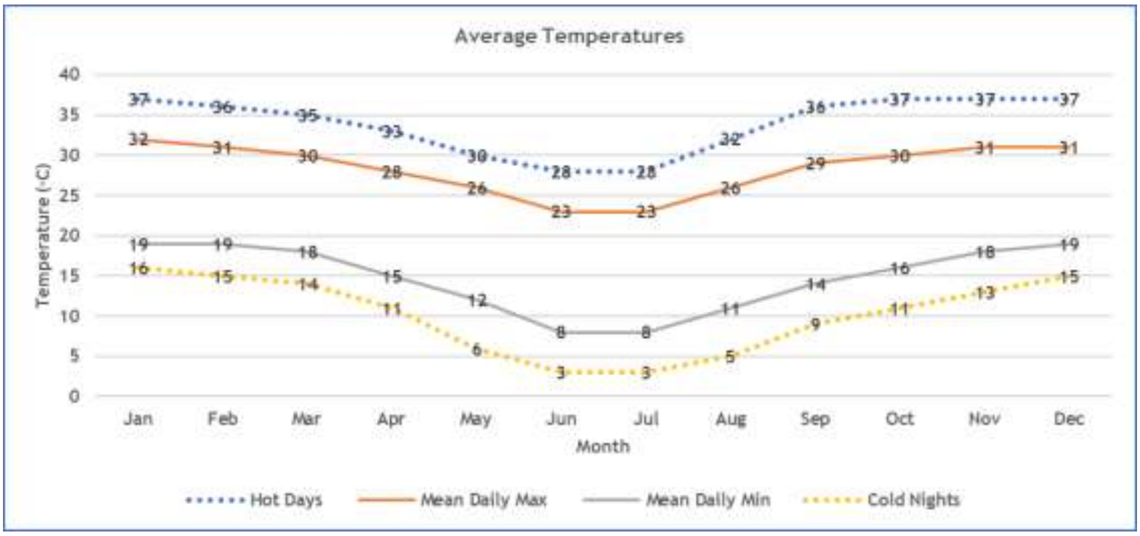


Figure 3-3: Average yearly temperatures (Meteoblue, 2021)

3.3.2 Wind speed and direction

Figure 3-4 shows the wind rose for the project area (the site used as a reference site) and presents the number of hours per year the wind blows from the indicated direction. Wind generally blows from NE, NNE, NNE at velocities from <5 to >28 km/h. Precipitation intensity during wind will likely cause intensity changes on slopes perpendicular to the wind direction, throughout the year.

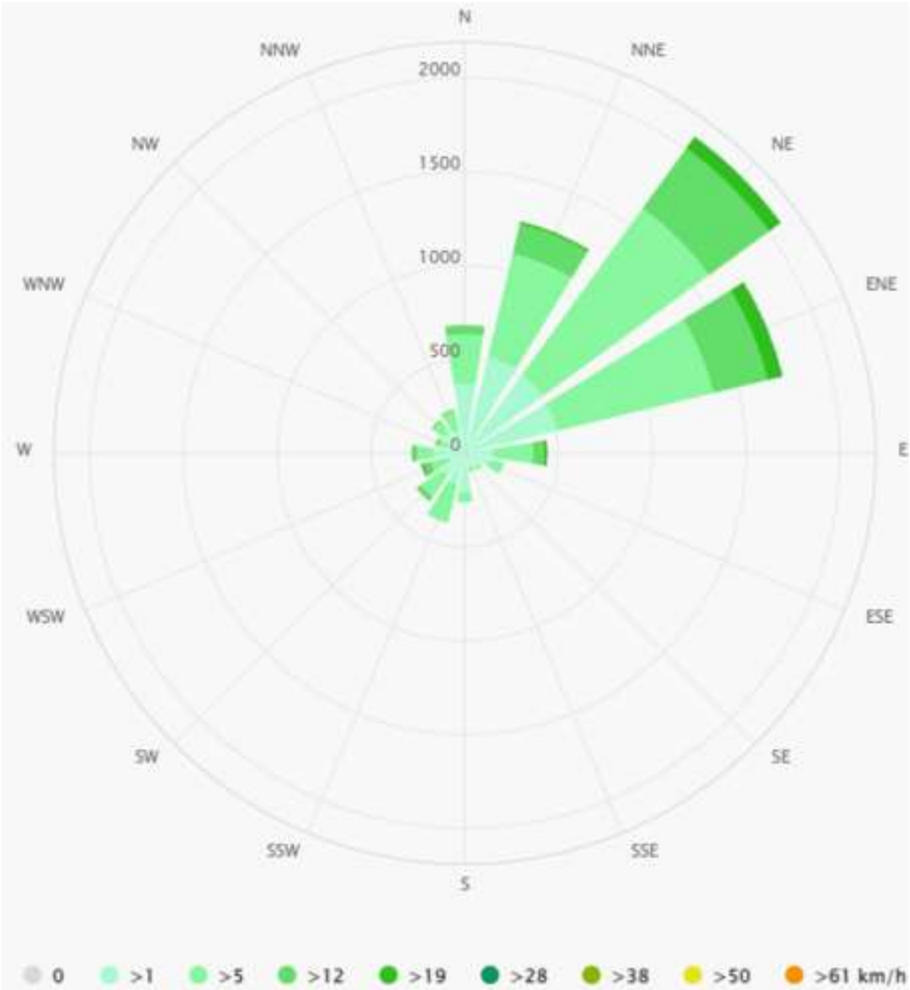


Figure 3-4: Wind rose (Meteoblue, 2021)

3.3.3 Rainfall and evaporation

The project area is situated in rainfall zone B4D. The rainfall data used to calculate Mean Annual Precipitation (MAP) was obtained from rainfall station 0593015 (station Sekhukhuneland situated 12km NW of the site). Available rainfall data suggest a MAP ranging from 319 (30^{th} percentile) to 1050 (90^{th} percentile) mm/yr, based on a historical record of 76 years (i.e., 1907 to 1983). The average rainfall is in the order of 554 mm/yr. Design rainfall data (Station: Sekhukhuneland) suggest a MAP in the order of 552 mm/yr – hence the data is in the same order of magnitude. Monthly rainfall for the site is likely to be distributed as shown in Figure 3-5, below.

The site falls within evaporation zone 4A, of which Mean Annual Evaporation (MAE) ranges from 1 300 to 1 500 mm/yr. The MAE far exceeds the MAP for the site, which implies greater evaporative losses when compared to incident rainfall. Monthly evapotranspiration for the site is likely to be distributed as shown in Figure 3-5, below.

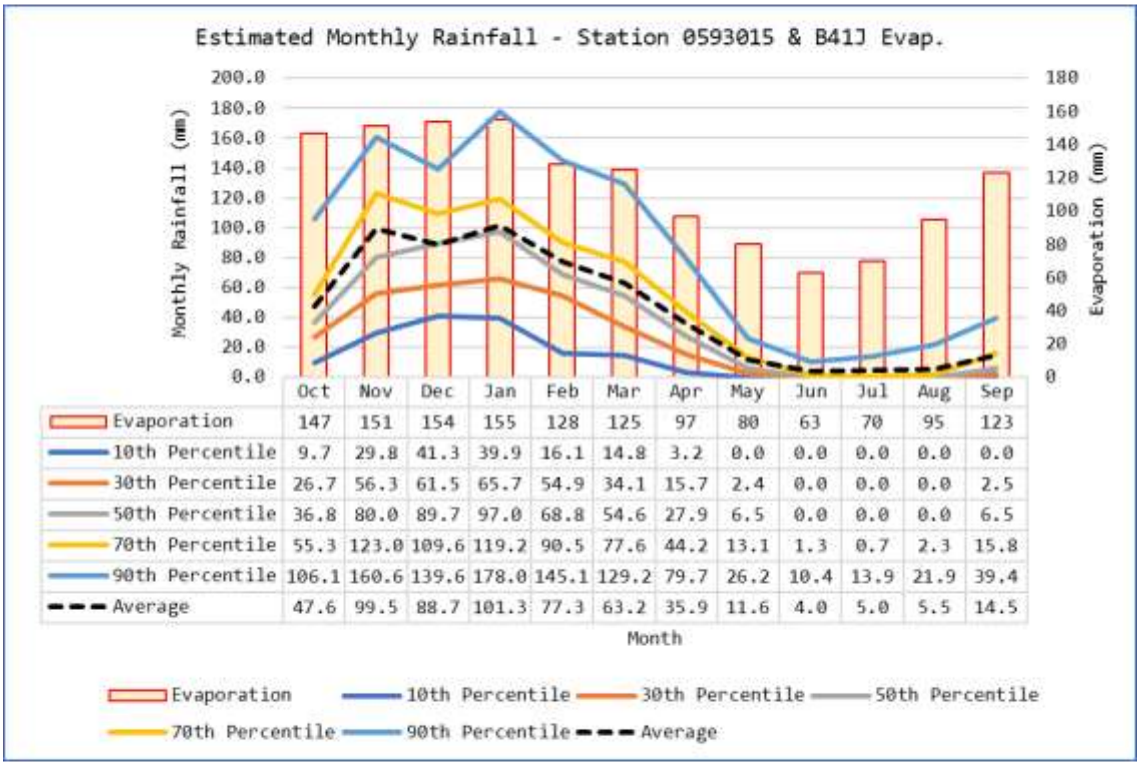
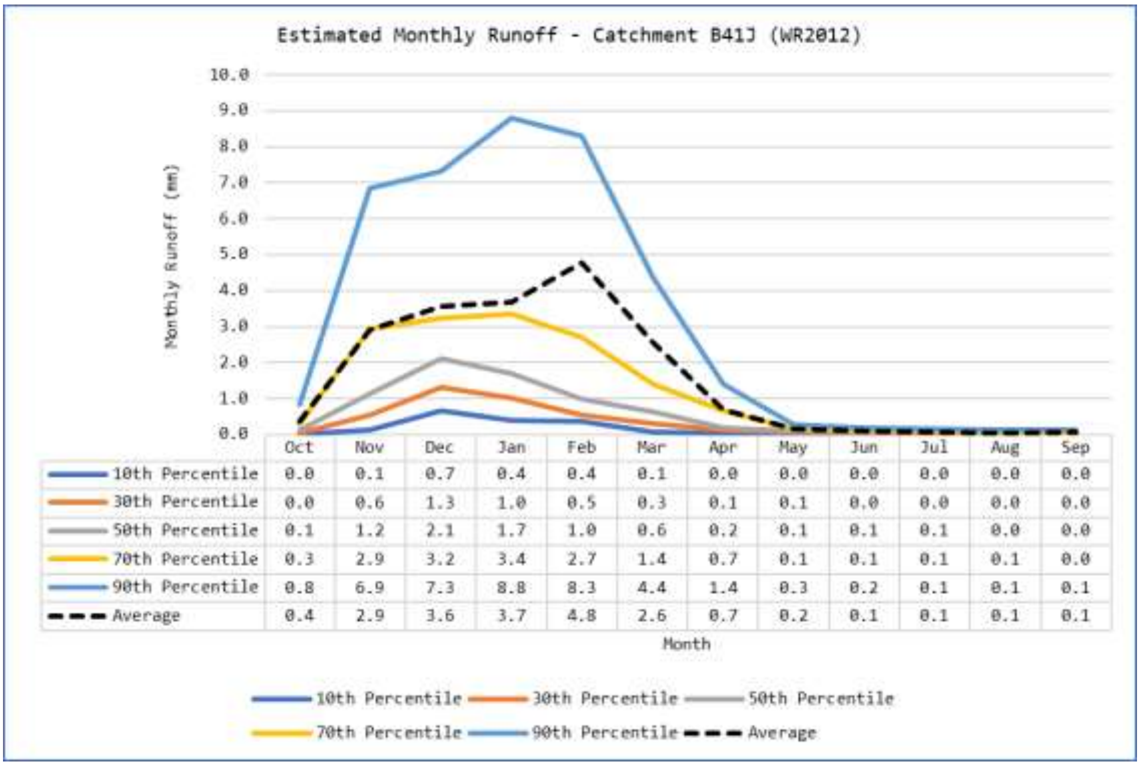


Figure 3-5: Rainfall distribution (station 0593015) (WRC, 2015)

3.3.4 Runoff

Runoff from natural (unmodified) catchments in Catchment B41J is simulated in WR2012 as being equivalent to 19 mm/yr over the surface area (WRC, 2015). This is equal to approximately 3% of the MAP and amounts to approximately 13 Mm^3/yr over the surface of the quaternary catchment. Monthly runoff is distributed as shown in Figure 3-6, below.



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
10th Percentile	0.0	0.1	0.7	0.4	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0
30th Percentile	0.0	0.6	1.3	1.0	0.5	0.3	0.1	0.1	0.0	0.0	0.0	0.0
50th Percentile	0.1	1.2	2.1	1.7	1.0	0.6	0.2	0.1	0.1	0.1	0.0	0.0
70th Percentile	0.3	2.9	3.2	3.4	2.7	1.4	0.7	0.1	0.1	0.1	0.1	0.0
90th Percentile	0.8	6.9	7.3	8.8	8.3	4.4	1.4	0.3	0.2	0.1	0.1	0.1
Average	0.4	2.9	3.6	3.7	4.8	2.6	0.7	0.2	0.1	0.1	0.1	0.1

Figure 3-6: Simulated runoff for quaternary catchment B41J (WRC, 2015)

3.4 Local geology and soils

The regional geology of the study area is discussed concerning data obtained from JMA (2019) and extracted from the 1:250 000 Geological Map Series of the Republic of South Africa - Sheet 2430 Pilgrim's Rest (DMEA, 1998).

The site is located in the Eastern Limb of the Bushveld Igneous Complex (BIC) and is underlain by the rocks of the Rustenburg Layered Suite (RLS). The site is underlain by rocks of the Rustenburg Layered Suite, largely belonging to the Winterveld Norite-Anorthosite unit of the Dwars River Sub-suite (critical zone) and a lesser extent by the overlying Dsjate Sub-suite (main zone). The regional geological dip is between 9° and 12° westwards.

The Surface geology to the east of the study area consists mainly of lithologies from the Transvaal Supergroup, these include the Silverton, Vermont Lakensvalei, Nederhorst and The Steenkampsberg Formations (denoted as "Vs", "Vv", "Vl", "Vn" and Vsq" on the geology map for the area). The surface geology to the far west of the site consists of the Nebo granite of the Lebowa Granite Suite.

Approximately 80% of the surface geology underlying Lion is made up of the Winterveld Norite-Anorthosite of the Dwars River Sub-suite (Vdr) and 20% is made up of the Dsjate Sub-suite (Vdj) consisting of layered anorthosite and a magnetite plug, both forming part of the RLS of the BIC.

The geological structure is relatively complex in comparison with most other areas of the Bushveld Complex. Several linear geological features occur regionally and locally. A large fault can be seen parallel with the Steelpoort River to the north to the northwest of the site. The dominant strike of dykes, is NNE to SSW, with the second direction of NW to SE. These dykes can in places be traced on the surface. All dykes appear to be vertical or near-vertical in orientation, very fine crystalline and doleritic in composition.

Large pipe bodies of magnetite iron ore occur in several areas around the southwest of the site.

According to the Land types of South Africa databases (Land Type Survey Staff, 1972 – 2006c), the soils in the area predominantly consist of freely drained, red, eutrophic, apedal soils comprise >40% of the land type. According to the agricultural compliance statement (Land Matters Environmental Consulting (Pty) Ltd, 2022), the following is noted:

- The study site can be classified into two separate soil types, the natural soils and the anthrosols. Natural soil formation gives rise to soil morphological expression and a sequence of soil horizons without significant human intervention. Anthrosols are soils that have been drastically altered by human intervention such that the natural soil properties are no longer identifiable, and an anthropogenic classification is applied.

- The natural soils were dominated by the Calcic soil group. Calcic soils are characterised by calcium within the soils that remain behind to form cemented soil through the evaporation of water. Most commonly it is encountered in the form of carbonate horizons, which was identified within the project site. Within the site, the neocarbonate soil horizon was identified with the soils classified as either the Palala or Hofmeyr soil forms. The Palala soil form consists of an Orthic A horizon which overlies a neocarbonate B horizon which overlies a pedocutanic C horizon. A Hofmeyr soil form consists of an Orthic A horizon which overlies a neocarbonate B horizon which overlies Hard Rock. The presence of a pedocutanic horizon, as well as the presence of Hard Rock, are both limiting factors to the agricultural potential of these soils. The Palala soils occupy 2.69ha or 63.1% of the site, while the Hofmeyr soils occupy 0.75ha or 17.6% of the site.
- Portions of the proposed project site have existing disturbances as a result of dirt roads. Due to the existence of the roads, the soils within these areas are described as Physically Disturbed Anthrosols. This soil is further classified as the Grabouw soil form and is no longer suitable for agricultural production as the original soil profile has been mixed and is no longer identifiable. The Grabouw soils occupy 0.81ha (19.4%) of the site.

3.5 Floodlines

A review of the hydrological assessment report compiled by Knight Piésold Consulting (2019) suggests that the site falls well outside the modelled 1:100 year flood lines of the Steelpoort River (refer to Figure 3-7).

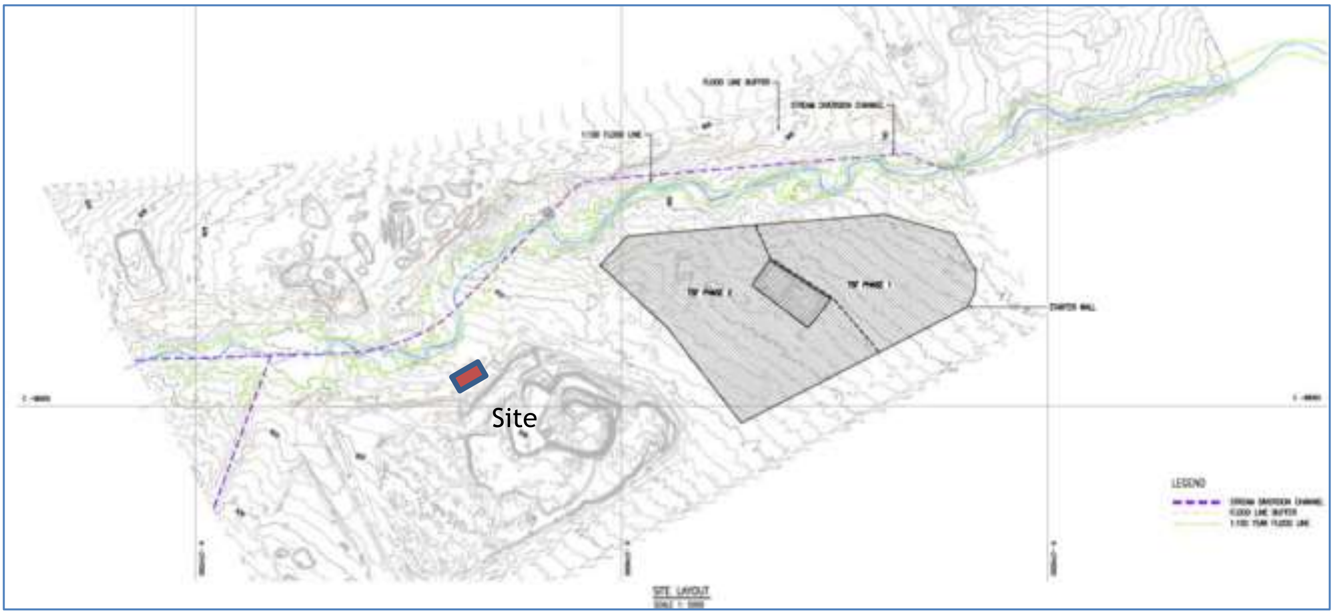


Figure 3-7: 1:100 year flood line for the Steelpoort River (extracted from Knight Piésold Consulting, 2019)

3.6 Depth to groundwater

According to WR2012 (Bailey & Pitman, 2015) and DWAF GRAII (DWAF, 2006) data, the groundwater level in the study area on average is in the order of 18.8 mbgl (metre below ground level). According to the hydrogeology report compiled by JMA (JMA, 2021), the depths to groundwater levels are also estimated to range between 10 m and 20 m below the surface.

3.7 Surface water users within the sub-catchment associated with the site

According to Water Allocation Registration Management System (WARMS) for Section 21(a) and Section 21 (b) water uses, there is one (1) registered water user within HRU1, and one (1) registered water user along the Steelpoort River (2 in total). Both water users are registered as Lion Smelter, one is an abstraction from a borehole along the Steelpoort River (ID: 24009350, 163520 m^3/yr) and the other is for water storage in a dam (ID: 24084090, total storage = 677 929 m^3/yr).

3.8 Wetland areas

Based on available National Wetland Freshwater Ecosystem Priority Areas (NFEPA) (Van Deventer, 2018) no recognised NFEPA wetlands fall within the study area. However, we refer to the Aquatic Compliance Statement (The Biodiversity Company, 2022) for a recognised riparian wetland situated approximately 500m downstream west of the site (refer to Figure 3-8).

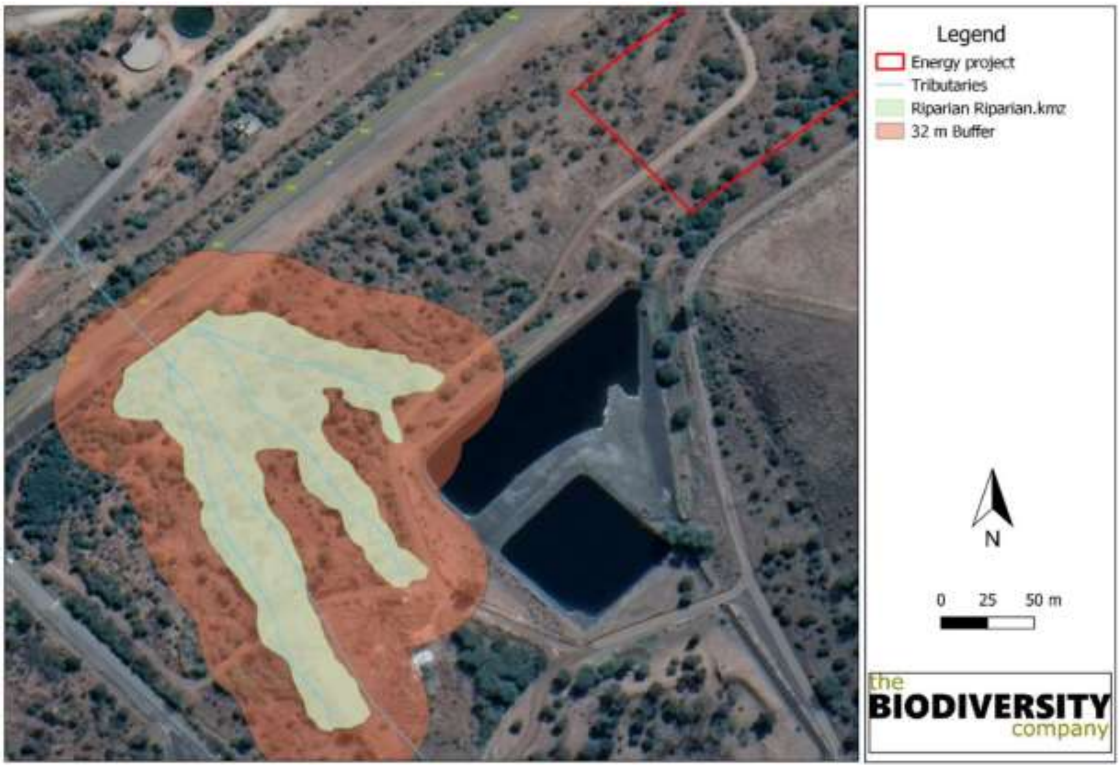


Figure 3-8: Illustration of the riparian zone and applied 32 m buffer (The Biodiversity Company, 2022)

3.9 Present ecological state (PES) and ecological importance and sensitivity (EIS)

Quaternary B41J PES is classified as a category C (largely modified) and EIS is classified as high sensitive (WRC, 2015).

3.10 Surface water quality

A review of the JMA (2021) monitoring reports (Jan 2021 to August 2021) suggest that there are 9 existing surface water monitoring points at Lion Smelter Operations (refer to Table 3-2 and Figure 3-9).

Table 3-2: Summary of monitoring points (JMA, 2021)

ID	Latitude	Longitude	Position
LSWM-S1	-24.79231	30.13089	Steelpoort River Downstream for Lion.
LSWM-S2	-24.80756	30.10963	Steelpoort River Opposite Lion.
LSWM-S3	-24.82850	30.08030	Steelpoort River Upstream from Lion.
LSWM-S4	-24.83303	30.07568	Steelpoort river upstream from Dwars River Confluence.
LSWM-D1	-24.83201	30.07980	Dwars River Upstream from Steelpoort River Confluence.
LSWM-D2	-24.85639	30.09959	Dwars River further Upstream at Irrigation Weir.
LSWM-D3	-24.92841	30.10860	Dwars River further Upstream at Big Bridge.
LSWM-D4	-24.99781	30.13400	Dwars River further Upstream at Small Bridge.
LSWM-D5	-25.04661	30.12080	Dwars River further Upstream at Upstream Weir.

A review of the hydrochemistry data for the sample points suggests that parameters measured (pH, TDS, Ca, Mg, Na, Cl, SO_4, NH_4, PO_4, F, Al, Mn, Cr^{6+} and Zn) generally fall well within regulatory limits, except for Al concentrations which have been observed to be high several times in from January to August 2021 – refer to Table 3-3 and Table 3-4 below for snapshots of typical water quality.

Table 3-3: Summary of hydrochemistry results for March 2021 (JMA, 2019)

	pH	TDS (mg/l)	Ca (mg/l)	Mg (mg/l)	Na (mg/l)	Cl (mg/l)	SO_4 (mg/l)	NH_4 (mg/l)	PO_4 (mg/l)	F* (mg/l)	Al* (mg/l)	Mn* (mg/l)	Cr^{6+}* (mg/l)	Zn* (mg/l)
RQO Olifants Catchment (Steelpoort River)									0.125	2	0.063	0.68	0.068	0.014
LSWM-S1	7.60	116	19.4	9.19	10.5	9.25	7.70	<0.45	<0.03	0.12	0.45	0.01	<0.02	<0.01
LSWM-S2	8.00	122	21.3	9.22	9.06	7.71	16.4	<0.45	<0.03	0.12	0.41	<0.01	<0.02	<0.01
LSWM-S3	7.95	121	19.8	10.6	9.29	8.61	8.30	<0.45	<0.03	0.10	0.51	<0.01	<0.02	<0.01
LSWM-S4	7.96	113	19.3	9.11	9.15	8.13	7.62	<0.45	<0.03	0.12	0.97	0.02	<0.02	<0.01
LSWM-D1	8.13	130	21.2	13.2	6.81	5.63	6.32	<0.45	<0.03	0.09	0.65	<0.01	<0.02	<0.01
LSWM-D2	8.01	141	21.0	12.9	7.21	7.58	18.5	<0.45	<0.03	0.10	0.88	0.01	<0.02	<0.01
LSWM-D3	7.94	108	16.4	11.3	5.04	3.62	6.91	<0.45	<0.03	0.10	1.18	<0.01	<0.02	<0.01
LSWM-D4	7.90	87.2	14.3	8.89	4.53	3.40	7.53	<0.45	<0.03	0.11	0.65	<0.01	<0.02	<0.01
LSWM-D5	7.62	72.1	14.4	6.48	3.84	2.28	5.06	<0.45	<0.03	0.10	0.67	<0.01	<0.02	<0.01

Table 3-4: Summary of hydrochemistry results for August 2021 (JMA, 2019)

	pH	TDS (mg/l)	Ca (mg/l)	Mg (mg/l)	Na (mg/l)	Cl (mg/l)	SO_4 (mg/l)	NH_4 (mg/l)	PO_4 (mg/l)	F* (mg/l)	Al* (mg/l)	Mn* (mg/l)	Cr^{6+}* (mg/l)	Zn* (mg/l)
RQO Olifants Catchment (Steelpoort River)									0.125	2	0.063	0.68	0.068	0.014
LSWM-S1	7.47	170	24.4	14.2	16.5	20.7	20.9	<0.45	<0.03	0.18	<0.01	<0.01	<0.02	<0.01
LSWM-S2	7.68	164	24.4	14.2	14.3	20.5	17.9	<0.45	<0.03	0.25	<0.01	<0.01	<0.02	<0.01
LSWM-S3	7.60	148	22.3	13.8	12.2	16.7	13.3	<0.45	<0.03	0.15	<0.01	<0.01	<0.02	<0.01
LSWM-S4	7.61	150	24.4	12.8	12.8	16.8	12.9	<0.45	<0.03	0.12	<0.01	<0.01	<0.02	<0.01
LSWM-D1	7.67	231	30.3	25.7	11.0	10.2	24.5	0.54	<0.03	<0.09	<0.01	<0.01	<0.02	<0.01
LSWM-D2	7.82	248	31.5	27.2	10.4	12.1	26.5	<0.45	<0.03	<0.09	<0.01	<0.01	<0.02	<0.01
LSWM-D3	7.78	213	27.7	23.0	7.41	7.70	21.1	<0.45	<0.03	<0.09	0.02	<0.01	<0.02	<0.01
LSWM-D4	7.69	124	20.1	12.9	5.20	5.12	17.9	<0.45	<0.03	<0.09	0.03	<0.01	<0.02	<0.01
LSWM-D5	7.57	82.8	14.9	8.82	3.42	2.63	5.89	<0.45	<0.03	0.12	0.26	<0.01	<0.02	<0.01

3.11 Surface water quality objectives

An integrated water quality management plan for the Olifants river system was conducted in August 2017 by the DWS. The study assessed the water quality downstream of the De Hoop Dam in the Steelpoort sub-catchment. Water Planning limits were then set for sub-catchment and are indicated in Table 3-5. Water Quality assessments for the Lion Smelter should be assessed to align with the Water quality limits set by the Department of Water and Sanitation for the Sub-Catchment, as well as the existing Water Use License (WUL) for the site.

Table 3-5: Water Quality limits for the Catchment downstream of De Hoop Dam catchments of the Steelpoort Sub-Catchment

Variable	Units	Value
Calcium	mg/L	15
Chloride	mg/L	25
Total Dissolved Solids	mg/L	260
Electrical Conductivity	µS/m	30
Fluoride	mg/L	0.7
Potassium	mg/L	10
Magnesium	mg/L	30
Sodium	mg/L	20
Ammonium	mg/L	0.05
Nitrate	mg/L	0.5
Total Phosphorus	mg/L	0.25
pH	ph Unit	6.5-8.4
Ortho-phosphate	mg/L	0.01
Sulphate	mg/L	20
Total Alkalinity	mg/L	120
Dissolved Organic Carbon	Carbon	5
Dissolved Oxygen	mg/L	9
SAR	Unitless Ratio	2
Suspended Solids	mg/L	25
Chlorophyll	µg/L	1
Escherichia coli	CFU/100mL	130
Faecal coliforms	CFU/100mL	130
Aluminium	mg/L	0.01
Boron	mg/L	0.5
Chromium (V)	µg/L	7
Iron	mg/L	0.1
Manganese	mg/L	0.2

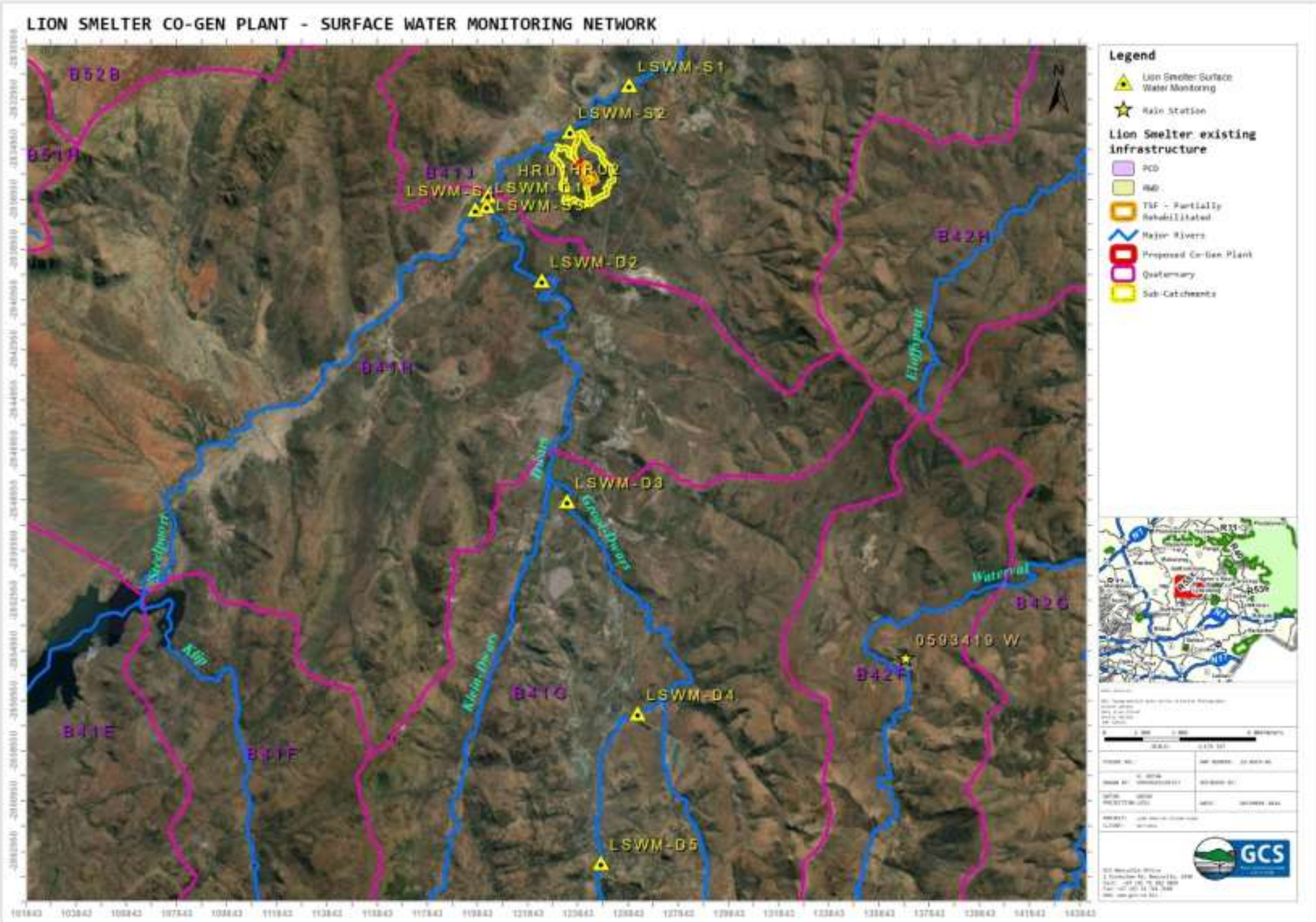


Figure 3-9: Positions of monitoring points (JMA, 2021)

4 CONCEPTUAL STORMWATER MANAGEMENT PLAN

The following section describes the CSWMP developed and is based on available hydrological data and site layout data.

4.1 Aim of the stormwater management plan

The CSWMP aims to:

- Illustrate likely stormwater sub-catchments (HRUs) and preferential overland runoff flow paths.
- Determine likely dirty and clean water HRUs.
- Provide water containment and diversion systems to prevent mixing of clean and dirty water, prevent soil erosion and flooding; and
- Attenuate stormwater back to the natural environment.

4.2 Existing stormwater infrastructure

Other than the existing stormwater associated with the larger project area (i.e., for the existing Lion Smelter facilities, TSF toe drain system, the main storm drain east of the return water dams and roadways etc.) no stormwater infrastructure is associated with the proposed development area.

It should be noted that the site stormwater management strategy will be developed as part of the detailed design. Each PWR BLOK will have a dedicated secondary containment receptible underneath it for the capture of potentially contaminated water. Clean water captured in general servitudes or areas will be suitably directed and integrated into the existing stormwater management strategy.

4.3 Stormwater drainage and delineation of clean and dirty water areas

Based on the ALOS DTM for the project area, two (2) stormwater sub-catchments were identified (namely SWHRU01 and SWHRU02) – refer to Figure 4-1. Based on the stormwater sub-catchment dimensions, it is observed that the upper portions of the catchments (i.e. associated with the TSF) will likely be dirty runoff generation areas. Moreover, the pavement / bunded area associated with the proposed development will become an isolated potentially dirty water area. Open areas falling outside of the plant and not associated with the TSF area will potentially be clean runoff areas. As such these areas need to be managed separately.

The aim is to control potentially dirty water that may be generated by the plant and water flowing towards the development (which may compromise the structural integrity of the developed area). The clean water captured in the servitudes will generally be free draining into the environment, with only dirty water from the TSF and the plant area to be captured/ released into suitable receiving environments. The CSWMP aims to mitigate the impacts of high flows that may lead to erosion, siltation, sedimentation and poor-quality overland runoff from the above-mentioned areas.

4.4 Assumptions

The following assumptions pertain to the CSWMP:

- The areas mentioned above are the only dirty water areas considered;
- The PWR BLOKs will have a dedicated secondary containment receptible underneath it for the capture of potentially contaminated water, which will be handled separately and not as part of the overall stormwater system (not part of this assessment);
- No runoff will occur from the proposed development surface area (i.e. the pavement area), and all runoff will be captured at a central point and released to the appropriate stormwater system (as recommended by this report); and
- The ALOS DTM used to delicate the dub-catchments are of sufficient resolution to accurately describe the runoff from the site.

4.5 Stormwater peak flows

Based on the surface areas, and assuming an 80% to 90% impermeable land surface coefficient, for the sub-catchments associated with the TSF drainage areas and 100% impermeability for the pavement site, the peak runoff volumes were estimated. The rational method was used to calculate the stormwater peak flows. 1:2, 1:10, 1:50 and 1:100 yr return periods are presented and are tabulated in Table 4-1.

Rainfall intensity and time concentrations were calculated based on the stormwater sub-catchment areas. Design rainfall was retrieved from station Sekhukhuneland and used to calculate peak flow volumes. The stormwater infrastructure should be sized to handle these minimum peak flow estimates for the proposed parking lot areas.

The CSIR guidelines (CSIR, 2005) suggest that the stormwater system needs to be sized to handle a 1:5-year return period.

Table 4-1: Stormwater return period estimates for the proposed parking lots

Peak Storm Runoff (m^3/sec)			
Return Period	**SWHRU01a-Dirty**	**SWHRU02a-Dirty**	**Pavement Area**
2	0.48	0.24	0.60
5	0.73	0.37	0.91
10	0.95	0.48	1.19
20	1.26	0.63	1.56
50	1.89	0.96	2.36
100	2.62	1.32	3.26
PMF	9.88	5.00	6.31

4.6 Proposed stormwater management measures

Considering the proposed activities and likely stormwater peak flows, the following stormwater systems are proposed (refer to Figure 4-2 and numbers assigned to the SW system):

1. It is proposed that a vegetated/grassed lined surface channel (or V-drain grassed equivalent) be installed along the existing access road, to capture any dirty water runoff from the TSFs that is not captured by the toe drains.
    a. It is proposed that any dirty water runoff captured in the vegetated/grassed lined surface channel be gravity fed to the two (2) existing return water dams/pollution control dams (RWDs/PCDs) downstream of the site (if possible – or whichever dam is suitable). Rock rip rap basin at the outfall from the channel, into the WRD, is sufficient to prevent erosion along the RWD/PCD banks.
2. No runoff from the development is anticipated from the site.
    a. As per the engineering designs for the development, all dirty water shall be managed with a dedicated secondary catchment under the PBU's (modular trays above the surface are envisaged). As such, all water captured above the slab shall be considered to be clean water (Swedish Stirling, 2021).
3. Stormwater runoff not captured in modular trays (potentially contaminated) on the pavement premises will need to be conveyed to the lowest portion of the site, to prevent runoff into the environment (i.e. to ensure no runoff as per item 2 above). The lowest corner of the site, as per the ALOS DTM assessed, is the northern corner.
    a. It is proposed that stormwater be conveyed to the lowest point of the property using several concrete drains with intake mesh (to be designed and sized by the civil designs engineer).
    b. Water captured in the system would need to pass through a silt trap (or several traps) and an oil trap before discharge into the environment.
    c. It is proposed that water from the development site be discharged to a vegetated/grassed lined surface channel (or V-drain grassed equivalent) and joint to the proposed system in Item 1 for discharge into the RWDs/PCDs.

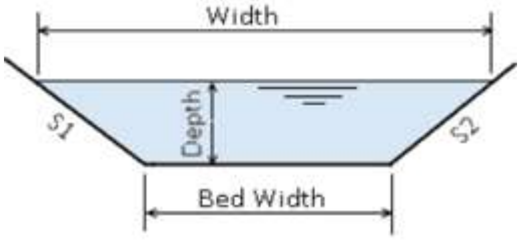
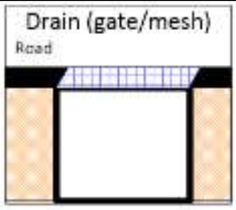
As an alternative, to the above-mentioned system, all stormwater generated from the pavement area could be conveyed to the existing stormwater main (situated 2.30m east of the site). However, this would entail the installation of a dedicated stormwater pipe/culvert drain system to join the existing stormwater drain. The final designs for the development stormwater system will determine which option may be most viable (if at all required).

To circumvent potential erosion and sedimentation in open and unvegetated areas associated with the site native species of vegetation in the area can be re-planted in eroded areas. The expansive root systems of these plants provide support within the soil and prevent erosion due to rain runoff.

4.7 Proposed stormwater system sizing

The stormwater systems were sized based on the calculated storm peak flows (refer to Section 4.5) and are listed in Table 4-2 refer to numbering for proposed sizing of systems in Figure 4-2. The proposed systems are subjected to changes if detailed stormwater modelling is undertaken.

Table 4-2: Proposed stormwater systems

ID	Type	Material	Proposed Dimensions
1	Vegetated/grassed lined surface channel (or V-drain equivalent)	Earth and local vegetation	 S1 & S2 = 1:1.5 Bed width = 1m, Depth = 0.5m, Width = 2m Compaction = 0.8 to 0.95% proctor (slopes and bed)
1. a	Rock rip rap basin	Earth, rock and local vegetation	
3. a	Drain	Concrete and mesh (cast iron)	 Height = 0.3 to 0.5 m Width = 0.3 to 0.5 m

4.8 Proposed stormwater monitoring requirements

It is advised that stormwater monitoring take place to ensure that the proposed stormwater system (both on-site and off-site) functions correctly. The following is proposed:

1. Routine cleanout of all grease traps and silt traps – monthly (in wet seasons), every 2nd month in dry seasons;
2. Routine hydraulic monitoring (i.e. observations of any blockages in the system) and clean out of the stormwater systems.
3. Quality monitoring:
    a. Water samples are to be collected during rainfall events at all outfalls. It is recommended that samples be taken during the rainfall event and 2 to 3 days after the event ceases.
    b. The samples should be analysed per NWA Government Gazette No. 20526 of 8 October 1999 – general limits.

Figure 4-1: Dirty & clean water areas

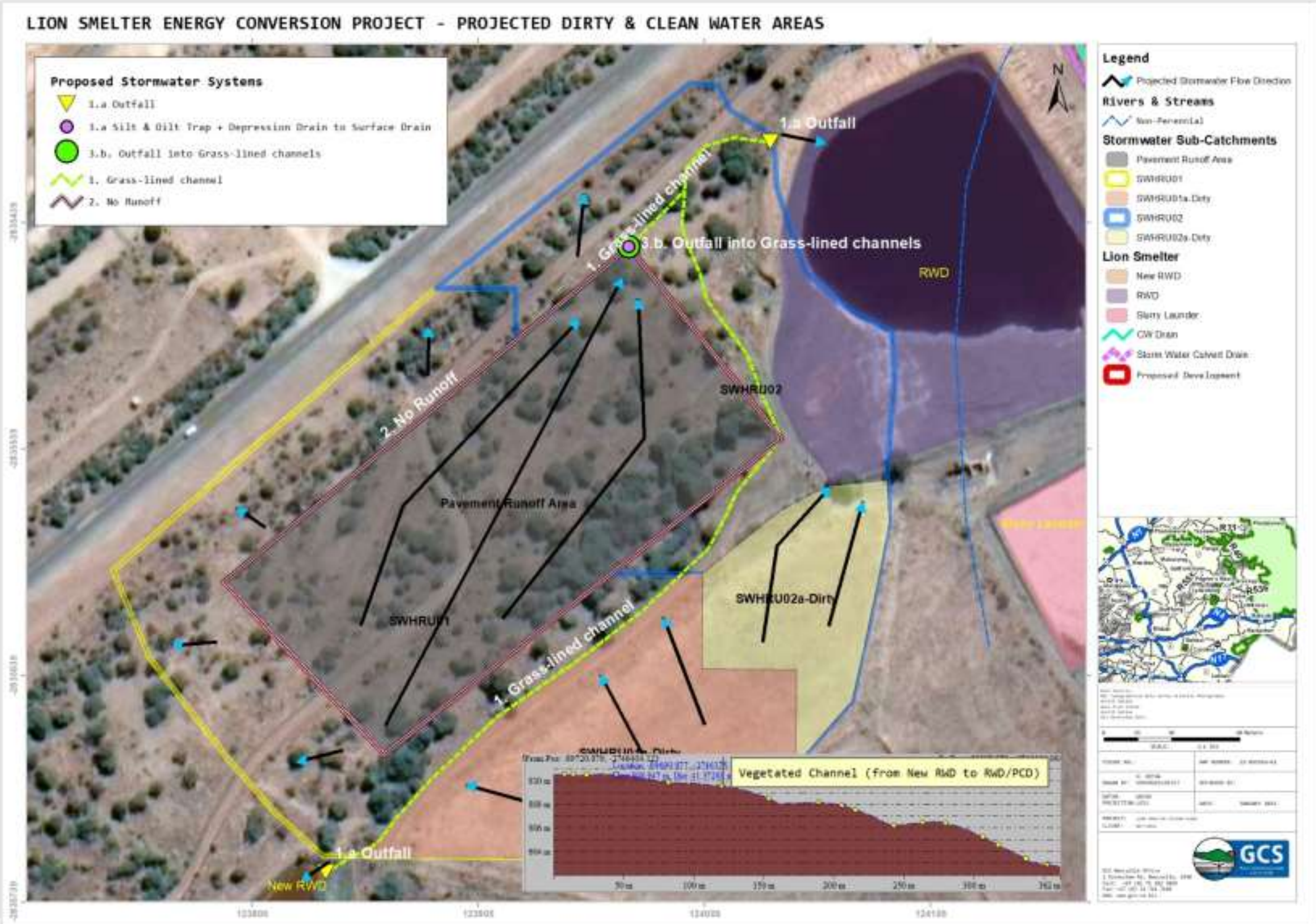


Figure 4-2: Conceptual stormwater management system

5 HYDROLOGICAL RISK ASSESSMENT

The anticipated hydrological risk concerning the construction and operational phases were assessed. The SPR model (DWAF, 2008) was used to evaluate potential pollution sources and primary receptors within the study area.

In terms of the proposed development, several hydrological risks during the construction and operational phase of the development were identified. The potential impacts identified and environmental significance for the construction and operational phase are listed in Table 5-1 and Table 5-2. No closure phase risks are anticipated, due to the project type.

Based on the SPR model applied to the site, the following potential pollution sources were identified:

- Construction phase risk (construction of the plant, laydown areas etc.)
    - Poor quality seepage and runoff from:
        - Building rubble, cement paint, oil and fuel spills during excavation and dredging.
        - Excavation of part of the vadose zone.
        - Temporary waste storing and handling facilities during construction.
    - Disturbing soils (land capability) due to demolishing activity.
- Operational (existing and proposed activities):
    - Poor quality runoff from:
        - Parking areas, and domestic waste storage areas;
        - Overflow from the site (i.e. stormwater runoff) which is not controlled, is conveyed to the proposed stormwater system.
    - Oil spillage from parked vehicles (service vehicles).

The risk assessment for both construction and post-construction phases of the project is considered marginal, with mostly reversible and manageable impacts. Mixing of dirty and clean water on the premises and potential overall runoff and stormwater discharge from the site into the surrounding environment (increased peak flows) may cause erosion of the soils surrounding the development and may impact land capability. This is the largest risk and should be managed with the on-site stormwater management plan (as per the developer designs) and the conceptual stormwater management plan as proposed in this document.

The risk of flooding, poor quality seepage via the vadose zone, and impacts on surface water quality is predicted to be zero during the construction and operational phase of the project. This is largely due to the proposed concrete barrier to be installed, the absence of any surface water streams, and the fact that the zoned area has already been modified as a result of the existing Lion Smelter activities.

5.1 Cumulative impacts

As all activities will take place on the same property, there will be cumulative impacts. The operational phase risk table includes cumulative risk about the site, and activities thereon. The cumulative impacts identified include:

1. Mixing of dirty and clean water during construction activities, from both the development site and the existing site conditions.
2. Stormwater discharge from the site will contribute to the total dirty water runoff from the Lion Smelter area. As such, dirty water should be allocated to existing stormwater systems to ensure no creation of new dirty water discharge areas.

Table 5-1: Construction (preparation and development) phase hydrological risk

Component Being Impacted On	Activity Which May Cause the Impact	Activity	Pre- Mitigation							Recommended Mitigation Measures	Post Mitigation							Confidence
			Duration (D)	Extent (E)	Potential for impact on irreplaceable resources (I)	Severity (S)	Consequence (C)	Probability (P)	Significance		Duration (D)	Extent (E)	Potential for impact on irreplaceable resources (I)	Severity (S)	Consequence (C)	Probability (P)	Significance	
Vadose zone soils	Disturbing vadose zone during excavations activities, contractor laydown areas. There is a potential for some erosion if there are storm events.	Earthworks	Short-term (2)	Site (2)	Yes (1)	Low (-1)	Negligible (0 to -6) (-5)	Definite (2)	Negligible (0 to -12) (-10)	• Only excavate areas applicable to the project area. • Keep the site clean of all general and domestic wastes. • All development footprint areas to remain as small as possible and vegetation clearing to be limited to what is essential. • Retain as much indigenous vegetation as possible / re-vegetate. • Exposed soils to be protected using a suitable covering. • Existing roads should be used as far as practical to gain access to the site.	Short-term (2)	Site (2)	Yes (1)	Negligible (0)	Negligible (0 to -6) (-4)	Definite (2)	Negligible (0 to -12) (-8)	Medium

Table 5-2: Operational phase hydrological risk

Component Being Impacted On	Activity Which May Cause the Impact	Activity	Pre- Mitigation							Recommended Mitigation Measures	Post Mitigation							Confidence
			Duration (D)	Extent (E)	Potential for impact on irreplaceable resources (I)	Severity (S)	Consequence (C)	Probability (P)	Significance		Duration (D)	Extent (E)	Potential for impact on irreplaceable resources (I)	Severity (S)	Consequence (C)	Probability (P)	Significance	
Vadose zone soils	• Poor quality seepage from vehicles parked at the site.	Nett result of development.	Short-term (2)	Site (2)	Yes (1)	Low (-1)	Negligible (0 to -6) (-5)	Probable (1)	Negligible (0 to -12) (-5)	• Ensure service vehicles are parked in designated areas, with drip trays placed under the vehicles. Vehicles to be pre-inspected for leakages before entering the site.	Short-term (2)	Site (2)	Yes (1)	Negligible (0)	Negligible (0 to -6) (-4)	Probable (1)	Negligible (0 to -12) (-4)	Medium
	• Poor quality stormwater discharge, or uncontrolled runoff not managed or captured by the proposed conceptual stormwater plan.	Nett result of development.	Short-term (2)	Site (2)	Yes (1)	Low (-1)	Negligible (0 to -6) (-5)	Probable (1)	Negligible (0 to -12) (-5)	• Keep the site clean of all general and domestic wastes. • Ensure proposed CSWMP is designed and implemented. • Ensure stormwater monitoring takes place (hydraulic and quality).	Short-term (2)	Site (2)	Yes (1)	Negligible (0)	Negligible (0 to -6) (-4)	Probable (1)	Negligible (0 to -12) (-4)	Medium

6 CONCLUSIONS

Based on the investigation undertaken, the following conclusions are made:

- The site is situated in Quaternary Catchment B41J of the Olifants Water Management Area (WMA)
  - The site means annual precipitation (MAP) is in the order of 552 mm/yr.
  - Natural runoff was recorded as approximately 19 mm/yr, which represents approximately 3% of the MAP.
  - Evaporation is reported as 1 300-1 500 mm/annum (S-Pan).
- No streams or rivers are associated with the proposed development site. Hence, the risk of surface water hydrology in the area is negligible.
- The CSWMP indicates that:
  - Two (2) stormwater sub-catchment makes up the drainage system for the project area and will govern stormwater generation for the portion of land on which the proposed development will take place.
  - Based on the stormwater sub-catchment dimensions, it is observed that the upper portions of the catchments (i.e. associated with the TSF) will likely be dirty runoff generation areas. Moreover, the pavement / bunded area associated with the proposed development will become an isolated potentially dirty water area. Open areas falling outside of the plant and not associated with the TSF area will potentially be clean runoff areas. As such these areas need to be managed separately.
  - Stormwater peak flows were estimated based on the Rational Method and per CSIR guidelines (refer to Section 4.5). Peak flows for dirty stormwater areas is estimated to range from 0.37 to 0.91 m^3/sec for a 1:5 year return period.
  - Several stormwater systems have been proposed to circumvent potential stormwater erosion and mixing of dirty and clean water (refer to Section 4.6 and 4.7). The proposed systems were sized to withstand the 1:5-year storm events and are subjected to changes if detailed stormwater modelling is undertaken.
- Several hydrological risks are associated with the site, of which mixing of dirty and clean water on the premises and discharge of the water to the environment via the on-site stormwater system (not part of the CSWMP but will be developed by the site engineer) environment is the greatest risk. The hydrological risk was evaluated (refer to Section 5) and the hydrological risk about the proposed activities is anticipated to be marginal. Mitigation measures were proposed to circumvent potential impacts (refer to Section 5).

6.1 Identification of any areas that should be avoided

No avoidance areas are recommended. This is based on the proposed development area, the site's unique hydrological conditions and drainage conditions, the distance to recognized rivers/streams and flooding areas; and founded on the premise that a proper stormwater system will be implemented. No alternative development sites are proposed.

6.2 Mitigation measures for inclusion in the EMPr and EIA

The following mitigation measures can be implemented as part of the EMPr to further reduce the risk of flooding on site and contribution to stormwater generation potential:

- Ensure a stormwater management plan is implemented, and that all stormwater systems are kept clean of any debris to reduce flooding risk.
- Ensure that eroded areas are re-vegetated, to ensure reduced sedimentation risk and reduced runoff volumes to the streams.
- To prevent erosion and deposition during construction use:
  - Straw bales at kerb inlets.
  - Silt fencing.
  - Temporary check dams.
  - Riprap; and
  - Geotextiles, mulching etc.
- Ensure dams (PCDs/RWDs) have enough freeboard to accommodate stormwater generation from the site for 1:50-year storm events.
- Visual inspections of the non-perennial stream and stormwater systems should be adequate to determine if there are flow obstructions, which could lead to ponding and flooding. No further monitoring or mitigation will be required as part of the EMPr.

6.3 Monitoring requirements, specifically related to the stormwater management

It is advised that stormwater monitoring take place to ensure that the proposed stormwater system (both on-site and off-site) functions correctly. The following is proposed:

1. Routine cleanout of all grease traps and silt traps – monthly (in wet seasons), every 2nd month in dry seasons;
2. Routine hydraulic monitoring (i.e. observations of any blockages in the system) and clean out of the stormwater systems.
3. Quality monitoring:
    a. Water samples are to be collected during rainfall events at all outfalls. It is recommended that samples be taken during the rainfall event and 2 to 3 days after the event ceases.
    b. The samples should be analysed per NWA Government Gazette No. 20526 of 8 October 1999 – general limits.

6.4 Reasoned opinion whether the activity should be authorized

This hydrological assessment cannot find any grounds or identify high hydrological risks not proceed with the development. This is grounded on the assumption that the proposed mitigation measures (Section 5), CSWMP, EMPr and EIA recommendations are implemented during the construction and operational phase of the development.

6.5 Recommendations

The following additional recommendations are made:

- Ensure that stormwater discharge at least adheres to the National Water Act, Government Gazette No. 20526, 8 October 1999. Wastewater limit values applicable to discharge of wastewater into a water resource.
- All building wastes generated during construction on site (this is temporary waste i.e. building rubble, garden refuge, used oil and paint containers etc.) must be stored in designated areas that are isolated from drainage lines / known flooding areas. Waste storage facilities should be covered to prevent dust and litter from leaving the containment area and rainwater accumulation.
- There is some potential for erosion. Measures should be taken to ensure that this is minimized where possible.
- It is proposed that water quality monitoring be implemented as discussed in Section 4.8 to monitor the impact of the development on the receiving environment as a result of stormwater discharge.

APPENDIX A: HYDROLOGICAL RISK ASSESSMENT RATING

Due to the hydrological assessment forming part of a larger risk assessment for the study area, the potential impacts and the determination of impact significance were assessed. The process of assessing the potential impacts of the project encompasses the following four activities:

1. Identification and assessment of potential impacts;
2. Prediction of the nature, magnitude, extent, and duration of potentially significant impacts;
3. Identification of mitigation measures that could be implemented to reduce the severity or significance of the impacts of the activity; and
4. Evaluation of the significance of the impact after the mitigation measures have been implemented i.e. the significance of the residual impact.

Per GNR 982 of the EIA Regulations (2014), the significance of potential impacts was assessed in terms of the following criteria:

I. Cumulative impacts;
II. Nature of the impact;
III. The extent of the impact;
IV. Probability of the impact occurring;
V. The degree to which the impact can be reversed;
VI. The degree to which the impact may cause irreplaceable loss of resources; and
VII. The degree to which the impact can be mitigated.

Table 6-1 provides a summary of the criteria used to assess the significance of the potential impacts identified. An explanation of these impact criteria is provided in Table 6-2.

The net consequence is established by the following equation:

Consequence = (Duration + Extent + Irreplaceability of resource) x Severity

And the environmental significance of an impact was determined by multiplying consequence with probability.

Table 6-1: Proposed Criteria and Rating Scales to be used in the Assessment of the Potential Impacts

Criteria	Rating Scales	Notes
Nature	Positive (+)	An evaluation of the effect of the impact related to the proposed development.
	Negative (-)	
Extent	Footprint (1)	The impact only affects the area in which the proposed activity will occur.
	Site (2)	The impact will affect only the development area.
	Local (3)	The impact affects the development area and adjacent properties.
	Regional (4)	The effect of the impact extends beyond municipal boundaries.
	National (5)	The effect of the impact extends beyond more than 2 regional/ provincial boundaries.
	International (6)	The effect of the impact extends beyond country borders.
Duration	Temporary (1)	The duration of the activity associated with the impact will last 0-6 months.
	Short term (2)	The duration of the activity associated with the impact will last 6-18 months.
	Medium-term (3)	The duration of the activity associated with the impact will last 18 months-5 years.
	Long term (4)	The duration of the activity associated with the impact will last more than 5 years.
Severity	Low (1)	Where the impact affects the environment in such a way that natural, cultural and social functions and processes are minimally affected.
	Moderate (2)	Where the affected environment is altered but natural, cultural and social functions and processes continue albeit in a modified way; and valued, important, sensitive, or vulnerable systems or communities are negatively affected.

Criteria	Rating Scales	Notes
	High (3)	Where natural, cultural, or social functions and processes are altered to the extent that the natural process will temporarily or permanently cease; and valued, important, sensitive, or vulnerable systems or communities are substantially affected.
Potential for impact on irreplaceable resources	No (0)	No irreplaceable resources will be impacted.
	Yes (1)	Irreplaceable resources will be impacted.
Consequence	Extremely detrimental (-25 to -33)	A combination of extent, duration, intensity, and the potential for impact on irreplaceable resources.
	Highly detrimental (-19 to -24)	
	Moderately detrimental (-13 to -18)	
	Slightly detrimental (-7 to -12)	
	Negligible (-6 to 0)	
	Slightly beneficial (0 to 6)	
	Moderately beneficial (13 to 18)	
	Highly beneficial (19 to 24)	
	Extremely beneficial (25 to 33)	
Probability (the likelihood of the impact occurring)	Improbable (0)	It is highly unlikely or less than 50 % likely that an impact will occur.
	Probable (1)	It is between 50 and 70 % certain that the impact will occur.
	Definite (2)	It is more than 75 % certain that the impact will occur or it is definite that the impact will occur.
Significance	Very high – negative (-49 to -66)	A function of Consequence and Probability.
	High – negative (-37 to -48)	
	Moderate – negative (-25 to -36)	
	Low – negative (-13 to -24)	
	Very low (0 to -12)	
	Low – positive (0 to 12)	

Criteria	Rating Scales	Notes
	Moderate – positive (13 to 24)	
	High–positive (37 to 48)	
	Very high – positive (49 to 66)	

Table 6-2: Explanation of Assessment Criteria

Criteria	Explanation
Nature	This is an evaluation of the type of effect the construction, operation, and management of the proposed development would have on the affected environment. Will the impact change in the environment be positive, negative, or neutral?
Extent or Scale	This refers to the spatial scale at which the impact will occur. The extent of the impact is described as footprint (affecting only the footprint of the development), site (limited to the site), and regional (limited to the immediate surroundings and closest towns to the site). The extent of scale refers to the actual physical footprint of the impact, not to the spatial significance. It is acknowledged that some impacts, even though they may be of a small extent, are of very high importance, e.g. impacts on species of very restricted range. To avoid "double counting, specialists have been requested to indicate spatial significance under "intensity" or "impact on irreplaceable resources" but not under "extent" as well.
Duration	The lifespan of the impact is indicated as temporary, short, medium, and long term.
Severity	This is a relative evaluation within the context of all the activities and the other impacts within the framework of the project. Does the activity destroy the impacted environment, alter its functioning, or render it slightly altered?
Impact on irreplaceable resources	This refers to the potential for an environmental resource to be replaced, should it be impacted. A resource could be replaced by natural processes (e.g. by natural colonization from surrounding areas), through artificial means (e.g. by reseeding disturbed areas or replanting rescued species) or by providing a substitute resource, in certain cases. In natural systems, providing substitute resources is usually not possible, but in social systems, substitutes are often possible (e.g. by constructing new social facilities for those that are lost). Should it not be possible to replace a resource, the resource is essentially irreplaceable e.g. red data species that are restricted to a particular site or habitat of a very limited extent.
Consequence	The consequence of the potential impacts is a summation of the above criteria, namely the extent, duration, intensity, and impact on irreplaceable resources.
Probability of occurrence	The probability of the impact occurring is based on the professional experience of the specialist with environments of a similar nature to the site and/or with similar projects. It is important to distinguish between the probability of the impact occurring and the probability that the activity causing a potential impact will occur. Probability is defined as the probability of the impact occurring, not as the probability of the activities that may result in the impact.

Criteria	Explanation
Significance	Impact significance is defined to be a combination of the consequence (as described below) and the probability of the impact occurring. The relationship between consequence and probability highlights that the risk (or impact significance) must be evaluated in terms of the seriousness (consequence) of the impact, weighted by the probability of the impact occurring. In simple terms, if the consequence and probability of an impact are high, then the impact will have a high significance. The significance defines the level to which the impact will influence the proposed development and/or environment. It determines whether mitigation measures need to be identified and implemented and whether the impact is important for decision-making.
Degree of confidence in predictions	Specialists and the EIR team were required to indicate the degree of confidence (low, medium, or high) that there is in the predictions made for each impact, based on the available information and their level of knowledge and expertise. The degree of confidence is not taken into account in the determination of consequence or probability.
Mitigation measures	Mitigation measures are designed to reduce the consequence or probability of an impact or to reduce both consequence and probability. The significance of impacts has been assessed both with mitigation and without mitigation.

APPENDIX B: DISCLAIMER AND DECELERATION OF INDEPENDENCE

The opinions expressed in this Report have been based on site /project information supplied to GCS (Pty) Ltd (GCS) by Green Door Environmental (GDE) and is based on public domain data, field data and data supplied to GCS by the client. GCS has acted and undertaken this assessment objectively and independently.

GCS has exercised all due care in reviewing the supplied information. Whilst GCS has compared key supplied data with expected values, the accuracy of the results and conclusions are entirely reliant on the accuracy and completeness of the supplied data. GCS does not accept responsibility for any errors or omissions in the supplied information and does not accept any consequential liability arising from commercial decisions or actions resulting from them.

Opinions presented in this report, apply to the site conditions, and features as they existed at the time of GCS's investigations, and those reasonably foreseeable. These opinions do not necessarily apply to conditions and features that may arise after the date of this report, about which GCS had no prior knowledge nor had the opportunity to evaluate.

DETAILS OF THE SPECIALIST, DECLARATION OF INTEREST AND UNDERTAKING UNDER OATH

Application for authorisation in terms of the National Environmental Management Act, Act No. 107 of 1998, as amended and the Environmental Impact Assessment (EIA) Regulations, 2014, as amended (the Regulations)

PROJECT TITLE

Conceptual Stormwater Management Plan for the Proposed Lion Smelter Energy Conversion Project

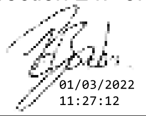
SPECIALIST INFORMATION

Specialist Company Name:	GCS Water and Environment Pty Ltd			
B-BBEE	Contribution level (indicate 1 to 8 or non-compliant)	4	Percentage Procurement recognition	
Specialist name:	Hendrik Botha			
Specialist Qualifications:	MSc Environmental Sciences (Geohydrology & Geochemistry) BSc Hons. Environmental Sciences (Hydrology)			
Professional affiliation/registration:	PR SCI NAT 400139/17			
Physical address:	1 Karbochem Road, Newcastle, KZN			
Postal address:				
Postal code:	2940	Cell:		
Telephone:	071 102 3819	Fax:		
E-mail:	hendrikb@gcs-sa.biz			

DECLARATION BY THE SPECIALIST

I, _Hendrik Botha, declare that –

- I act as the independent specialist in this application.
- I will perform the work relating to the application objectively, 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 Act, Regulations and any guidelines that have relevance to the proposed activity.
- I will comply with the Act, Regulations and all other applicable legislation.
- I have no, 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 concerning 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; and
- I realise that a false declaration is an offence in terms of regulation 48 and is punishable in terms of section 24F of the Act.



Signature of the Specialist

GCS

Name of Company:

22 March 2022

Date

CV OF SPECIALIST

Hendrik Botha

Snr. Hydro-geologist / Modeller

CORE SKILLS

- Project management
- Analytical and numerical groundwater modelling
- Geochemical assessments and geochemical modelling
- Hydropedology and hydrological assessments
- Hydrology, floodline modelling & storm water management
- Groundwater vulnerability, impact, and risk assessments
- Technical report writing
- GIS and mapping

DETAILS

Qualifications
- BSc Chemistry and Geology (Environmental Sciences) (2012)
- BSc Hons Hydrology (Environmental Sciences) (2013)
- MSc Geohydrology and Hydrology (Environmental Sciences) (2014-2016)

Membership
- Groundwater Division of GSSA
- Groundwater Association of KwaZulu Natal Member
- International Mine Water Association (IMWA)

Languages
- Afrikaans - Speak, read, write.
- English - Speak, read, write.

Countries Worked In
- South Africa

PROFILE

Hendrik (Henri) Botha is currently the manager of the GCS Newcastle Office and occupies the role of principal hydrogeologist. Groundwater, geochemistry and surface hydrology, as well as knowledge of water chemistry together with GIS, analytical and numerical modelling skills, is some of his sought-after expertise. General and applied logical knowledge are his key elements in problem-solving.

Professional Affiliations:

SACNASP Professional Natural Scientist (400139/17)

Areas of Expertise:

- Waste classification and Impact Assessments
- Aquifer vulnerability assessments
- Geochemical sampling, data interpretation and modelling
- Geophysical surveys and data interpretation
- GIS
- Water quality sampling and data interpretation
- Groundwater impact and risk assessments
- Numerical and Conceptual Visual Modelling (Visual Modflow, ModflowFLEX, Voxler, RockWorks, Surfer and Excel)
- Hydropedology (Hydrological Soil Types) & Soils Assessments
- Floodline Modelling (HEC-RAS)
- Stormwater Management Systems and Modelling
- Surface Water Yield Assessments
- Water and Salt Balances

Page 1 of 8

Work Experience

Period	Employer	Position	Role/ Responsibility
2014 - Current	GCS (Pty) Ltd	Snr. Hydrogeologist	Client liaison, client management, hydrology, geohydrology, hydropedology and geochemistry related work GCS Newcastle Office manager since July 2020.
2013	Centre for Water Science and Management at North-West University	Modeller	Hydrological rainfall-runoff modelling with EPA SWMM
2013	Chemistry Department at North-West University	Demonstrator	▫ Preparation of chemical agents used during experiments ▫ Demonstration of some chemistry principles to undergraduate students ▫ Helped students during experiments

Page 2 of 5

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PROFESSIONAL EXPERIENCE

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PROFESSIONAL EXPERIENCE – EARTH SCIENCES FIELD

Year	*Client*	*Project Description*	*Role / Responsibility*
Geochemistry, Waste Classification, Geochemical Modelling, Soil Chemistry and Water Chemistry Assessments			
2021	Modikwa Platinum	Modikwa Platinum Soil Study	Project Manager, Field Specialist, Reporting, Client liaison
2020	Tendele Coal (Pty)ltd	Somkhele Water & Geochemical Report	Project Manager, Field Specialist, Reporting, Client liaison
2019	Thalo Environmental	Waste Classification for the Fortuna WTW	Project Manager, Assessor, Reporting, Client liaison
2019-2020	Tendele Coal (Pty) Ltd	Area 9 (KwaQubuka Pit) Waste Evaluation & Risk-Based Approach Geohydrological Closure Assessment	Project Manager, Field Specialist, Modler, Analyst, Reporting, Client liaison
2019	Tendele Coal (Pty) Ltd	Geochemical Model Update for Somkhele Anthracite Mine	Project Manager, Field Specialist, Modler, Analyst, Reporting, Client liaison
2019	Buffalo Coal (Pty) Ltd	Aviemore Colliery Decant and Stream Loss Assessment	Project Manager, Modler, Analyst, Reporting, Client liaison
2019	Buffalo Coal (Pty) Ltd	Aviemore Colliery AMD Treatment Strategy	Project Manager, Modler, Analyst, Reporting, Client liaison
2018	Tendele Coal (Pty) Ltd	Geochemical Model Development for the Somkhele Anthracite Mine	Project Manager, Field Specialist, Modler, Analyst, Reporting, Client liaison
2016	Tendele Coal (Pty) Ltd	Somkhele Co-Disposal Assessment	Project Manager, Field Specialist, Modler, Analyst, Reporting, Client liaison

Page 3 of 5

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PROFESSIONAL EXPERIENCE

Scan here for full record

Year	Client	Project Description	Role / Responsibility
2015	Crest Choice Chicken	Potchefstroom Bottling Facility WQ Analysis	Interpretation and Analysis, Reporting
2015	Total Coal South Africa (TCSA)	Springbok Siding Soil Analyses	Interpretation and Analysis, Reporting
2015	Exxaro	(Malta Mine) Water Chemistry Analysis	Interpretation and Analysis, Reporting
2015	Tendele	AdHoc: Somkhele Sample Water Quality	Interpretation and Analysis, Reporting
2015	Hatch Goba	Mukulu Soil Analysis	Interpretation and Analysis, Reporting
2015	Northam Platinum	Soil Chemistry Interpretation	Interpretation and Analysis, Reporting
2015	Private Client	Soil Chemistry Analysis and Interpretation	Interpretation and Analysis, Reporting
2015	Molo	Molo Graphite Project Soil Analysis	Interpretation and Analysis, Reporting
2014	Estima	Soil and water chemistry analyses	Interpretation and Analysis, Reporting
2014	Kangra	Bokoni Platinum - Soil Monitoring	Interpretation and Analysis, Reporting
2014	Booysendal Mine	Soils, Land-Use and Land Capability Assessment for Booysendal Mine: Soil Chemistry Analysis	Interpretation and Analysis, Reporting
2014	Kangra	Longridge Soil Testing to identify Fertilizer Use: Soil Chemistry Interpretation	Interpretation and Analysis, Reporting
2017-ongoing	Tendele Coal (Pty) Ltd	Kinetic Column Leach Test Assessments for Mining Area 8 and Area 9 at the Somkhele Anthracite Mine	Project Manager, Field Specialist, Analyst, Reporting, Client liaison
Geohydrological, Hydrological and Hydropedological Assessments (EIA, WULA, BA, IWULA, EMP) - Groundwater Investigations, Numerical and Analytical Modelling Application, Floodline Modelling, CSWMP, Water Balances and Hydropedology			
2021	Wallace & Green	Izinga Eco Estate Floodline Update	Project Manager, Field Specialist, Reporting, Client liaison
2021	KSEMS Environmental Consulting	Dingo Animal Kingdom Floodline	Project Manager, Field Specialist, Reporting, Client liaison

Page 4 of 5

PROFESSIONAL EXPERIENCE

Scan here for full record

Year	Client	Project Description	Role / Responsibility
2021	Mkhoba Trust	Mkhoba Trust water use license Application - Geohydrology Assessment	Project Manager, Field Specialist, Reporting, Client liaison
2021	Joseph Baynes Estate (Pty)ltd	Baynesfields Groundwater Supply	Project Manager, Field Specialist, Reporting, Client liaison
2020	Triplo4 Sustainable Solutions (Pty) Ltd	Karpowership SA - Geohydrological, hydropedology and hydrological assessments	Project Manager, Field Specialist, Reporting, Client liaison
2020	Green Door Environmental	Justin Lusso Poultry Farm - Geohydrology and Hydrological Assessments	Project Manager, Field Specialist, Reporting, Client liaison
2020	Metamorphosis Environmental Consulting	Proposed Shongweni Landfill Hydrological Assessment	Project Manager, Field Specialist, Reporting, Client liaison
2020	Green Door Environmental	Middeldrift Bulk Augmentation Hydrological and Hydropedological Assessment	Project Manager, Field Specialist, Reporting, Client liaison
2020	EnviroMatrix	Manyatseng Cemetery Geohydrological and Flood Line Assessment	Project Manager, Field Specialist, Reporting, Client liaison
2021	ECA Consulting	Hydrological study - Okhahlamba	Project Manager, Field Specialist, Reporting, Client liaison
2020	Wallace & Green	Glendale Sugar Mill Hydrology Assessment & Groundwater Numerical Model Development	Project Manager, Field Specialist, Reporting, Client liaison
2020	GIBB	Newcastle Cemetery (Roy Point) Expansion Geohydrological & Hydrological Assessment	Project Manager, Field Specialist, Reporting, Client liaison
2020	GIBB	Newcastle Cemetery (Roy Point) Expansion Hydropeoidogy Assessment	Project Manager, Field Specialist, Reporting, Client liaison
2019	Green Door Environmental	Hydrological Assessment for the Chep Weatherboard Dam	Project Manager, Field Specialist, Reporting, Client liaison
2019	Triplo4 Sustainable	Elaleni Hydropedology Assessment	Project Manager, Field

Page 5 of 5

PROFESSIONAL EXPERIENCE

Scan here for full record

Year	Client	Project Description	Role / Responsibility
	Solutions (Pty) Ltd		Specialist, Reporting, Client liaison
2019	Green Door Environmental	Geohydrological Assessment for the Sani Pass Hotel Expansion	Project Manager, Field Specialist, Modler, Analyst, Reporting, Client liaison
2019	Green Door Environmental	Evergreen Hilton Retirement Village Geo hydrological Assessment	Project Manager, Field Specialist, Modler, Analyst, Reporting, Client liaison
2019	Cato Scrap CC	Cato Scrap Metal Facility Geohydrological Assessment	Project Manager, Field Specialist, Modler, Analyst, Reporting, Client liaison
2019	Green Door Environmental	Hydrogeological Assessment for the Goedgedacht Farm	Project Manager, Field Specialist, Modler, Analyst, Reporting, Client liaison
2019	ACER (Africa) Environmental Consultants	Hydrogeological Assessment for the Mtuzini Sewage Works	Project Manager, Field Specialist, Modler, Analyst, Reporting, Client liaison
2019	Tripo4 Sustainable Solutions (Pty) Ltd	Hydrogeological Assessment for the Sezela Mill Molasses Bladder Development Site	Project Manager, Field Specialist, Modler, Analyst, Reporting, Client liaison
2018	GIBB	Illovo Automotive Supplier Park (ASP) Geohydrological Assessment	Project Manager, Field Specialist, Modler, Analyst, Reporting, Client liaison
2018	Kangra Coal (Pty) Ltd	Numerical Groundwater Model update for the Maquasa East, Maquasa West and Nooitgezien mining operations	Project Manager, Field Specialist, Modler, Analyst, Reporting, Client liaison
2018	Tripo4 Sustainable Solutions (Pty) Ltd	Hydrogeological Assessment and Numerical Groundwater Model Development for the Illovo Noodsburg Sugar Mill	Project Manager, Field Specialist, Modler, Analyst, Reporting, Client liaison

Scan here for full record

PROFESSIONAL EXPERIENCE

Year	Client	Project Description	Role / Responsibility
2018	Zululand Anthracite Colliery (ZAC)	Hydrogeological Assessment and Numerical Model Development for the Deep E Opencast and New Mngeni Shaft operational areas.	Project Manager, Field Specialist, Modler, Analyst, Reporting, Client liaison
2018	Green Door Environmental	Hydrogeological Assessment for the Isandlwana Settlement Development	Project Manager, Field Specialist, Assessments, Reporting, Client liaison
2018	Green Door Environmental	Hydrogeological Assessment for the Rem 8532 Northington Farm Bottling Plant	Project Manager, Field Specialist, Assessments, Reporting, Client liaison
2018	EnvironMatrix	Hydrogeological Assessment for the Spilsbury Piggery	Project Manager, Field Specialist, Assessments, Reporting, Client liaison
2018	Tripo4 Sustainable Solutions (Pty) Ltd	Hydrogeological Assessment for the UCL Sugar Mill	Project Manager, Field Specialist, Assessments, Reporting, Client liaison
2018	Triplo4 (Pty) Ltd	Hydrogeological Investigation for the Noodsburg Sugar Mill	Project Manager, Field Specialist, Modler, Analyst, Reporting, Client liaison
2018	Green Door Environmental	Hydrogeological Assessment for the Burnlea farm, situated near Underberg.	Project Manager, Field Specialist, Assessments, Reporting, Client liaison
2018	EcoLeges	Hydrogeological Assessment for the Proposed Development of Chicken Farms near Klippan	Project Manager, Field Specialist, Assessments, Reporting, Client liaison
2018	EcoLeges	Hydrogeological Assessment for the E&T Abattoir	Project Manager, Assessments, Reporting, Client liaison
2017	Zinoju Coal (Buffalo Coal)	Numerical Groundwater Model Update for the Magdalena Colliery	Project Manager, Field Specialist, Modler, Analyst, Reporting, Client liaison
2017	Tendele Coal (Pty) Ltd (Somkhele Anthracite Mine)	Hydrogeological Investigation for KwaQubuka and Luhlanga Opencast Operations	Project Manager, Field Specialist, Modler, Analyst, Reporting, Client liaison

Page 7 of 5

PROFESSIONAL EXPERIENCE

Scan here for full record

Year	Client	Project Description	Role / Responsibility
2017	Glencore	Numerical Groundwater Flow and Transport Model Development for the Lydenburg Smelter	Project Manager, Field Specialist, Modler, Analyst, Reporting, Client liaison
2017	Tripo4 Sustainable Solutions (Pty) Ltd	Hydrogeological investigation for the Illovo Eston Sugar Mill	Project Manager, Field Specialist, Modler, Analyst, Reporting, Client liaison
2017	Frame Knitting Factory	Hydrogeological investigation for the Frame Knitting Factory - As part of the WULA	Project Manager, Analyst, Reporting, Client liaison
2017	Royal HaskoningDHV - South Africa	Hydrogeological Assessment for the proposed Ballito Hills Development project	Project Manager, Field Specialist, Modler, Analyst, Reporting, Client liaison
2016	Tripo4 Sustainable Solutions (Pty) Ltd	Geohydrological Assessment for the Priority 1 Sewer Pipeline Development Project	Project Manager, Field Specialist, Assessments, Reporting, Client liaison
2016	Tongaat Hulett Developments (Pty) Ltd	Geohydrological Assessment for the Tinley Manor Development Project	Project Manager, Field Specialist, Assessments, Reporting, Client liaison
2016	Tongaat Hulett Developments (Pty) Ltd	Geohydrological Assessment for the Inyaninga Development Project	Project Manager, Field Specialist, Assessments, Reporting, Client liaison
2016	GIBB	Umzimkhulu WWTW Geohydrological Assessment	Project Manager, Field Specialist, Assessments, Reporting, Client liaison
2015	Magalela and Associates	Geohydrological Assessment Elandspruit	Project Manager, Field Specialist, Modler, Analyst, Reporting, Client liaison
2015	Tripo4 Sustainable Solutions (Pty) Ltd	Gledhow Sewer Pipeline Geohydrological Assessment	Project Manager, Field Specialist, Analyst, Reporting, Client liaison
2015	Ground Truth	Matuba Mall Geohydrological Assessment for WULA	Project Manager, Field Specialist, Analyst, Reporting, Client liaison
2015	Royal HaskoningDHV	Desktop Geohydrological Assessment for Sibaya Sewer Pump Stations	Project Manager, Field Specialist, Analyst,

Page 8 of 5

PROFESSIONAL EXPERIENCE

Scan here for full record

Year	Client	Project Description	Role / Responsibility
			Reporting, Client liaison
2015	Anglo Gold Ashanti	AngloGold Ashanti VR, MWS and WW Salt Load Allocations per Source Facility Update	Project Manager, Field Specialist, Analyst, Reporting, Client liaison
2014	Anglo Gold Ashanti	Surface and Groundwater Monitoring Assessment	Reporting, Analyst, Reporting, Client liaison
2014	EIMS	De Wittekrans Groundwater Update and Hydrocensus	Field Specialist
2014	Kangra Coal (Pty) Ltd	Ballengeich Pollution Control Project	Project Manager, Field Specialist, Analyst, Reporting, Client liaison
2014	Kemafahla and Trading	Cornfields Geohydrological Assessment	Project Manager, Field Specialist, Analyst, Reporting, Client liaison
2014	Total Coal South Africa (TCSA)	Dorsfontein and Forzando Geohydrological Assessment	Project Manager, Field Specialist, Analyst, Reporting, Client liaison
2014	Sivest	Preliminary and Desktop Hydrogeological Assessment for the Msinga Local Municipality Landfill Site in the Pomeroy Area	Reporting
2014	Tripo4 Sustainable Solutions (Pty) Ltd	King Shaka Mall Geohydrological Assessment	Project Manager, Field Specialist, Analyst, Reporting, Client liaison
2014	Tripo4 Sustainable Solutions (Pty) Ltd	Steve Biko Housing Development Geohydrological Assessment	Project Manager, Field Specialist, Analyst, Reporting, Client liaison
2014-2016	Tendele Coal (Pty) Ltd	Somkhele Waste and Geochemical Management Plan	Project Manager, Field Specialist, Analyst, Reporting, Client liaison
2016-2018	Tendele Coal (Pty) Ltd	Area 1 Pit Lake Feasibility Assessment	Project Manager, Field Specialist, Modler, Analyst, Reporting, Client liaison
Water Supply			

Page 9 of 5

GCS

PROFESSIONAL EXPERIENCE

Scan here for full record

Year	Client	Project Description	Role / Responsibility
2021	Joseph Baynes Estate (Pty)ltd	Baynesfields Groundwater Supply	Project Manager, Field Specialist, Reporting, Client liaison
2020	Wallace & Green	Izinga Eco Estate & Balito Hills Water Supply	Project Manager, Field Specialist, Reporting, Client liaison
2020	Triplo4	Siza Water Groundwater Supply & Geohydrological Evaluation	Project Manager, Field Specialist, Modler, Analyst, Reporting, Client liaison
2018	MBB Projects	Groundwater Supply Investigation for the iSimangaliso Wetland Park	Project Manager, Analyst, Reporting, Client liaison
2018	MBB Projects	Groundwater Supply Investigation for the iSimangaliso Wetland Park	Project Manager, Analyst, Reporting, Client liaison
2016	Condor Construction (Pty) Ltd	Geohydrological Investigation and Drilling Feasibility for Mount Ayliff Police Station	Project Manager, Field Specialist, Analyst, Reporting, Client liaison
2015	Tendele Coal (Pty) Ltd	Somkhele Water Supply	Project Manager, Field Specialist, Reporting, Client liaison
2015	DWS	Rural Water Supply & Resource Management	Field Specialist
2016-2017	Focus Project Management	KZN Drought Relief Borehole Feasibility Study	Project Manager, Field Specialist, Modler, Analyst, Reporting, Client liaison
Water Monitoring			
2014 2016	Buffalo Coal	Buffalo Coal Water Monitoring	Field Specialist, Reporting
2018	Tripo4 Sustainable Solutions (Pty) Ltd	Groutville D Sanitation Programme - Water Monitoring	Project Manager, Field Specialist, Assessments, Reporting, Client liaison
2016	Tripo4 Sustainable Solutions (Pty) Ltd	Monitoring Plan for the Proposed Bhamshela Filling Station	Project Manager, Field Specialist, Reporting, Client liaison

Page 10 of

GCS

PROFESSIONAL EXPERIENCE

Scan here for full record

Year	Client	Project Description	Role / Responsibility
2014-2015	Total Coal South Africa (TCSA)	Steincoalspruit Colliery Water Monitoring for Closure	Project Manager, Field Specialist, Reporting, Client liaison
2016-2019	Tripo4 Sustainable Solutions (Pty) Ltd	Avon Peaking Power Plant Groundwater and Surface Water Monitoring	Project Manager, Field Specialist, Assessments, Reporting, Client liaison
2015-2019	Tripo4 Sustainable Solutions (Pty) Ltd	King Shaka Mall Monitoring Plan and Water Monitoring	Project Manager, Field Specialist, Reporting, Client liaison
2014-Ongoing	Tendele Coal (Pty) Ltd	Somkhele Anthracite Mine Water Monitoring	Project Manager, Field Specialist, Reporting, Client liaison
2019	Wallace & Green	Glendale Sugar Mill Groundwater Model	Project Manager, Field Specialist, Reporting, Client liaison
Hydropedological Assessments			
2019	Rokwil Civils	InyaningaSoil Pollution Study	Project Manager, Field Specialist, Assessments, Reporting, Client liaison
2020	GIBB AFRICA	Newcastle Cemetery Geohydrology & Hydropedology	Project Manager, Field Specialist, Assessments, Reporting, Client liaison
2020	EnviroPro	N12 Filling stations Geohydrological & Hydropedology	Project Manager, Field Specialist, Reporting, Client liaison
2020	Nemai Consulting	Duvha Power Station Seepage Drains Hydropedological Assessment	Project Manager, Field Specialist, Reporting, Client liaison
2020	KSEMS Environmental Consulting	Renishaw Hills Estate Hydropedology	Project Manager, Field Specialist, Assessments, Reporting, Client liaison
2020	Zimbali Coastal Resort	Hydropedology study	Project Manager, Field Specialist, Reporting, Client liaison
2020	KJS Developments	Msinsi Mews Hydropedology	Project Manager, Field Specialist, Reporting, Client liaison

Page 11 of

GCS

PROFESSIONAL EXPERIENCE

Scan here for full record

Year	Client	Project Description	Role / Responsibility
2020	Eco-Pulse Environmental Consulting Services	Langefontein Hydropedology	Project Manager, Field Specialist, Reporting, Client liaison
2020	Eco-Pulse Environmental Consulting Services	South Coast Stone Crushers Hydropedology	Project Manager, Field Specialist, Reporting, Client liaison
2020	Eco-Pulse Environmental Consulting Services	Widenham Development Hydropedology	Project Manager, Field Specialist, Reporting, Client liaison
2020	Triplo4 Sustainable Solutions	Glendow Sugar Mill Hydropedology	Project Manager, Field Specialist, Reporting, Client liaison
2020	Acer Africa	Mtunzini Development Hydropedology	Project Manager, Field Specialist, Reporting, Client liaison
2021	Modikwa Platinum	Modikwa Platinum Soil Study	Project Manager, Field Specialist, Reporting, Client liaison
2021	Thirsti Bottling Plant	Thirsti Hydropedology	Project Manager, Field Specialist, Reporting, Client liaison

Page 12 of

PROFESSIONAL EXPERIENCE

Scan here for full record

PAPERS / DISSERTATIONS: -

Year	Title	Presented
2013	*Hydrological Modelling of the Boskop Dam Catchment with SWMM (Thesis)*	*North-West University*
2015	Understanding Site Hydrology of the Northern Kwazulu-Natal Anthracite Coal Fields With Special Reference to Discard and Tailings Disposal Practices (Paper)	14th Biennial Groundwater Division Conference: From Theory to Action
2016	Geohydrological impact of co-disposed coal material into an opencast pit (Thesis)	North-West University
2018	Viability Of Converting A South African Coal Mining Pit Lake System Into A Water Storage Facility	ICARD 2018
2019	Evaluating Groundwater Availability Based on Land Cover and Local Hydrogeology - A Groundwater Balance Approach	*16th Groundwater Conference and Exhibition, Port Elizabeth, 20-23 October 2019.*
2021	Impact of Engineered Tree Plantations on Water Transfer through the Upper Vadose Zone and Implications on Vertical Groundwater recharge.	*17th Biennual GWD Groundwater Conference and Exhibition*

CONFERENCES/ TRAINING: -

Year	Course/ Conference
2015	14th Biennial Groundwater Division Conference: From Theory to Action
2015	Fire Prevention and Protection Training Course
2018	*International Mine Water Association (IMWA) - International Convention for Acid Rock Drainage (ICARD) Conference*
2019	*16th Groundwater Conference and Exhibition, Port Elizabeth, 20-23 October 2019.*

Page **13** of

GCS

PROFESSIONAL EXPERIENCE

Scan here for full record

2021	Digital Soils Africa (DSA) Webinar – Hydropedology Requirements in South Africa
2021	17th Biennual GWD Groundwater Conference and Exhibition

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DECELERATION

DECLARATION

I, **Henrik Botha** hereby declare that the details furnished above are true and correct to the best of my knowledge and belief and I undertake to inform you of any changes therein, immediately. In case any of the above information is found to be false or untrue or misleading or misrepresenting, I am aware that I may be held liable for it.

Signature:__________ Date: 28 February 2022