GEOTECHNICAL DESK STUDY FOR CAMDEN I RENEWABLE ENERGY COMPLEX.

Camden, Mpumalanga

Prepared for: Enertrag SA

SLR Project No.: 720.05085.00004
Report No.: 02
Revision No.: B
April 2022

DOCUMENT INFORMATION

Title	Geotechnical Desk Study for Camden I Renewable Energy Complex.
Project Manager	Muhammad Osman
Project Manager Email	mosman@slrconsulting.com
Author	Muhammad Osman
Reviewer	Angus Bracken
Keywords	Wind Energy, Green Hydrogen, Ammonia, Engineering Geology, Geotechnical Influence, Impact Assessment Matrix, Recommendations
Status	Final
Report No.	02
SLR Company	SLR Consulting (South Africa) (Pty) Ltd

DOCUMENT REVISION RECORD

Rev No.	Issue Date	Description	Issued By
A	December 2021	Final	MO
B	April 2022	Final – Includes Revised Layouts and Project Descriptions	MO

REPORT SIGN OFF AND APPROVALS

Muhammad Osman
(Project Manager)

Angus Bracken
(Reviewer)

BASIS OF REPORT

This document has been prepared by an SLR Group company with reasonable skill, care and diligence, and taking account of the manpower, timescales and resources devoted to it by agreement with **Enertrag SA** (the Client) as part or all of the services it has been appointed by the Client to carry out. It is subject to the terms and conditions of that appointment.

SLR shall not be liable for the use of or reliance on any information, advice, recommendations and opinions in this document for any purpose by any person other than the Client. Reliance may be granted to a third party only in the event that SLR and the third party have executed a reliance agreement or collateral warranty.

Information reported herein may be based on the interpretation of public domain data collected by SLR, and/or information supplied by the Client and/or its other advisors and associates. These data have been accepted in good faith as being accurate and valid.

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

The copyright and intellectual property in all drawings, reports, specifications, bills of quantities, calculations and other information set out in this report remain vested in SLR unless the terms of appointment state otherwise.

This document may contain information of a specialised and/or highly technical nature and the Client is advised to seek clarification on any elements which may be unclear to it.

Information, advice, recommendations and opinions in this document should only be relied upon in the context of the whole document and any documents referenced explicitly herein and should then only be used within the context of the appointment.

National Environmental Management Act, 1998 (Act No. 107 Of 1998) And Environmental Impact Regulations, 2014 (As Amended) - Requirements for Specialist Reports (Appendix 6)

Regulation GNR 326 of 4 December 2014, as amended 7 April 2017, Appendix 6	Section of Report
1. (1) A specialist report prepared in terms of these Regulations must contain - a) details of - i. the specialist who prepared the report; and ii. the expertise of that specialist to compile a specialist report including a curriculum vitae;	Cover page, Page iv. Appendix B
b) a declaration that the specialist is independent in a form as may be specified by the competent authority;	Appendix B
c) an indication of the scope of, and the purpose for which, the report was prepared;	1
(cA) an indication of the quality and age of base data used for the specialist report;	4, 5, 6, 11.
(cB) a description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change;	9
d) the date and season of the site investigation and the relevance of the season to the outcome of the assessment;	-
e) a description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used;	2
f) details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure, inclusive of a site plan identifying site alternatives;	Appendix A 1, 2, 3, 4, 5, 7.
g) an identification of any areas to be avoided, including buffers;	1, 2, 3, 4, 5, 7.
h) a map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	1, 2, 3, 4, 5, 7.
i) a description of any assumptions made and any uncertainties or gaps in knowledge;	2.5
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;	3, 4, 5, 6, 7, 8.
k) any mitigation measures for inclusion in the EMPr;	N/A

Regulation GNR 326 of 4 December 2014, as amended 7 April 2017, Appendix 6	Section of Report
l) any conditions for inclusion in the environmental authorisation;	N/A
m) any monitoring requirements for inclusion in the EMPr or environmental authorisation;	N/A
n) a 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, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan;	9, 10. 9, 10. N/A
o) a description of any consultation process that was undertaken during the course of preparing the specialist report;	N/A
p) a summary and copies of any comments received during any consultation process and where applicable all responses thereto; and	N/A
q) any other information requested by the competent authority.	N/A
2) Where a government notice *gazetted* by the Minister provides for any protocol or minimum information requirement to be applied to a specialist report, the requirements as indicated in such notice will apply.	N/A

environmental affairs
Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

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

	(For official use only)
File Reference Number:	
NEAS Reference Number:	DEA/EIA/
Date Received:	

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

PROPOSED CAMDEN I RENEWABLE ENERGY COMPLEX:
CAMDEN I WIND ENERGY FACILITY, SOLAR ENERGY FACILITY, GREEN HYDROGEN AND AMMONIA FACILITY, PROPOSED GRID CONNECTIONS VIA SUBSTATIONS AND POWERLINES AND ALL ASSOCIATED INFRASTRUCTURE.

Kindly note the following:

1. This form must always be used for applications that must be subjected to Basic Assessment or Scoping & Environmental Impact Reporting where this Department is the Competent Authority.
2. This form is current as of 01 September 2018. It is the responsibility of the Applicant / Environmental Assessment Practitioner (EAP) to ascertain whether subsequent versions of the form have been published or produced by the Competent Authority. The latest available Departmental templates are available at https://www.environment.gov.za/documents/forms.
3. A copy of this form containing original signatures must be appended to all Draft and Final Reports submitted to the department for consideration.
4. All documentation delivered to the physical address contained in this form must be delivered during the official Departmental Officer Hours which is visible on the Departmental gate.
5. All EIA related documents (includes application forms, reports or any EIA related submissions) that are faxed; emailed; delivered to Security or placed in the Departmental Tender Box will not be accepted, only hardcopy submissions are accepted.

Departmental Details

Postal address:
Department of Environmental Affairs
Attention: Chief Director: Integrated Environmental Authorisations
Private Bag X447
Pretoria
0001

Physical address:
Department of Environmental Affairs
Attention: Chief Director: Integrated Environmental Authorisations
Environment House
473 Steve Biko Road
Arcadia

Queries must be directed to the Directorate: Coordination, Strategic Planning and Support at:
Email: EIAAdmin@environment.gov.za

SPECIALIST INFORMATION

Specialist Company Name:	SLR Consulting (South Africa) (Pty) Ltd			
B-BBEE	Contribution level (indicate 1 to 8 or non-compliant)	4	Percentage Procurement recognition	
Specialist name:	Muhammad Osman			
Specialist Qualifications:	BSc Honours Engineering and Environmental Geology			
Professional affiliation/registration:	Pr. Sci. Nat – Registered as Professional Natural Scientist with SACNASP			
Physical address:	57 Hilton Avenue, Hilton			
Postal address:	Same as Above			
Postal code:	3245	Cell:	071 895 9635	
Telephone:		Fax:		
E-mail:	mosman@slrconsulting.com			

DECLARATION BY THE SPECIALIST

I, _Muhammad Osman______, declare that –

- I act as the independent specialist in this application;
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the 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 with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- all the particulars furnished by me in this form are true and correct; 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

SLR Consulting (South Africa) (Pty) Ltd

Name of Company:

05/04/2022

Date

EXECUTIVE SUMMARY

This report presents the preliminary findings of a geotechnical desk study for the proposed Camden I Renewable Energy Complex, located adjacent to the Camden Power Station and 15 Km south of Ermelo, in Mpumalanga. The complex in its entirety consists of the Camden I Wind Energy Facility, Solar Wind Energy Facility, green hydrogen and ammonia facility as well as associated powerlines and grid connections.

In accordance with the 1:250 000 Geological Maps 2628 East Rand and 2630 Mbabane, published by the Council of Geoscience, the study area is underlain by stratigraphic units of the Ecca Group, Karoo Supergroup which is extensively intruded by post-Karoo dolerite. The Ecca Group is represented by sandstones, shales and coal seams of the Vryheid Formation.

Due to the economic viability of the Vryheid Formation, more specifically relating to the presence of coal seams in the area, the proposed development area is bounded by a single underground coal mine, namely the Mooiplaats Colliery.

Based on a preliminary hydrogeological assessment, the aquifers of the Karoo Supergroup display characteristics of intergranular and fractured rock. The borehole yielding potential of the aquifer is classified as D2, which implies an average borehole yield varying between 0.1 and 0.5 l/s.

One of the key elements of a geotechnical desk study report is the geotechnical impact assessment matrix, which generally details the impact of the development on the natural geological environment. Due to the geotechnical desk study report forming part of an environmental scoping report, a detailed impact assessment matrix is not required. An important impact to the development will be the potential presence of undermined areas within the study area. As the study area is underlain by large bodies of dolerite, the likelihood of coal mining operations is low. Although the potential of undermined areas are low, detailed mining plans indicating the extent of current operations and future expansions must be retrieved prior to the detailed geotechnical investigation and design.

No fatal flaws have been identified that can pose a constraint to the proposed development. It is recommended that a detailed geotechnical investigation be undertaken as part of the detailed design component of the project, to determine the prevailing subsurface conditions across the site and to optimise the positioning of the wind turbine generators, solar PV array and other associated infrastructure.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDICES

Geotechnical Desk Study for Camden I Renewable Energy Complex.

1. INTRODUCTION

SLR Consulting South Africa (Pty) Ltd has been appointed by Enertrag South Africa, hereafter referred to as "Enertrag", to undertake a geotechnical desk study assessment for the proposed construction of the Camden I Renewable Energy Complex located west of the town of Camden Power Station, in the Mpumalanga Province of South Africa. The complex is being developed in the context of the Department of Mineral Resources and Energy's (DMRE) Integrated Resource Plan, and the Renewable Energy Independent Power Producer Procurement Programme (REIPPP). It is therefore understood that a desktop level geotechnical report is required as part of an environmental submission for an Environmental Impact Assessment (EIA) report being undertaken by WSP, who are the appointed Environmental Assessment Practitioners (EAP) on the project.

The Camden l Renewable Energy Complex, hereafter referred to as "CIREC", is made up of various components such as the Camden I Wind Energy Facility, Solar Energy Facility, a green hydrogen and ammonia facility as well as associated powerlines and grid connections. It is anticipated that the proposed Camden I Wind Energy Facility (WEF) will comprise a total of forty-seven (47No.) wind turbines with a maximum total energy generation capacity of up to approximately 210 MW. The electricity generated by the proposed WEF development will be fed into the on-site Eskom substations located on the eastern and southern portions of the site, which will then connect to an overhead powerline leading to the Camden Power Station Complex. The overhead powerline will have a capacity of up to 400 kV. Battery Energy Storage Systems (BESS) will be located next to the on-site substations on both the eastern and southern portions of the site and will have storage capacities of 100MW/400MWh (Solar) and 200MW/800MWh (WEF) each. At this stage, it is proposed that Lithium Battery Technologies, such as Lithium Iron Phosphate, Lithium Nickel Manganese Cobalt oxides or Vanadium Redox flow technologies will be considered as the preferred battery technology. As an additional source of power generation, a green hydrogen and ammonia facility will be constructed on approximately 21 hectares (ha) of the CIREC.

In terms of the EIA Regulations, various aspects of the proposed development may have an impact on the environment and are considered to be listed activities. These activities require authorisation from the National Competent Authority (CA), namely the Department of Forestry, Fisheries and the Environment (DFFE), prior to the commencement thereof. Specialist studies have been commissioned to verify the sensitivity and assess the impacts of the renewable energy complex under the Gazetted specialist protocols (GN R 320 and GN R 1150 of 2020).

The aforementioned components of the CIREC will each be subjected to separate applications for environmental authorisation in terms of the National Environmental Management Act, 1998 (Act

107 of 1998) (NEMA) and are included together in this specialist report, taking cognisance that the impact assessments undertaken have considered the cumulative nature of impacts as well as the potential impacts of individual components.

1.1 CAMDEN I RENEWABLE ENERGY COMPLEX COMPONENTS

The detailed project summaries of each component of the CIREC, as provided by WSP, are discussed in this Section as well as the affected land parcels. The various project components inclusive of associated infrastructure are indicated on Figure 1.1 below.

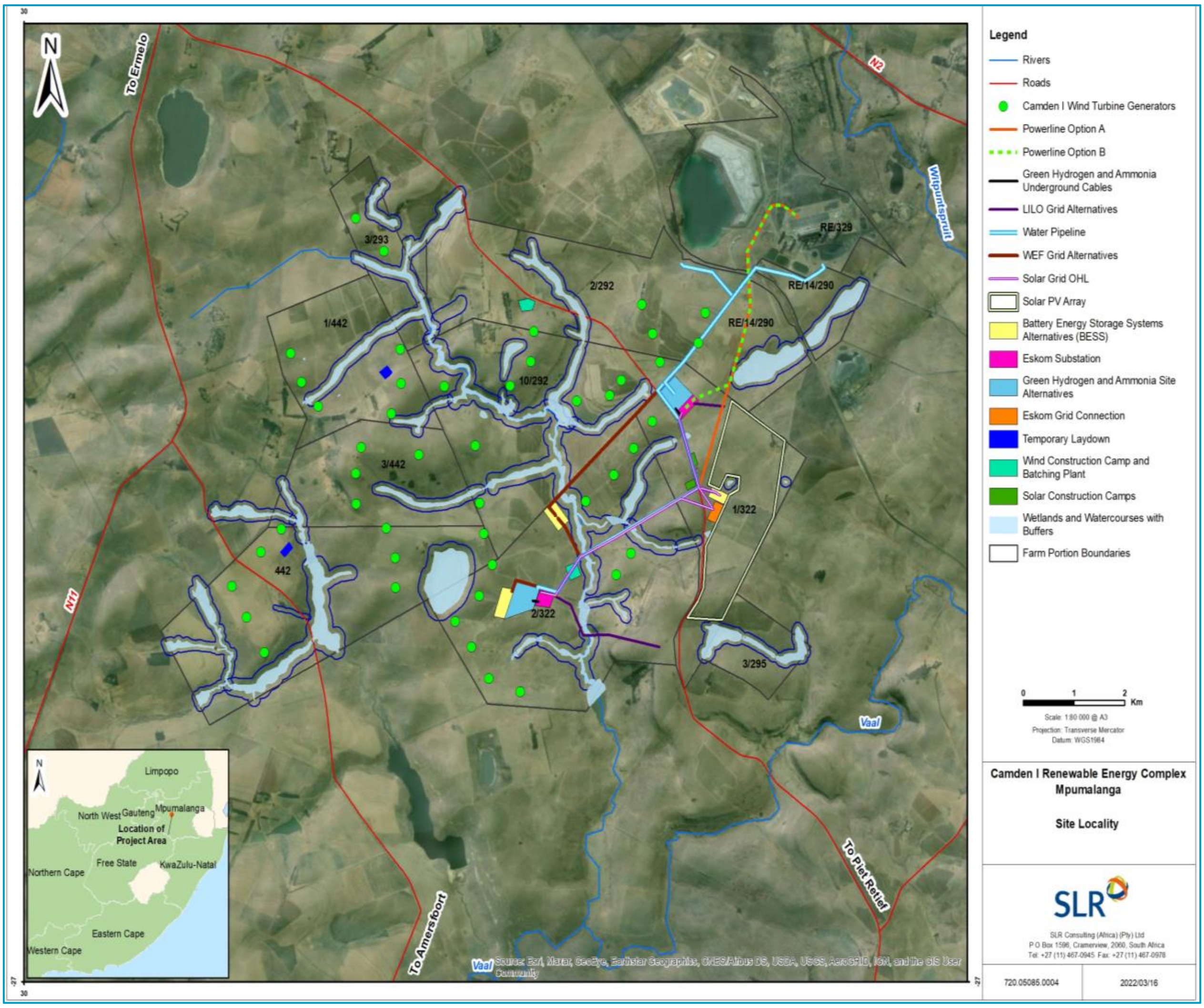


Figure 1.1: Site Locality Map showing all Project Components.

1.1.1 Camden I Wind Energy Facility

The proposed Camden I WEF will comprise a total of forty-seven (47No.) wind turbine generators with a total capacity of up to 210 MW, constructed over an aerial extent of approximately 6000 hectares. The project summary for Camden I WEF is itemised in Table 1.1 overleaf.

Table 1.1: Project Summary for Camden I Wind Energy Facility.

Sub-component	Description
Applicant	Camden I Wind Energy Facility (RF) Propriety Limited
Municipalities	Msukaligwa Local Municipality of the Gert Sibande District Municipality
Affected Farms	o Portion 0 of Klipfontein Farm No. 442 o Portion 1 of Welgelegen Farm No. 322 o Portion 1 of Klipfontein Farm No. 442 o Portion 2 of Uitkomst Farm No. 292 o Portion 2 of Welgelegen Farm No. 322 o Portion 3 of Langverwatch Farm No. 293 o Portion 3 of Klipbank Farm No. 295 o Portion 3 of Klipfontein Farm No. 442 o Portion 10 of Uitkomst Farm No. 292 o Portion 14 of Mooiplaats Farm No. 290
Extent	6000 ha
Buildable area	Approximately 200 ha
Capacity	Up to 210 MW
Number of turbines	Up to 47
Turbine hub height:	Up to 200 m
Rotor Diameter:	Up to 200 m
Foundation	Approximately 25 m^2 diameter x 3 m deep – 500 – 650 m^3 concrete. Excavation approximately 1000 m^2, in sandy soils due to access requirements and safe slope stability requirements.
Operations and Maintenance (O&M) building footprint:	Located in close proximity to the substation. Septic tanks with portable toilets. Typical areas include: - Operations building – 20 m x 10 m = 200 m^2 - Workshop – 15 m x 10 m = 150 m^2 Stores – 15 m x 10 m = 150 m^2
Construction camp laydown	Typical area 100 m x 50 m = 5000 m^2. Sewage: Septic tanks and portable toilets.
Temporary laydown or staging area:	Typical area 220 m x 100 m = 22000 m^2. Laydown area could increase to 30000 m^2 for concrete towers, should they be required.
Cement batching plant (temporary):	Gravel and sand will be stored in separate heaps whilst the cement will be contained in a silo. The footprint will be around 0.5 ha. Maximum height of the silo will be 20 m.

Sub-component	Description
Internal Roads:	Width of internal road – Between 5 m and 6 m, this can be increased to 8 m on bends. Length of internal road – Approximately 60 km.
Cables:	The medium voltage collector system will comprise of cables up to and include 33 kV that run underground, except where a technical assessment suggest that overhead lines are required, in the facility connecting the turbines to the onsite substation.
Independent Power Producer (IPP) site substation and battery energy storage system (BESS):	Total footprint will be up to 10 ha in extent. The substation will consist of a high voltage substation yard to allow for multiple (up to) 400 kV feeder bays and transformers, control building, telecommunication infrastructure, access roads, etc. The associated BESS storage capacity will be up to 200MW/800MWh with up to four hours of storage. It is proposed that Lithium Battery Technologies, such as Lithium Iron Phosphate, Lithium Nickel Manganese Cobalt oxides or Vanadium Redox flow technologies will be considered as the preferred battery technology. The main components of the BESS include the batteries, power conversion system and transformer which will all be stored in various rows of containers.

1.1.2 Camden l WEF Grid Connection

It is proposed that the Camden l WEF will connect to the nearby Camden Collector substation and Camden Power Station through an up to 132 kV powerline. The powerline will be approximately 14 km in length which will depend on the finalisation of the location for the collector substation. The on-site grid connection substation will consist of a high voltage substation yard to allow for multiple (up to 132 kV) feeder bays and transformers, control building, telecommunication infrastructure and access roads.

The area for the proposed on-site substation will be up to 1.5 ha and a 250 m corridor has been included for the 132 kV powerline and substation.

The affected properties and surface rights ownerships are included in Table 1.2.

Table 1.2: Affected Properties and Surface Rights Ownerships - Camden I WEF Grid Connection.

Parent Farm	Farm No	Portion No	Owner
Klipbank	295	0	Reyneke Hendrik Jackobus Willem
Adrianople	296	0	Rassie Saaiman Trust
Adrianople	296	1	Lood De Jager Trust
Welgelegen	322	1	Reyneke Hendrik Jackobus Willem
Welgelegen	322	2	Reyneke Hendrik Jackobus Willem
Klipbank	295	3	Reyneke Hendrik Jackobus Willem
Adrianople	296	3	Van Der Meulen Trust

1.1.3 Camden I WEF 400 kV Powerline

In order to connect the Camden I WEF to the Camden Power Station, an overhead powerline, up to 400 kV, is proposed from the on-site Eskom main sub-station to the Camden Power Station substation (Camden and Uitkoms substations), located within the Msukaligwa Local Municipality of the Gert Sibande District Municipality. A preferred alternative will be via a Loop-In-Loop-Out (LILO) connection into the existing Eskom Camden l Incandu 400 kV line traversing the Camden l project site. The on-site sub-station will consist of a high voltage yard to allow for multiple (up to 400 kV) feeder bays and transformers, control building, telecommunications infrastructure and access roads, which are anticipated to occupy an aerial extent of approximately 5 ha. If required, the Camden Power Station substation will be extended by 1 ha to accommodate the development.

The overhead powerline will be approximately 8 Km in length and will follow the same route as the existing powerlines in the area. Two alternative new powerline routes, as illustrated on Figure 1.1, are being investigated for direct connection into the Camden Power Station. In addition, two alternate routes are envisaged from the respective on-site collector substation for the LILO option. A 250 m wide corridor has been included in the assessment to allow flexibility in the location and design of the final powerline routes.

The affected properties and associated surface rights ownerships are included in Table 1.3.

Table 1.3: Affected Properties and Surface Rights Ownerships - Camden I WEF Eskom Grid.

Parent Farm	Farm No.	Portion No.	Owner
Indicative Option 1			
Mooiplaasts	290	14	Lood De Jager Trust
Welgelegen	322	1	Reyneke Hendrik Jackobus Willem
Indicative Option 2			
Mooiplaasts	290	14	Lood De Jager Trust
Welgelegen	322	1	Reyneke Hendrik Jackobus Willem
Welgelegen	322	2	Reyneke Hendrik Jackobus Willem

1.1.4 Camden I Solar Energy Facility

The proposed Camden I Solar Energy Facility (SEF) will comprise an array that will produce approximately 100 MW of energy to complement the energy produced by the WEF. The Solar PV array will be constructed over an aerial extent of approximately 297 hectares. The project summary for Camden I SEF is itemised in Table 1.4.

Table 1.4: Project Summary for Camden I Solar Energy Facility.

Facility Name	Camden I Solar Energy Facility
Applicant	Camden I Solar Energy Facility (RF) Propriety Limited
Municipalities	Msukaligwa Local Municipality of the Gert Sibande District Municipality
Affected Farms	Portion 1 of Welgelegen Farm No. 322
Extent	297 ha
Buildable area	Approximately 280 ha, subject to finalization based on technical and environmental requirements
Capacity	Up to 100 MW
Power system technology	Solar PV
Operations and Maintenance (O&M) building footprint:	Located near the substation. Septic tanks with portable toilets Typical areas include: - Operations building – 20 m x 10 m = 200 m^2 - Workshop – 15 m x 10 m = 150 m^2 Stores – 15 m x 10 m = 150 m^2
Construction camp and laydown area	Typical construction camp area 100 m x 50 m = 5 000 m^2. Typical laydown area 100 m x 200 m = 20 000 m^2. Sewage: Septic tanks and portable toilets
Cement batching plant (temporary):	Gravel and sand will be stored in separate heaps whilst the cement will be contained in a silo. The footprint will be around 0.5 ha. Maximum height of the silo will be 20 m.
Internal Roads:	Width of internal road – Between 4 m and 5 m, this can be increased to 6 m on bends. Length of internal road – Approximately 8 km.
Cables:	Communication, AC and DC cables.
Independent Power Producer (IPP) site substation and battery energy storage system (BESS):	Total footprint will be up to 6.5 ha in extent (5 ha for the BESS and 1.5 ha for the IPP portion of the substation). The substation will consist of a high voltage substation yard to allow for multiple (up to) 132 kV feeder bays and transformers, control building, telecommunication infrastructure, access roads, etc. The associated BESS storage capacity will be up to 100 MW/400 MWh with up to four hours of storage. It is proposed that Lithium Battery Technologies, such as Lithium Iron Phosphate, Lithium Nickel Manganese Cobalt oxides or Vanadium Redox flow technologies will be considered as the preferred battery technology. The main components of the BESS include the batteries, power conversion system and transformer which will all be stored in various rows of containers.

1.1.5 Camden I SEF 400 kV Powerline

In order to connect the Camden I SEF to the Eskom grid, an overhead powerline, up to 132 kV, is proposed from the on-site grid connection substation to the Camden Collector substation, located within the Msukaligwa Local Municipality of the Gert Sibande District Municipality. The powerline will be approximately 14km in length, depending on the authorized location of the collector substation. The onsite grid connection substation will consist of a high voltage substation yard to allow for multiple up to 132 kV feeder bays and transformers, control building, telecommunication infrastructure, and access roads. The area for the onsite substation will be up to 1.5 ha. The up to 132 kV powerline and substation will have a 250 m corridor.

The affected properties and associated surface rights ownerships are included in Table 1.5.

Table 1.5: Affected Properties and Surface Rights Ownerships - Camden I SEF Eskom Grid.

Parent Farm	Farm No	Portion No	Owner
Indicative Option One			
Welgelegen	322	1	Reyneke Hendrik Jackobus Willem
Welgelegen	322	2	Reyneke Hendrik Jackobus Willem
Indicative Option Two			
Welgelegen	322	2	Reyneke Hendrik Jackobus Willem

1.1.6 Green Hydrogen and Ammonia Facility

As part of the development, Enertrag proposes to construct a green hydrogen and ammonia facility which will be located on approximately 25 ha of the CIREC. Two alternative locations are being assessed, the locations of which are included in Figure 1.1. The facility will function by using air and water to produce green hydrogen and ammonia, a process that is more environmentally friendly than the traditional method of burning fossil fuels.

A simplified process flow diagram and green and ammonia production life cycle example are illustrated in Figure 1.2 and Figure 1.3.

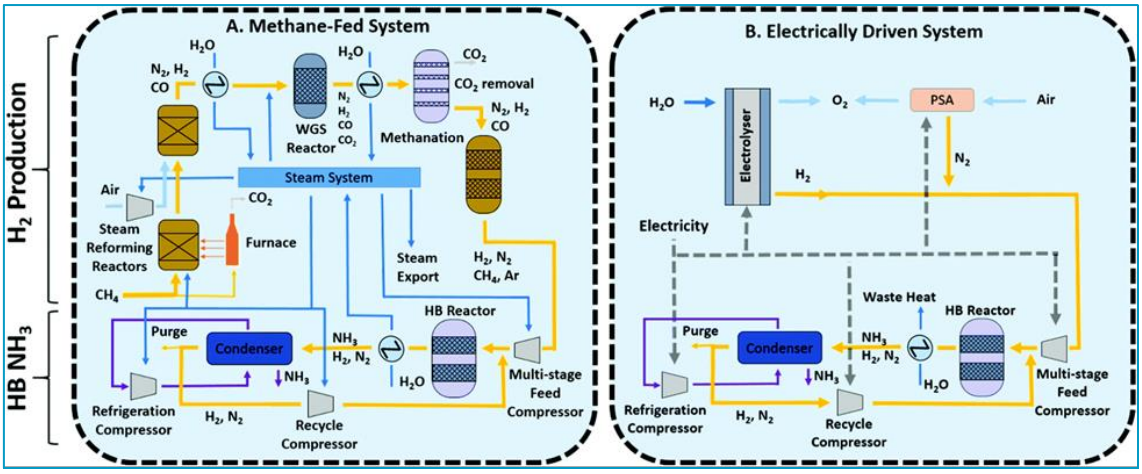


Figure 1.2: Green Hydrogen and Ammonia Production - Simplified Process Flow Diagram.

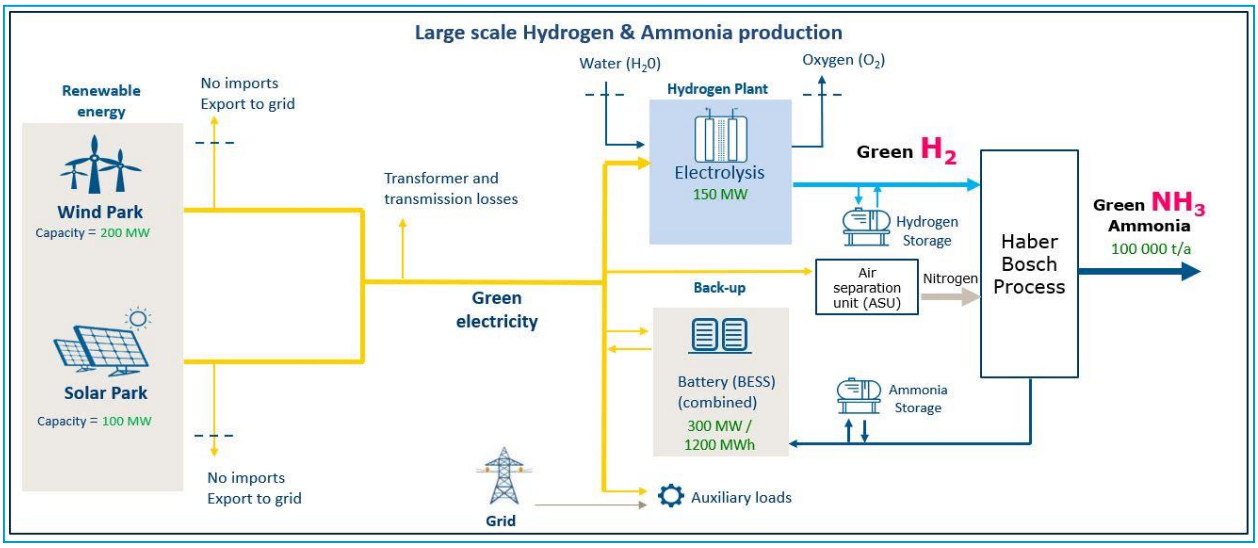


Figure 1.3: Simplified Green Hydrogen and Ammonia Production Life Cycle Example.

The facility will comprise various component structures to ensure the efficient production of green hydrogen and ammonia. A summary of the components that will be required is itemised in Table 1.6 and Table 1.7 as well as their respective footprints and maximum capacities. These parameters are based on the assumption that a 150 MW electrolyser

Table 1.6: Summary of Components Proposed for the Green Hydrogen and Ammonia Facility.

Component	Footprint (Ha)	Maximum Capacity (tpa)
Water Reservoir	2	800
Water Treatment Unit	1.5	160 000
Electrolyser Unit	1	20 000
Air Separation Unit	0.5	110 000
Ammonia Processing Unit	2.5	100 000
Liquid Air Storage Unit (LAES)	1	405 000

Component	Footprint (Ha)	Maximum Capacity (tpa)
Liquid Ammonia Storage Tank	2	175 000
Hydrogen Storage Tank	11	90 000
Total Footprint	21	

Associated infrastructure required for the proposed facility includes, but are not limited to:

- Electrical infrastructure required for power supply to the facility.
- Temporary and permanent laydown areas required for temporary storage and assembly of components and materials.
- Access road/s to the site and internal roads between project components, with a width of up to up to 6 m wide respectively.
- A temporary concrete batching plant (if necessary).
- Temporary staff accommodation.
- Fencing and lighting.
- Lightning protection.
- Telecommunication infrastructure.
- Stormwater channels.
- Water pipelines.
- Offices.
- Operational control centre.
- Operation and Maintenance Area / Warehouse / workshop.
- Ablution facilities.
- A gate house.
- Control centre, offices, warehouses.
- Security building.

Table 1.7: Summary of Components Proposed for the Green Hydrogen and Ammonia Facility.

No.	Component	Footprint (Ha)	Storage Capacity (m^3/tons)	Maximum Throughput (m^3/tpa)	Conversion	Note
1	Water Reservoir	2	6 800/6 800	800/800	Density of water taken as 1 000 kg/m^3	-
2	Water Treatment Unit	1.5	N/A	160 000/160 000	Density of water taken as 1 000 kg/m^3	-
3	Electrolyser Unit	1	N/A	(1 239 157 – 301 932 367)/20 000	Density of hydrogen can be 16.14 kg/m^3 at 200 barg and 25 °C or 0.06624 kg/m^3 at 0 barg and 90 °C depending on the operating conditions of the unit.	Hydrogen Output
4	Air Separation Unit	0.5	N/A	92 905 405/110 000	The density of air taken as 1.184 kg/m^3	Air Input
5	Ammonia Processing Unit	2	N/A	149 253/100 000	The density of liquid ammonia taken at 670 kg/m^3 at -33 °C at 1 atm	Ammonia Output
6	Liquid Air Storage System (LAES)	1	3 983/3 505	460 227/405 000	The density of liquid nitrogen taken 880 kg/m^3 at -33 °C at 1 atm	Nitrogen Storage
7	Liquid Ammonia Storage Tank	2	2 273/ 1 523	261 194 / 175 000	The density of liquid ammonia taken as 670 kg/m3 at -196 °C at 1 atm	-
8	Hydrogen and Oxygen Storage Tank Farm	12	59 566/800	5 576 208/90 000	A density of 16.14kg/m^3 for hydrogen at 200 barg and 25 °C	-
9	Ancillary infrastructure	3	n/a	n/a	n/a	Includes temporary and permanent laydown areas, parking, offices and other related infrastructure.
	Total Footprint	25				

Typical examples of the components required for the green hydrogen and ammonia facility, as provided by WSP, are included in Figure 1.4 below.

Figure 1.4: Typical Examples for the Green Hydrogen and Ammonia Facility Components.

The preliminary layout for the above components is included in Figure 1.5 overleaf.

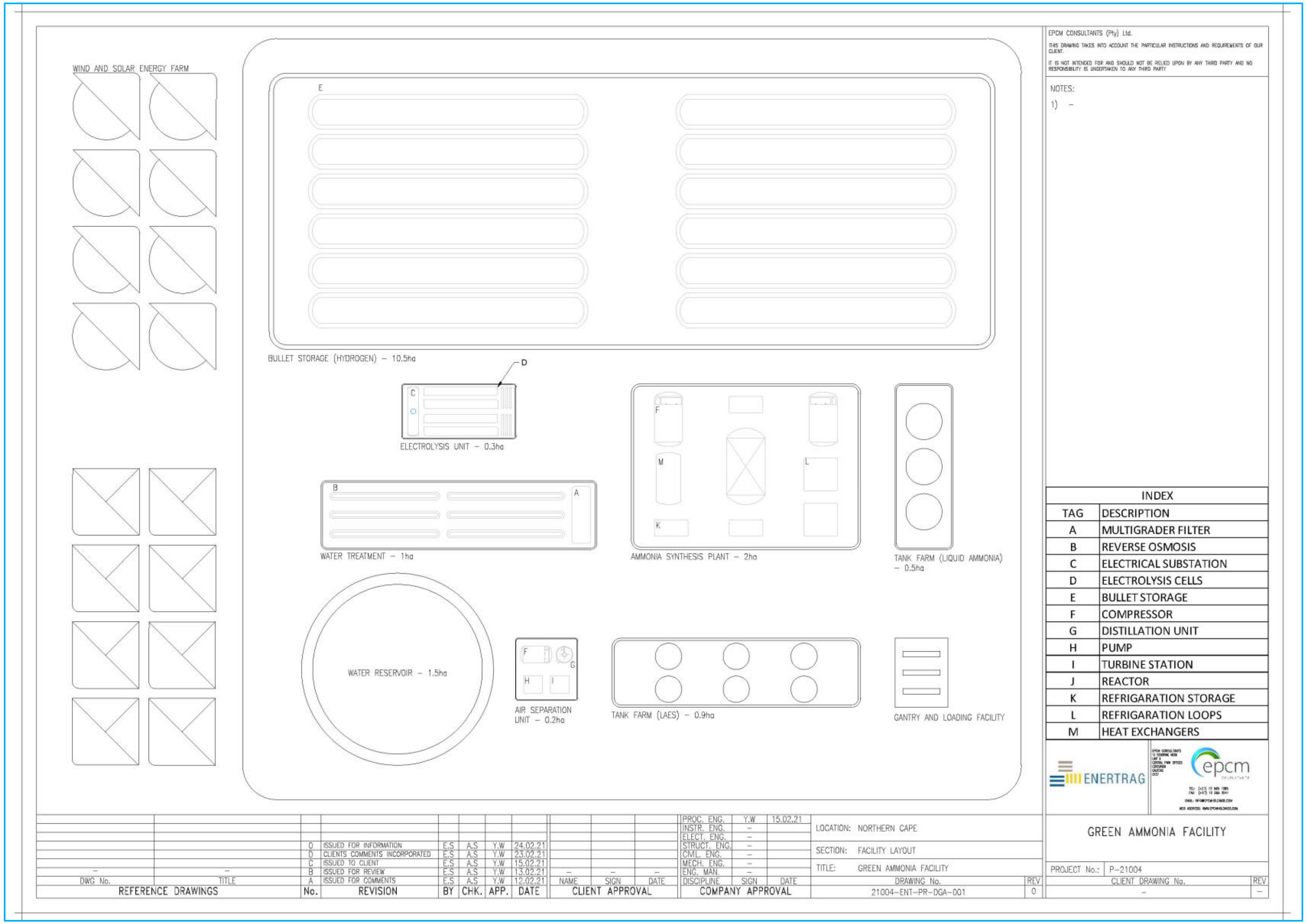


Figure 1.5: Preliminary Layout of Component Structures for the Green Hydrogen and Ammonia Facility.

2. ASSESSMENT METHODOLOGY

2.1 SCOPE OF WORKS

The objectives of this desk study were to assess the geological and geotechnical conditions prevailing across the study area as well as the potential geotechnical hazards relating to mining operations and undermined areas.

This involved a literature review and a review of topographic and geological maps of the region. Consideration was given to, but not limited to the following from a desktop level:

- The influence of topography on site suitability.
- The envisaged geological and geotechnical influences on the competency of foundations for the construction of structures.
- Tectonic influences and mine related seismicity on overall stability, namely the presence of faulting, lineaments, preferred discontinuity orientations and underground coal mines.
- Potential implications for the geotechnical design and engineering of the respective sites.
- Recommendations regarding requirements for subsequent detailed geotechnical investigations to inform the engineering design process.

2.2 TERMS OF REFERENCE

The geotechnical desk study assessment is based upon SLR's proposal entitled, "720.05085.P0004 Enertrag Geotechnical Desk Study," dated the 09 March 2021.

The detailed proposal submitted to Enertrag SA is included in **Appendix A** of this report.

2.3 SPECIALIST CREDENTIALS

Mr. Osman is a qualified engineering geologist, having attained a Bachelor of Science Honours Degree in Engineering and Environmental Geology, from the University of Kwa-Zulu Natal. He is registered as a Professional Natural Scientist (Registration No. 115552). Mr. Osman holds the position of Senior Engineering Geologist at SLR's Hilton branch. He has experience in the various fields of earth science and ground engineering, namely: engineering geology, geotechnical engineering and materials investigations. At present Mr. Osman specializes in conducting foundation investigations and material investigations for dams, roads and renewable energy projects.

This report was reviewed by Mr. Angus Bracken. Mr Bracken is a qualified Principal Engineering Geologist with 30 years' experience in geological, environmental and geotechnical engineering applied to mining and civil engineering projects in 27 countries across Africa, Asia and Europe. He has managed numerous geotechnical studies ranging from small housing and commercial properties to large industrial and mining complexes as well as various renewable energy projects.

The detailed Curriculum Vitaes' of the key personnel are included in **Appendix B** of this report.

2.4 APPROACH

The geotechnical desk study assessment for the Camden I Renewable Energy Complex entailed a review of available geotechnical reports as well as a review of topographic and geological maps. Consideration was given to the terrain, geology, hydrogeology and envisaged geotechnical constraints. Furthermore, as the proposed development footprint is located in an area with open cast and underground coal mines, mining activity data was retrieved from the Department of Mineral Resources and Energy's online self-service database.

The assessment involved a review of the following information:

- 1:250 000 scale Geological Maps 2628 East Rand and 2630 Mbabane (Council for Geoscience, 1991).
- Aerial photography (Google Earth imagery, current and historical) and project component shape files provided by Enertrag SA.
- Technical report entitled, "Engineering Geological Evaluation Report for the Proposed Ash Disposal Facility, Camden Power Station, Mpumalanga", produced by Africa Exposed Consulting Engineering Geologists, dated July 2011.
- Technical report entitled, "Geological Assessment of the Meerlus Region between Komati and Hendrina, Mpumalanga", produced by WSP Environmental (Pty) Ltd, dated 14 June 2019.
- Technical report entitled, "Geotechnical Desk Study: Proposed Construction of the 132 Kv Boschmanskop – Hendrina/Aberdeen Powerline and Substation", produced by M.J van der Walt Engineering Geologist CC, dated November 2017.
- Project Description and Impact Assessment Methodology for Camden I Renewable Energy Complex produced by WSP, dated 14 July 2021.
- Mining and seismicity data from the Department of Mineral Resources and Energy's website.

2.5 ASSUMPTIONS AND LIMITATIONS

The interpretation of the overall geotechnical conditions across the site is based on a review of available information on the project area. Subsurface and geotechnical conditions have been inferred at a desktop level from the available information, past experience in the project area and professional judgement. The information and interpretations are given as a guideline only and there is no guarantee that the information given is totally representative of the entire area in every respect. No responsibility will be accepted for consequences arising out of the fact that actual conditions vary from those inferred. The information must be verified by the undertaking of a detailed geotechnical site investigation.

3. SITE DESCRIPTION

3.1 LOCALITY

The proposed renewable energy complex is located immediately west of the Camden Power Station and approximately 15 Km south of the town of Ermelo in the Mpumalanga Province of South Africa and occupies an aerial extent of approximately 6 600 ha. The project area is situated within the Msukaligwa Local Municipality of the Gert Sibande District Municipality.

As illustrated in Figure 3.1 below, access to the study area can be gained via the N11 to the west and the N2 to the east, which leads onto unnamed district gravel roads.

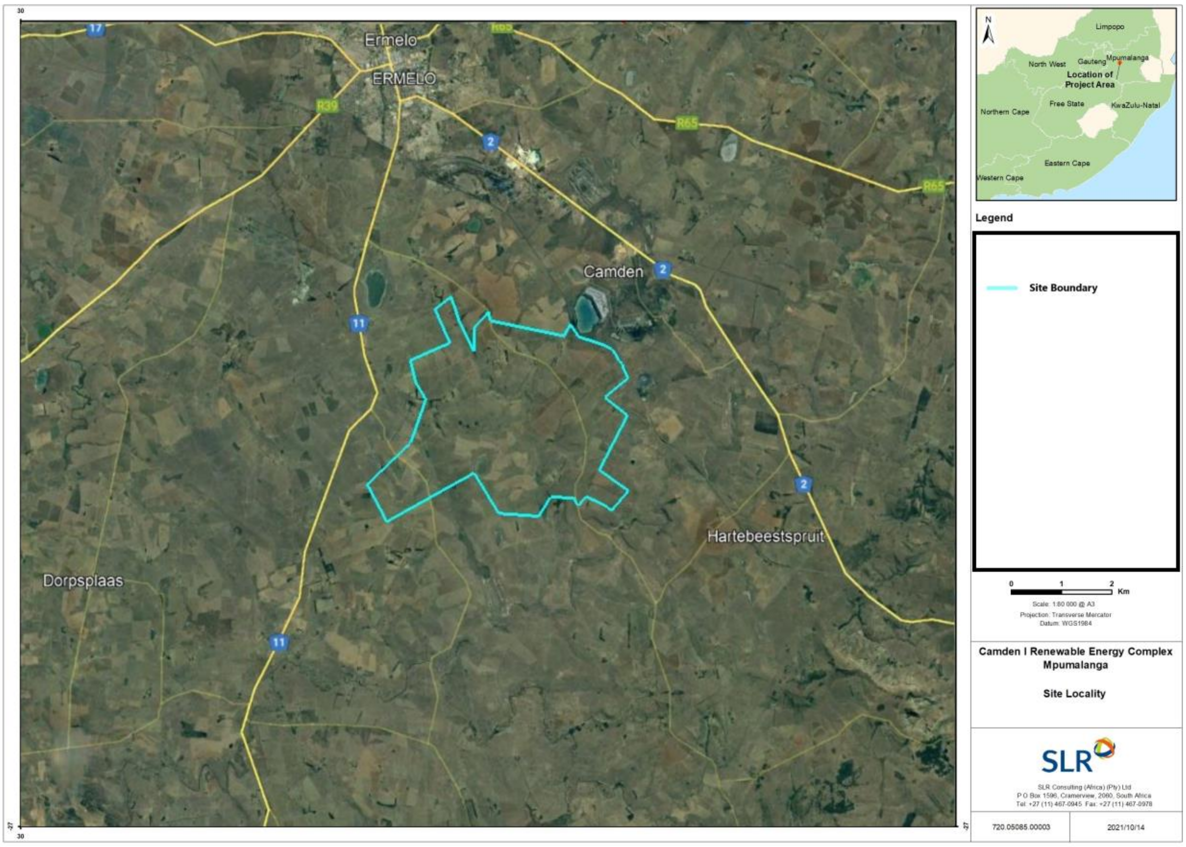


Figure 3.1: Camden I Site Locality.

3.2 LAND USE AND VEGETATION

Based on a preliminary assessment, the proposed renewable energy complex is bounded predominantly by cultivated agricultural lands with a minor land parcel occupied by an underground coal mine, which is situated outside the eastern boundary of the study area. The coal mine, which was identified from basic aerial photographic analysis, is the Mooiplaats Colliery which focuses on the mining of bituminous coal.

According to Mucina et al (2005), the regional biome within which the study site is located is classed as the Grassland Biome, comprising sweet and sour grass plants.

3.3 CLIMATE

The study area is characterized by a warm and temperate climate with a "Cwb" classification according to the Köppen-Geiger climate classification. Camden receives a relatively low mean annual precipitation of 482 mm. The average lowest rainfall is received in July (2 mm) and the highest in December (93 mm), which is a seasonal variation of 91 mm.

The average maximum midday temperatures for Camden ranges from 30°C in January to 21°C in July. The minimum temperatures for Hendrina ranges from 13°C in December to 3°C in July. Figure 3.2 below summarizes the climatic conditions for Camden, Mpumalanga.

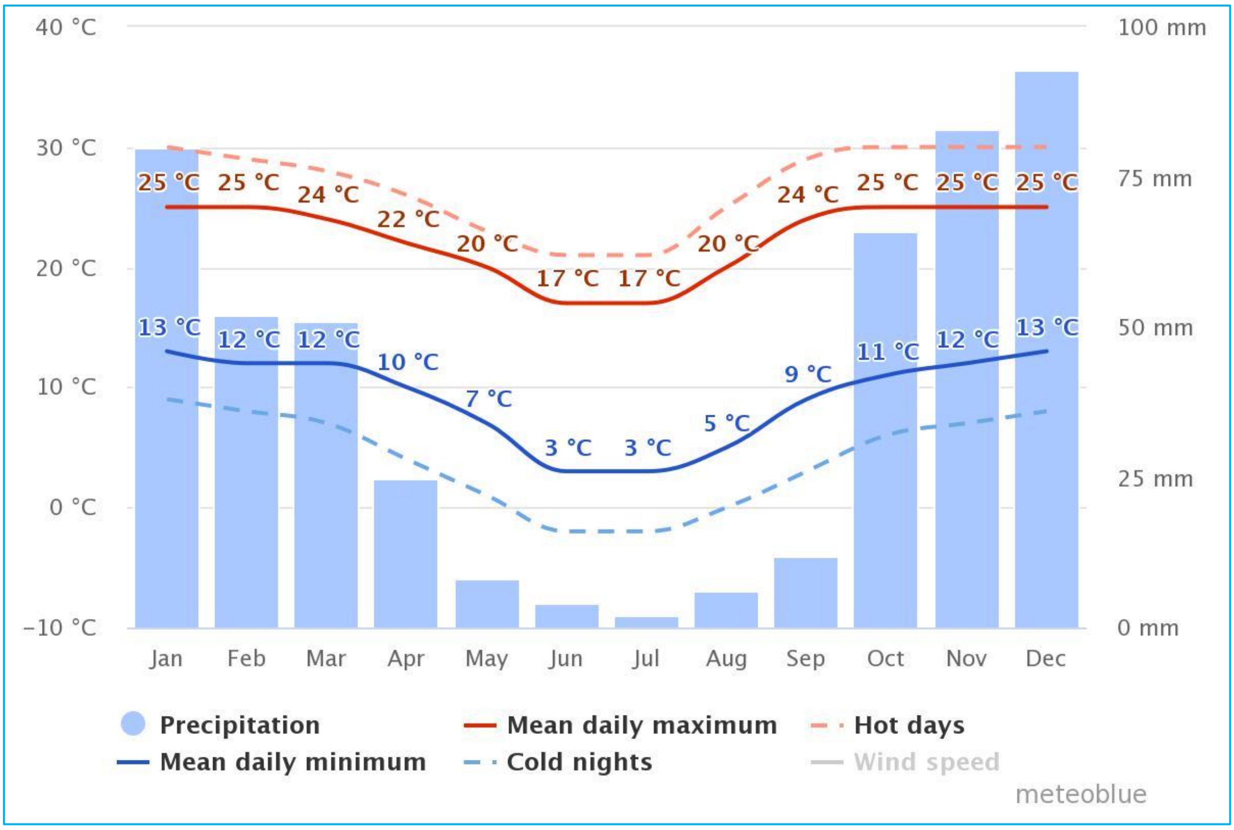


Figure 3.2: Summary of Climatic Conditions *(Source: Meteoblue)*.

3.4 DRAINAGE AND TOPOGRAPHY

Based on a desk study assessment, the project area consists of a number of aquatic features associated with catchments and rivers such as wetland areas, perennial and non-perennial tributaries. Of specific importance is the presence of an assumed non-perennial tributory of the Vaal River, which flows to the south and drains into and out of two farm dams constructed on the southern extremity of study area.

Slope variation analysis undertaken for the proposed area in its entirety indicates that the topography is characterised by flat to gentle terrain, comprising slope angles ranging between 0° and 6.5°. Spot heights indicate that the elevation across the site ranges between 1574 m and 1692 m above mean sea level, with a difference in elevation of approximately 118 m occurring in localised areas.

The general drainage features observed and the topographic variation occurring across the proposed development area is included in Figure 3.3 and Figure 3.4.

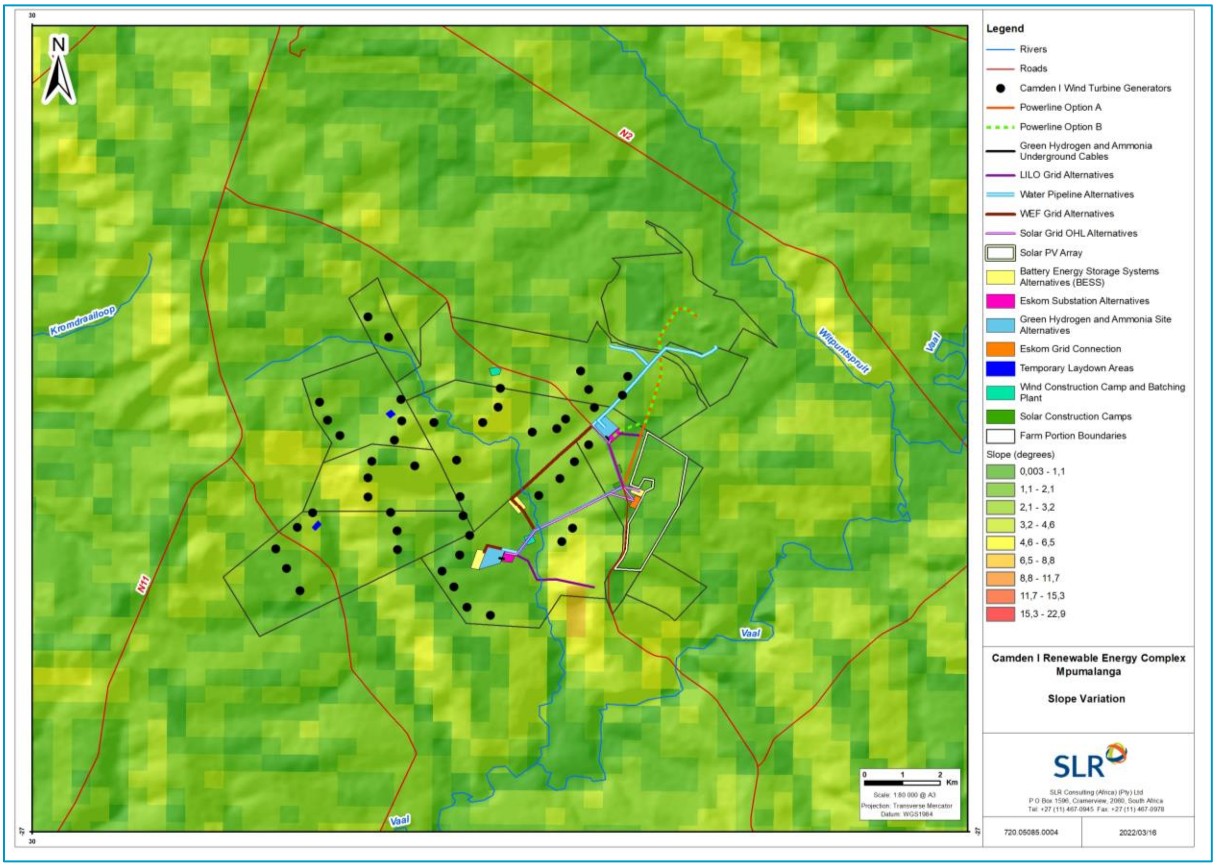


Figure 3.3: Slope Variation in Degrees and Drainage Features.

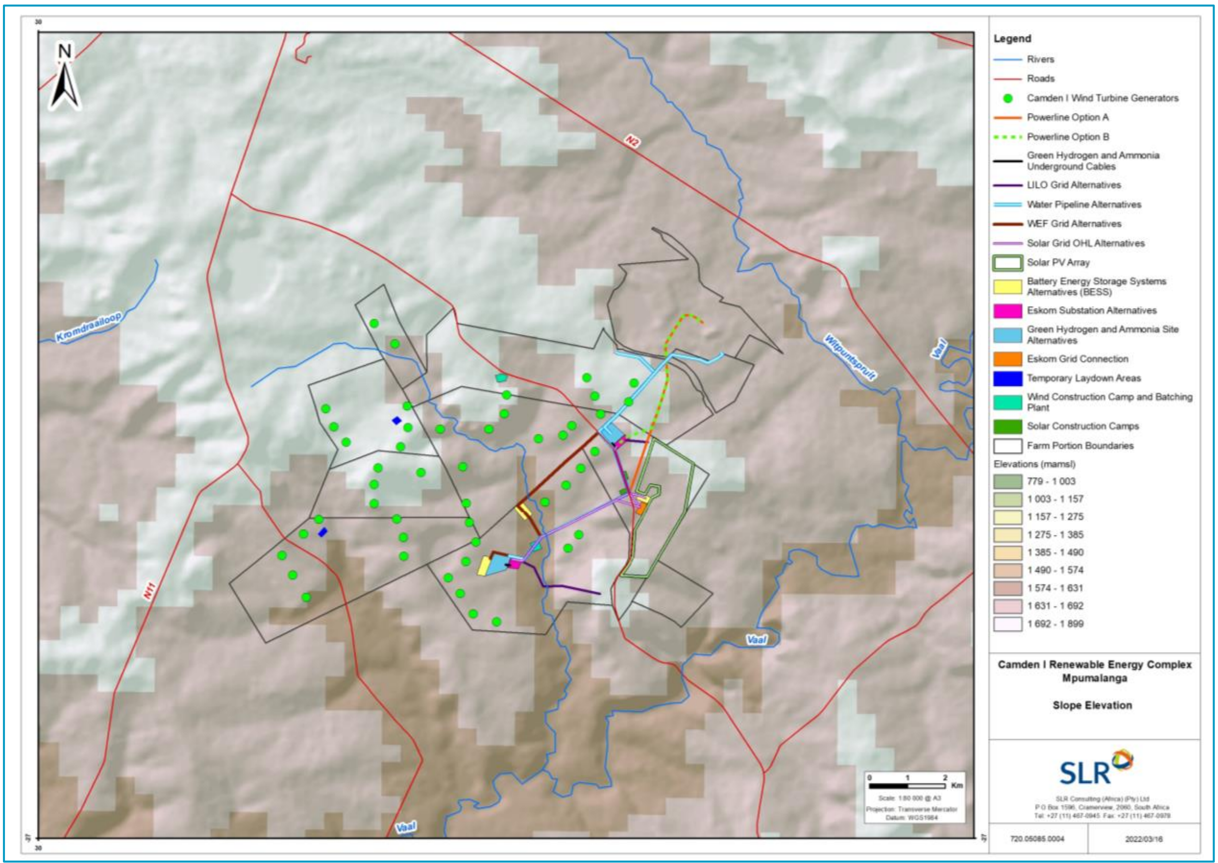


Figure 3.4: Elevation (mamsl) and Drainage Features.

4. GEOLOGY

In accordance with the 1:250 000 Geological Maps 2628 East Rand and 2630 Mbabane, published by the Council of Geoscience, the study area is underlain by stratigraphic units of the Ecca Group, Karoo Supergroup which is extensively intruded by post-Karoo dolerite.

4.1 VRYHEID FORMATION, ECCA GROUP

The proposed development area is predominantly underlain by lithological units of the Ecca Group which is represented by sandstones, shales and coal seams of the Vryheid Formation, all deposited in a shallow marine environment. The Vryheid Formation has been extensively intruded by Jurassic aged dolerite, becoming relatively more prevalent further east of the proposed study area.

Sandstones comprise a larger portion of the Karoo sediments and are generally closely intercalated with mudrocks, resulting in alternating bands of arenaceous and argillaceous sediments. The Vryheid Formation sandstones may typically occur as arkosic to greywacke, ranging from a generally coarse grained, poorly sorted material to a fine grained, well sorted material, with an abrupt upward transition.

Of significant economic importance is the presence of coal seams located stratigraphically between the sandstone and mudrock bedding partings, at the base of the Vryheid Formation. The lower coal seams attain thicknesses of approximately 18 m which progressively diminishes upwards through the formation, due to various depositional and post-depositional factors (Brink, 1983).

4.2 POST-KAROO DOLERITE

Dolerite is an intrusive, hyperbyssal igneous rock of post-Karoo age that has intruded the sedimentary host rocks, mainly in the form of concordant sills and to a lesser extent as discordant dykes. It is a dark grey, crystalline, rock composed mainly of plagioclase feldspar and pyroxene, with accessory amounts of olivine, biotite, amphibole, apatite and iron ore minerals.

Whilst generally of medium grained texture, the dolerite adjacent to the sedimentary contacts is often of a finer texture due to rapid cooling of the magma. The intrusions have also frequently resulted in the formation of an alteration or “baked” zone in the sedimentary rocks adjacent to the contacts. The joints in the dolerite are in most cases filled or coated by secondary calcite and chlorite, deposited by the subsequent circulation of magmatic fluids (Brink, 1983).

4.3 RECENT DEPOSITS

Transported soils, referred to as recent deposits, are generally un-lithified sediments that have been derived from the slow disintegration of the parent bedrock material, which have been disbursed from their original locations and deposited by geomorphic processes. The transported soils anticipated to occur across the study area are:

- **Colluvium:** A term that includes all soils on hill slopes that have been displaced under the influence of gravity. In certain cases, the geotechnical characteristics of the colluvial soils may lead to an approximation of the parent bedrock material.
- **Alluvium:** Deposits that result from the transportation and deposition of sediments by rivers or similar water courses. These deposits are generally present along rivers and floodplains and may contain fine to coarse grain sizes which is dependent on the origin of the sediment as well as through the processes of eluviation and illuviation.
- **Pedocretes:** Superficial deposits that have formed either as weathering residues or by cementation of pre-existing soils by various authigenic minerals precipitated from the soil water or ground water. The pedocretes likely to be encountered across the study area are mainly ferricrete with sub-ordinate calcrete which may occur as nodular or hardpan.
- **Pebble Marker:** The base of the transported soil which is characterised by the presence of a gravel horizon, representing the most recent major geological unconformity in the soil profile. The pebble marker is generally a zone of high permeability due to the abundance of angular, sub-angular and rounded gravel fragments of mixed origin.

A detailed Geological Map of the underlying lithologies occurring across the study area is presented in Figure 4.1.

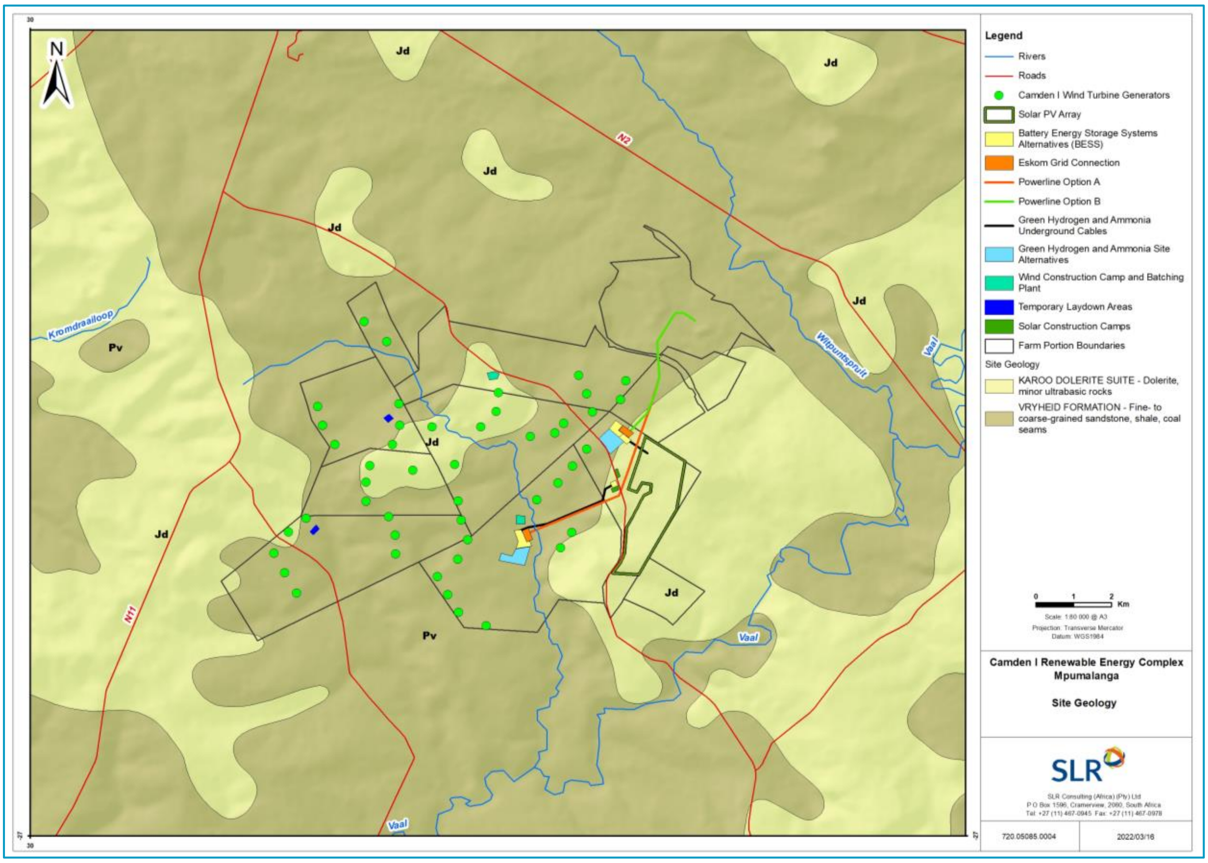


Figure 4.1: Geological Map of the Proposed Development Area.

5. HYDROGEOLOGY

The Camden I Renewable Energy Complex is underlain by Karoo sedimentary rocks and dolerite intrusions, as mentioned in Section 4, and the hydrogeological characteristics of the study area are a function of the geological formations. The aquifers of the Karoo Supergroup display characteristics of intergranular and fractured rock. The borehole yielding potential of the aquifer is classified as D2, which implies an average borehole yield varying between 0.1 and 0.5 l/s.

According to Barnard (2000), there are typically six different modes of groundwater occurrence associated with these formations:

- Weathered and fractured sedimentary rocks not associated with dolerite intrusions.
- Indurated and jointed sedimentary rocks alongside dykes.
- Narrow weathered and fractured dolerite dykes.
- Basins of weathering in dolerite sills and highly jointed sedimentary rocks enclosed by dolerite.
- Weathered and fractured upper contact zones of dolerite sills.
- Weathered and fractured lower contact zones of dolerite sills.

Numerous springs occur at lithological contacts such as where sandstone overlies an impervious shale horizon, along fault zones or along impermeable dolerite dykes. Groundwater seepage in lower lying areas contributes substantially to sustaining the dry season flow in the stream systems that drain these landscapes.

A detailed Hydrogeological Map illustrating the aquifer types and borehole yielding potential across the study area is presented in Figure 5.1 below.

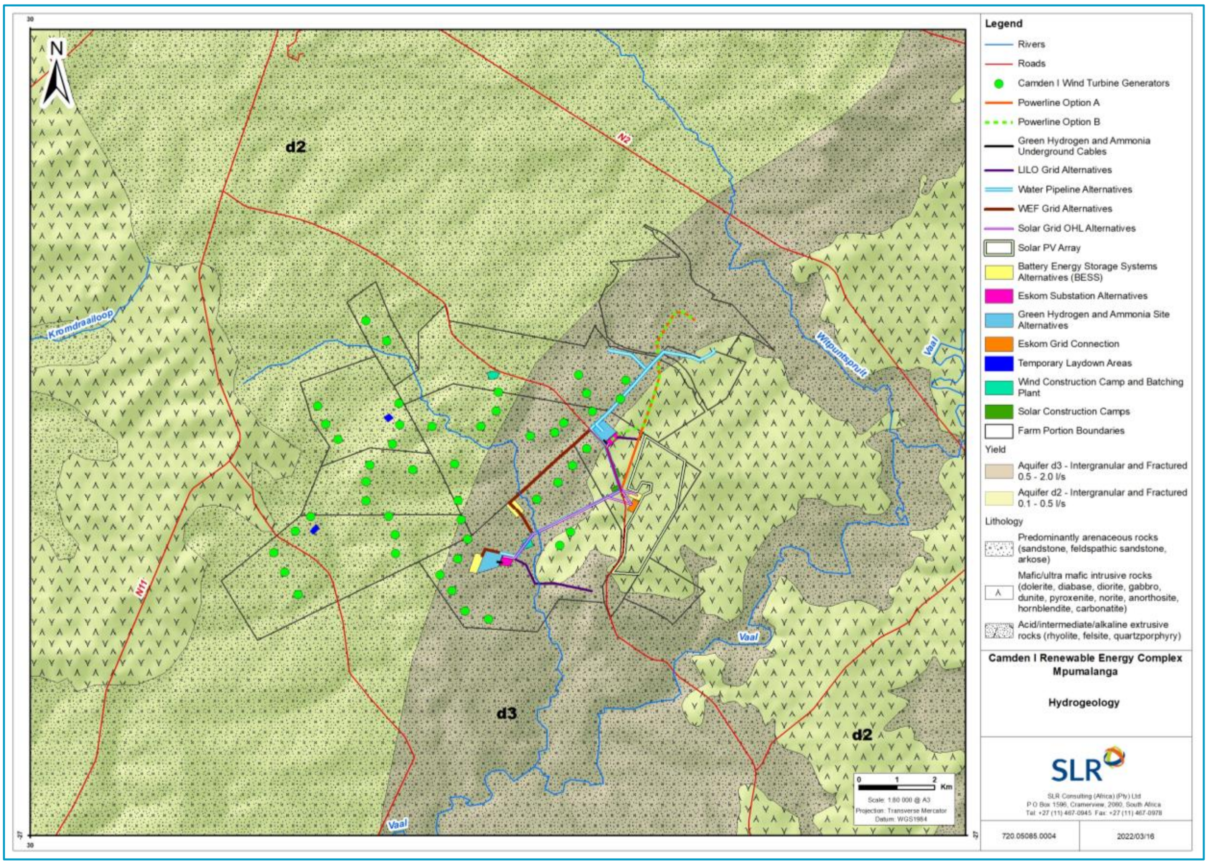


Figure 5.1: Hydrogeological Map of the Proposed Development Area.

6. ENGINEERING GEOLOGY

Engineering geology refers to the engineering characteristics of the natural earth materials for founding of structures and identifies the suitability of in-situ soils for use as construction materials. The majority of the study area is dominated by the Vryheid Formation with occurrences of post-Karoo dolerite intrusions. Colluvial deposits can be anticipated along hillslopes with alluvial deposits anticipated near drainage features, especially adjacent to the rivers crossing the site.

The climatic regime plays a fundamental role in the development of a soil profile. Weinert (1964) demonstrated that mechanical disintegration is the predominant mode of rock weathering in areas where the climatic “N-value” is greater than 5, while chemical decomposition predominates where the N-value is less than 5. Weinert’s climatic N-value for the Camden area is approximately 1.8.

This implies that chemical decomposition is the dominant mode of weathering in the study area. Chemical decomposition is the chemical alteration of certain minerals, which result in the formation of clay minerals. The nature of the weathering is supported during previous investigations, with both dolerite and the sedimentary rocks weathering to residual soils with moderate to high clay contents.

6.1 VRYHEID FORMATION

The Vryheid Formation is predominantly arenaceous, coarse grained, and consists predominantly of sandstones, grits, arkoses, with subordinate mudrocks and coal seams. The sandstones of the Vryheid formation, while consisting predominantly of quartz, may contain significant quantities of rock fragments consisting of micaceous fragments (mica / clay minerals / chlorite) and felsite (fine grained quartz / feldspar mixture). The quartz-rich sandstones disintegrate to form sandy residual soils, whereas the feldspathic sandstones generally decompose to form clayey sands or sandy clays of low to medium plasticity (Brink, 1983). Based on previous investigations undertaken in near proximity to the study area, the sandstone bedrock was observed to weather to sandy and clayey residual soils.

The abovementioned rock types may be closely intercalated, resulting in highly variable geotechnical conditions, both vertically and horizontally. It is not unusual for a weak lens of mudrock to occur within a competent layer of sandstone, or for a band of rock to disappear horizontally over a short distance. The occurrence of weaker strata within or below competent rock strata may be problematic for the founding of heavy structures. The assumption that the founding conditions will improve with depth does not necessarily apply in the case of the Vryheid Formation.

In respect of sourcing construction materials for roads and laydown areas consideration could be given to natural gravely or crushed sandstone bedrock. Selective usage must be exercised to avoid using sandstone containing excessive pyrite and muscovite, which can cause distress when used as basecourse (Brink, 1983). In addition, where chemical stabilization is required the clay matrix of sandstones make them suitable for stabilization with lime (Brink, 1983). The occurrence, nature, material quality and quantity of sandstone and other potential construction materials will have to be assessed during the detailed geotechnical investigation. It is recommended that provision be made to procure aggregates for use in upper pavement layerworks construction and the manufacture of concrete from commercial sources.

On the contrary, mudrocks such as siltstone, mudstone and “mud-shales” are not considered suitable for use as construction materials, due to their swelling characteristics, excessive absorption of water and poor engineering performance. Slope stability issues can arise in areas where closely intercalated sandstones and mudrock co-exist. When mudrocks slake or disintegrate the exposed sandstone layers are undercut, which can result in rockfalls (Brink, 1983).

6.2 POST-KAROO DOLERITE

The types of materials that may form from the weathering of dolerite, as described by Brink (1983) are fractured dolerite, boulder dolerite, gravel dolerite, granular dolerite and residual dolerite soil. Fractured dolerite forms where the unweathered rock mass is closely jointed or fractured while boulder dolerite forms where the widely spaced fractures occur. The disintegration or decomposition of dolerite takes place from surface and preferentially along joints and fractures. Weathering along vertical and horizontal joints and fractures leads to the formation of hard corestones with weathered zones surrounding the boulders. The preferential weathering along joints and fractures may result in variable geotechnical conditions, both laterally and vertically over short distances and a variable bedrock profile.

The dolerite observed on the site, based on previous geotechnical investigations undertaken, was found to be weathered to moderate depths and the rock was overlain by residual soils, typically with a moderate to high clay content.

7. MINING ACTIVITY AND SEISMICITY

A major component of the geotechnical desk study is to assess the affects that current coal mining operations have on the proposed development. As the Vryheid Formation comprises the most economically expoitable coal seams in South Africa, one cannot ignore the presence of undermined ground and the negative development constraints these can have in general.

The older coal mining operations utilised the board and pillar method of extraction, resulting in these areas being relatively more prone to surface subsidence. Due to the increased demand for coal, either for generation of electricity or for export purposes, more advanced mining methods were utilised, such as, pillar extraction, longwall mining or open cast and strip mining.

As the study area is underlain by relatively large concerntrations of post-Karoo dolerite, it can be safe to deduce that coal mining operations will not be as significant as areas located to the north, thereby reducing the potential for undermined ground. This is predominantly due to the intrusions significantly decreasing the calorific potential of most coal layers resulting in the distruption of the lateral continuity of the coal seams in the area.

Based on a review of Google Earth satellite imagery and the Department of Mineral Resources and Energy’s online self-service database, it was observed that only one coal mine is present, which is situated outside the eastern boundary of the site with the mine shaft proceeding in an easterly direction. Table 7.1 summarises the details of the coal mining operation, which presumably focuses on the bituminous coal commodity. Figure 7.1 illustrates the study area relative to the coal mine.

Table 7.1: List of Coal Mines in Near Proximity to Study Area.

Item	Name of Mine	Type	Farm Portion	Owner
1	Mooiplaats Colliery	Underground	Mooiplaats 290 IT 1 & 9	Coal of Africa (Pty) Ltd

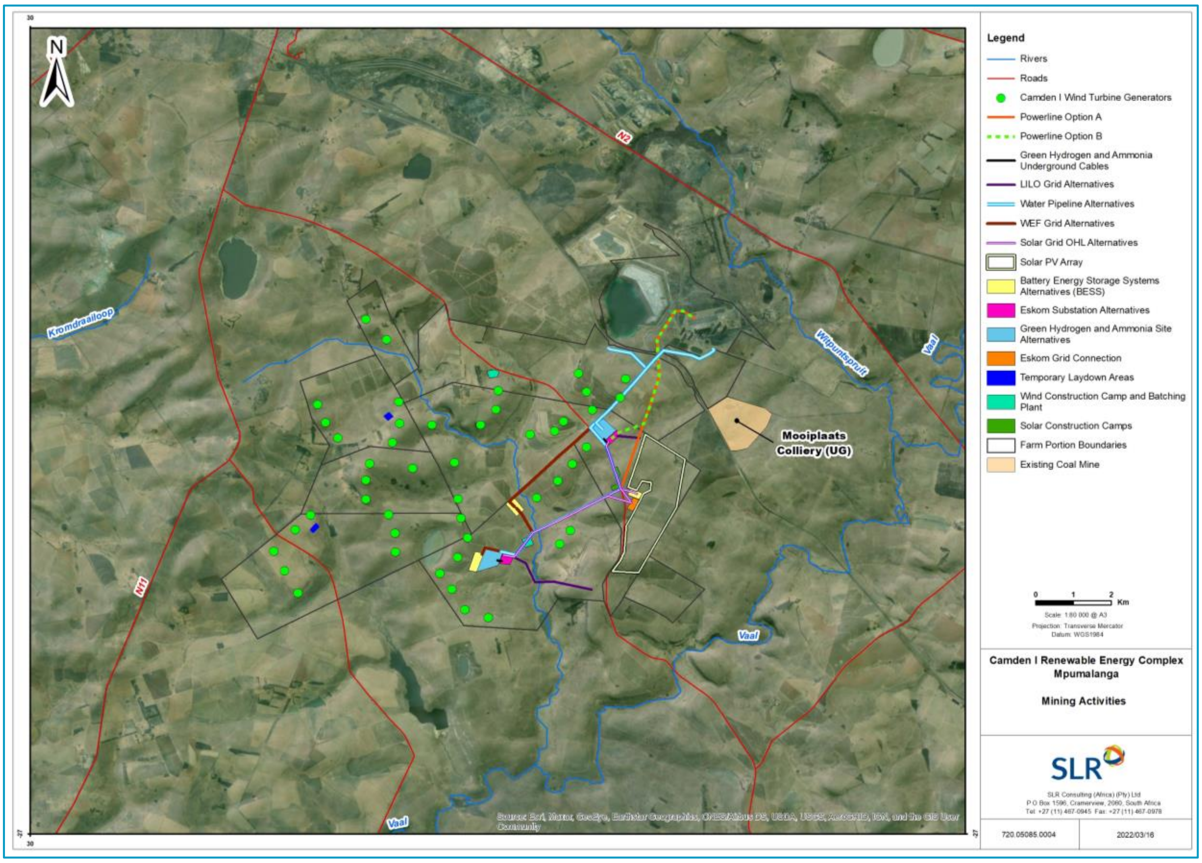


Figure 7.1: Coal Mine Locations Relative to Study Area.

Although minimal coal mining operations were observed, the extent and direction of current mining operations cannot accurately be determined during the desk study phase. A detailed geotechnical investigation will be required to confirm their presence, which will comprise of rotary core drilling, geophysics, test pitting and in-situ testing.

In accordance with research undertaken by Andrzej Kijko, in particular, studies entitled, "Data Driven Probabilistic Seismic Hazard Assessment Procedure for Regions with Uncertain Seismogenic Zones" and "The South African National Seismograph Network", it is observed that moderate to high expected peak ground accelerations (PGA) can be correlated with the presence of mining activities occurring in an area. The Seismic Hazard Map of South Africa (Kijko, 2008) included as Figure 7.2, indicates that the proposed study area comprises peak ground accelerations ranging between 0.12 g and 0.16 g, with a 10% probability of being exceeded in a 50 year period, which may potentially be due to the presence of mining activities in the area.

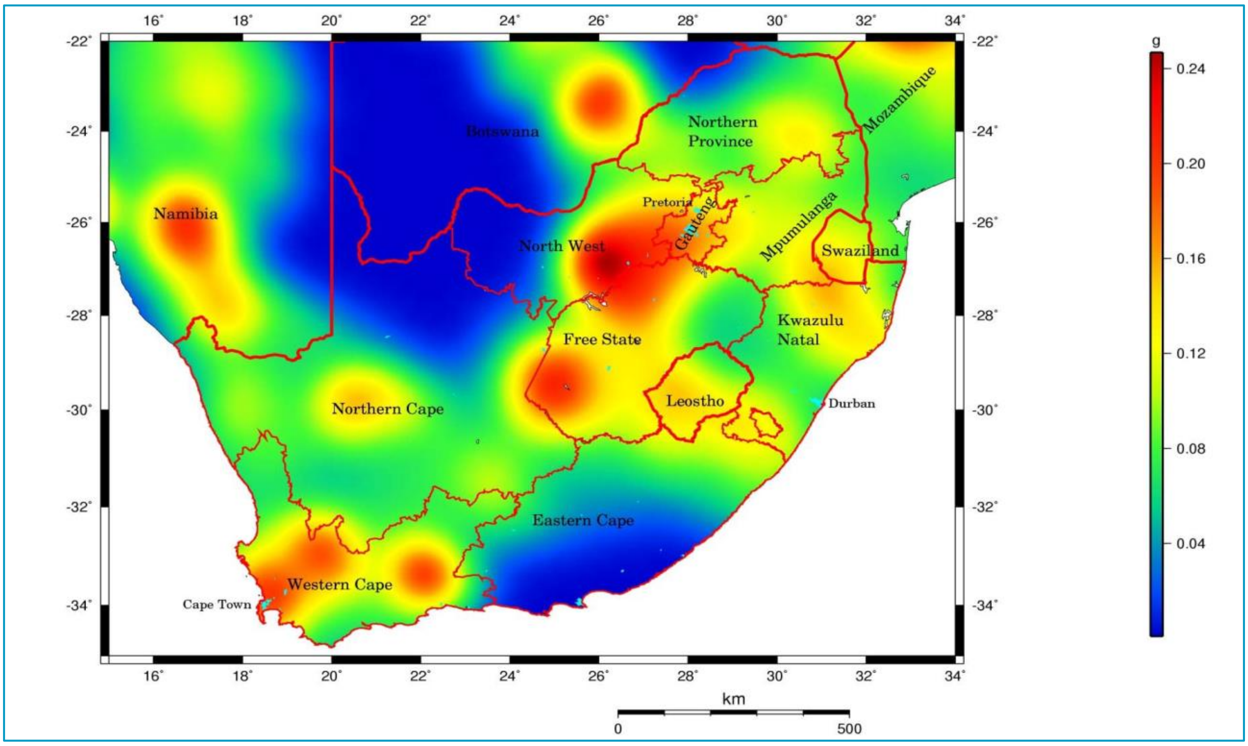


Figure 7.2: Seismic Hazard Map of South Africa – Peak Ground Acceleration (g) with a 10% probability of being exceeded in 50 years (Kijko, 2008).

Mining induced seismicity is the failure of the Earth's crust or rock mass due to changes in rock stress levels. Seismic events range in size from barely discernible ground motions to very large tremors. There are three types of mining induced seismicity:

- Failure at pre-existing geological zones of weakness such as faults, dykes and joints which results in medium to large events often far away from current workings.
- Failure of the intact rock mass in the form of shear fractures that results in larger events close to current workings.
- Localised bursting or failure of brittle rock types often referred to as strain bursting (Van der Walt, 2017).

In addition to the direct damage that may be caused by a seismic event, indirect effects such as the liquefaction of saturated soils and slope failures may also pose a hazard to structures.

8. GEOTECHNICAL APPRAISAL

Based on previous investigations carried out in near proximity to study area as well as Weinert's climatic N-Value, deeply weathered residual soils of a clayey and sandy nature may prevail across the proposed development area.

Competent, founding conditions can be anticipated at depths beyond 3 m from natural ground level and will need to be assessed and verified during the detailed geotechnical investigation. It must be noted that no details pertaining to the foundation design were provided during compilation of this report. At this early stage, consideration can be given to the following foundation types:

Wind Turbines

- Ballasted Foundations (concrete raft) – these foundations are suitable in areas where shallow bedrock conditions are encountered or in poor, non-cohesive soils, where helical or screw-in piles are not suitable. The limitation is that; ballasted foundations require additional design considerations on steep slopes, they are not suited to areas susceptible to settlement and areas underlain by expansiveness soil conditions. Alternatively, consideration may be given to an anchored foundation option, which has the potential to be more cost effective due to decreased excavation and concrete volumes.

- Driven Piles - these piles are suited to clay, gravel and dense sand where shallow groundwater conditions can be anticipated. The advantage is that they can be accurately positioned, no curing is required, and the cost of installation is relatively low (e.g Duktus pile). Deep foundations such as drilled piling/cast in-situ piles can also be considered and will depend on the geotechnical conditions encountered on site.

- Spread Footings – The use of reinforced spread footings designed to resist the uplift and downward pressures. Footings can be dowelled into the bedrock to resist dynamic forces. Deep excavations will be required for the spread footings, excavation side walls will need to be battered back or supported. This should be assessed by the suitably qualified personnel during construction. All earthworks should be undertaken in accordance with SANS 1200 D. Disadvantages of using spread footings are the speed of construction as piles are quicker to install.

It is important to select the correct foundation type with particular attention focused on the dynamic loading of the wind turbine structure. The presence of uplift and downward forces in the form of wind loads must be taken into consideration during foundation design. Consideration must also be given to lateral loads due to overturning moments.

In order to optimize the design of the foundations, a detailed and comprehensive geotechnical investigation is required, which will ideally be undertaken prior to construction and upon finalisation of the site layout plan.

Solar Energy Facility

Photovoltaic structures generally impose light foundation loads on the subsurface materials, although wind loads exert uplift and lateral forces, which must be accounted for in the design.

Depending on the subsurface materials and founding conditions, the following foundation solution can be considered:

- Steel H piles – these are end bearing piles that are driven into the underlying competent rock. The pile is then socketed into the competent rock. Steel H piles can be driven through soil horizons and have previously been used on solar projects in South Africa. This solution is considered when competent bedrock is present at shallow depths and corresponds to the proposed invert level of the foundation.

- Pre-bored Piles – An alternate solution where bedrock is shallow or appears on surface. Pilot holes are percussion drilled in the bedrock to the founding level. Thereafter, piles are socketed into competent, bedrock conditions. The holes are then backfilled with grout or an inert granular material that meets the engineer's specification (G5).

- Driven Cast In-situ Piles – In areas where bedrock is relatively deeper than the invert level, driven cast in-situ piles can be considered. It typically utilises the friction of the pile against the soil to provide lateral and vertical support. This solution can be considered where the subsoils are firm/dense with gravel fragments or ferricrete.

For any of the abovementioned alternatives to be pragmatically viable, it is recommended that the ultimate pull-out loads, vertical and horizontal deflections be assessed by undertaking pull-out testing during a detailed geotechnical investigation. The pull-out tests must be supervised and verified by a competent geotechnical professional at the proposed embedment depths during testing.

Green Hydrogen and Ammonia Facility, Substations and Associated Buildings

It is assumed that the green hydrogen and ammonia facility will comprise various structures such as water reservoirs, compressed hydrogen storage and air separation units, as such, multiple foundation solutions may be required to satisfy the loading requirements of each structure. Consideration can be given to the following foundation types:

- Due to the dynamic loading of the water reservoir, a ring beam foundation would be ideal to support the structure and distribute the loads into the residual soils or weathered bedrock.

- Pad footings, comprising columns and reinforced bases can be considered for founding of the compressed hydrogen tanks and associated buildings relating to the green hydrogen and ammonia facility. The pad footings are required to be keyed into a competent horizon, either weathered bedrock or a pre-treated subgrade comprising good quality material.

- Ancillary structures proposed across the development area, including hardstanding areas for each wind turbine generator, electrical substations, switch-gear buildings and control rooms, are recommended to be founded on an engineered raft foundation solution and depends upon the size and loads of the proposed structures. As it is assumed that these structures will be lightly loaded, subgrade pre-treatment accompanied by addition of water can be implemented to break the bonds between the soil particles. This will entail over-excavating the material to beyond the optimal founding depth, followed by backfilling of the same material in layers compacted to at least 95% of Modified AASHTO maximum dry density at or near to the optimum moisture content. This will result in densification of the subsurface materials and reducing collapse settlement to within acceptable limits. It is also recommended that an impermeable concrete apron be constructed around the perimeter of these structures following construction and that management of surface water be properly implemented. Alternatively, lightly reinforced strip footings can be considered for the proposed substations and associated buildings.

It must be noted that a detailed geotechnical investigation will inform and finalise the recommendations of the most effective foundation solution for all structures and will play a pivotal role in determining the actual founding conditions prevailing across the proposed development area.

Of specific importance to the development of the REC is the excavation conditions prevailing across the site, which will generally impact the preparation and construction of foundations, trenches for buried services and access roads. Based on the geology of the area and the subsequent engineering geological implications mentioned in Sections 4 and 6, the following excavation conditions can be anticipated but will need to be confirmed during a detailed site investigation:

- Topsoil and Colluvium – generally soft excavation.
- Residual and pedocretes – soft to generally intermediate excavation. Can possibly occur as hard excavation if hardpan pedocretes are encountered.
- Weathered bedrock – generally intermediate to hard excavation.

The above excavation conditions have been referenced from SANS 1200 (1986), which is further summarised in Table 8.1.

Table 8.1: Summary of Excavation Conditions (SANS 1200, 1986).

Class of Excavation	Definition
Soft	Material that can be efficiently excavated, without prior ripping by the following equipment: • Bulldozer with a mass of at least 22 tons and an engine developing approximately 145 kW at the flywheel. • A tractor-scraper unit with a mass of at least 28 tons and an engine developing approximately 245 kW at the flywheel, pushed by a bulldozer during loading (35 tons, 220 kW). • Track-type front end loader with a mass of at least 22 tons and an engine developing approximately 140 kW at the flywheel.
Intermediate	Material that can be efficiently ripped by a bulldozer with a mass of at least 35 tons when fitted with a single tine ripper and an engine developing approximately 220 kW at the flywheel.
Hard	Material that cannot be efficiently ripped by a bulldozer equivalent to that described for Intermediate Excavation and requires blasting.
Boulder Class A	Material containing in excess of 40% by volume of boulders between 0.03 m^3 and 20 m^3 in size, in a matrix of softer material or smaller boulders.
Boulder Class B	Materials containing 40% or less by volume of boulders ranging from 0.03 m^3 to 20 m^3 in size, in a matrix of soft material or smaller boulders

9. GEOTECHNICAL IMPACT ASSESSMENT MATRIX

From a preliminary geological and geotechnical assessment, **no fatal flaws** have been identified that will pose a significant constraint to the construction of the Camden I Renewable Energy Facility.

As the geotechnical desk study will be included in just a scoping report, no impact assessment matrix was undertaken. The impact assessment criteria provided is included in **Appendix C**. The potential impacts are listed below:

9.1 IMPACT OF THE PROJECT ON THE GEOLOGICAL ENVIRONMENT

Based on a preliminary assessment, the impact of the development from a geotechnical perspective will be restricted to the possible presence of undermined areas as well as the removal and displacement of soil, boulders and bedrock referred to in this report as "subsoils". The presence of undermined areas will have a negative effect on foundations, resulting in subsidence of the ground and potential collapse of both lightly and heavily loaded structures. As discussed in Section 7 of this report, the likelihood of undermined areas within the proposed development area is low, as the site is predominantly underlain by dolerite. To confirm this assumption, the retrieval of mining plans must be arranged prior to the detailed geotechnical investigation and design. As this information is generally confidential, application by the relevant environmental assessment practitioner will be necessary.

The levelling of areas to create building platforms will also result in the displacement and exposure of subsoils. These impacts will have a negative visual impact on the environment, which in some cases can be remediated. The risk of soil erosion is also increased during construction activities, by the removal of vegetation and by possible disturbance to the natural drainage environment, subsequently leading to the prevention of infiltration of rainwater and increased surface run-off. Areas of concentrated surface flow can be anticipated at the energy facilities, resulting in gradual erosion of unconsolidated soil during the operational life of the facilities. This can result in the creation of preferential drainage features, unless remediated through proper engineering design (i.e., stormwater drainage).

Areas with steep slope inclinations are not favoured for the proposed developments due to the earthworks requirements and the potential need for advanced foundations. The topography of the site is relatively gentle and significant earthworks are not anticipated (although some minor earthworks are anticipated where local undulations occur). The soils and topography render the site moderately susceptible to soil erosion.

The Karoo Supergroup is known for its fossil bearing units which will have to be more accurately assessed by a palaeontologist. The removal of rock which contains these fossils will result in the destruction of these fossils.

Based on the preliminary geotechnical assessment, the site is considered suitable for the proposed development provided that the recommendations presented in this report are adhered to, which needs to be verified by more detailed geotechnical investigations during the detailed design stage.

10. CONCLUSIONS AND RECOMMENDATIONS

The foregoing report presents the findings concluded from a geotechnical desk study undertaken for the proposed Camden I Renewable Energy Complex. The complex consists of the Camden I Wind Energy Facility, Solar Energy Facility, green hydrogen and ammonia facility as well as associated powerlines and grid connections.

In accordance with the 1:250 000 Geological Maps 2628 East Rand and 2630 Mbabane, published by the Council of Geoscience, the study area is underlain by stratigraphic units of the Ecca Group, Karoo Supergroup which is extensively intruded by post-Karoo dolerite. The site is anticipated to be underlain by deep residual soils. It is recommended that the structures, in particular the wind turbines, be constructed on relatively flat to gentle, open areas (0 - 8.7˚ slopes) with maximum wind exposure.

The potential presence of undermined areas at any given location across the study area has been identified as negligible due to the presence of the underlying dolerite stratigraphy. **No fatal flaw** to the proposed development has been identified. It must be noted that the extent or presence of any undermined areas cannot accurately be determined at a desk study level and will require further investigation.

Based on a preliminary geotechnical assessment, the site is considered suitable for the proposed development provided the recommendations highlighted in this report are adhered to.

Conclusions presented in this report will have to be more accurately confirmed during the detailed geotechnical investigation, which is recommended to be undertaken during the detailed design phase of the project. The detailed geotechnical investigation must entail the following:

- Profiling and sampling exploratory test pits to determine founding conditions for the substation, the construction laydown areas, powerline routes and the BESS. An investigation for determining the subgrade conditions for internal roads is also recommended.
- Profiling rotary core boreholes to determine foundation conditions for the wind turbines.
- Geotechnical materials investigation for construction sources – gravel and rock.
- Thermal resistivity and electrical resistivity geophysical testing for electrical design and ground earthing requirements.
- Groundwater sampling of existing boreholes to establish a baseline of the groundwater quality for construction purposes.
- Disturbed and undisturbed sampling to be carried out across the proposed development area for laboratory analysis.

11. REFERENCES

- Brink. A.B.A (1979). Engineering Geology of Southern Africa: The First 2000 Million Years of Geological Time. Volume 1. Building Publications: Pretoria.
- Brink. A.B.A (1981). Engineering Geology of Southern Africa: Rocks of 2000 to 300 Million Years in Age. Volume 2. Building Publications: Pretoria.
- Brink. A.B.A (1983). Engineering Geology of Southern Africa: The Karoo Sequence. Volume 3. Building Publications: Cape Town.
- Climatic Data, Camden. Accessed November 2021 from: https://meteoblue.com/
- Kijko, A. (2007). Data Driven Probablistic Seismic Hazard Assessment Procedure for Regions with Uncertain Seismogenic Zones. Council for Geoscience.
- Mining and seismicity data from the Department of Mineral Resources and Energy's website.
- SANS 1200 (1986). Standardised Specification for Civil Engineering Construction. South African National Standards.
- Saunders, I. Brandt, M. Steyn, J. Robin, D. Kijko, A. (2008). The South African National Seismograph Network. Council of Geoscience, South Africa.
- Project Description and Impact Assessment Methodology for Camden Renewable Energy Complex produced by WSP, dated 14 July 2021.
- Technical report entitled, "Engineering Geological Evaluation Report for the Proposed Ash Disposal Facility, Camden Power Station, Mpumalanga", produced by Africa Exposed Consulting Engineering Geologists, dated July 2011.
- Technical report entitled, "Geological Assessment of the Meerlus Region between Komati and Hendrina, Mpumalanga", produced by WSP Environmental (Pty) Ltd, dated 14 June 2019.
- Technical report entitled, "Geotechnical Desk Study: Proposed Construction of the 132 Kv Boschmanskop – Hendrina/Aberdeen Powerline and Substation", produced by M.J van der Walt Engineering Geologist CC, dated November 2017.

APPENDIX A: SLR CONSULTING PROPOSAL

Project Reference: 720.05085.P0004

File Ref. 2020-03-09_ Enertrag Gotechnical Desk Study

09 March 2021

ENERTRAG SOUTH AFRICA (PTY) LTD

Office Number 9100,
Atrium on 5th, 9th Floor
Sandton

ATTENTION: MICHAEL BARNES

Dear Sir,

PROPOSAL | ENERTRAG GOTECHNICAL DESK STUDY

1. INTRODUCTION

Enertrag South Africa (Pty) Ltd (ESA) is proposing to develop three (3) Renewable Energy Facilities linked to Electrolysers and Ammonia Complexes 10 km west of the town Hendrina and 10 km south of the town Ermelo in the Mpumalanga Province. The proposed projects are known as Hendrina I, Camden I, and Camden II and have a total generating capacity of up to 1 350 MW. Each of the proposed projects will be associated with grid connection infrastructure (i.e., collector substations and power lines, etc.), Battery Energy Storage Systems (BESS) and Electrolyser and Ammonia Complexes.

ESA is seeking an Independent Environmental Assessment Practitioner (EAP) to complete the requisite Environmental Impact Assessments (EIA) and a main proposal is being submitted by SLR Consulting (South Africa) (Pty) Ltd (SLR) to address these requirements. During the discussions between ESA and SLR regarding the scope of work, SLR was requested to submit a separate proposal for a geotechnical desk study of the site. This letter proposal presents the proposed geotechnical scope, programme and cost for the geotechnical desk study. The main EIA proposal includes a significant amount of information regarding SLRs overall capability and experience, and this has mostly been excluded herein to avoid unnecessary repetition.

The proposal includes the following:

- This letter, including Scope of Work.
- CVs of Proposed Staff (Annexure A).
- Experience on Similar Projects (Annexure B).
- The commercial agreement and assumptions linked to the cost estimate (Annexure C).
- The SLR Standard Conditions of Engagement (Annexure D).
- An acceptance form (Annexure E).

SLR is ISO 9001:2015 certified and has quality management systems in place that assure the quality of the service delivered to our clients.

2. PROPOSED SCOPE OF WORK

Relevant information in the public domain will be obtained for each of the three sites, including, but not necessarily restricted to:

- Geological mapping, seismicity mapping and mining information held by the Council of GeoScience.
- Google Earth satellite imagery.
- Mining plans held by the current owners or mining operators of mines within the project areas and/or plans held by the Department of Mineral Resources.

A report will be prepared comprising of the following main sections:

- A summary of the site geological and geotechnical characteristics based on the information obtained for each of the three sites.
- The potential geotechnical hazards identified from review of the information. Particular attention will be paid to the potential stability hazards related to mining operations.
- Potential implications for the geotechnical design and engineering of the sites.
- Recommendations for the further work necessary to characterise the sites and geotechnical hazards to a level necessary for engineering design.

The cost proposal allows for a trip to the site to obtain mining records.

3. PROJECT TEAM

The project team will be comprised of the key people listed in Table 3-1 below.

TABLE 3-1: PROPOSED PROJECT TEAM

Name	*Role, Experience and Skills*
Angus Bracken	**Project Role: Project Manager**
	Angus is a Principal Engineering Geologist with 30 years experience in Geological, Environmental and Geotechnical Engineering applied to mining and civil engineering projects in 27 countries across Africa, Asia and Europe. He has managed numerous geotechnical studies ranging from small housing and commercial properties to large industrial and mining complexes and national linear infrastructure. These projects have involved many geotechnical investigation methods.
Carl Fietze	**Project Role: Project Reviewer and Underground Stability Specialist**
	Carl is a Principal Engineering Geologist with 20 year in geological and geotechnical Engineering in the Mining Industry in Africa. Carl's experience includes a significant number of projects assessing the stability of open cast and underground mines.
Aubrey de Beer	**Project Role: Engineering Geologist**
	Aubrey is an Engineering Geologist for Ground Engineering Division with SLR. He has 16 years of practical experience in Geological and Geotechnical Engineering and applied his trade to mining and civil engineering projects. Aubrey's project experience includes the planning, analysis and design in the geotechnical field.

The core team will be supported by SLR drawing, support and junior engineering staff as necessary.

SLR reserves right to substitute these personnel with equivalent resources, if required. The CV's of the proposed Staff have been included in Annexure A.

General relevant experience of the SLR team has been included in Appendix B.

4. PROGRAMME

It is estimated that three weeks will be required to obtain information from the owners and custodians relevant information. Thereafter the report can be prepared in one week. It is therefore estimated that a desk study report can be delivered within four weeks of appointment.

Commencement of this timeframe is the date on which written acceptance of this proposal is received by SLR.

5. COST ESTIMATE

The cost estimate for the proposed work is summarised in Table 5-1 below. The commercial agreement and assumptions relevant to this cost estimate are included in Annexure C.

TABLE 5-1: DETAIL OF PROFESSIONAL COSTS AND DISBURSEMENTS

Item	Detail	Cost estimate (excl. VAT)
SLR	Professional fees	101 143
	Disbursements	12 936
TOTAL (EXCL. VAT)		**114 079**

Changes to the project scope may result in additional costs not provided for in this proposal.

6. CONDITIONS OF ENGAGEMENT

We have assumed that the work will be carried out in accordance with the SLR Standard Conditions of Engagement – V5.0 and tis has been attached as Appendix D. An acceptance form to this proposal is provided in E.

Should the proposal be accepted, it will form the basis of an agreement between SLR and Enertrag South Africa (Pty) Ltd. The acceptance should be conveyed in writing.

Should you need to discuss any aspect of this proposal further please do not hesitate to contact us.

Kind regards

Angus Bracken
Proposal Manager

Carl Fietze
Reviewer

ANNEXURE A: TEAM CVS

CURRICULUM VITAE

ANGUS BRACKEN

PRINCIPAL ENGINEERING GEOLOGIST

South Africa and Africa

QUALIFICATIONS

MSc	1991	Engineering Geology – Imperial College, London, UK
DIC	1991	Engineering Geology – Imperial College, London, UK
BSc (Hons)	1987	Geology – University of Hull, UK
Professional Registration		SACNASP: 400155/05
		UK Geological Society: 1002069

EXPERTISE

- Geotechnical Investigations
- Earthwork assessment and Design
- Contaminated Land Assessment
- Ground Treatment
- Tailings Disposal Facilities
- Foundation Assessment
- Project Management

Angus offers 30 years of practical experience in Geological, Environmental and Geotechnical Engineering applied to mining and civil engineering projects in 27 countries across Africa, Asia and Europe.

He has managed, or been a team member, in numerous geotechnical ground investigations ranging from small housing and commercial properties to large industrial and mining complexes and linear infrastructure 100's of kilometre in length. These projects have involved many field sampling and testing techniques, laboratory testing methods and data handling methods. He also has extensive experience in the analysis of geotechnical data and its interpretation in relation to ground engineering including; slope stability, foundations and ground treatment.

He has good experience in environmental engineering having been involved in hydrogeological and contamination assessments in Africa and the UK, and environmental impact and management studies in Africa, in addition to involvement in the environmental engineering components of many civil and mining projects.

Angus has significant experience in mining, including the geotechnical assessment, auditing and management of the geotechnical elements of mine surface excavations, tailings disposal facilities, waste dumps and structures. He has also project managed feasibility studies, design and construction projects for new tailings disposal facilities and expansion schemes.

PROJECTS

CIVIL ENGINEERING INFRASTRUCTURE

Darwendale Mine, Great Dyke Investments, Zimbabwe

Project manager for the geotechnical investigation and preliminary foundation design for a mining plant and infrastructure for a proposed new mine.

Fairbreeze Mine, Tronox, South Africa

Geotechnical investigation and construction project manager for a large return water dam. The dam presented particular challenges resulting from very weak and deep foundation soils and the scarcity of good construction materials.

SLR

Eskom Sub Stations, South Africa	Responsible for the desk study, ground investigation and foundation assessment for several large Eskom substations.
Simandou Rail Line, Rio Tinto, Guinea,	Technical Director for a ground investigation for a proposed 700 Km railway line which included a wide range of geotechnical techniques.
Katanga Mine Development, DRC	Responsible for several geotechnical investigations and preliminary geotechnical designs related to the plant foundations and earthworks and the road and power infrastructure for the redevelopment of a mine in Kolwezi
Konkola Copper Mines, Zambia	Responsible for various geotechnical ground investigations and foundation assessments at the mine plant and office complex.
Kwazulu-Natal Low Cost Housing, South Africa	Responsible for the geotechnical foundation and infrastructure inputs for many low cost housing projects in Kwazulu-Natal
Ngezi Mine, Zimbabwe	Responsible for several geotechnical investigations and foundation assessments for the plant and infrastructure.
Khumani Mine, Assmang, South Africa	Responsible for several geotechnical investigations and preliminary geotechnical designs related to the plant foundations and earthworks and also the road and rail infrastructure.
Port of Luanda, Angola	Field project manager for an overwater geotechnical investigation for an expansion of facilities in the harbour
Port of Maputo, Mozambique	Responsible for several geotechnical ground investigations and foundation assessments for new and existing structures at the port over a number of years.
Southern Mauritius Waste Facility, Mauritius	Ground Investigation manager for a new waste facility to service the whole of Mauritius. The study concentrated particularly on the hydrogeological conditions and the potential for the release of contaminated leachate into the ground water.
Niassa Province Bridges, Irish Aid, Mozambique	Responsible for the geotechnical inputs for a condition survey of all bridges in Niassa province.
Union Texas Access Road, Pakistan	Geotechnical investigation project manager for an access road and bridge foundations to accommodate abnormally heavy load oil drilling plant across tidal mud flats in the Ran of Kutch.
Melen Water Transfer Scheme, Turkey	Joint field team leader for a ground investigation along the route of a 200 km water transfer pipeline tunnel, including intermediate reservoirs, pump stations and a tunnel beneath the bosphorus channel. The investigation involved the application of field mapping and a wide range of field and testing techniques in highly variable geological terrain.
Katsina Water Transfer Scheme, Nigeria	Responsible for the route field mapping, ground investigation management and reporting for a 120 km water transfer pipeline with intermediate pumping stations.

London Underground Earth Structures, UK	Involved in various roles over a number of years in the initial geotechnical condition survey of the network, followed by the geotechnical investigation, testing and modelling of high risk cutting and embankment areas and ultimately the design and construction of mitigation measures.
Dumpil Irrigation Scheme, Indonesia	Ground investigation manager for the geotechnical investigation of 70 km of primary irrigation canal, assessments of the cause of recent catastrophic slope failures and the design and implementation of remedial measures.
Invicta Power Station, British Gas, Indonesia	Project manager for the ground investigation and preliminary foundation and excavation assessment for a proposed new power station.
Heathrow Terminal 5, British Airports Authority, UK	Project manager for various geotechnical investigations for the tunnels, structures and pavements.
Felixstowe Port Expansion, UK	Team member for a large wastewater transfer and treatment scheme in southern England, employing a wide range of land and overwater geotechnical field and laboratory testing techniques.
Dover and Folkestone Wastewater Scheme, UK	Team member for a large wastewater transfer and treatment scheme in southern England, employing a wide range of geotechnical field and laboratory testing techniques.
Hinkley Point “C” Nuclear Power Station	Member of field investigation team responsible for drilling and insitu stress measurement.
Mussenden Temple, UK	Detailed cliff face mapping and stability assessment for a coastal cliff beneath an important national monument.
National Rail Cutting, Nr Wakefield, UK	Detailed rock cutting mapping and stability assessment for a 20 m high main line railway cutting.

ENVIRONMENTAL

Maputo Port, Mozambique	Project manager for a soil and ground water contamination study for the whole port area.
Zimasco Smelter, Zimbabwe	Project manager for an Environmental Impact Assessment for proposed new developments at the smelter complex.
Port of Luanda, Angola	Team member responsible for the physical and engineering inputs to an Environmental Impact Assessment for a proposed expansion of the port.
Unki Mine, Zimbabwe	Responsible for geotechnical and engineering inputs for an Environmental Impact Assessment and Environmental Management Plan.
Total Zimbabwe	Team member for contamination assessments of fuel storage and dispensing stations in Zimbabwe.
Various Industrial Installations, Harare	Conducted a number of contamination risk assessments for industrial facilities in an around Harare, following implementation of new national contamination control legislation.

London Waste Regulation Authority	Team member responsible for many contamination audits in the London area as part of a term contract held by Mott MacDonald.
Niassa Reserve, Mozambique	Responsible for the physical and engineering inputs into an EIA for a proposed development of road infrastructure in the Niassa Reserve.
MINE WASTE DUMPS AND TAILINGS FACILITIES	
Mareesburg Tailings Dam, Anglo American Platinum	Project Director for the detailed design, pre-commissioning works construction and commissioning.
Helena Tailings Dam, Anglo American Platinum, South Africa	Reported tailings dam failures elsewhere in the world raised Anglo American's concerns regarding the stability of their own facilities. Following a review of all facilities, Helena was identified as the highest risk worldwide. A detailed ground investigation, instrumentation and remodelling exercise was carried out for the facility, focusing particularly on the liquefaction risks, ultimately culminating in the design and construction of a rock buttress. I was the project manager for the investigation, studies and mitigation works.
Fairbreeze Mine, Tronox, South Africa	Consultant project manager responsible for technical advice during the latter stages of construction and subsequently the commissioning and operation of the tailings facility.
Ngezi Mine, Zimplats, Zimbabwe	Responsible for the ground investigation and foundation assessment of the tailings facility.
Modikwa Platinum Mine, South Africa	Responsible for carrying out geotechnical safety audits and a review of the stability of the tailings facility.
ZCCM Tailings and Waste Dumps, Zambia	Team member for responsible for all geotechnical inputs for a condition survey and design of additional closure measures for all tailings disposal facilities and waste dumps managed by the national ZCCM in the Zambian Copper Belt. Subsequently responsible for reassessing certain facilities in more detail.
Katanga Mining Area, Kolwezi, DRC	Responsible for a number of geotechnical investigations, audits, feasibility studies and other development studies for a number of tailings dams in the Kolwezi area over several years.
Harmony, South Africa	Responsible for the tailings disposal portion of an overall audit for all Harmony mines in South Africa.
Pan African Resources, South Africa	Responsible for the tailings disposal portion of an overall audit for all Pan African Resources mines in South Africa.
Freda Rebecca Mine, Zimbabwe	Responsible for a geotechnical safety audit and assessment of the stability of the tailings facility.
Bindura Mine, Zimbabwe	Responsible for a geotechnical safety audit and assessment of the stability of the tailings facility.

Arcturus Mine, Zimbabwe	Responsible for a geotechnical safety audit and assessment of the stability of the tailings facility.
Blanket Mine, Zimbabwe	Responsible for a geotechnical safety audit and assessment of the stability of the tailings facility.
Zimbabwe Phosphates, Zimbabwe	Project manager for the geotechnical investigation, design and construction of a new tailings disposal facility and the geotechnical safety management of the pre-existing facility.
Molo Mine, Madagascar	Project manager for the geotechnical investigations and feasibility design for a new tailings disposal facility.
Darwendale Mine, Great Dyke Investments, Zimbabwe	Project manager for the geotechnical investigations and feasibility design for a new tailings disposal facility.

MINING

TI04 Mineral Sand Mining Project, Rio Tinto, Madagascar	Geotechnical investigation project manager for the mine development. A ground investigation was carried out to assess the excavatability of the sands and stability of excavation and dump faces for the dredging and dry mining operations. The investigation involved a comprehensive campaign using different drilling and sampling techniques, piezocone and laboratory testing. The project was unusual as the sands were weakly cemented with a biological cement.
Richards Bay Minerals, South Africa	Various audits and assessments of the geotechnical stability of the sand mining excavations and backfilling activities at Richard Bay.
Moma Mineral Sands Mine, Kenmare, Mozambique	Responsible for regular safety audits of all geotechnical facilities and management systems at the mine, including tailings and waste dumps, dry mining and rapidly moving dredge mining excavations.
Eiffel Flats, Zimbabwe	Responsible for a stability study of all historic underground mining cavities owned by Rio Tinto in the Eiffel Flats area of Zimbabwe, to ultimately identify the risk of surface subsidence.
Ngezi Mine, Zimbabwe,	Mapping, data collection and rock slope stability assessment for the trial mining excavation as part of the mine development design
Shurugwi Mines, Zimbabwe	Responsible for all geotechnical and environmental inputs into a closure study for historic mines around Shurugwi.

MEMBERSHIPS & REGISTRATIONS

Geological Society of London	Fellow and Chartered Geologist
South African Council for Natural Scientific Professions	Registered Professional Natural Scientist (Earth Sciences)

South African Institute for Engineering and Environmental Geologists	Member

CURRICULUM VITAE

AUBREY DE BEER

SENIOR ENGINEERING GEOLOGIST

Geotechnical Engineering, South Africa

QUALIFICATIONS

BSc Bachelors	2002	BSc Earth Science (Geology), University of Pretoria, 2002
BSc (Hons)	2003	BSc (Hons) Environmental and Engineering Geology, 2003

EXPERTISE

- Geotechnical Investigations
- Dolomite Stability Investigations
- Slope Stability Analysis
- Kinematic Analysis
- Rock Mass Assessment
- Foundation Investigations
- Aerial Photography Interpretation
- Borrow Pit Investigations
- Township Establishment
- Pipeline Investigations

Aubrey is an Associate Engineering Geologist for Ground Engineering Division with SLR. He has 16 years of practical experience in Geological and Geotechnical Engineering and applied his trade to mining and civil engineering projects.
Aubrey's project experience includes the planning, analysis and design in the geotechnical field and have vast experience with regards to site supervision for rotary / percussion drilling, test pitting within the civil and mining infrastructure projects.
His capabilities range within the geotechnical and geological environments which includes foundations; open pit slope design, tailings/ash dams; waste rock dump designs; dolomite stability investigations; borrow pit investigations and township establishments.
Investigation techniques include, geotechnical face mapping, aerial photography interpretation, laboratory test analysis, modelling slope stability and carry out kinematic analysis (Stereo nets) for rock mass assessment.

PROJECTS

Contractor/Freelancing (2004)	Carry out fieldwork and sampling for various small contractors. The fieldwork entailed, test pitting, rotary core logging, percussion chip logging. The work also entailed compiling factual report.
CCIC Exploration core logger, Rustenburg	Work for 6 months for CCIC Exploration firm logging core and supervision drilling rig for 6 months in Rustenburg. CCIC was contracted by Anglo-Platinum.
Stone Ridge – MNT development (2005)	Dolomite Stability Investigation for township establishment in Monavoni, Centurion.
Waterval Mine – Anglo Platinum (2005)	Carried out drilling supervision and geotechnical core logging and data capturing for Waterval Mine
Eco Park – Highveld (2004 to 2006)	Preliminary geotechnical investigation for shallow geotechnical investigation on Eco Park Township. Work entailed test pitting and geotechnical sampling.

Orange Farm Township – (2006)	Test pitting and geotechnical founding investigation for township establishment.
Nova Vida – (2006)	Feasibility study which entailed test pitting and geotechnical founding investigation for township establishment in Luanda, Angola.
Ambatovi Nickle and Cobalt Project (2006)	Carried out drilling supervision and geotechnical core logging with SPT testing for ore refinery plant and port expansion
Murray Hill Defence (2006 to 2007)	Preliminary and detailed foundation investigation for a training facility for the military defence force. The investigation entailed, test pitting and auger drilling. Geotechnical sampling and permeability tests for a French drain.
Thaba Thala Estate (2006 to 2007)	Dolomite Stability Investigation for township establishment in Doornrandjies, Centurion.
Moreletta Fall-out sewer (2007)	Detailed geotechnical investigation for the phase 2 fall-out sewer pipeline next to the Moreleta Spruit in Pretoria. Work entailed test pitting with TLB and 20 ton excavator and rotary core drilling.
Cedar Fall Estate (2007)	Preliminary geotechnical investigation for township establishment in Modimolli. Work entailed test pitting and geotechnical sampling.
Serengeti Wildlife and Golf Estate (2007)	Design level geotechnical investigation for township establishment at Serengeti Golf Estate, Kempton Park.
Sonlandpark – Africon (2007)	Dolomite Stability Investigation for township establishment in Sonlandpark, Vereeniging.
Soyo Kwanda Base, Angola (2007)	Preliminary geotechnical investigation for the docking station at Soyo Kwanda seaport base.
Dilokong Substation – Eskom (2007)	Preliminary geotechnical investigations for a substation at Dilokong Mpumalanga. Work entailed, test pitting and analysis of geophysical electrical resistivity data.
Spitskop Substation – Eskom (2007)	Preliminary geotechnical investigations for a substation at Spitskop. Work entailed, test pitting and analysis of geophysical electrical resistivity data.
Kashamane Border Post – (2007)	Preliminary geotechnical investigations for upgrading the existing border post between Namibia and Angola. Work entailed, test pitting, DCP testing and soil sampling.
Melmoth Substation – (2007)	Site selection investigation for sub-station in Melmoth, Kwa-Zulu Natal. Investigation entailed desk top study, test pitting and soil sampling over 3 sites.
Prairirie-B Substation – Eskom (2008)	Preliminary geotechnical investigations for a substation at Machadodorp, Mpumalanga. Work entailed, test pitting and analysis of geophysical electrical resistivity data.
Footbridges, Metrorail (2008)	Detailed geotechnical investigations for two pedestrian bridges at Wonderboom and Atteridgeville Metrorail stations. Investigation entailed test pitting, DCP testing and soil sampling.

GleWap Pipeline, Tzaneen (2008)	Detailed geotechnical investigations for a 30km bulk water pipeline in Tzaneen. Work entailed test pitting and soil sampling and to identify potential bedding material for pipeline.
Diversion of Sasol Pipeline, Olifantsfontein (2008)	Preliminary geotechnical investigation which entailed identifying suitable route to diverge the main Sasol gas pipeline to avoid main residential areas in Tembisa and Olifantsfontein.
Mmamabula Power and Coal Project – CIC Energy (2006 to 2009)	Carried out the Bankable Feasibility and detailed geotechnical investigation for the Mmamabula Power and Coal Project, which included rotary core drilling, SPT testing, geophysics and collection of soil and rock samples. Also provided review on the collected geotechnical data, in order to provided geotechnical design parameters for foundation design.
Mafutha Coal Boxcut design - SASOL (2009)	Carried out drilling supervision and geotechnical core logging which included core orientation in order to determine potential kinematic instabilities. A rock mass assessment was carried out using RMR and MRMR to assess rock mass properties. Slope stability analysis was carried out to determine safe slopes for the box cut.
Overvaal Tunnel Investigation - Transnet (2009)	The investigation entailed joint mapping, rotary core logging including core orientation, rock mass analysis (Q-Value and RMR) and determining preliminary support for the tunnel. The investigation also focused on determining potential rapid weathering dolerite zones intersecting the tunnel.
Kappa Substation - Eskom (2009)	Site selection investigation for sub-station in Ceres, Western Cape. Investigation entailed desk top study, test pitting and soil sampling over 3 sites. It included a borrow pit investigation.
Medupi Power Station – ESKOM (2009)	Determined the rock mass stiffness through joint mapping and rock mass assessment (RMR, Q-Value and Hoek & Brown criteria) for both chimneys at Medupi, crane foundations and 10 k silos at Medupi Power Station.
Impumelelo Mine - SASOL Mining (2009 to 2010)	Slope stability for the box cut and rock mass assessment for the incline shaft and ventilation shafts, this entailed rotary core logging, core orientation and test pitting. The rock mass assessment entailed Q and RMR and MRMR. Also included foundation investigation for general mining infrastructure and 20 to 30km conveyor belt. Potential borrow material was located through Aerial photography investigation and test pitting.
Clay Liner – Sappi Enstra (2010)	Geotechnical investigation to locate material which will be suitable for clay liner requirements.
Smutsoog Decant – Tselentis Mine (2010)	Geotechnical investigation for a cut-off drains to divert decant pollution from a rehabilitated mine to a pollution control dam.
Spitskop Decant – AngloCoal Mine (2010)	Geotechnical investigation for a cut-off drains to divert decant pollution from a rehabilitated mine to a pollution control dam.
Isobonelo Mine – AngloCoal (2010)	Geotechnical investigation for a water diversion canal and haul road for coal mine in Secunda. Evolved test pitting, DCP testing and geotechnical sampling.
Optimum mine river diversion – Anglo Coal (2010)	Optimum mine river diversion over area that reached 11m deep. Entailed test pitting and rotary core logging. Rock mass assessment was conducted by determining the RMR and MRMR form the rotary core boreholes.
Unifoods – (2010)	Auger drilling investigation for piling design. Investigation entailed soil profiling and sampling

Kangra Coal Audit (2010 to 2011)	The investigation started with a preliminary site selection investigation which entailed aerial photography interpretation and site walk over study. This was followed by Kangra Coal Audit Investigation entailed orientation core logging and logging of rotary core boreholes. Rock mass assessment by means of RMR, MRMR and Q for the proposed inclined shaft and box cut.
API Zonnebloem – AngloCoal (2011)	Aerial Photography Interpretation and walkover study for a proposed conveyer belt to Zonnebloem Coal mine in Middelburg.
IDC Iron and Steel – Middelburg (2011)	Aerial Photography Interpretation for a site selection on 3 sites for a process plant of Iron and Steel in Middelburg.
Kumba Iron Ore (2012)	Geotechnical investigation for a proposed concentrator and slimes dam. The investigation entailed, test pitting and core logging.
CEENEX WWTW Pipeline – (2012)	58km bulk water pipeline to supply water to a new proposed independent mine near Medupi Power Plant, Lephalale.
Global Metals (2012)	Deep clean water canal diversion for a proposed Naobian mine which entailed logging of the rotary core boreholes. Rock mass assessment was determined through joint mapping and determining the RMR and Q.
Rooipoort Mine– De Beers (2012)	Slope stability assessment for alluvial diggings at Rooipoort which entailed sampling of soil samples for triaxial tests and soil profiling of the existing open cuts.
Kuyasa IPP– Kuyasa Mining (2012 to 2014)	A geotechnical foundation investigation which stretched from feasibility to detailed design investigation for a proposed independent power plant near Delmas. The investigation involved drilling, test pitting, packer testing, SPT testing. Investigation was done for both power plant and ash dam facility. Potential Borrow sources were identified through aerial photography interpretation and test pitting. A preliminary geotechnical investigation was conducted for a 30km bulk water pipeline to supply the power plant with water. The investigation entailed hand auger, DCP testing and soil sampling.
Cut-off drain – Delmas Coal (2010)	Geotechnical investigation for a cut-off drains to divert pollution from a dilapidated coal discard dump a pollution control dam.
SASOL Mining (2013)	Rock slope stability investigation which entailed face mapping and stereo plotting and analysis of different kinematic failure mechanisms.
Bevcan Springs - Arup (2013)	Dolomite Stability Investigation for the expansion of the existing processing plant in Springs. The investigation included to setting up of a Dolomite Risk Management Strategy for the Plant.
J&W Doornkloof - J&W Properties (2013)	Dolomite Stability Investigation for the new office building of J&W in Doornkloof, Centurion. The investigation included to setting up of a Dolomite Risk Management Strategy for the Plant.
Fine Ash Dam 6 – SASOL Secunda (2013 to 2016)	Foundation and geotechnical investigation for the proposed FAD 6 ash dam at SASOL 2 and 3 plants. The investigation entailed test pitting, sampling for clay liner requirements, estimating strength parameters. I was involved with a group who assessed the potential hazard of the undermined areas which may cause failure. The quantity and quality of G7 dolerite for the starter wall and as wearing course for maintenance roads.

SLR

Shondoni Conveyor - SASOL Mining (2014)	Third party geotechnical study for a claim by contractor which entailed the inspection of the founding condition along the conveyor and to determine if appropriate G7 material was used as specified in the design specification.
Extension of the Slurry Facility at Lanxess Newcastle – (2014)	Geotechnical investigation for the extension of existing slurry facility at Lanxess. The investigation entailed the review of the founding conditions, potential uses of the in-situ material in regards to impermeable to semi-impermeable material. To create a geological model of the underlying geology.
Pollution Control Dams: Venetia Mine – De Beers – (2014)	Geotechnical investigation for 4 proposed pollution control dams located within Venetia Mine, Limpopo.
SANS 1936:2012 Part 1 and Part 2 review (2014 to 2017)	Part of a panel who reviewed the published SANS document by SABS called SANS1936:2012 Development on Dolomite Land. Our overview entailed only the overview for Part 1: General principles and requirements and Part 2: Geotechnical Investigation and determination. The review entailed redefining and rewording of the dolomite classifications defined in the code and to drive potential research topics which will be required to understand dolomite instabilities.
Temane Well Pads - SASOL Mozambique (2015)	Site Manager in Temane – Mozambique for Sasol. Overseeing the rotary core drilling for Wellpads and the Geophysical Survey. The investigation entailed founding solutions for all relevant infrastructures. The scope also included the assessment for potential sinkhole development at each well pad.
Rietspruit Coal Mine Rehabilitation - (2015)	Borrow pit investigation for topsoil and capping material to be used over an existing coal discard dump and cover material backfilled back into the open pit.
Majuba Ash Dam extension – Eskom (2015)	Geotechnical investigation for the extension of the existing fine ash dam facility at Majuba power plant. The investigation entailed test pitting and testing of soil sample for suitable material for liner requirements.
Target Gold Tailing Facility - Welkom (2015 - 2016)	Overview of the existing overburden that exist at TGF at Welkom. The investigation entailed test pitting and sampling to determine the stability of the existing material. Assisted in analysing the XRD and XRF test conducted from drilling investigations.
Inhassoro Pipeline - SASOL Mozambique (2015 to 2016)	The geotechnical assessment of one major river crossing (Govuro River) and Land Fall crossing (Beach North of Inhassoro) for a major gas and oil pipeline.
Wilfordon Ext. 7 - DMR Development (2016)	Undermining Study in Johannesburg to apply for reduction of the 100m buffer zone to 10m buffer zone in Roodepoort, Wilfordon Ext 7.
Roy Point Rehabilitation – South 32 (2016)	Geotechnical investigation to assist in managing groundwater pollution of a closed underground coal mine in Newcastle. The investigation entailed founding solutions for a pump station, suitable material for liner requirements, diversion canals and to find a suitable source for rip-rap material.

Salamanca Desktop Study – (2016)	Desktop study and google earth interpretation for a proposed urainuim mine in Salamanca Spain.
Overland Conveyor Obotan Gold Mine – DRM Consulting (2016)	Preliminary geotechnical investigation for a proposed 15km conveyor belt which linked two gold mines in Ghana. The investigation entailed, test pitting with a 20 ton excavator, TLB and had dug excavation. Special founding solutions had to be considered over areas where illegal mining (Galamseys) had severely impacted the soil stability across the route.
D4 Dolomite Review for Olifantsfontein Fire station – AVC Consulting (2016)	The study entailed the review of dolomite stability report by a previous consultant and if it adhered to the SANS1936 code. The review panel had to review the proposed founding designs which entailed piling. We had to either approve the founding designs or improve or consider alternative founding solutions.
Agitator Tank Subsidence due to Dolomite Ground– Flexilube (2017)	A detailed geotechnical assessment was conducted to determine the subsidence occurring on 2 Agitator Tanks in Meyorton, Gauteng. The area is located on dolomite ground. My involvement was to define the geological model of the site and possible mechanisms which caused the subsidence.
Rail settlement at Delmas Coal Mine (2017)	Geotechnical assessment of the continuous settlement over 1km of railway track that enters Delmas Coal mine. The investigation entailed an undermining study, continuous survey and test pitting.
Dust netting Wall and Conveyor – Sigma Coal - SASOL (2017)	Geotechnical foundation investigation for a conveyor and dust netting wall at Sigma Coal, Sasolburg. The investigation entailed, test pitting and rotary core drilling, soil sampling and recommendations on piling foundations.
Rail settlement at Delmas Coal Mine (2017)	Geotechnical assessment of the continuous settlement over 1km of railway track that enters Delmas Coal mine. The investigation entailed an undermining study, continuous survey and test pitting.
Dust netting Wall and Conveyor – Sigma Coal - SASOL (2017)	Geotechnical foundation investigation for a conveyor and dust netting wall at Sigma Coal, Sasolburg. The investigation entailed, test pitting and rotary core drilling, soil sampling and recommendations on piling foundations.
Siguiri Power Plant (2017)	Geotechnical foundation investigation for the extension of the existing power plant at Siguiri Gold Mine in Guinea. The investigation entailed test pitting and rotary core drilling.
D4 Dolomite Review for Carletonville Police Station – (2017)	The dolomite study determined that the police station at Carletonville is located on a D4 dolomite designation. The study entailed to create a review panel to review the proposed founding designs which entailed piling. We had to either approve the proposed founding designs or improve or consider alternative any alternative founding solutions.
Medupi Ash Dam Facility – Eskom (2017)	Borrow pit investigation to find suitable hillwash sands which could be mixed with bentonite for liner requirements.
Swallets in Gamagara River - Shisen Mine (2017)	Review on Sinkhole development in the Gamagara River, South of Shisen Mine, Northern Cape. It also entailed researching any similar situation in the world and how they mitigate the problem.

Grootegeluk bulk material handling process (2017)	Feasibility investigation for proposed overland conveyor to transport mass overburden material from the open pit to back of the mine for rehabilitation process off the mine. The investigation entailed test pitting with a 20 ton excavator, desk study, walk over study and DCP testing.
Kanshansi Copper Mine, Zambia. (2018)	Conducted Orientation Core logging at Kansanshi mine for the extension of the existing open pit Coppermine in Zambia. Also conducted training for geotechnical engineers at the mine to log core and soil profile.
Isanti, Coca-Cola Bottle Process plant, Vereeniging Geotechnical Investigation (2018)	Foundation geotechnical investigation for a propose glass process plant in Vereeniging. The work entailed test pitting, geotechnical drilling, DPSH Testing and laboratory analysis. A report was issued to the client with the analysis and founding recommendations.
Isanti, Coca-Cola Bottle Process plant, Vereeniging Dolomite Stability Investigation (2018)	Assess the risk for sinkhole formation for the proposed glass process plant in Vereeniging. The work was conducted in accordance to the SANS 1936 code Part 1 to Part 3.
Globeleq – GetFit Solar Plant, Zambia, Mazambuka (2018)	Investigation for a photovoltaic solar power plant in Zambia which forms part of a tender bid towards the government initiate called Get-Fit. The investigation entailed test pitting and laboratory testing.
Globeleq – GetFit Solar Plant, Zambia, Kafue (2018)	Investigation for a photovoltaic solar power plant in Zambia which forms part of a tender bid towards the government initiate called Get-Fit. The investigation entailed test pitting and laboratory testing.
Globeleq – GetFit Solar Plant, Zambia, Chibombo (2018)	Desk top study and a walkover study for a tender which forms part of the Get-Fit initiate to construct numerous photovoltaic solar power plant in Zambia.
Engie Solar– GetFit Solar Chibaye Solar Plant	Investigation for a photovoltaic solar power plant in Zambia which forms part of a tender bid towards the government initiate called Get-Fit. The investigation entailed test pitting and laboratory testing.
Malingunde Graphite Mine, Malawi. Geotechnical Investigation (2018 – 2019)	Geotechnical investigation for the proposed tailings facility at Malingunde in Malawi. The work entailed core logging and laboratory testing. Final report were issued to the client with complete analysis and recommendations.
Doornpoort Penstock settlement assessment (2018)	Settlement calculation was conducted for the 30m high penstock at the new tailings' facility near Fochville. The mine is Twin Shaft owned by Deep South Mining
Royal Sheeba, Barberton (2019)	Geotechnical investigation for the proposed tailings facility and river diversion for Barberton Mining. The project was cancelled midway.
Rappa-Holdings Sinkhole assessment (2019)	Assessment for the formation of sinkholes along a water tunnel within the Rappa-Holdings in Boksburg. The investigation entailed the analysis of Ground Penetration Radar and Electrical Resistivity. The work also entailed a site walkover.

Bramber Expansion of the TSF, Barberton Mining (2019)	Geotechnical investigation for the expansion of the existing tailings storage facility at Bramber TSF, Barberton Mining. The work entailed test pitting and laboratory testing. A final report was issued to the client with full analysis and recommendation
Doornpoort Slickensided Geotechnical Investigation (2019 – 2020)	Deep South Mining is concern of the stability of the Tailings Storage Facility at Doornpoort since the tailings dam traverses over Slickensided clays and residual andesite which has relict joints which is closely spaced. The investigation entailed test pitting and sampling of undisturbed sampling. The laboratory testing entails direct shear and triaxial testing with 4 specimen loads. Detailed analysis of laboratory testing and modelling of the material stability.
Akyem Goldmine, TSF Expansion, Large Strain Calculation (2019 to 2020)	Conducting a large strain calculation for the foundation of the tailing's storage facility with the new lift expansion of the tailings dam at Akyem Gold Mine in Ghana.

MEMBERSHIPS

SACNASP (4000566/08)	South African Council for Natural Scientific Professions
SAIEG (09/247)	The South African Institute for Engineering and Environmental Geologist

CURRICULUM VITAE

CARL FIETZE

TECHNICAL DIRECTOR – GEOTECHNICAL ENGINEERING

Ground Engineering, South Africa and Africa

QUALIFICATIONS

BSc (Hons)	1998	BSc (Hons) Engineering Geology – University of Natal
GDE	2007	Gradate Diploma Engineering Mining Engineering – University of Witwatersrand

EXPERTISE

- Geotechnical Engineering
- Geotechnical Modelling
- Geotechnical Investigations
- Tailings Dam Geotechnical Investigations
- Rock Mechanics
- Waste Rock Dump Designs
- Foundation Engineering

Carl is Technical Discipline Leader for Ground Engineering with SLR and has 20 years of practical experience in Geological and Geotechnical Engineering, applied to mining and civil engineering projects. Carl has managed and carried out design work on large open pit projects in gold, manganese, copper, iron ore, coal and uranium including the Moatize Coal Project for VALE, the Simandou Iron Ore Project for Rio Tinto, Husab Uranium Project for Swakop Uranium and the Kansanshi Copper Project for FQM. Carl has carried out extensive slope design work on saprolite slopes in Central, East and West Africa. He has also carried out extensive geotechnical underground work in South Africa, Botswana, Zambia, and the DRC, including the evaluation of the geotechnical aspects for sub-level opening stoping, sub-level caving, bord and pillar mining methods. Carl has also carried out several crown pillar designs using empirical and numerical modelling techniques.

Carl has carried out extensive geotechnical investigations for civil engineering projects across Africa, such as the Ewaso Nigero Hydro-Electrical Scheme in Kenya, the Sonangol Lebito offshore and onshore refinery project in Angola and the expansion of the Conakry port for the Simandou Iron Ore Project.

Carl has carried out numerous geotechnical investigations for Tailings Storage Facility (TSF) across Africa including the assessment of foundation conditions for starter walls, penstocks, and upstream/downstream raises. He has developed geotechnical models to assess consolidation of the foundations and for the structural integrity of the tailings structure.

PROJECTS

ROCK ENGINEERING

Bilboes Gold Project, Zimbabwe	SLR was appointed to carry out a BFS Study for the design of the open pit slopes. The investigation included Drilling, Geophysics and Packer Testing.
Sentinel Mine Crusher Support Design FQM, Zambia	SLR was appointed to carry out a support design for the in-pit crusher pocket. The design was complicated by a ubiquitous foliation which necessitated the design of a composite support system.

SLR

Vale Moatize Section 6 Underground Study	Vale was exploring the option of mining through a block of ground which was mined historically using bord and pillar mining methods. SLR's geotechnical team were requested to provided operating procedures for methods to rehabilitate the underground workings and sinkholes/subsidence
Vale Section 4, 5 and 6 Open Pit Design and Geomechanical Development	Carried out detailed design of the pits mine slopes for Mine Sections 4, 5 and 6, including detailed risk assessment and development of a geomechanical model in Vulcan.
Mutoshi Copper Study	SLR was appointed to carry out a technical study for the design of the pit slopes. The project was challenging due to an existing pit which was flooded. SLR geotechnical team provided recommendations on how to either mine to the boundary of the existing pit or to mine through and form one super pit.
Bushveld Minerals Open Pit design	Carried out a pre-feasibility design for the proposed open pit slopes using drilling, geophysics and laboratory test work.
Bushveld Minerals Open Pit design	Carried out a pre-feasibility design for the proposed open pit
Section 1 to 6, VALE, Moatize	Carried out a review of the intact rock properties and developed a database of the properties for the various lithology's which would be encountered in during mining
Triton Graphite Project; Balama North, Mozambique	Carried out the pre-feasibility design for the open pit slopes, including coupled analysis with the incorporation of pore pressures along defined failure surfaces
Peak Resources, Ngualla Rare Earth Project, Tanzania	Carried the bankable feasibility pit slope design for project. Challenges included a thick saprolite horizon and the carbonite geological terrain
Lubembe Mine Ukwazi/Meterox, Democratic Republic of Congo	Carried out a geotechnical evaluation of the proposed sub-level caving mining including subsidence evaluation and the core geotechnical risks associated with the mining method
Vale Moatize River Diversion	Carried out a geotechnical investigation and excavatibility assessment for the proposed Moatize River Diversion
African Copper Botswana	Carried out a geotechnical evaluation of the proposed sub-level open stoping and sub-level caving mining method and the evaluation of core geotechnical risks
Konkola North, Teal Exploration Zambia	Detailed assessment of the geotechnics of the underground mine, which included geotechnical input parameters for sublevel open stoping and pillar design.
Simandou Iron Ore Project, Rio Tinto, Guinea	Project managed and Technical Manager for the design of the open pit slopes, haul roads and waste rock dumps for the Simandou Iron Ore Project
Nkomati Joint Venture South Africa	Carried out an open pit investigation of the overburden slopes for the existing Pit 3. Results of the analysis indicated that significant optimization of the slopes could be achieved which would lead to a significant decrease in stripping and waste generation.

Panada Hill, Tanzania	Carried out a detailed geotechnical investigation for the proposed Thickened Tailings Dam
Reptile Namibia - Iron Ore Namibia	Carried out a geotechnical audit for the design of the proposed open pit.
Debswana Diamond Mines, Debswana Botswana	Involved in the Strategic Planning for generating and monitoring the Mines plan for mine water control and the assessment of pore pressure distribution within Debswana's Pit Slopes.
GrootBoom Open Pit, South Africa	Bankable Feasibility level analysis on bench face, inter-ramp and overall slope angles for the purposes of pit optimisation to a final depth of 120 metres.
Sedibelo Platinum Project, Barrick Mining South Africa	Detailed Rock Engineering Design for the two proposed decline portal which included an assessment of the permanent side wall angles and kinematics analyses to a Factor of Safety of 2.0
Lumwana Mine Zambia	Operational geotechnical study carried out to assess condition of the rock mass and discontinuities for open pit design, including project management of the pit geotechnical investigation.
Husab Project - Swakop Uranium Namibia	Review manager on the Level 4 Open Investigation for the Husab Project.
Sedibelo Platinum Project, Barrick Mining South Africa	Detailed review and analysis of orientated core procedures and data analysis for Planar, Wedge, Toppling and Step Path Failure for the proposed pit slope geometry.
Kansanshi Mining, FQM Zambia	Involved in the management of the geotechnical aspects of the current open pit (final depth 400 metres), which includes training of site geologists on geotechnical data collection and review of pit slopes from data collected (Bench Face geometry, Inter-ramp and Overall Slopes).
South Kriel Decline Shaft, Anglo Coal South Africa	Detailed Rock Engineering Investigation for the proposed decline portal which included an assessment of the permanent side wall angles and kinematics analyses to a Factor of Safety of 1.5
Bushmen-Copper Project, SNC Lavalin Botswana	Detailed Rock Engineering Investigation for the proposed open pit, which included an assessment of the pit angles, both overall, inter-ramp and bench face angles.
Diamond Mine Botswana	Desk study assessment of the potential for rapid weathering of a prominent argillaceous horizon and the its impact on the stability of the pit slopes and measures to offset negative impacts
Scorpion Zinc Project, Anglo American Namibia	Rock Engineering Investigation for the open pit, which included detailed rock mass rating of the rock mass, utilizing both the RMR and Q-system.
Buzwagi Gold Project, Barrick Tanzania	Rock Engineering Investigation for the open pit, which included detailed geomechanical core logging, structural data collection and the evaluation of the permeability of the rock mass.

Frontier Copper Mine, FQM Democratic Republic of Congo	Involved in the management of the geotechnical aspects of the current open pit (final depth 400 metres), which includes training of site geologists on geotechnical data collection and review of pit slopes from data collected (Bench Face geometry, Inter-ramp and Overall Slopes).
Deziwa Copper Project, AMC Democratic Republic of Congo	Scoping, Pre-feasibility and Bankable Feasibility level analysis on overall slope angles for the purposes of pit optimisation to a final depth of 400 metres.
Legadembi North Pit, Midroc, Ethiopia	Back analysis was carried out on a progressive inter-ramp toppling failure using a finite-discrete element approach to assess the stability of the North Pit Hanging wall. The analysis was supported by field observations and a finite-discrete hybrid software package used to replicate the failure mode and progression accurately. Recommendations were made on suitable remedial action required to mitigate the effects of the progressive failure which included slope unloading, re-profiling and the installation of slope support.
Mkushi Mine, Seringa Mining Limited, Zambia	Detailed Rock Engineering investigation and Project Management for the design of the proposed open pit slopes to a final depth of 150 metres, which included a hydro-geological investigation, core orientation and rock mass assessment. Detailed reporting on results of the analysis and preparation of slope design charts at pre-feasibility and feasibility level.

TAILINGS AND WASTE ROCK DUMPS

Risk Assessment Waste Rock Dumps, Dwarsrivier Chrome Mine South Africa	A risk assessment was carried out on the rock dumps at Dwarsrivier Mine to assess the potential for slope instabilities.
Co-disposal and Waste Rock Dump, Nkomati Mine South Africa	Detailed geotechnical investigation for the Co-disposal and Waste Rock Dump Facility which included the evaluation and interpretation of field and laboratory data; carry out limited equilibrium and finite element assessment on three waste rock sections and carry out an assessment on the influence the dolomites would have on the Waste Rock Dump.
PCR Stockpile Slope Stability Modelling, Nkomati Joint Venture South Africa	Geotechnical work indicated that the underlying soils were of a poor geotechnical quality and further work was required to assess the stability of the stockpile. Analysis included the assessment of the effect staged loading would have on the underlying soils (assessing consolidation time and pore pressure dissipation). Shear strength reduction was used for each staged load to assess potential slope instabilities.
Samira Hill Tailings Dam, SML Nigel	Detailed geotechnical investigation for the tailings disposal facility. The investigation included, sample collection, testpitting and in situ permeability testing. Recommendations were made on the construction of the tailings dam.
Tabakota Gold Project, Nevsun Mali	Detailed geotechnical investigation was carried out for the tailings disposal facility and plant site. The investigation included, sample collection, testpitting and in situ permeability testing. Recommendations were made on foundation design and construction of the tailings dam.
Kimberley Small Mining, De Beers South Africa	Detailed geotechnical investigation for the tailings disposal facility

Mimosa Tailings Dam, Mimosa Platinum Mine Zimbabwe	Detailed geotechnical investigation for the tailings disposal facility, which included seepage analysis and slope stability assessment. Detailed geotechnical audit was carried out to assess potential borrow areas for use in earthworks and construction of drains.
Nchanga/Konkola Dump, KCM Zambia	A detailed geotechnical investigation was carried out to assess techniques to mitigate run-off of fines from the overburden dumps. This included the zoning of the dumps in terms of material type, slope configuration, topography and foundation type.

FOUNDATION DESIGN

Simandou Iron Ore Project – Port Expansion, Rio Tinto, Guinea	Provided input for the design of the geotechnical program which included rotary core drilling, spt and cpt testing, geophysics and collection of soil and rock samples. Also provided review on the collection of geotechnical data, in order to provided geotechnical design parameters for the port extension.
Sonangol Grass Roots Refinary, Lebito, Angola	Carried out the onshore and offshore geotechnical investigation. The onshore investigation included test pitting, spt-testing and rotary core drilling for the design of the foundations for the refinery. The offshore investigation included drilling at sea off barge for assessing foundation conditions for the extension of the quay for receiving crude oil.
Power Station Geotechnical Investigation, Vale Mozambique	Project Manager for the foundation investigation. Three sites were investigated and the investigation included core drilling, SPT testing and laboratory testing. All results from the investigation were used for the design of foundations and rank the site in terms geotechnical challenges.
TFMine, Freeport, Democratic Republic of Congo	Carried out the design of the foundations for the plant site, which was challenging due to thick >20 m saprolites and with the exclusion of a piled foundation as a solution, this necessitated the design of soil improvement methods.
Kriel Colliery, Anglo Coal South Africa	Detailed geotechnical investigation for a proposed pipeline route, which included test pitting, soil profiling and the collection of soil samples.
Ewaso Nigero Hydro-Electrical Scheme,Kenya	Detailed geotechnical investigation for the three dam sites, which including hydro-geological work, core logging, core orientation, packer testing for grout design, thermal gradient testing, test pitting for access roads and rock and soil sample collection
Cosac Project, Avmin Zambia	Foundation Investigation for the proposed new plant site, which included testing, SPT testing, DPSH testing, soil sample collection, geotechnical analysis of results using stiffness parameters for the predication of total and differential settlement.
Mozal Smelter, Franki Mozambique	Involved in the Foundation investigation for the pot rooms at the smelter, which included the optimization of the founding level for the proposed piling.
Sappi Plant Swaziland	Geotechnical Investigation for remedial measures for a failing retaining wall, which included SPT testing, collection of soil samples (Raymond Spoon), logging of drilled core, evaluation of parameters for analysis of the retaining wall.

MEMBERSHIPS

SANIRE	South African National Institute Rock Engineering

PUBLICATIONS

Fietze, C., A. Creighton, L. Castro and R. Hammah. 2013. Pit Slope Design in Phyllites for the Simandou Large Open Pit Project. Slope Stability, September. Brisbane, Australia.

Whyte, S.R., C.P. Fietze and V.R. Kumar Vadapalli. 2009. Influence of Mine Water PH on the Leach Characteristics and Structural Integrity of Two Backfill Products. International Mine Water Conference, October. Pretoria, South Africa.

Fietze, Carl and Peter Hornsby. 2011. Geotechnical Characteristics of the African Copperbelt Saprolites and their Influence on Pit Slopes. Slope Stability 2011: International Symposium on Rock Slope Stability in Open Pit Mining and Civil Engineering. Vancouver, Canada.

Kuppusamy, Valenica, Colin Jermy and Carl Fietze. 2011. Comparison of borehole discontinuity data collection methods – Uncertainty and quality concerns. Slope Stability 2011: International Symposium on Rock Slope Stability in Open Pit Mining and Civil Engineering. Vancouver, Canada.

Kuppusamy, Valencia, Colin Jermy and Carl Fietze. 2010. Analysis of a Toppling Failure at a Gold Mine in Ethiopia. 11th Congress of the IAEG –Geologically Active, September. Auckland, New Zealand.

ANNEXURE B: PROJECT EXPERIENCE

ANNEXURE B: PROJECT REFERENCE LIST

Client		Date	Country	Applicable Standards/Investor	Descriptions
Confidential client		2020	South Africa	South African	**ESIA for 4 x 100MW to 150MW solar PV plants and associated transmission lines.** SLR was appointed to undertake an ESIA for the development of 4 x 100MW to 150MW solar PV plants and associated transmission lines. The ESIA will include a full scope of specialist studies and extensive stakeholder engagement. Separate ESIA and Basic Assessments will be undertaken for the solar PV plants and the transmission lines respectively.
Gigawatt Global		2020	Liberia	IFC and Liberian	**ESIA a 20MW solar PV plant and associated transmission line.** SLR was appointed to undertake an ESIA for the development of a 20MW solar PV plant and associated transmission line. The ESIA includes biodiversity, social and heritage baseline studies, stakeholder engagement and compilation of an ESIA Report and ESMP. The ESIA will be aligned with the IFC Performance Standards.
Confidential		2020	South Africa	South African	**Environmental and Social Screening Study for the establishment of offshore wind farm development.** SLR was appointed to undertake a regulator review and issues analysis for the development of offshore wind farms in South Africa.
AFD		2020	Tanzania	AFD/World Bank and Tanzanian	**ESIA for the 87MW Kakono hydropower project.** SLR was appointed by the French Development Agency (AF) to undertake an ESIA for the development of a 87MW hydropower plant in Tanzania.
Mphepo Power		2019-20	Zambia	IFC and Zambian	**ESIA for an 80-200MW wind farm development.** SLR was appointed to undertake an ESIA for the development of a wind farm in Zambia. The ESIA included terrestrial and aquatic, social, heritage, noise and visual baseline studies, stakeholder engagement and compilation of an ESIA Report and ESMP. The ESIA was aligned with the IFC Performance Standards.

Client		Date	Country	Applicable Standards/Investor	Descriptions
Confidential client		2020	South Africa	IFC	**Environmental and Social Due Diligence (ESDD) assessment of a renewable energy holding company (wind, solar, hydro, and biomass).** SLR was appointed to undertake an ESDD of a renewable energy holdings company which develops, designs and operates renewable energy assets across multiple renewable energy categories (wind, solar, hydro, and biomass).
Confidential client		2019	Namibia	IFC and Namibian	**Environmental and Social (E&S) Due Diligence (Red Flags only) of a 5 MW solar PV plant.** SLR was appointed to undertake Red Flags only analysis of a 5 MW operational solar PV plant in northern Namibia.
Confidential client		2019	Mali	IFC	**Environmental and Social Scan for a 40MW hybrid HFO-Solar PV Captive Power Plant.** SLR was appointed to undertake a high level environmental and social scan of the mining area in which the client was considering developing a 40MW hybrid HFO-Solar PV captive power plant. The scan included a wide coverage of all social media and internet activity and reporting on the proposed mine site area, with the focus of identifying environmental and social risks.
CIGenCo		2019	Eswatini	IFC	**Environmental and Social Screening Study for a 10MW solar PV plant.** SLR was appointed to undertake a high-level environmental and social screening study to identify potential fatal flaws and to document the EIA permitting process.
Confidential client		2019	South Africa, Uganda, Zambia and Mali	IFC	**Environmental and Social advisory services to undertake an Environmental and Social Due Diligence (ESDD)** for a potential investment into 11 renewable energy projects (wind, solar PV and hydro) located in South Africa, Mali, Zambia and Uganda.
Swakop Uranium Pty Ltd		2019	Namibia	IFC	**ESIA amendment for a 12 MW solar PV Plant on the Husab Mine.** SLR was appointed to undertake an amendment to the existing environmental authorisation for the Husab Mine, to accommodate the construction and operation of a 12 MW solar PV power plant. The ESIA included biodiversity studies and the review of existing social and heritage baseline studies, stakeholder engagement and compilation of an EIA Report and ESMP. Stakeholder engagement also formed part of the ESIA process.

Client		Date	Country	Applicable Standards/Investor	Descriptions
Nampower		2019	Namibia		**Geotechnical Investigation for Omburu PV Solar Power Plant** SLR was appointed to undertake a geotechnical investigation for a IPP PV Solar Power Plant in Namibia. The work entailed fieldwork which included rotary core drilling, test pitting, SPT testing, electrical and thermal Resistivity surveys, soil sampling for laboratory testing. A factual geotechnical report was compiled at the close of the project.
Confidential client		2019	DRC	IFC	**Review and Gap Analysis to IFC Performance Standards: 100MW solar PV plant.** SLR was appointed as the lead for the review of the locally approved ESIA. The ESIA was reviewed against the IFC Performance Standards and gaps identified and an Environmental and Social Action Plan (ESAP) developed to close the gaps.
Globeleq		2019	Zambia	IFC	**Supplementary Studies: Environmental and Social Impact Assessment for 2 x 20MW solar PV plants.** SLR was appointed to undertake supplementary studies for the ESIA for 2 x 20MW solar PV plants that were being developed as part of the Zambia GETFiT Programme. The supplementary studies included wet season biodiversity baseline data gathering, initial soil and groundwater contamination screening, climate change study and additional stakeholder engagement. All studies were aligned with the IFC Performance Standards.
Globeleq		2018	Zambia	IFC and Zambian	**ESIA for 2 x 20MW solar PV plants.** SLR was appointed to undertake an ESIA for 2 x 20MW solar PV plants that were being developed as part of the Zambia GETFiT Programme. The ESIA included biodiversity, social and heritage baseline studies, stakeholder engagement and compilation of an ESIA Report and ESMP. The ESIA was aligned with the IFC Performance Standards.
Globeleq APS Consortium		2018	Zambia		**Geotechnical Investigation for 20MW Solar Power Plant** SLR was appointed to undertake a geotechnical assessment for 3 proposed sites for a 20MW PV Solar Power Plant as part of the Zambia GETFiT Programme. The work entailed site walkover study, test pitting, soil sampling for laboratory testing. The data was compiled and presented in a geotechnical report.

Client		Date	Country	Applicable Standards/Investor	Descriptions
Engie Africa (Pty) Ltd.		2018	Zambia		**Geotechnical Investigation for 20MW Solar Power Plant** SLR was appointed to undertake a geotechnical assessment for 2 proposed sites for a 20MW PV Solar Power Plant as part of the Zambia GETFiT Programme. The work entailed, test pitting, soil sampling for laboratory testing. The data was compiled and presented in a geotechnical report.
Confidential		2018	Zambia	IFC and Zambian	**Environmental and Social Screening Study for 3 x 40MW solar PV plants.** SLR was appointed to undertake an environmental and social screening study for 3 x solar PV sites in Zambia. The Screening Study included the review of desk top information and site visits to assess environmental and social risks. A comparative analysis was undertaken to select the site with the least environmental and social risks. This was combined with the technical analysis to select the preferred site to be taken into more detailed studies.
Volt Renewable Energy Pty Ltd		2018	Zimbabwe	IFC	**Review and Gap Analysis to IFC Performance Standards: 50MW solar PV plant.** SLR was appointed as the lead for the review of the locally approved EIA. The EIA was reviewed against the IFC Performance Standards and gaps identified and an Environmental and Social Action Plan (ESAP) developed to close the gaps.
AIIM		2018	South Africa	IFC	**Environmental & Social Review and Gap Analysis Perdekraal and Kagnas Windfarms.** SLR was appointed as the lead for the review of the locally approved EIA. The EIA was reviewed against the IFC Performance Standards and gaps identified and an Environmental and Social Action Plan (ESAP) developed to close the gaps.
Confidential		2018	Namibia	Namibian EIA Regulations	**Environmental and Social Management Support for the proposed construction of the 37 MW Solar Power Plant in Mariental.**
AIIM		2018	South Africa	IFC	**Environmental and Social Due Diligence to IFC Performance Standards: Copperton Wind Energy Facility.**
AIIM		2018	South Africa	IFC	**Environmental and Social Due Diligence to IFC Performance Standards: Jasper Solar PV Plant.**

Client		Date	Country	Applicable Standards/Investor	Descriptions
Engie		2018	Zambia	N/A	**Geotech study for a 40MW solar PV plant in Zambia.**
AFD		2018	Senegal Gambia	AFD	**Review of E&S documentation: Sambangalou Hydropower Project.** SLR was appointed to undertake a review of the downstream impact assessment on wetlands for the French Agency for Development (AFD) Review of the existing study at Phase 1 stage, i.e. post baseline description but predefinition of mitigation measures. Reporting on compliance with initial Terms of Reference and definition of recommendations for Phase 2 and 3.
AFD		2018	Niger	AFD, BID WB, BAD	**Social Due Diligence to World Bank Operational Safeguard 4.12: Kandadji Dam and 130MW Hydropower Project.** SLR was appointed to undertake a Social Due Diligence for the French Agency for Development (AFD). This included a review of the Resettlement Action Plan (50,000 people displaced), identification of risks, recommendation to close gaps with World Bank Operational Safeguard 4.12 and to mitigate implementation risks during the lenders conference. Three contracts.
AFD		2018	Niger	AFD, BID WB, BAD	**Review and Gap Analysis of E&S documents to International Standards: Kandadji Dam and 130MW Hydropower Project.** SLR was appointed to undertake a review of the E&S documentation and preparation of SoW for the French Agency for Development (AFD) Identification of E&S issues and potential impacts downstream of the dam and preparation of the scope of work for the ESIA for the downstream impacts.
Globeleq		2018	Zambia	N/A	**Geotech study for 3 sites for 40MW solar PV plants.**
NamPower		2017-20	Namibia	EIB	**ESIA for the proposed Encroacher Bush Biomass Power Project.** SLR Was appointed by the EIB to undertake an Environmental and Socio-Economic Impact Assessment process for the proposed project. The process followed included a comprehensive public participation process and detailed specialist studies.

Client		Date	Country	Applicable Standards/Investor	Descriptions
SunEQ GmbH (SunEQ)		2017	Namibia	Namibian Regulations	**EIA for a 10MW solar PV plant for SunEq Solar.** SLR was appointed to undertake an EIA for the construction and operation of a 10 MW Solar PV plant to be operated by SunEQ GmbH (SunEQ) required for supporting the Ohorongo Cement Factory's power demand.
Swakop Uranium		2016	Namibia		**EIA for the proposed amendment to the Husab Mine Linear Infrastructure - 33kV Overhead Powerline at the B2 Vehicle Staging Area.**
AFD		2016	Ghana	AFD	**Review and Gap Analysis against IFC Performance Standards: Pwalugu Multipurpose Dam Project.** SLR was appointed to review various documents and identify gaps against IFC Performance Standards and develop a Corrective Action Plan.
Infraco Africa/ EleQtra		2015	Uganda		**ESIA for the 52MW Duel Fule Power Plant: Lake Albert Infrastructure Project.** The Project involves the development, finance, construction and. ESHIA for the Lake Albert Infrastructure Project for Infraco Africa/EleQtra Preparation of an IFC-compliant ESIA study, including inception, environmental and social baseline surveys, stakeholder engagement, impact modelling, impact assessment report preparation and coordination with the National Environment Management Agency (NEMA) for obtaining the project's environmental permit.
Siginik Energy		2015	Ghana	Standard Bank	**ESDD to IFC Performance Standards: Siginik 50MW Solar PV Project.** Siginik Energy is proposing to establish a 50 MW AC commercial photovoltaic (PV) solar energy facility in Ghana in Kakease-Bole, which falls within the Bole District of the Northern Region, situated approximately 223 kilometres from the regional capital Tamale. Environmental and social expert of the Equator Principles Due Diligence audit for the Standard Bank in South Africa The Standard Bank (South Africa) is one of the financial institutions providing financial assistance to the Project. One of the requirements of the Standard bank is that an environmental and social due diligence of the project be performed by an independent specialist consultancy. The audit carried out by SLR comprised assessment of compliance with the Equator Principles, and in particular compliance with the International Finance Corporation (IFC) Performance Standards. The tasks comprised a review of the project ESIA, environmental permitting,

Client		Date	Country	Applicable Standards/Investor	Descriptions
					stakeholder engagement activities, and related documents. A site visit was undertaken and a concise audit report prepared flagging non-compliance issues and providing recommendations and an action plan.
SolarReserve		2014	South Africa	South Africa EIA Regulations	**Environmental and Social Impact Assessment (ESIA) for Kalkaar 200 MW Concentrating Solar Thermal Power Project.** SLR was appointed to undertake the Environmental and Social Impact Assessment (ESIA) process for the proposed project. SLR also undertook specialist investigations as and led the public participation process.
SolarReserve		2014	South Africa	South Africa EIA Regulations	**Environmental and Social Impact Assessment (ESIA) for Kalkaar 100 MW Solar PV Project.** SLR was appointed to undertake the Environmental and Social Impact Assessment (ESIA) process for the proposed project. SLR also undertook specialist investigations as and led the public participation process.

ANNEXURE C: PROJECT EXPERIENCE COMMERCIAL AGREEMENT AND ASSUMPTIONS

COMMERCIAL AGREEMENT

- The work will be carried out in accordance with the SLR Standard Conditions of Engagement (V5.0).
- In the event that Client places a formal order on SLR with different terms and conditions to those contained in this letter, and if SLR has already been instructed to proceed with the work by Client the terms and conditions as set out hereunder shall apply from the time of notification to proceed with the work to the time that such an order is signed and accepted by both parties. Any work undertaken between the date of acceptance of this proposal and the date of acceptance of the clients order or any revised conditions, shall be in accordance with the terms and conditions set out in this proposal.
- Unless otherwise agreed, invoices will be in SA Rand (ZAR) and made out to the client as per the address in South Africa. VAT will be charged on all work.
- All amounts due to SLR in accordance with this Agreement shall be paid within 30 days of the date of SLR's invoice. The work will be charged on a (time and expense basis). SLR reserves the right to adjust the allocations of the budgets per work scope item whilst maintaining the total as per the budget.
- In the event that the activities described extends across calendar years, SLR reserves the right to escalate the fees at an inflation rate to be discussed and agreed with the client.
- A professional indemnity insurance policy is maintained by SLR. Professional indemnity insurance cover up to a maximum value of twice the fee value is included in the cost of this proposal.
- This proposal has taken into consideration certain known measures and controls that may be required due to the COVID-19 pandemic. SLR notes that the full impacts of the COVID-19 pandemic are not fully understood. The proposed scope of services, cost and schedule do not consider additional potential impacts caused by COVID-19, beyond what has been described in the proposal. Any adjustments required due to any additional impacts to accommodate COVID-19 related concerns (including but not limited to travel restrictions, projects delays, economic interruption, supply chain issues, or any governmental guidance) will require an equitable adjustment in scope, programme and cost.
- The content of this proposal is the intellectual property of SLR and should not be shared with any third party for any purpose without prior written consent from SLR.

COST ESTIMATE ASSUMPTIONS

- 7.5% of professional fees has been included in the budget and will be charged for incidental office expenses such as IT, telephone, minor printing, etc.
- Incidental printing jobs (on all printers and plotters at SLR), that are not separately priced in the proposal/tender/contract are covered by the mark-up on professional fees.
- This proposal will only remain valid for a period of 30 days from 09 March 2021
- The cost estimate (Table 5-1) only provides for the scope of work as set out, subject to the assumptions set out in **Error! Reference source not found.**. Any additional work forming part of an appointment will require an adjustment to the cost estimate.
- Documentation will be prepared in English only. No allowance is included for translation.
- No allowance is included for laboratory test work or field measurements.
- Additional site visits (outside the defined scope of work) or meetings (if required) will be at a separate cost.
- No allowance has been made for field delays due to the Client or factors outside of SRK's control.

ANNEXURE D: SLR CONDITIONS OF ENGAGEMENT

SLR CONSULTING LIMITED
STANDARD
CONDITIONS OF ENGAGEMENT

CONTENTS

CONDITIONS OF ENGAGEMENT

1 DEFINITIONS

1.1 The following definitions shall apply throughout this Agreement:

“The Client”	As described in SLR’s Proposal or in the Memorandum of Agreement (if a Memorandum of Agreement is signed by SLR and the Client)
"SLR"	Either SLR Consulting (Africa) Pty Ltd or SLR Consulting (South Africa) Pty Ltd or SLR Environmental Consulting (Namibia) Pty Ltd , Synergistics and CCA Environmental depending on the SLR group company submitting the Proposal or Memorandum of Agreement
“Adjudicator”	A person appointed under Condition 5.4 of this Agreement to study and give his decision on any dispute notified by either party during the progress of The Services
“Agreement”	The Agreement comprises SLR’s Proposal and the Memorandum of Agreement (if a Memorandum of Agreement is signed by SLR and the Client) and these Conditions of Engagement
“Description of Services”	A description of the requirements for the relevant Services to be performed by SLR in SLR’s Proposal or the Memorandum of Agreement covering the Services
“Client Manager”	The person designated by the Client pursuant to Condition 3.5 to manage the contract as the Client’s representative
“Insolvency”	Either party becoming bankrupt, going into liquidation (either voluntary or compulsory unless as part of a bona fide scheme of reconstruction or amalgamation), being dissolved, compounding with its creditors or having a receiver or administrative receiver appointed of the whole or any part of its assets
“Mediator”	An independent person appointed under Condition 5.2 to conduct a non-binding procedure towards resolving a difference

"Notice"	A notice given in accordance with Condition 8
"Other Consultants"	Consultants and specialist advisers, other than SLR, appointed or to be appointed by the Client to perform professional services in relation to the Services.
"Project Manager"	The person designated by SLR under Condition 2.2 of this Agreement and named as such in the Proposal or Memorandum of Agreement, or his replacement appointed in accordance with that Condition.
"Proposal"	SLR's proposal to the Client presenting the Description of Services to be provided, the cost of those services and the fee rates.
"The Services"	The totality of Services defined in SLR's Proposal, and in the Memorandum of Agreement (if a Memorandum of Agreement is signed by SLR and the Client) and such of the Additional Services as may be requested or consented to by the Client.
"Additional Services"	Services which are not foreseen as being required by the Client at the commencement of the Agreement but which are identified as being necessary during the performance of the Services.
"Contractor"	A person or firm appointed by the Client to execute work required in furtherance of the Services and to co-ordinate and supervise such execution.

1.2 Headings are explanatory and do not form part of the Conditions.

2 OBLIGATIONS OF SLR

2.1 Skill and Care

SLR shall exercise reasonable skill, care and diligence in the performance of the Services.

2.2 Assignment

SLR shall not assign or transfer any benefit or obligation under this Agreement unless agreed by the Client with such agreement not to be unreasonably withheld.

2.3 Other Consultants

SLR shall if so requested advise the Client on the need for and the selection and appointment of Other Consultants to perform services in respect of the Services.

SLR shall co-operate with any Other Consultants and if so requested by the Client shall co-ordinate and integrate the results of their services with the Services performed under this Agreement. SLR will not be responsible for the services performed by any Other Consultant or liable for defects in or omissions from them.

2.4 Specialist Sub-Consultants

SLR may recommend to the Client that it sub-lets to a specialist sub-consultant the performance of any of the Services.

The Client shall not unreasonably withhold consent to such recommendation and SLR shall integrate such sub-consultant's services with his own. SLR shall be responsible for the performance and the payment of any sub-consultant.

2.5 Authority

SLR shall not without the approval of the Client perform Services other than those required by the Description of Services and other instructions given by the Client in accordance with this Agreement.

Save in the event of any emergency, SLR shall not without the approval of the Client issue instructions to any Contractor the effect of which would be to incur additional costs to the Client beyond whatever limits may have been agreed for such additional costs.

2.6 Additional Services

In the event the Client requires Additional Services or SLR recommends that Additional Services are required, then SLR shall prepare a memorandum to reflect such Additional Services. SLR shall either quote the Client a fixed price for the Additional Services or estimate the costs to carry out the Additional Services on a time and material basis in accordance with its current charging rates. Any Additional Services shall be attached as an addendum to the project documentation and will be incorporated into this Agreement.

2.7 SLR's Discretion

If in the performance of the Services SLR has a discretion exercisable as between the Client and a Contractor SLR shall exercise that discretion fairly.

2.8 Pollution and Contamination

The obligations of SLR under this Agreement do not include a duty to advise as to the actual or possible presence of pollution or contamination or as to the risks of such matters having occurred being present or occurring in the future nor shall SLR have any duty to consider such matters as influencing any aspect of the Services to be performed by SLR under this Agreement, except where the Description of Services specifically includes provision of such advice or consideration.

2.9 Professional Opinion

Where the scope of the Services includes a site investigation or environmental assessment, audit, review or investigation which includes the interpretation, interpolation or extrapolation of data from discrete sampling locations and/or discrete times, the Client accepts and agrees that these data may not represent actual conditions between these locations or between these times and that SLR's conclusions and recommendations based on such data are statements of professional opinion and not statements of fact. Whilst SLR will carry out such Services and provide its conclusions and recommendations with reasonable skill, care and diligence, it accepts no liability if the actual conditions between the locations and times is different to SLR's conclusions or recommendations.

3 OBLIGATIONS OF THE CLIENT

3.1 Information needed by SLR

The Client shall supply to SLR, without charge and in such time so as not to delay or disrupt the performance by SLR of the Services, all necessary and relevant data and information (including details of the services to be performed by any Other Consultants) in the possession of the Client, his agents, servants, Other Consultants or Contractors.

3.2 Assistance

The Client shall give, and shall procure that his agents, servants, Other Consultants and Contractors give, such assistance as shall reasonably be required by SLR in the performance of the Services.

3.3 Decisions

The Client shall ensure that his decisions, instructions, consents or approvals on or to all matters properly referred to him shall be given in such reasonable time so as not to delay or disrupt the performance of the Services by SLR.

3.4 Assignment

The Client shall not assign or transfer any benefit or obligation under this Agreement.

3.5 Client Manager

The Client shall designate a Client Manager who shall be deemed to have authority to make decisions on behalf of the Client under this Agreement. The Client shall notify SLR immediately if the Client Manager is replaced.

3.6 Contractors

The Client shall appoint Contractors to execute and/or to manage such work not being part of the Services as may be required in furtherance of the Services. The Client shall require that the Contractors execute such work in accordance with the terms of the relevant contracts.

Neither the provision of Site Staff nor periodic visits by the Consultant or his staff to the site of any work being executed by Contractors in furtherance of the Services will in any way affect the responsibilities of the Contractors for executing such work in compliance with the relevant contract documents and any instructions issued by SLR.

3.7 Pollution and Contamination

It is the responsibility of the Client to decide on the extent of investigation that may be necessary and to investigate whether pollution or contamination may affect the Services or any site relevant thereto by making such investigations and/or taking advice (other than under the terms of this Agreement) as to such matters, except where such investigations are specifically included in the Description of Services.

3.8 Buried Services and Structures

Without affecting the generality of Condition 3.1, where excavating, boring, probing or the like below existing ground level is required as part of the Services, the Client shall provide in a timely fashion drawings or plans showing accurate and complete locations of all underground services, structures or artificial obstructions to SLR who, in performing such Services as set out in this Condition, shall take reasonable precautions to avoid damage or injury to such underground services, structures or artificial obstructions as shown in such drawings or plans. SLR will not be responsible for any damage to underground services, structures or obstructions or for any damage, claims, expenses or loss arising as a result of such excavating, boring, proving or the like below existing ground level, unless their locations on site are accurately shown on drawings or plans furnished to SLR in good time prior to commencement of such Services.

4 TERMINATION OF APPOINTMENT

4.1 Duration of Appointment

Notwithstanding the date stated in SLR's Proposal, the effective date of the appointment of SLR shall be the date of the Client's written instruction to proceed with the Services, the date upon which any Memorandum of Agreement was executed by the parties or the date when SLR shall have first commenced performance of the Services, whichever is the earlier.

Unless suspended or terminated in accordance with this Agreement, the appointment of SLR shall be completed when SLR has performed the Services required under this Agreement.

4.2 Termination by the Client

The Client may terminate the appointment of SLR at any time by not less than four weeks' Notice in respect of all or any part of the Services.

4.3 Postponement by the Client

The Client may at any time by not less than four weeks notice require SLR to postpone the performance of all or any part of the Services.

On notice of postponement of all or any part of the Services SLR shall cease such postponed Services in an orderly and economical manner compatible with a possible order to restart.

If the postponement of the performance of all or any part of the Services exceeds three months in aggregate SLR may by Notice treat the Services or that part of the Services as having been abandoned and the appointment of SLR in respect of all or any part of the Services affected shall be automatically terminated and treated as if the Client had terminated the Agreement in accordance with Condition 4.2.

4.4 Termination by the Client following Breach of this Agreement by SLR

In the event of a material breach of this Agreement by SLR the Client may give four weeks' Notice of his intention to terminate the appointment of SLR setting out the acts or omissions of SLR relied upon as evidence of such breach. If the breach is remediable and SLR does not take expeditious steps to repair the breach during the notice period the Client may forthwith on the expiry of the notice period terminate the appointment of SLR by a further Notice.

4.5 Suspension or Termination by SLR

Upon the occurrence of any circumstance beyond the reasonable control of SLR which is such as to prevent or significantly impede the performance by SLR of the Services under this Agreement, including non-payment of fees by the Client, SLR may suspend for a period of up to twenty-six weeks the performance of the Services under this Agreement or if it is still prevented from performing such Services for reasons beyond its reasonable control terminate its appointment forthwith by a further Notice in respect of all or any part of the Services affected.

4.6 Termination by SLR following Breach of this Agreement by the Client

In the event of a material breach of this Agreement by the Client (including but not limited by any failure by the Client to pay any invoices when due in accordance with Condition 9) SLR may give two weeks' Notice of its intention to terminate this Agreement setting out the acts or omissions of the Client relied upon as evidence of such breach. If the breach is remediable and the Client does not, to the reasonable satisfaction of SLR, take expeditious steps to repair the breach during the notice period SLR may forthwith on the expiry of the notice period immediately terminate this Agreement by a further Notice.

4.7 Insolvency

Either party may by Notice immediately terminate this Agreement in the event of Insolvency of the other party.

4.8 Accrued Rights

Termination of the SLR's appointment under this Agreement shall not prejudice or affect the accrued rights or claims of either party to this Agreement.

4.9 No effect

Termination of this Agreement shall not affect those provisions which expressly or impliedly survive termination.

5 DISPUTE RESOLUTION

5.1 No person appointed as Mediator or Adjudicator in respect of any difference or dispute in connection with the Services or this Agreement may be called to give witness thereon in any subsequent proceedings.

5.2 Should any dispute whatsoever arise between the parties, then either party hereto may declare a dispute by delivering notice of the details thereof to the other party, which dispute shall be referred to arbitration

5.3 Prior to arbitration and should the parties so agree, the dispute may be referred to a single mediator without the parties having legal representation. The mediator shall be selected by agreement between the parties within fourteen (14) days. Failing such agreement, nominated on the application of either party by the President of the Association of Arbitrators of South Africa. The alternative for SLR Environmental Consulting (Namibia) contracts is the Professional Arbitration and Mediation Association of Namibia. The mediator shall be appointed jointly by the parties

5.4 The mediator shall have absolute discretion in the manner in which the mediation proceedings shall be conducted

5.5 The mediator shall deliver a copy of his reasoned opinion to each party within twenty one (21) days of his appointment

5.6 The opinion so expressed by the mediator shall be final and binding on the parties unless either party within twenty one (21) days of the delivery of the opinion, notifies the other party of its unwillingness to accept the said opinion, in which event the dispute shall be referred to arbitration in terms of this agreement

5.7 The costs of mediation shall be determined by the mediator and shall be borne equally by the parties and shall be due and payable to the mediator on presentation to them of his written account

5.8 Each party shall bear any other costs it may have incurred in connection with the mediation

5.9 The mediation proceedings shall not prejudice the rights of the parties in any manner whatsoever in the event of the dispute proceeding to arbitration

5.10 Arbitration shall be by a single arbitrator who shall be selected by agreement between the parties within fourteen (14) days. Failing such agreement, nominated on the application of either party President of the Association of Arbitrators of South Africa. The arbitrator shall be appointed jointly by the parties, failing which by either one of the parties.

5.11 The arbitrator shall have power to open up, review and revise any opinion, decision, requisition or notice and to determine all matters in dispute which shall be submitted to him, and of which notice shall have been given as aforesaid, in the same manner as if no such opinion, decision, requisition or notice had been given.

5.12 The arbitration shall be conducted according to the rules of the Association of Arbitrators (SA) and such decision shall be final and binding on the parties.

6 LIABILITY

6.1 The total liability of SLR shall be limited to twice the amount of fees payable to SLR and for a period of three years from date of termination or completion of the agreement.

6.2 SLR shall not be liable for any losses or damage (whether or not such losses or damage were foreseen, direct, foreseeable, known or otherwise) due to any general, indirect, special or consequential loss or damage howsoever caused, including any losses arising as a result of any third party bringing a claim in respect of any of the above types of loss.

6.3 The Client shall indemnify and keep indemnified SLR from and against all claims, demands, proceedings, damages, costs, charges and expenses arising out of or in connection with this Agreement and/or Services in excess of the stated maximum liability and maximum liability period.

6.4 Personal Liability

The Client agrees that it will not bring any claim personally against any director, employee or consultant of SLR in respect of any loss or damage suffered by the Client arising out of this Agreement. No personal liability whatsoever whether in contract or tort or otherwise is accepted by individual directors or employees of SLR in relation to acts, omissions or defaults arising out of this Agreement.

6.5 Opinions of Cost

If so designated as part of the Services, SLR shall use reasonable endeavours to provide a realistic estimate of the construction costs and/or the costs of remedying environmental damage. Such estimate being intended primarily to provide information on the order of magnitude or scale of such costs. The Client agrees and acknowledges that such estimate is not a binding quotation, that no reliance can be placed on such estimate and that the actual cost of such work will depend upon a number of factors including but not limited to regional economics, local construction practices, labour costs, the availability of raw materials, site and weather conditions, unforeseeable ground conditions, the terms on which contractors and consultants are employed and many other factors beyond the control of SLR. In no event will SLR be liable for any loss suffered by or claim made by the Client if the actual costs of construction or remedying environmental damage exceeds SLR's estimate.

6.6 Claims

In the event that the Client makes a claim against SLR at law or otherwise for any alleged error, omission or other act arising out of the Services and to the extent that the Client fails to prove such claim the Client shall indemnify SLR and keep it indemnified against all losses, costs and expenses incurred by SLR including without limitation all SLR's staff costs and all solicitor's and any other professional fees incurred by SLR in defending itself against the claim.

6.7 Warranties

Except as expressly set out in the Agreement, SLR expressly disclaims and excludes any and all other liabilities (whether in contract, tort or otherwise), representations and warranties, express or implied and in any event shall not be liable for any claims or liability in contract, tort or otherwise for loss of profits, goodwill, data or any type of special, indirect or consequential loss (including loss or damage suffered by the Client as a result of an action brought by a third party) even if such loss was reasonably foreseeable or SLR had been advised of the possibility of the Client incurring the same.

6.8 No liability for Force Majeure

SLR shall not be liable for any delays in performing or failure to perform the Services to the extent that such delays or failures result from causes beyond SLR's reasonable control including but not limited to any act of God or public enemy, act of any military, civil or regulatory authority, change in any law or regulation, fire, flood, earthquake, storm or other similar event, disruption or outage of communications, power or other utility, national labour problems or strikes, which the affected party could not have reasonably prevented, and any other cause, whether similar or dissimilar to any of the foregoing, which could not have been prevented through the use of reasonable care or which was not reasonably foreseeable by the affected party.

7 OWNERSHIP OF DOCUMENTS AND COPYRIGHT

7.1 Copyright

The copyright in all drawings, reports, specifications, bills of quantities, calculations and other documents and information (hereinafter termed 'intellectual property') prepared by or on behalf of SLR in connection with the Services for delivery to the Client shall remain vested in SLR. When so agreed by SLR and recorded in writing prior to the delivery of such intellectual property and subject to SLR having received payment of all fees and disbursements properly due under this Agreement, the Client shall have a licence to copy and use such intellectual property for purposes directly related to the Services. Such licence shall enable the Client to copy and use the intellectual property but solely for his own purposes and such use shall not include any licence to reproduce any conceptual designs or professional opinions contained therein. Save as above, the Client shall not make copies of such intellectual property nor shall he use the same in connection with any other works or for any other purpose nor pass them to any third party without the prior written approval of SLR and upon such terms as may be agreed by SLR.

SLR shall not be liable for the use by any person of any drawings reports specifications or other documents or information for any purpose other than that for which the same were prepared by or on behalf of SLR.

No documents, drawings or records may be copied, passed on to third parties, or submitted to any authority in support of any application until all fee and disbursement accounts relating to that document have been settled in full.

7.2 Publication by SLR

The SLR shall not, without the written consent of the Client, publish alone or in conjunction with any other person any articles, photographs or other illustrations relating to the Services.

SLR shall not disclose to any person any information provided by the Client as private and confidential unless so authorised by the Client.

8 NOTICES

Any Notice to be given by the Client under this Agreement shall be deemed to be duly given if it is in writing and delivered by hand at or sent by registered post to SLR the address of SLR as shown on SLR's Proposal or Memorandum of Agreement. Any notice to be given by SLR shall be deemed to be duly given if it is in writing and delivered by hand at or sent by registered post to the Client at the address of the Client as shown on SLR's Proposal or the Memorandum of Agreement. These Notices shall if sent by registered post be deemed to have been received forty eight hours after being posted.

9 PAYMENTS

9.1 Payment for Services and Disbursements

The Client shall pay fees to SLR for the performance of the Services monthly in arrears against submission of an SLR invoice unless otherwise stated in the Proposal or Memorandum of Agreement.

9.2 Variation or Disruption of SLR's Work

If SLR has to carry out additional work and/or suffers disruption in the performance of the Services because the Description of Services is or are varied by the Client, or because of any delay by the Client in fulfilling his obligations under Condition 3.1, 3.2 or 3.3 or in taking any other step necessary for the execution of the Services, or because SLR is delayed by others (or by events which were not reasonably foreseeable), or for other reasons beyond the reasonable control of SLR, the Client shall make an additional payment to SLR in respect of the additional work carried out and additional resources employed (unless and to the extent that the additional work has been occasioned by the failure of SLR to exercise reasonable skill, care and diligence) and/or the disruption suffered, calculated (unless otherwise agreed) on the basis of time based fees as set out in SLR's Proposal or the Memorandum of Agreement.

SLR shall advise the Client when it becomes aware that any such additional work beyond the Services will be required and shall if so requested by the Client give an initial estimate of the additional payment likely to be incurred. Where the Client requires that payment for such additional work is to be in the form of lump sums, these lump sums should be agreed by the parties prior to the additional work being commenced.

For the avoidance of doubt it is hereby agreed that if SLR carries out any work which subsequently becomes nugatory the Client is still obliged (unless SLR agrees otherwise) to pay SLR on the basis of time based fees as set out in SLR's Proposal or the Memorandum of Agreement.

9.3 Effect of Termination or Postponement

In the event of any termination by the Client in accordance with Condition 4.2 or any postponement by the Client in accordance with Condition 4.3 or any suspension by SLR in accordance with Condition 4.5 or any termination by SLR in accordance with Condition 4.3 or 4.5 or 4.6, the Client shall pay SLR all fees incurred to date of termination, suspension or postponement and any outstanding disbursements, all charges and expenses incurred or committed on behalf of the Client together with a sum for loss and costs of disruption (calculated on the basis of the loss to SLR and costs to which SLR is committed in respect of planned future work on the Services).

In the event of any termination by the Client in accordance with Condition 4.4 and 4.6 the Client shall pay SLR a fair and reasonable amount on account of the fees due under Condition 9.1 commensurate with the Services performed to the date of termination and any outstanding disbursements.

~~Other than in the case of a breach by the consultant, the consultant shall, in addition to the fee, be paid a surcharge of ten per cent (10%) of the remaining fee which would have been payable had the services been rendered in full in terms of this agreement~~

9.4 VAT

All sums due under this Agreement are exclusive of Value Added Tax, the amount of which shall be paid by the Client to SLR at the rate and in the manner prescribed by law.

9.5 Contested Invoices

If any part of any invoice submitted by SLR is contested, payment shall be made in full of all that is not contested.

9.6 Time for Payment

All amounts due to SLR in accordance with this Agreement shall be paid within 30 days of the date of SLR's invoice. Interest shall be added to all amounts remaining unpaid thereafter (including any amounts of any contested invoices remaining unpaid under Condition 9.5 to the extent that they or it shall subsequently be agreed or determined to have been due to SLR) at the rate of prime plus 2%

9.7 Credit Checks

Where a credit check by SLR using a reputable credit checking agency indicates that the Client has a recommended credit limit of less than the contract value, SLR will be entitled to delay commencement of work or continuation of work under the Contract and require payment in advance, parent company guarantees, or other sureties acceptable to SLR.

10 GENERAL

10.1 In the event of any inconsistency between any of the documentation which makes up this Agreement, the Agreement shall be interpreted in the following order of priority:

1. Proposal
2. Conditions of Engagement

10.2 This Agreement shall be personal to the Client and incapable of assignment in whole or in part and SLR may immediately terminate this Agreement upon any purported assignment by the other.

10.3 Any waiver by either party of a breach of any provision of this Agreement shall not be considered as a waiver of any subsequent breach of the same or any other provision thereof.

10.4 No amendments to this Agreement will be valid or effective unless in writing and signed by both parties.

10.5 If any term or condition of this Agreement or the application thereof shall be illegal, invalid or unenforceable, all other provisions shall continue in full force and effect as if the illegal, invalid or unenforceable provision were not a part of this Agreement.

10.6 Save in the case of a fraudulent misrepresentation, this Agreement and any documents referred to herein constitute the entire agreement between the parties in relation to the Services and supersede and replace any previous agreement or understanding between the parties in relation to such Services.

10.7 The jurisdiction of this Agreement shall be the Republic of South Africa or Republic of Namibia.

10.8 It is hereby confirmed that the Consultant is NOT appointed to act as the Health & Safety agent as contemplated in all and any legislation. In the case of RSA the pertinent Act would be Section 4.5 of the Construction Regulations, promulgated in terms of the Occupational Health and Safety Act 85 of 1993 (South Africa).

APPENDIX B: CV'S OF KEY PERSONNEL

CURRICULUM VITAE

ANGUS BRACKEN

PRINCIPAL ENGINEERING GEOLOGIST

South Africa and Africa

QUALIFICATIONS

MSc	1991	Engineering Geology – Imperial College, London, UK
DIC	1991	Engineering Geology – Imperial College, London, UK
BSc (Hons)	1987	Geology – University of Hull, UK
Professional Registration		SACNASP: 400155/05
		UK Geological Society: 1002069

EXPERTISE

- Geotechnical Investigations
- Earthwork assessment and Design
- Contaminated Land Assessment
- Ground Treatment
- Tailings Disposal Facilities
- Foundation Assessment
- Project Management

Angus offers 30 years of practical experience in Geological, Environmental and Geotechnical Engineering applied to mining and civil engineering projects in 27 countries across Africa, Asia and Europe.

He has managed, or been a team member, in numerous geotechnical ground investigations ranging from small housing and commercial properties to large industrial and mining complexes and linear infrastructure 100's of kilometre in length. These projects have involved many field sampling and testing techniques, laboratory testing methods and data handling methods. He also has extensive experience in the analysis of geotechnical data and its interpretation in relation to ground engineering including; slope stability, foundations and ground treatment.

He has good experience in environmental engineering having been involved in hydrogeological and contamination assessments in Africa and the UK, and environmental impact and management studies in Africa, in addition to involvement in the environmental engineering components of many civil and mining projects.

Angus has significant experience in mining, including the geotechnical assessment, auditing and management of the geotechnical elements of mine surface excavations, tailings disposal facilities, waste dumps and structures. He has also project managed feasibility studies, design and construction projects for new tailings disposal facilities and expansion schemes.

PROJECTS

CIVIL ENGINEERING INFRASTRUCTURE

Darwendale Mine, Great Dyke Investments, Zimbabwe

Project manager for the geotechnical investigation and preliminary foundation design for a mining plant and infrastructure for a proposed new mine.

Fairbreeze Mine, Tronox, South Africa

Geotechnical investigation and construction project manager for a large return water dam. The dam presented particular challenges resulting from very weak and deep foundation soils and the scarcity of good construction materials.

SLR

Eskom Sub Stations, South Africa	Responsible for the desk study, ground investigation and foundation assessment for several large Eskom substations.
Simandou Rail Line, Rio Tinto, Guinea,	Technical Director for a ground investigation for a proposed 700 Km railway line which included a wide range of geotechnical techniques.
Katanga Mine Development, DRC	Responsible for several geotechnical investigations and preliminary geotechnical designs related to the plant foundations and earthworks and the road and power infrastructure for the redevelopment of a mine in Kolwezi
Konkola Copper Mines, Zambia	Responsible for various geotechnical ground investigations and foundation assessments at the mine plant and office complex.
Kwazulu-Natal Low Cost Housing, South Africa	Responsible for the geotechnical foundation and infrastructure inputs for many low cost housing projects in Kwazulu-Natal
Ngezi Mine, Zimbabwe	Responsible for several geotechnical investigations and foundation assessments for the plant and infrastructure.
Khumani Mine, Assmang, South Africa	Responsible for several geotechnical investigations and preliminary geotechnical designs related to the plant foundations and earthworks and also the road and rail infrastructure.
Port of Luanda, Angola	Field project manager for an overwater geotechnical investigation for an expansion of facilities in the harbour
Port of Maputo, Mozambique	Responsible for several geotechnical ground investigations and foundation assessments for new and existing structures at the port over a number of years.
Southern Mauritius Waste Facility, Mauritius	Ground Investigation manager for a new waste facility to service the whole of Mauritius. The study concentrated particularly on the hydrogeological conditions and the potential for the release of contaminated leachate into the ground water.
Niassa Province Bridges, Irish Aid, Mozambique	Responsible for the geotechnical inputs for a condition survey of all bridges in Niassa province.
Union Texas Access Road, Pakistan	Geotechnical investigation project manager for an access road and bridge foundations to accommodate abnormally heavy load oil drilling plant across tidal mud flats in the Ran of Kutch.
Melen Water Transfer Scheme, Turkey	Joint field team leader for a ground investigation along the route of a 200 km water transfer pipeline tunnel, including intermediate reservoirs, pump stations and a tunnel beneath the bosphorus channel. The investigation involved the application of field mapping and a wide range of field and testing techniques in highly variable geological terrain.
Katsina Water Transfer Scheme, Nigeria	Responsible for the route field mapping, ground investigation management and reporting for a 120 km water transfer pipeline with intermediate pumping stations.

London Underground Earth Structures, UK	Involved in various roles over a number of years in the initial geotechnical condition survey of the network, followed by the geotechnical investigation, testing and modelling of high risk cutting and embankment areas and ultimately the design and construction of mitigation measures.
Dumpil Irrigation Scheme, Indonesia	Ground investigation manager for the geotechnical investigation of 70 km of primary irrigation canal, assessments of the cause of recent catastrophic slope failures and the design and implementation of remedial measures.
Invicta Power Station, British Gas, Indonesia	Project manager for the ground investigation and preliminary foundation and excavation assessment for a proposed new power station.
Heathrow Terminal 5, British Airports Authority, UK	Project manager for various geotechnical investigations for the tunnels, structures and pavements.
Felixstowe Port Expansion, UK	Team member for a large wastewater transfer and treatment scheme in southern England, employing a wide range of land and overwater geotechnical field and laboratory testing techniques.
Dover and Folkestone Wastewater Scheme, UK	Team member for a large wastewater transfer and treatment scheme in southern England, employing a wide range of geotechnical field and laboratory testing techniques.
Hinkley Point "C" Nuclear Power Station	Member of field investigation team responsible for drilling and insitu stress measurement.
Mussenden Temple, UK	Detailed cliff face mapping and stability assessment for a coastal cliff beneath an important national monument.
National Rail Cutting, Nr Wakefield, UK	Detailed rock cutting mapping and stability assessment for a 20 m high main line railway cutting.

ENVIRONMENTAL

Maputo Port, Mozambique	Project manager for a soil and ground water contamination study for the whole port area.
Zimasco Smelter, Zimbabwe	Project manager for an Environmental Impact Assessment for proposed new developments at the smelter complex.
Port of Luanda, Angola	Team member responsible for the physical and engineering inputs to an Environmental Impact Assessment for a proposed expansion of the port.
Unki Mine, Zimbabwe	Responsible for geotechnical and engineering inputs for an Environmental Impact Assessment and Environmental Management Plan.
Total Zimbabwe	Team member for contamination assessments of fuel storage and dispensing stations in Zimbabwe.
Various Industrial Installations, Harare	Conducted a number of contamination risk assessments for industrial facilities in an around Harare, following implementation of new national contamination control legislation.

London Waste Regulation Authority	Team member responsible for many contamination audits in the London area as part of a term contract held by Mott MacDonald.
Niassa Reserve, Mozambique	Responsible for the physical and engineering inputs into an EIA for a proposed development of road infrastructure in the Niassa Reserve.
MINE WASTE DUMPS AND TAILINGS FACILITIES	
Mareesburg Tailings Dam, Anglo American Platinum	Project Director for the detailed design, pre-commissioning works construction and commissioning.
Helena Tailings Dam, Anglo American Platinum, South Africa	Reported tailings dam failures elsewhere in the world raised Anglo American's concerns regarding the stability of their own facilities. Following a review of all facilities, Helena was identified as the highest risk worldwide. A detailed ground investigation, instrumentation and remodelling exercise was carried out for the facility, focusing particularly on the liquefaction risks, ultimately culminating in the design and construction of a rock buttress. I was the project manager for the investigation, studies and mitigation works.
Fairbreeze Mine, Tronox, South Africa	Consultant project manager responsible for technical advice during the latter stages of construction and subsequently the commissioning and operation of the tailings facility.
Ngezi Mine, Zimplats, Zimbabwe	Responsible for the ground investigation and foundation assessment of the tailings facility.
Modikwa Platinum Mine, South Africa	Responsible for carrying out geotechnical safety audits and a review of the stability of the tailings facility.
ZCCM Tailings and Waste Dumps, Zambia	Team member for responsible for all geotechnical inputs for a condition survey and design of additional closure measures for all tailings disposal facilities and waste dumps managed by the national ZCCM in the Zambian Copper Belt. Subsequently responsible for reassessing certain facilities in more detail.
Katanga Mining Area, Kolwezi, DRC	Responsible for a number of geotechnical investigations, audits, feasibility studies and other development studies for a number of tailings dams in the Kolwezi area over several years.
Harmony, South Africa	Responsible for the tailings disposal portion of an overall audit for all Harmony mines in South Africa.
Pan African Resources, South Africa	Responsible for the tailings disposal portion of an overall audit for all Pan African Resources mines in South Africa.
Freda Rebecca Mine, Zimbabwe	Responsible for a geotechnical safety audit and assessment of the stability of the tailings facility.
Bindura Mine, Zimbabwe	Responsible for a geotechnical safety audit and assessment of the stability of the tailings facility.

Arcturus Mine, Zimbabwe	Responsible for a geotechnical safety audit and assessment of the stability of the tailings facility.
Blanket Mine, Zimbabwe	Responsible for a geotechnical safety audit and assessment of the stability of the tailings facility.
Zimbabwe Phosphates, Zimbabwe	Project manager for the geotechnical investigation, design and construction of a new tailings disposal facility and the geotechnical safety management of the pre-existing facility.
Molo Mine, Madagascar	Project manager for the geotechnical investigations and feasibility design for a new tailings disposal facility.
Darwendale Mine, Great Dyke Investments, Zimbabwe	Project manager for the geotechnical investigations and feasibility design for a new tailings disposal facility.

MINING

TI04 Mineral Sand Mining Project, Rio Tinto, Madagascar	Geotechnical investigation project manager for the mine development. A ground investigation was carried out to assess the excavatability of the sands and stability of excavation and dump faces for the dredging and dry mining operations. The investigation involved a comprehensive campaign using different drilling and sampling techniques, piezocone and laboratory testing. The project was unusual as the sands were weakly cemented with a biological cement.
Richards Bay Minerals, South Africa	Various audits and assessments of the geotechnical stability of the sand mining excavations and backfilling activities at Richard Bay.
Moma Mineral Sands Mine, Kenmare, Mozambique	Responsible for regular safety audits of all geotechnical facilities and management systems at the mine, including tailings and waste dumps, dry mining and rapidly moving dredge mining excavations.
Eiffel Flats, Zimbabwe	Responsible for a stability study of all historic underground mining cavities owned by Rio Tinto in the Eiffel Flats area of Zimbabwe, to ultimately identify the risk of surface subsidence.
Ngezi Mine, Zimbabwe,	Mapping, data collection and rock slope stability assessment for the trial mining excavation as part of the mine development design
Shurugwi Mines, Zimbabwe	Responsible for all geotechnical and environmental inputs into a closure study for historic mines around Shurugwi.

MEMBERSHIPS & REGISTRATIONS

Geological Society of London	Fellow and Chartered Geologist
South African Council for Natural Scientific Professions	Registered Professional Natural Scientist (Earth Sciences)

South African Institute for Engineering and Environmental Geologists	Member

CURRICULUM VITAE

MUHAMMAD OSMAN

SENIOR ENGINEERING GEOLOGIST

Geotechnical Engineering, Kwa-Zulu Natal.

QUALIFICATIONS

Pr Sci Nat	2021	Professional Natural Scientist with SACNASP
BSc Hons	2014	BSc Honours in Engineering and Environmental Geology, University of Kwa-Zulu Natal
BSc Geol	2013	BSc Degree in Geological Sciences, University of Kwa-Zulu Natal

EXPERTISE

- Project Management
- Subcontractor Supervision
- Infrastructure Development
- Renewable Energy
- Housing/Township Investigations
- Centre-line Investigations and Road Reserve Upgrades
- Borrow Pit and Materials Investigations
- Dam Investigations (Water)
- Pipeline and Reservoir Construction
- Heavily and Lightly Loaded Structures
- Foundation Assessments
- Slope Stability Analysis

Mr Muhammad Osman is a qualified engineering geologist with a BSc Honours degree in Engineering and Environmental Geology attained from the University of Kwa-Zulu Natal. He has 6 years of experience in the fields of engineering geology, geotechnical and materials investigations across South Africa and in Mozambique, for renewable energy projects, dams, roads, pipelines, single and multiple storey structures, as well as the co-ordination and supervision of geotechnical drilling operations.

As part of a geotechnical team, his responsibilities include preparation of detailed proposals and tender procurement documents, coordinating and undertaking field investigations and in-situ testing, analysis and interpretation of laboratory test results, detailed report compilation, supervision as well as management of projects and their budgets.

Muhammad is registered as a Professional Natural Scientist (Pr.Sci.Nat) with the South African Council for Natural Scientific Professions in the geological sciences (Reg No.115558).

PROJECTS

	Use This Title Style if the CV is Sorted by Project Type – Delete if not required
Ludeke Dam Remediation (2021)	Detailed geotechnical investigation to determine the cause of seepage on the right flank and settlement of the gravity retaining walls on the left flank of the Category 3 dam. Carried out drilling supervision, core logging and CPT testing.
Heineken Solar PV Plant (2021)	Project Leader and Field Engineering Geologist for the proposed Heineken Solar PV Plant underlain by Dolomite terrain in Sedibeng, Johannesburg. Field work comprised off trial pitting and DPL testing on a grid and surface mapping.

SLR

Kenhardt Solar PV Plant (2021)	Assistant project leader for the geotechnical investigation for the proposed Kenhardt Solar PV Plant in Upington. The investigation entailed the undertaking of trial pitting and percussion drilling in predominantly calcrete materials.
Brandvlei Wind Energy Facility (2021)	Desktop geotechnical study for the proposed Brandvlei Wind Energy Facility located in the Northern Cape. The study also focused on associated structures such as powerlines and substations.
Rietkloof Wind Energy Facility (2021)	Desktop geotechnical study for the proposed Rietkloof Wind Energy Facility located in the Northern Cape. The study also focused on associated structures such as powerlines and substations.
Karreebosch Wind Energy Facility (2021)	Desktop geotechnical study for the proposed Karrebosch Wind Energy Facility located in the Northern Cape. The study also focused on associated structures such as powerlines and substations.
Bevenson Dam (2020)	Detailed geotechnical investigation to determine the cause of seepage along the downstream shoulder of Bevenson Dam. The investigation entailed the drilling of rotary boreholes at various elevations of the downstream shoulder and analysis of the clay core material.
N2 Ballito to Tinley Manor (2020)	Assisting in the compilation of an interpretative geotechnical report for the proposed National Route 2 (N2) upgrade from Ballito to Tinley Manor, approximately 27km of road alignment.
Gluckstadt Water Supply Scheme (2020)	Project Leader and Field Engineering Geologist for the construction and installation of approximately 100Km of bulk and reticulation pipelines, 8 concrete reservoirs, a water treatment works and associated pump stations. The field investigation comprised the undertaking of trial pits, in-situ testing and representative disturbed/undisturbed sampling.
Eskom Eastern Cape Radio Towers (2020)	Geotechnical investigation for the proposed Eskom Radio Tower project comprising the erection of radio masts across the Eastern Cape. The investigation entailed the excavation of trial pits and DPL testing.
Piesang River Wetland Rehabilitation (2020)	Project Leader and Field Engineering Geologist undertaking a geotechnical materials investigation to determine the suitability and utilisation of in-situ materials for construction purposes.
National Route 3 (N3) Upgrade (2019)	Compilation of an interpretative geotechnical report for the proposed National Route 3 (N3) upgrade from Ashburton to Townhill. The project comprised the upgrading and construction of new carriageways, interchanges and drainage infrastructure.
Usuthu RWSS Off Channel Storage Dam (2019)	Detailed geotechnical investigation for the proposed construction of Usuthu RWSS Off Channel Storage Category 3 dam. The investigation entailed the drilling of rotary core boreholes along the proposed centre line, right and left flanks. A detailed materials investigation was also conducted, comprising drilling and trial pitting, for use during construction.

Ntuzuma to Ogunjini Water Supply Scheme (2019)	Geotechnical investigation for the proposed construction of a 20Km pipeline and 20Ml reservoir. The investigation entailed trial pitting along the proposed pipeline alignment and drilling supervision at the reservoir site.
Darvill Wastewater Treatment Works Sludge Dam (2019)	Geotechnical investigation for the proposed Darvill WWTW Sludge Dam and materials investigation for construction purposes. The field investigation consisted of trial pitting and in-situ testing.
Namas and Zonnequa Wind Farms (2018)	Pre-feasibility geotechnical investigation for the proposed Namas and Zonnequa Windfarms comprising a total of 100 wind turbine generators and associated substations. The investigation comprised trial pitting through aeolian and pedocrete materials.
Mzingazi Canal Bridge (2018)	Pre-feasibility geotechnical investigation for the proposed upgrade of the Mzingazi Canal Bridge crossing the Tuzi Gazi Waterfront in Richards Bay.
Military Veterans Residential Units (2018)	Detailed geotechnical investigation for proposed Military Veterans Housing Project in and around Pietermaritzburg. The investigation comprised trial pitting and in-situ testing for single and multiple storey units.
Bellair Clusters 1 & 2 Housing Development (2017)	Project Leader and Field Engineering Geologist for the proposed low to medium income housing as part of DOHS Serviced Sites Programme.
Department of Public Works Offices (2017)	Geotechnical and foundation investigation for the proposed upgrade to the Department of Public Works offices in Pietermaritzburg, in order to determine the cause of settlement and cracking. The investigation comprised the excavation and exposure of foundations, undisturbed sampling and in-situ testing.
Ethekwini Municipality Housing Developments (2017)	Geotechnical investigations for various housing developments in and around Durban. The investigations comprised trial pitting and in-situ testing for single and multiple storey residential units.
South 32 Mozal Desalination Plant (2017)	Geotechnical investigation for the proposed desalination plant to be constructed at the Mozambique Aluminium (Mozal) smelter in Matola, Mozambique. The investigation also included the pipeline alignment from the harbour.
Pietermaritzburg Airport Expansion (2016)	Detailed geotechnical investigation for the proposed upgrade to Pietermaritzburg Airport which included the construction of new access roads and additional buildings across the airport compound. The investigation entailed the excavation of trial pits, undisturbed sampling and in-situ testing.
Various Small to Medium Scale Projects (2015-2016)	Geotechnical investigation for various small to medium scale projects, including but not limited to housing developments, pipeline investigations and sanitation projects across Kwa-Zulu Natal.

MEMBERSHIPS

SACNASP (Pr Sci Nat)	Professional Natural Scientist with the South African Natural Scientific Professions

APPENDIX C: WSP IMPACT ASSESSMENT CRITERIA

Date: 26 October 2021

Project Description for the Camden Renewable Energy Cluster

BY

ENERTRAG South Africa Proprietary Limited

(Registration Number: 2017/143710/07)

Contents

Table of Figures

List of Tables

Table 12: Listed activities potentially applicable to the proposed developmentError! Bookmark not defined.

1 Project Description: Camden Renewable Energy Cluster near Ermelo, Mpumalanga Province

This document is intended to provide a description of the proposed Camden Renewable Energy Cluster of projects. The Cluster is being developed in the context of the Department of Mineral Resources and Energy's (DMRE) Integrated Resource Plan, and the Renewable Energy Independent Power Producer Procurement Programme (REIPPP), with further potential for private off-take by nearby mining and industrial operations.

The Cluster comprises eight (8) distinct projects, namely:

i. Camden I Wind Energy Facility (up to 210MW).
ii. Camden I Wind Grid Connection (up to 132kV).
iii. Camden up to 400kV Gid Connection and Collector substation.
iv. Camden I Solar 100MW.
v. Camden I Solar up to 132kV Gid Connection.
vi. Camden Green Hydrogen and Ammonia Facility, including grid connection infrastructure.
vii. Camden II Wind Energy Facility (up to 210MW).
viii. Camden II Wind Energy Facility up to 132kV Gid Connection.

These project descriptions are intended to provide sufficient project detail to facilitate effective Environmental Impact Assessment (EIA) of each proposed project in different specialist disciplines. If additional detail on any of the projects or project components are required, please contact WSP.

2 Introduction

Enertrag South Africa is a subsidiary of the German-based Enertrag AG, a hydrogen and renewable energy developer founded in 1992. Enertrag AG has an established track-record of renewable energy projects around the world, comprising over 100 wind turbines with an installed capacity of over 760MW, and over 500 employees. Current Projects are in Germany, United Kingdom, France, Poland, Bulgaria and Belarus.

Enertrag South Africa (hereafter "Enertrag SA") was established in 2017, with the intention to investigate and develop renewable energy projects in South Africa. The transition from coal-based energy supply to renewables in the Country is inevitable, as coal resources are depleted, coal-based power stations reach the end of their economic life and considering international obligations and commitments to reduced emissions. The Complex development area is blanketed with numerous coal prospecting and mining rights. Coal mining and energy derived from coal mining is the likely alternative to the Complex. Enertrag SA goals is to be a market leader in making the Just Energy Transition a reality for South Africa. This Complex serves as the first step to this transition.

Enertrag SA currently has numerous wind measurement campaigns throughout South Africa and owns the Darling Wind Farm in the Western Cape. Enertrag SA was the first Independent Power Producer to commence with wind measurement campaigns in Mpumalanga. During the time of the installation of the campaigns, mainstream belief was that there were insufficient wind resources in Mpumalanga for a wind farm to be viable. Data from the wind measurement campaigns has now shown that the wind resource is viable for wind farm development in the region. Other Independent Power Producers are now following suit and securing land for renewable energy development throughout Mpumalanga.

The proposed Camden Renewable Energy Cluster covers the following farms:

1. **Camden I Wind Energy Facility (up to 210MW)**
    - Portion 0 of Klipfontein Farm No. 442
    - Portion 1 of Welgelegen Farm No. 322
    - Portion 1 of Klipfontein Farm No. 442
    - Portion 2 of Uitkomst Farm No. 292
    - Portion 2 of Welgelegen Farm No. 322
    - Portion 3 of Langverwatch Farm No. 293
    - Portion 3 of Klipbank Farm No. 295
    - Portion 3 of Klipfontein Farm No. 442
    - Portion 10 of Uitkomst Farm No. 292
    - Portion 14 of Mooiplaats Farm No. 290

2. **Camden I Wind Grid Connection (up to 132kV)**
    - Potions XX

3. **Camden Grid Connection (up to 400kV) and Collector Substation**

    Indicative Option One
    - Portion 0 of Farm No. 329
    - Portion 14 of Mooiplaasts Farm No. 290
    - Portion 1 of Welgelegen Farm No. 322

    Indicative Option Two
    - Portion 0 of Farm No. 329
    - Portion 14 of Mooiplaasts Farm No. 290
    - Portion 1 of Welgelegen Farm No. 322
    - Portion 2 of Welgelegen Farm No. 322

4. **Camden I Solar Energy Facility (up to 100MW)**
    - Portion 1 of Welgelegen Farm No. 322

5. **Camden I Solar Grid Connection (Up to 132kV)**

    Indicative Option One
    - Portion 1 of Welgelegen Farm No. 322

- Portion 2 of Welgelegen Farm No. 322

Indicative Option Two

- Portion 1 of Welgelegen Farm No. 322

6. Camden Green Hydrogen and Ammonia Facility, including grid connection (up to 132kV)

- Portion 1 of Welgelegen Farm No. 322
- Portion 2 of Welgelegen Farm No. 322

7. Camden II Wind Energy Facility (up to 210MW)

- Portion 0 of Adrianople Farm No. 296
- Portion 1 of Adrianople Farm No. 296
- Portion 2 of Adrianople Farm No. 296
- Portion 3 of Adrianople Farm No. 296
- Portion 3 of Buhrmansvallei Farm No. 297
- Portion 4 of Buhrmansvallei Farm No. 297
- Portion 3 of De Emigrate Farm No. 327
- Portion 5 of Buhrmansvallei Farm No. 297
- Portion 5 of Klipfontein Farm No. 326
- Portion 6 of De Emigrate Farm No. 327

***8.* Camden II Wind Gid Connection (Up to 132kV)**

Indicative Option One Portions 0, and 3 of Adrianople Farm No. 296

- Portion 3 of Klipbank Farm No. 295
- Portions 1 and 2 of Welgelegen 322

Indicative Option Two
Portions 0, 2, 3 of Adrianople Farm No. 296

- Portion 3 of Klipbank Farm No. 295
- Portions 1 and 2 of Welgelegen 322

Enertrag SA proposes to develop the Cluster as detailed in this document and has appointed WSP as the independent Environmental Assessment Practitioner (EAP) to facilitate the respective Environmental Impact Assessment (EIA) Processes.

Each of the projects will be described as a stand-alone project in this document, though they are inevitably linked and integrated. As such, the impact assessments to be undertaken must consider the cumulative nature of impacts as well as the potential impact(s) of individual projects and project components.

3 Camden I Wind Energy Facility (up to 210MW)

Table 1 Project Summary- Camden I Wind Energy Facility (WEF)

Facility Name	Camden I Wind Energy Facility
Applicant	Camden I Wind Energy Facility (RF) Propriety Limited
Municipalities	Msukaligwa Local Municipality of the Gert Sibande District Municipality
Affected Farms[1]	o Portion 0 of Klipfontein Farm No. 442 o Portion 1 of Welgelegen Farm No. 322 o Portion 1 of Klipfontein Farm No. 442 o Portion 2 of Uitkomst Farm No. 292 o Portion 2 of Welgelegen Farm No. 322 o Portion 3 of Langverwatch Farm No. 293 o Portion 3 of Klipbank Farm No. 295 o Portion 3 of Klipfontein Farm No. 442 o Portion 10 of Uitkomst Farm No. 292 o Portion 14 of Mooiplaats Farm No. 290
Extent	6 000 ha
Buildable area	Approximately 200 ha, subject to finalization based on technical and environmental requirements
Capacity	Up to 210MW
Number of turbines	Up to 47
Turbine hub height:	Up to 200m
Rotor Diameter:	Up to 200m
Foundation	Approximately 25m^2 diameter x 3m deep – 500 – 650m^3 concrete. Excavation approximately 1000m^2, in sandy soils due to access requirements and safe slop stability requirements.
Operations and Maintenance (O&M) building footprint:	Located in close proximity to the substation. Septic tanks with portable toilets Typical areas include: - Operations building – 20m x 10m = 200m^2 - Workshop – 15m x 10m = 150m^2 Stores - 15m x 10m = 150m^2
Construction camp laydown	Typical area 100m x 50m = 5000m^2. Sewage: Septic tanks and portable toilets
Temporary laydown or staging area:	Typical area 220m x 100m = 22000m^2. Laydown area could increase to 30000m^2 for concrete towers, should they be required.
Cement batching plant (temporary):	Gravel and sand will be stored in separate heaps whilst the cement will be contained in a silo.

[1] Based on the current conceptual layout.

Internal Roads:	Width of internal road – Between 5m and 6m. Length of internal road – Approximately 60km. Where required for turning circle/bypass areas, access or internal roads may be up to 20m to allow for larger component transport.
Cables:	The medium voltage collector system will comprise of cables up to and including 33kV that run underground, except where a technical assessment suggest that overhead lines are required, within the facility connecting the turbines to the onsite substation.
Independent Power Producer (IPP) site substation and battery energy storage system (BESS):	Total footprint will be up to 6.5ha in extent (5ha for the BESS and 1.5ha for the IPP portion of the substation). The substation will consist of a high voltage substation yard to allow for multiple (up to) 132kV feeder bays and transformers, control building, telecommunication infrastructure, access roads, and other substation components as required. The associated BESS storage capacity will be up to 200MW/800MWh with up to four hours of storage. It is proposed that Lithium Battery Technologies, such as Lithium Iron Phosphate, Lithium Nickel Manganese Cobalt oxides or Vanadium Redox flow technologies will be considered as the preferred battery technology however the specific technology will only be determined following EPC procurement. The main components of the BESS include the batteries, power conversion system and transformer which will all be stored in various rows of containers.

Table 2 Affected Properties[2] and associated surface rights ownership- Camden 1 Wind Energy Facility (WEF)

Parent Farm	Farm No	Portion No	Owner
Klipbank	295	3	Hendrick Jackobus Willem Reyneke
Klipfontein	442	0	Zeelie Broers CC
Klipfontein	442	1	Lood De Jager Trust
Klipfontein	442	3	Zeelie Broers CC
Langverwacht	293	3	Lood De Jager Trust
Mooiplaasts	290	14	Lood De Jager Trust

[2] Based on the current conceptual layout.

Parent Farm	Farm No	Portion No	Owner
Uitkomst	292	2	Lood De Jager Trust
Uitkomst	292	10	De Jager Johannes Lowewyk
Welgelegen	322	1	Reyneke Hendrik Jackobus Willem
Welgelegen	322	2	Reyneke Hendrik Jackobus Willem

4 Camden I Wind Grid Connection (up to 132kV)

It is proposed that Camden I will connect to the nearby Camden Collector substation (which in turn will connect to the Camden Power Station), through an up to 132kV powerline (either single or double circuit) between the grid connection substation portion (immediately adjacent the Camden I on-site IPP substation portion) and that of the Camden Collector substation. The powerline will be approximately 14km in length, depending on the authorized location of the collector substation. The onsite grid connection substation will consist of high voltage substation yard to allow for multiple (up to) 132kV feeder bays and transformers, control building, telecommunication infrastructure, access roads, etc. The area for the onsite substation will be up to 1.5ha. The up to 132kV powerline and substation will have a 250m corridor. This application includes the necessary up to 132kV voltage electrical components required for connection at the Collector Substation.

Portions of the following farms are affected:

Table 3 Affected Properties and associated surface rights ownership- Camden I Wind Grid Connection (up to 132kV)

Parent Farm	Farm No	Portion No	Owner
Klipbank	295	0	Reyneke Hendrik Jackobus Willem
Adrianople	296	0	Rassie Saaiman Trust
Adrianople	296	1	Lood De Jager Trust
Welgelegen	322	1	Reyneke Hendrik Jackobus Willem
Welgelegen	322	2	Reyneke Hendrik Jackobus Willem
Klipbank	295	3	Reyneke Hendrik Jackobus Willem
Adrianople	296	3	Van Der Meulen Trust

5 Camden up to 400kV powerline and Collector Substation

It is proposed that the broader Camden developments will connect to the nearby Camden Power Station substation (Camden substation and Uitkoms substation) through an up to 400kV powerline (either single or double circuit) either directly (alternate option), or via a Loop-In-Loop-Out (LILO) option into the existing Eskom Camden I – Incandu 400kV line traversing the Camden I project site (preferred option). Where direct connection is envisaged, the powerline will be approximately 8km in length. Depending on location, the LILO into the Camden I – Incandu 400kV line will require a 400kV line of approximately 2km in length.

The onsite Collector Substation (MTS)(two alternatives being provided for the purposes of assessment) will consist of a high voltage substation yard to allow for multiple (up to) 400kV feeder bays and transformers, control building, telecommunication infrastructure, access roads, etc. This substation will comprise the high-voltage components of the export solution for the broader Camden Cluster development and will comprise 132kV Collector substation components, which collect all the incoming 132kV power lines from the respective facilities, as well as the 400kV step-up infrastructure required for connection to the Camden Power Station. In addition, the expansion of the Camden Power Station substation as required forms part of this application.

The area for the onsite Collector Substation (MTS) will be up to 5ha and up to 1ha for the Camden Power Station substation expansion (if and as required). The up to 400kV powerline and substation will have a 250m assessment corridor to allow for micro-siting.

Two alternative new powerline routes are being investigated for direct connection into the Camden Power Station. In addition, two alternate routes are envisaged from the respective on-site Collector Substation for the Loop-In-Loop-Out option connection. Each of these will have a 250m assessment corridor to allow for micro-siting.

Portions of the following farms are affected:

Table 4 Affected Properties and associated surface rights ownership- Camden up to 400kV grid connection and Collector Substation

Parent Farm	**Farm No**	**Portion No**	**Owner**
Indicative Option 1			
Mooiplaasts	290	14	Lood De Jager Trust
Welgelegen	322	1	Reyneke Hendrik Jackobus Willem
Indicative Option 2			
Mooiplaasts	290	14	Lood De Jager Trust
Welgelegen	322	1	Reyneke Hendrik Jackobus Willem
Welgelegen	322	2	Reyneke Hendrik Jackobus Willem

6 Camden I Solar PV (100MW)

Camden I Solar will consist of a 100MW Solar PV facility, to complement the energy production from the Camden I WEF. The solar PV array will cover an area of 297ha, subject to finalization based on technical and environmental requirements.

Table 5: Camden I Solar PV Facility details

Facility Name	Camden I Solar Energy Facility
Applicant	Camden I Solar Energy Facility (RF) Propriety Limited
Municipalities	Msukaligwa Local Municipality of the Gert Sibande District Municipality
Affected Farms[3]	Portion 1 of Welgelegen Farm No. 322
Extent	~ 297 ha
Buildable area	Approximately 280 ha, subject to finalization based on technical and environmental requirements
Capacity	Up to 100MW
Power system technology	Solar PV
Operations and Maintenance (O&M) building footprint:	Located near the substation. Septic tanks with portable toilets Typical areas include: - Operations building – 20m x 10m = 200m^2 - Workshop – 15m x 10m = 150m^2 Stores - 15m x 10m = 150m^2
Construction camp and laydown area	Typical construction camp area 100m x 50m = 5,000m^2. Typical laydown area 100m x 200m = 20,000m^2. Sewage: Septic tanks and portable toilets
Cement batching plant (temporary):	Gravel and sand will be stored in separate heaps whilst the cement will be contained in a silo.
Internal Roads:	Width of internal road – Between 4m and 5m. Where required for turning circle/bypass areas, access or internal roads may be up to 20m to allow for larger component transport. Length of internal road – Approximately 8km.
Cables:	Communication, AC and DC cables.
Independent Power Producer (IPP) site substation and battery energy storage system (BESS):	Total footprint will be up to 6.5ha in extent (5ha for the BESS and 1.5ha for the IPP portion of the substation). The substation will consist of a high voltage substation yard to allow for multiple

[3] Based on the current conceptual layout.

	(up to) 132kV feeder bays and transformers, control building, telecommunication infrastructure, access roads, etc. The associated BESS storage capacity will be up to 100MW/400MWh with up to four hours of storage. It is proposed that Lithium Battery Technologies, such as Lithium Iron Phosphate, Lithium Nickel Manganese Cobalt oxides or Vanadium Redox flow technologies will be considered as the preferred battery technology. The main components of the BESS include the batteries, power conversion system and transformer which will all be stored in various rows of containers.

7 Camden I Solar Energy Facility up to 132kV powerline

It is proposed that Camden I Solar will connect to the nearby Camden Collector substation (which in turn will connect to the Camden Power Station), through an up to 132kV powerline (either single or double circuit) between the grid connection substation portion (immediately adjacent the Camden I Solar PV on-site IPP substation portion) and that of the Camden Collector substation. The powerline will be approximately 14km in length, depending on the authorized location of the collector substation. The onsite grid connection substation will consist of high voltage substation yard to allow for multiple (up to) 132kV feeder bays and transformers, control building, telecommunication infrastructure, access roads, etc. The area for the onsite substation will be up to 1.5ha. The up to 132kV powerline and substation will have a 250m corridor. This application includes the necessary up to 132kV voltage electrical components required for connection at the Collector Substation (i.e. the termination works).

Table 6 Affected Properties and associated surface rights ownership- Camden I Solar Powerline

Parent Farm	**Farm No**	**Portion No**	**Owner**
Indicative Option One			
Welgelegen	322	1	Reyneke Hendrik Jackobus Willem
Welgelegen	322	2	Reyneke Hendrik Jackobus Willem
Indicative Option Two			
Welgelegen	322	2	Reyneke Hendrik Jackobus Willem

8 Camden II Wind Energy Facility (up to 210MW)

Table 7 Project Summary- Camden II Wind Energy Facility (WEF)

Facility Name	Camden II Wind Energy Facility
Applicant	Camden II Wind Energy Facility (RF) Propriety Limited
Municipalities	Msukaligwa Local Municipality of the Gert Sibande District Municipality
Affected Farms[4]	○ Portion 0 of Adrianople Farm No. 296 ○ Portion 1 of Adrianople Farm No. 296 ○ Portion 2 of Adrianople Farm No. 296 ○ Portion 3 of Adrianople Farm No. 296 ○ Portion 3 of Buhrmansvallei Farm No. 297 ○ Portion 4 of Buhrmansvallei Farm No. 297 ○ Portion 3 of De Emigrate Farm No. 327 ○ Portion 5 of Klipfontein Farm No. 326 ○ Portion 6 of De Emigrate Farm No. 327
Extent	4300 ha
Buildable area	Approximately 200 ha, subject to finalization based on technical and environmental requirements
Capacity	Up to 210MW
Number of turbines	Up to 50
Turbine hub height:	Up to 200m
Rotor Diameter:	Up to 200m
Foundation	Approximately $25m^2$ diameter x 3m deep – 500 – $650m^3$ concrete. Excavation approximately $1000m^2$, in sandy soils due to access requirements and safe slop stability requirements.
O&M building footprint:	Located near the substation. Septic tanks (operational phase) with portable toilets for construction phase. Typical areas include: - Operations building – 20m x 10m = $200m^2$ - Workshop – 15m x 10m = $150m^2$ - Stores - 15m x 10m = $150m^2$
Construction camp laydown	Typical area 100m x 50m = $5000m^2$. Sewage: Portable toilets.
Temporary laydown or staging area:	Typical area 220m x 100m = $22000m^2$. Laydown area could increase to $30000m^2$ for concrete towers, should they be required.
Cement batching plant (temporary):	Gravel and sand will be stored in separate heaps whilst the cement will be contained in a silo.
Internal Roads:	Width of internal road – Between 5m and 6m. Length of internal road – Approximately 60km. Where required for turning circle/bypass areas, access or internal roads may be up to 20m to allow for larger component transport.
Cables:	The medium voltage collector system will comprise of cables up to and include 33kV that run underground, except where a technical assessment suggest that

[4] Based on the current conceptual layout.

	overhead lines are required, in the facility connecting the turbines to the onsite substation.
IPP site substation and battery energy storage system (BESS):	Total footprint will be up to 6.5ha in extent (5ha for the BESS and 1.5ha for the IPP portion of the substation). The substation will consist of a high voltage substation yard to allow for multiple (up to) 132kV feeder bays and transformers, control building, telecommunication infrastructure, access roads, etc. The BESS storage capacity will be up to 200MW/800MWh with up to four hours of storage. It is proposed that Lithium Battery Technologies, such as Lithium Iron Phosphate, Lithium Nickel Manganese Cobalt oxides or Vanadium Redox flow technologies will be considered as the preferred battery technology. The main components of the BESS include the batteries, power conversion system and transformer which will all be stored in various rows of containers.

Table 8 Affected Properties[5] and associated surface rights ownership- Camden II Wind Energy Facility (WEF)

Parent Farm	Farm No	Portion No	Owner
Adrianople	296	0	Rassie Saaiman
Adrianople	296	1	Lood De Jager Trust
Adrianople	296	2	Smuts Willem Francois
Adrianople	296	3	Van Der Meulen Trust
Buhrmanvallei	297	3	Van Der Meulen Trust
Buhrmanvallei	297	4	Van Der Meulen Trust
De Emigrate	327	3	Buhrman Hendrik Theodor
Buhrmanvallei	297	5	Van Der Meulen Trust
Klipfontein	326	5	Van Der Meulen Trust
De Emigrate	327	6	Van Der Meulen Trust

9 Camden II Wind Energy Facility up to 132kV powerline

It is proposed that Camden II will connect to the nearby Camden Collector substation (which in turn will connect to the Camden Power Station), through an up to 132kV powerline (either single or double circuit) from the Camden II Wind Energy Facility grid connection substation portion and that of the Collector substation. The powerline will be approximately 14km in length. The onsite grid connection substation will consist of high voltage substation yard to allow for multiple (up to) 132kV feeder bays and transformers, control building, telecommunication infrastructure, access roads, etc. The area for the onsite substation will be up to 1.5ha. The up to 132kV powerline and substation will have a 250m corridor.

[5] Based on the current conceptual layout.

Portions of the following farms are affected:

Table 9 Affected Properties and associated surface rights ownership- Camden II Wind up to 132kV Grid

Parent Farm	Farm No	Portion No	Owner
Klipbank	295	0	Reyneke Hendrik Jackobus Willem
Adrianople	296	0	Rassie Saaiman Trust
Adrianople	296	1	Lood De Jager Trust
Welgelegen	322	1	Reyneke Hendrik Jackobus Willem
Welgelegen	322	2	Reyneke Hendrik Jackobus Willem
Klipbank	295	3	Reyneke Hendrik Jackobus Willem
Adrianople	296	3	Van Der Meulen Trust

10 Camden I Green Hydrogen and Ammonia

Enertrag developed its first green hydrogen facility, Hybridkraftwerk, in Germany which is powered by wind energy. The Hybridkraftwerk was commissioned in October 2011 and produces 94 tons of hydrogen per year (refer figure below).

Figure 1: Enertrag Germany's Hybridkraftwerk.

Figure 2: Closer View of Electrolyser Housing and Storage Tanks.

Camden Green Energy RF (Pty) Ltd, a special purpose vehicle ("SPV") to be established for the sole purpose of developing, owning and operating the proposed up to 150MW green hydrogen and ammonia facility ('Facility'). The Facility will encompass approximately 25 hectares of land (two alternative locations being assessed), and the affected land parcels are shown in Table 10.

"Green" hydrogen and ammonia production differs from traditional production technologies in that the process relies exclusively on renewable resources (renewable energy) and for input air and water (feedstock), to produce commercially usable green hydrogen and ammonia. The only solid waste stream is the production of brine from the water treatment plant. Ammonia spillages may occur however these will be accidental and mitigation measures will be developed and implemented, including amongst others suitable containment related to storage and emergency response measures.

A gaseous 'waste' (oxygen) is generated from the electrolyses process. Another source of gaseous 'wastes' is from the Air Separation Unit. This is where nitrogen is removed from the air and the other natural gases as expelled back to the environment.

Traditional hydrogen and ammonia are produced thought the burning of fossil fuels (coal or natural gas) to provide the required energy needed for their production. This method of production results in 'brown' hydrogen as fossil fuels are used and therefore carbon forms an integral part of such traditional hydrogen production.

Commercially, hydrogen is used as a fuel for transport in hydrogen fuel cells. Alternatively, hydrogen is used for welding and in the production of other chemicals such as methanol and hydrochloric acid and also has other commercial uses like the filling of balloons. It is also a primary input to the production of ammonia. Ammonia in turn is primarily used in the production of ammonium nitrate (fertiliser) and is also used as refrigerant gas and the manufacture of plastics, explosives, textiles, pesticides and other chemicals. Ammonia can also be used as a stable 'carrier' of hydrogen, allowing hydrogen to be readily stored and transported. A simplified flow process diagram is shown in Figure 3 and Figure 4.

Table 10 Affected Properties and associated surface rights ownership - Camden I Green Hydrogen Plant

Parent Farm	Farm No	Portion No	Owner
Indicative Option One			
Welgelegen	322	1	Reyneke Hendrik Jackobus Willem
Indicative Option Two			
Welgelegen	322	2	Reyneke Hendrik Jackobus Willem

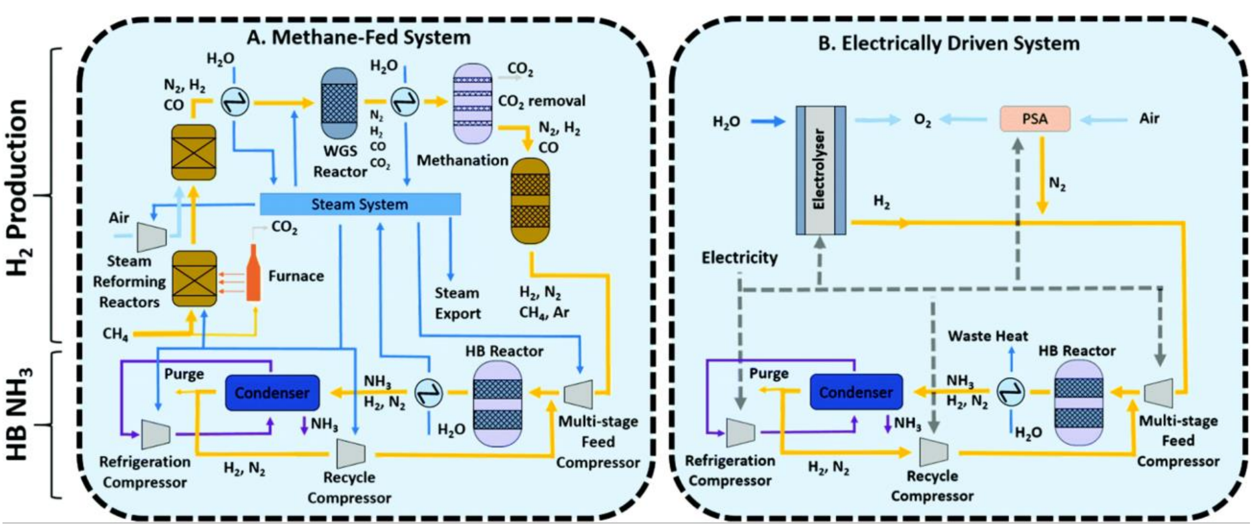


Figure 3: Simplified process flow diagram- traditional ammonia vs green ammonia production.

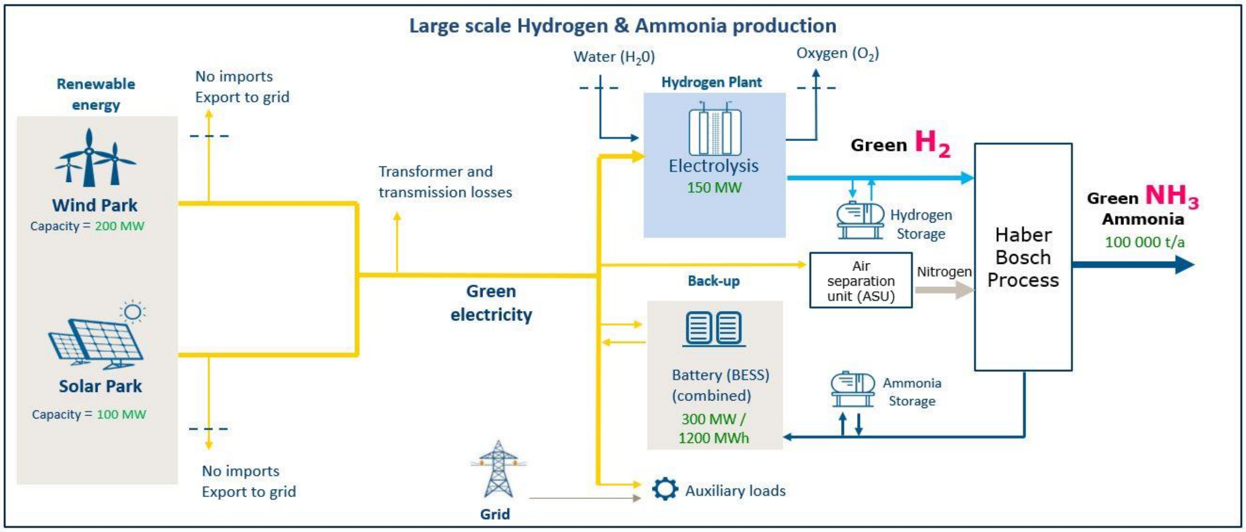


Figure 4: Simplified green hydrogen and ammonia production life cycle example.

The production, storage and transport of hydrogen and ammonia is an industry undergoing in-depth research and developments. Consequently, technological solutions are constantly being improved and changing. Thus, the below Facility description is based on available technological solutions, however, the underlying fundamentals will remain.

The facility comprises the following components as summarised in Table 11, where the footprint and capacities are presented. These parameters on based on the assumption that an up to 150MW electrolyser is installed (maximum). These components are detailed further below, but comprise the following general components:

- Water treatment.
- Electrolyser.
- Air separator.
- Ammonia processing unit.
- Liquid air energy system (LAES) for nitrogen storage.
- Feedstock and product storage.
- Utilities.
- Gantry and loading bay.

Associated infrastructure further include:

- Electrical infrastructure required for power supply to the facility.
- Temporary and permanent laydown areas required for temporary storage and assembly of components and materials.
- Access road/s to the site and internal roads between project components, with a width of up to up to 6m wide respectively.
- A temporary concrete batching plant (if necessary).
- Temporary staff accommodation.

- Fencing and lighting.
- Lightning protection.
- Telecommunication infrastructure.
- Stormwater channels.
- Water pipelines.
- Offices.
- Operational control centre.
- Operation and Maintenance Area / Warehouse / workshop.
- Ablution facilities.
- A gate house.
- Control centre, offices, warehouses.
- Security building.

Access to the site is possible primarily via an unnamed gravel road immediately off the N11 (south of Ermelo town). Existing roads will be used where feasible and practical.

Table 11 Facility Components

No.	Component	Footprint (Ha)	Storage Capacity (m^3 / tons)	Maximum Throughput (m^3 / tpa)	Conversion	Note
1	Water Reservoir	2	6 800 / 6 800	800 / 800	Density of water taken as 1 000 kg/m3	Process and utilities water
2	Water Treatment Unit	1.5	N/A	192 000 / 192 000	Density of water taken as 1 000 kg/m3	Process and utilities water
3	Electrolyser Unit	1	N/A	(1 239 157 – 301 932 367) / 20 000	Density of hydrogen can be 16.14kg/m3 at 200 barg and 25 °C or 0.06624 kg/m3 at 0 barg and 90 °C depending on the operating conditions of the unit.	Hydrogen Output Oxygen Output
4	Air Separation Unit	0.5	N/A	92 905 405 / 110 000	The density of air taken as 1.184 kg/m3	Air Input
5	Ammonia Processing Unit	2	N/A	149 253 / 100 000	The density of liquid ammonia taken 670 kg/m3 at -33 °C at 1 atm	Ammonia Output
6	Liquid Air Storage System (LAES)	1	3 983/ 3 505	460 227 / 405 000	The density of liquid nitrogen taken 880 kg/m3 at -33 °C at 1 atm	Nitrogen Storage
7	Liquid Ammonia Storage Tank	2	2 273/ 1 523	261 194 / 175 000	The density of liquid ammonia taken as 670 kg/m3 at -196 °C at 1 atm	
8	Hydrogen and Oxygen Storage Tank Farm	12	59 566/ 800	5 576 208 / 90 000	A density of 16.14kg/m^3 for hydrogen at 200 barg and 25 °C. Oxygen density estimated at liquid boiling point and 1 atmosphere pressure, totaling 1141 kg/m^3.	Hydrogen and Oxygen storage (combined tank farm), i.e. feedstock storage
9	Ancillary infrastructure	3	n/a	n/a	n/a	Includes temporary and permanent laydown areas, parking, offices and other related infrastructure.
	Total Footprint	**25**				

10.1 Water Reservoir

- Water will be stored in a water reservoir with a footprint of up to 1.5ha. The water reservoir will have a capacity of approximately 6800 m^3.
- It is proposed that three water reservoirs will be located on site. Each reservoir will have a diameter of up to 25m and a height of 6m (maximum height up to 15m).
- The water reservoirs will consist of a reinforced concrete or steel cylindrical tanks (refer Figure 5 below).

10.1.1 Identification of possible water sources:

A variety of water sources are being investigated for the broader development, and include the following:

- Groundwater: Various boreholes may be utilised across the project site for extraction of construction and operational water requirements. The volumes will be dependent on the available groundwater and the quality thereof, which has not yet been determined.
- Municipal water: Where available, water may be sourced for construction and operation from municipal reticulation. No defined off-take point has been determined currently however discussions with the municipality is ongoing towards the most appropriate off-take point.
- Purified wastewater: Wastewater from nearby commercial or mining facilities could be sourced to provide the facility with water. This would depend on availability of suitable quality wastewater and agreements with the respective entities involved. It is possible that water may be sourced from existing surrounding mining operations that are experiencing or anticipating mine water decant from their operations. Using this water in the green hydrogen and ammonia facility is potentially beneficial.
- Usuthu pipeline (preferred option): Bulk water infrastructure currently feeding the surrounding coal mines and power stations (specifically Eskom Camden Power Station) may be utilised for construction and operational water Initial water results indicate good quality supply in sufficient quantities is available. This option is the preferred water sourcing for the development.

Figure 5 Typical water reservoir (left concrete, right steel tank ~ 6m).

10.2 Water treatment

Water is required for the production of hydrogen and for heating and cooling purposes. The water treatment facility will be housed in a warehouse with a footprint of 1 ha.

- Water treatment technology:
  - Water treatment facilities usually contain multi-filtration stages and pumps.
  - Water for the facility must first be purified (ASTM Type II quality) through a Reverse Osmosis system (RO). The RO system consumes between 10 - 16 liters of water per kg -of hydrogen. Water consumption ultimately depend on the quality of the feed water.
  - The water treatment facility is estimated to consume up to 192 000 tons per annum (tpa) of water per annum, with an additional estimated 2 000 tpa for utilities related to general running of the plant.
  - Purified water from the water treatment facility is the main input to the next step in the process, namely the electrolyser.

Figure 6 Example of a water treatment plant (EcoPura RO Plant).

10.2.1 Waste stream

- Water treatment is associated with the generation of concentrated wastes removed from the water, such as brine salt. The quantity of brine produced is directly related to the quality of the feedwater and efficiency of the RO process. Based on standard tap water, it can be assumed that for every 10 litres of purified water there will be 4 litres of bine produced. Liquid brine can be made into a solid through several available technologies such as, settlement tanks, cooling water circuits, and forced crystallization.

- Based on the water samples taken to date and the quality of the Usuthu pipeline feedwater, a total dissolved solids content of around 200mg/l is anticipated. Should plant consume up to 192 000 tons of water, this would result in a maximum of 38 tons of sold salt being created per year (~105kg per day) assuming all salts are removed. This represents the worst-case scenario. Liquid brine will be dewatered to recycle water and reduce the need for new input water. This dewatered, solid brine will then be readily disposed off at the nearest suitably licenced waste disposal facility. On-site storage of solid brine blocks will be in containerised waste skips with sufficient capacity for replacement every 1 – 2 weeks, during which time a large truck will remove the filled container to a waste disposal facility. Many of the surrounding mines have existing, licensed waste management facilities potentially suitable for the disposal of such wastes, or nearby (Ermelo) waste disposal facilities may be utilised.

- Alternatively (least preferred option), the wastewater will be used for irrigation water for the local famers by diluting the concentrated liquid brine produced by the hydrogen and ammonia plant by introducing additional fresh water, or where possible re-used process water from the RO plant.
- In addition, should sufficient quantities of feed water be available, brine may be diluted with fresh feedwater and used for Solar PV panel washing, dust suppression or similar use.

10.3 Electrolyser (up to 150MW)

- The up to 150MW electrolyser will be housed in a warehouse building and will have a footprint of up to 1ha.
- The electrolyser will use direct electric current (obtained from the Renewable Energy Facilities) to drive an otherwise non-spontaneous chemical reaction, in this case the separation of $2H_2O$ (water molecule from the RO process) through a reduction-oxidation (redox) process into H_2 (Hydrogen on the cathode side) and O_2 (Oxygen on the anode side). Electrolysers are modular and currently range in size from 5MW – 20MW. It is proposed that the Green Hydrogen Facility will consist of 15 sets of 10MW electrolysers. Each electrolyser unit will be powered through its own set of transformers and rectifiers.
- Two electrolysis technologies may be considered, namely alkaline- and polymer electrolyte membrane electrolysis ('PEM'). The most likely technology to be used in the PEM, however this will only be confirmed once detailed engineering design has been completed and EPC contractual arrangements concluded.
- An up to 150MW electrolyser would produce up to 20,000 tons per annum (tpa) of green hydrogen and up to 40 000 tpa of green oxygen. The oxygen may be released or stored and sold as a by-product. The hydrogen may be directed to the Ammonia production plant (see "ammonia processing" below) or be stored and sold to interested parties directly.

Figure 7: Example of an Electrolyser Unit (Nel Proton PEM)

10.4 Air separator unit

- The air separation until will occupy a footprint of up to 0.5ha and the intake tower will have a maximum height of up to 40m (due to the height of the 'cold box' – the tallest vertical component of the air separation unit).
- Air is obtained from the immediate surroundings and separated into nitrogen (N_2) and oxygen (O_2) with the impurities removed. The process involves air compression and temperature manipulation in a pressure-controlled environment to separate gasses from one another and produce gaseous N_2.
- The air separation unit will have a maximum capacity of up to 110,000 tpa.
- Alternative technologies exist (including Pressure Swing Adsorption (PSA) and Membrane Separation Technologies) and are being evaluated; the most efficient process will be implemented in the final project design.

Figure 8: Example of an Air Separation Unit (Linde ECOGAN Containerized System)

10.5 Ammonia Processing Unit

- Ammonia is produced through the Haber-Bosch process. This is where stoichiometric amounts of nitrogen and hydrogen are reacted to produce ammonia. The conversion is typically achieved at 100 barg and between 400 - 500 °C to favour the formation of ammonia at equilibrium. A catalyst is also used to favour the production of ammonia. The gas is then rapidly cooled to form anhydrous ammonia with the unreacted nitrogen and hydrogen recycled back to reactor.

- Nitrogen (N_2) from the air separator process and Hydrogen (H_2) from the electrolyser are reacted over a bed of catalyst to favour the production of ammonia (NH_3). The gas is then rapidly cooled to form anhydrous (free from water) ammonia because it is more stable and less toxic in liquid form. Un-reacted N_2 and H_2 will be recycled back to the reactor.
- If the full 20,000 tpa of green hydrogen generated by the electrolyser is directed to this process, this will produce up to 100,000 tpa of liquid, green ammonia for market.
- Typical components of an ammonia production plant include compressors, filters, reactor chamber and beds, heat exchangers, water storage vessels, condensers, separators, circulators, absorbers and gas release valves.

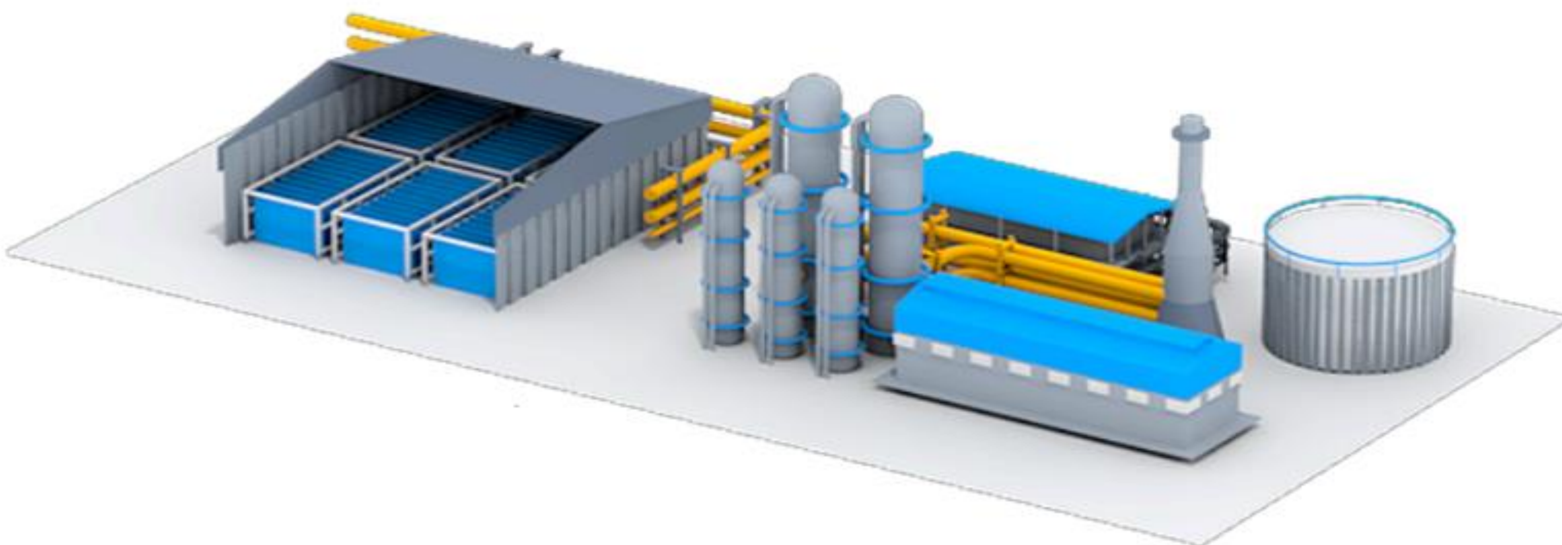


Figure 9: Example of integrated hydrogen and ammonia complex (ThyssenKrupp)

10.6 Liquid Air Energy System (LAES) for Nitrogen production:

Liquid air energy will be used to liquefy nitrogen for storage, energy and feedstock requirements. Liquid air energy is the use of liquefied air, nitrogen, oxygen and even hydrogen to store Energy. LAES consists of three main stages:

- (1) cooling and separation of the air,
- (2) storage (usually in insulated vessels at low pressure) and
- (3) expanded for energy and/or production.

The first stage is the cooling of the air which is done by the air separation unit, the second stage is storage (usually in insulated vessel at low pressure) and the third stage is when extra energy is needed (the liquefied air is pumped and superheated to evaporate at atmospheric temperature). The change in pressure is used to turn gas turbines. These gas turbines produce electricity via the rotation of the generator shaft (mechanical energy is converted to electrical energy).

Components in the LAES include compressors, ambient and cryogenic heat exchangers, expansion valves, storage vessels, pumps, small turbines and generators.

10.7 Storage tanks – general

Storage Tanks can be stored in pressurised as or gas in liquid form through the utilisation of a variety of specialised tanks. There are different kinds of storage tanks designs to store anhydrous ammonia, these include but are not limited to:

- Fixed roof tanks,
- Floating roof tanks,
- Low-temperature storage tanks, and
- Pressure tanks.

10.7.1 Fixed roof storage tanks

Fixed roof storage tanks are cylindrical storage containers that have flat or conical roofs joined to the shell. These storage tanks are often used to store large quantities of petroleum distillates, petrochemicals, and other liquid chemicals at atmospheric pressure. When the level of fluid in the tank rises and falls, air and vapor are pushed out and drawn into the tank headspace. Consequently, the vapor is lost into the atmosphere during the process of emptying the tank.

A double-walled tank is designed to provide secondary containment by enhancing the protection against tank failure. It can be customized by adding ultrasonic level indicators, leak detectors, and tank ladder assemblies to identify and monitor in case of any leakage. Below are examples of fixed roof storage tanks:

Figure 10 single-walled fixed storage tanks (left and double-walled fixed roof tank (right)

10.7.2 Floating roof tanks

The roof of floating roof tanks floats above the liquid stored at atmospheric pressure. The roof rises and falls as the fluid does. Consequently, floating roof tanks reduce vapor loss, fire, and tank collapse hazards of fixed roof storage tanks. Below are examples of floating roof tanks:

Figure 11: Double-deck floating roof storage tank

10.7.3 Low-pressure storage tanks

Low-pressure storage tanks are insulated tanks. These kinds of tanks are more suitable to store volatile liquids for atmospheric storage. They are often used to store ammonia, and liquified gases such as butane at a pressure set by their vapor pressure at the working temperature. Below are examples of low-pressure storage tanks.

Figure 12: Low-pressure storage tank

Figure 13: Stainless steel single-layered low-pressure tanks

10.7.4 Pressure tanks

Pressure tanks are horizontal-welded pressure vessels with elliptical or hemispherical heads known as bullet tanks. A bullet tank is a storage container that stores natural gas liquids. Bullet tanks are used for high-pressure fluids. Pressure tanks also include spherical pressure tanks known as Horton Spheres and are used to store large quantities of high-pressure fluids. Below are examples of pressure tanks:

Figure 14: Bullet storage tank (ammonia storage)

10.8 Storage requirements for the development

10.8.1 Nitrogen

Nitrogen will be stored (7-14 days) as a liquid with in large cylindrical cryogenic storage tanks with a combine volume of approximately 4 100 tons of nitrogen. A storage tank is usually considered to have 85% usable capacity, this is to allow 15% vapor space to allow for expansion. It is proposed that the facility will house up to two cylindrical cryogenic storage tanks. Each tank will have a diameter of up to 14m and a height of up to 15m with a capacity of up to 2032 tons.

10.8.2 Ammonia

Green ammonia will be stored as anhydrous liquid ammonia, using similar storage equipment as that utilised for storage of Liquid Natural Gas (LNG), i.e. in a storage tank farm (refer Figure 15 Energas example and Figure 16). Ammonia storage tanks are containers used to store ammonia as liquid or compressed gases. It is important to take note of the design and layout of storage tanks as these properties affect the safety and economical aspect of the plant. Anhydrous ammonia (gas or liquid) is a colorless gas with a sharp smell under atmospheric conditions. The temperature of anhydrous ammonia increases with the increase of surrounding temperature resulting in the vapor pressure in the tank to increase. Thus, it is important to store anhydrous ammonia in containers that can withstand the physical and chemical properties of the liquid form.

Figure 15: Liquid Ammonia Storage system (Energas example).

Anhydrous ammonia will be stored within large cylindrical cryogenic storage tanks with a combined volume of 3 750 tons of ammonia. A storage tank is usually considered to have 85% usable capacity, this is to allow 15% vapor space to allow for expansion.

It is proposed that the facility will house up to three cylindrical cryogenic storage tanks. Each tank will have a diameter of up to 14m and a height of up to 15m with a capacity of up to 1250 tons each.

Figure 16: Cryogenic ammonia storage tanks

10.8.3 Hydrogen

Hydrogen is stored in vertical or horizontal storage bullets. Compressed hydrogen can be storage as a gas or in liquid form. Compressed hydrogen can be stored at ambient temperature. Up to 800 tons of hydrogen will be stored at the facility, in conjunction with that of the oxygen stored on site, in a tank farm of up to 12 ha. The facility will house up to 20 horizontal pressure bullets for the storage of hydrogen. Each bullet will have a diameter of up to 4m and a length of up to 15m.

Figure 17: Compressed Hydrogen Storage – horizontal tank

10.8.4 Oxygen

Oxygen will be stored in vertical or horizontal storage bullets and stored under high-pressures. The tanks have a vacuum-insulated double wall consisting of two concentric vessels, a steel inner tank and an outer jacket in carbon steel. Up to 800 tons of oxygen will be stored at the facility, in conjunction with that of the hydrogen stored on site, in a tank farm of up to 12 ha. It is proposed that the facility will house up to 16 vertical cryogenic storage bullets for the storage of oxygen. Each bullet will have a diameter of up to 4m and a length of up to 15m.

Figure 18: Cryogenic storage tanks – vertical tanks.

10.9 Gantry and loading bay

Ammonia is easily transported by truck and rail as a pressurized liquid. Three loading gantries were assumed where international organisation for standardisation (ISO) containers can be filled with anhydrous ammonia and trucked to an export port location, or similar consumer or off-take point (for example nearby railroad sidings). The following equipment forms part of these gantries:

- Custody transfer metering.
- Loading arm with coupling.
- Control valve.
- Control unit.

10.10 Transport

Liquid Ammonia may readily be transported via road, rail or a combination of the two by means of Standard pressurised road tanker or ISOtainer (for road transport options), or via pressured rail container (Isotank).

10.10.1 Rail

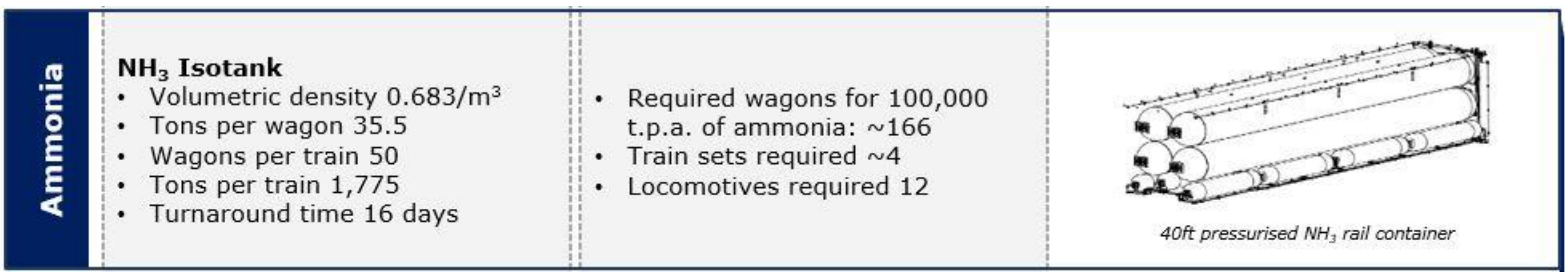


Figure 19: Rail Isotank NH3 storage and transport

10.10.2 Road

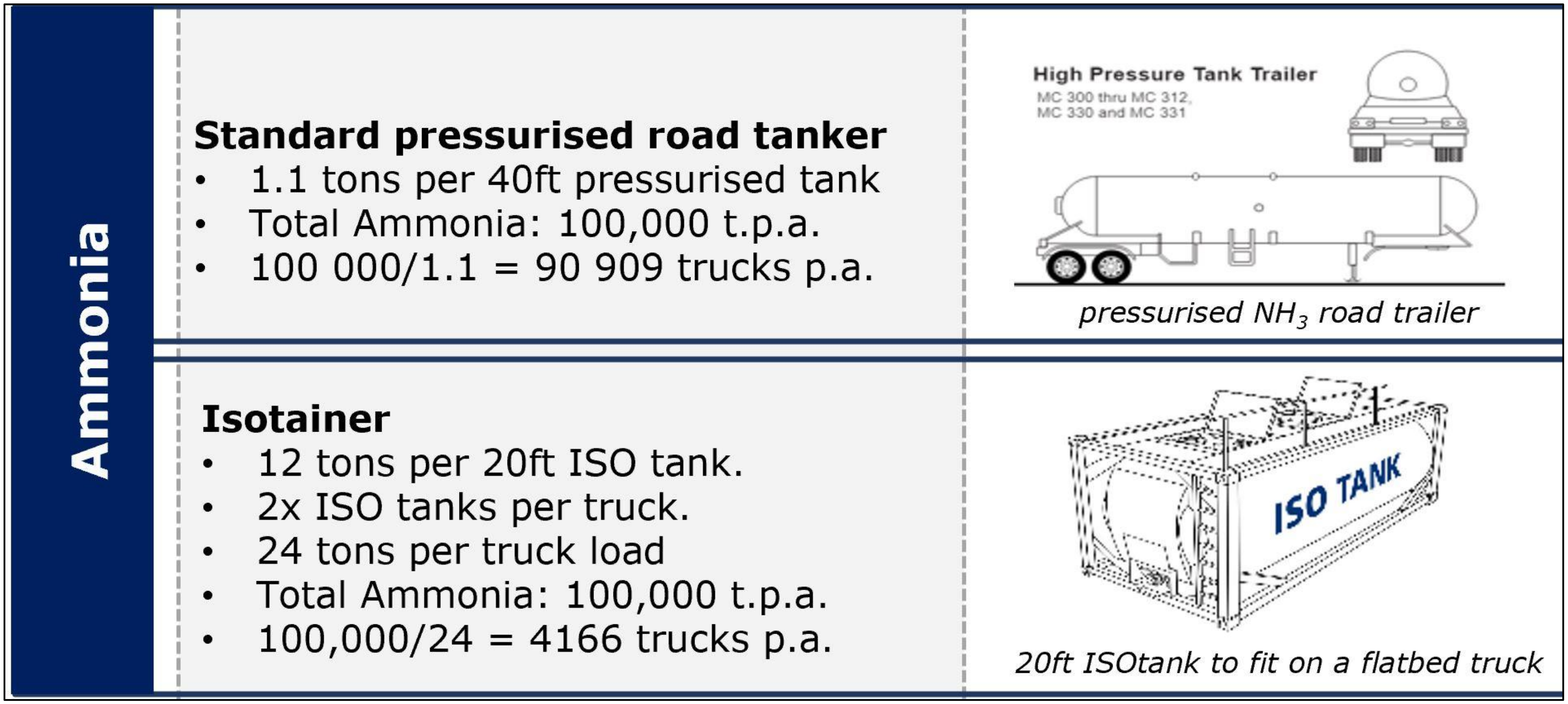
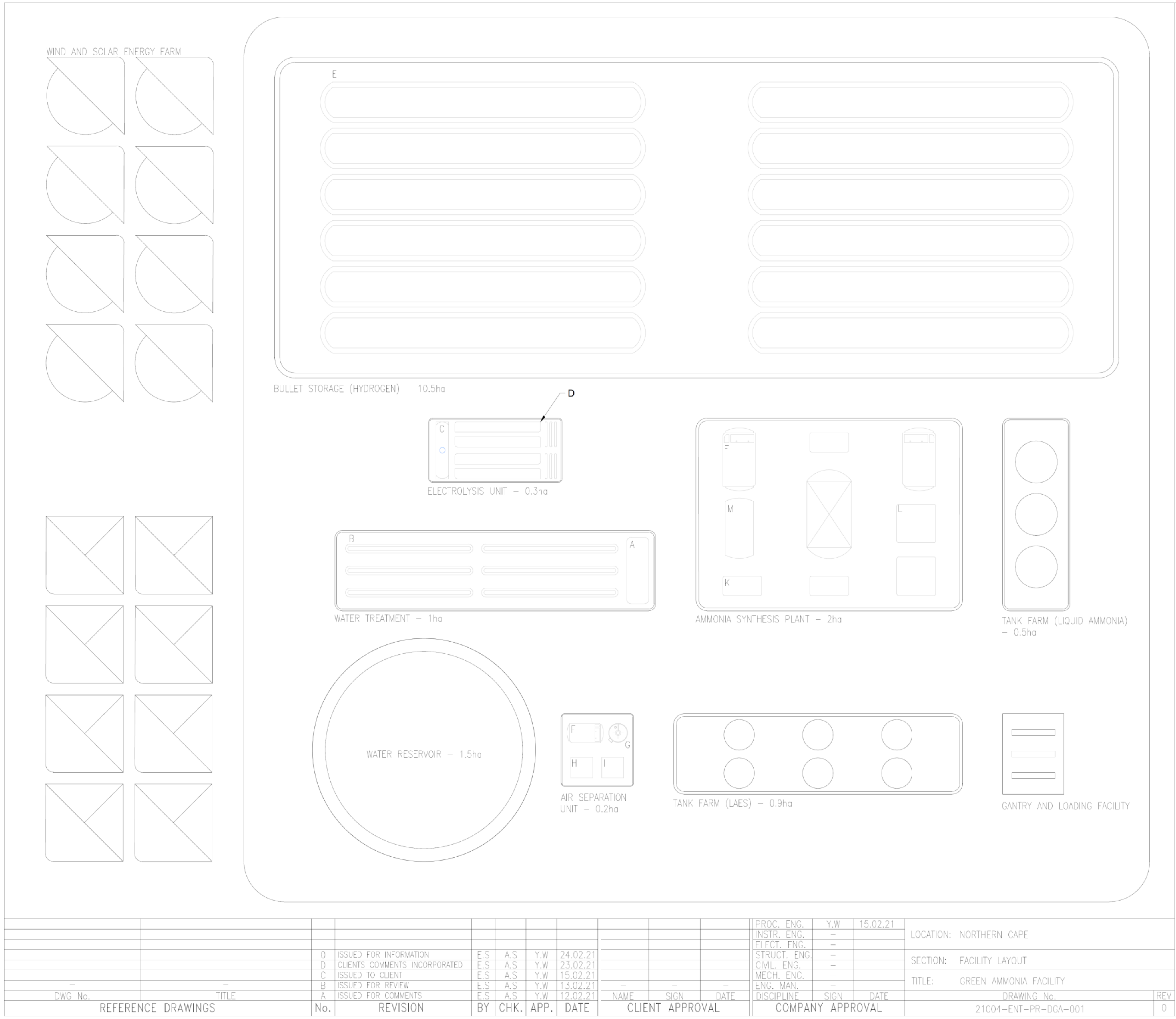


Figure 20: Road standard pressured tanker and Isotainer transport.

Use of 40ft pressured tanker trucks or trucks with ISOtainer capability (20ft length each). Volumes will be up to 24 tons per truck load depending on pressured tanker or Isotainer, therefore 12 daily 24ton truck ISOtainer trucks envisaged. Depending on the final volumes transported, technical and financial feasibility, between 1 - 24ton road tankers (pressured tanker trucks or ISOtainers) may be utilised.



INDEX	
TAG	DESCRIPTION
A	MULTIGRADER FILTER
B	REVERSE OSMOSIS
C	ELECTRICAL SUBSTATION
D	ELECTROLYSIS CELLS
E	BULLET STORAGE
F	COMPRESSOR
G	DISTILLATION UNIT
H	PUMP
I	TURBINE STATION
J	REACTOR
K	REFRIGARATION STORAGE
L	REFRIGARATION LOOPS
M	HEAT EXCHANGERS

Figure 21: Indicative block layout of the proposed hydrogen and ammonia plant.

RECORD OF REPORT DISTRIBUTION

SLR Reference:	720.05085.00004
Title:	Geotechnical Desk Study for Camden I Renewable Energy Complex.
Report Number:	02
Client:	Enertrag SA

Name	Entity	Copy No.	Date Issued	Issuer
Ashlea Strong	WSP	1	14/12/2021	M. Osman
Ashlea Strong	WSP	2	05/04/2022	M. Osman

AFRICAN OFFICES

South Africa

CAPE TOWN
T: +27 21 461 1118

JOHANNESBURG
T: +27 11 467 0945

DURBAN
T: +27 11 467 0945

Ghana

ACCRA
T: +233 24 243 9716

Namibia

WINDHOEK
T: + 264 61 231 287