PRELIMINARY GEOTECHNICAL REPORT

PROPOSED 165MW KHAUTA NORTH PHOTOVOLTAIC SOLAR FARM ON PORTION 0 OF THE FARM KOPJE ALLEEN NO. 81 AND PORTION 1 OF THE FARM KOPJE ALLEEN NO. 81, RIEBEECKSTAD NEAR WELKOM, MATJHABENG LOCAL MUNICIPALITY, FREE STATE PROVINCE

3 February 2023 (Rev 0)

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Report review history:

Revision No	Date	Prepared by:	Reviewed by:	Approved by:
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Authors qualifications and affiliations:

Iain Paton has post graduate degrees in Geology and Geotechnical Engineering and has over 25 years' experience in the mining, energy and construction industries. Iain Paton is a registered professional with the Engineering Council of South Africa (ECSA) and the South African Council for Natural and Scientific Professions (SACNSP). Iain Paton is a member of the Geotechnical Division of the South African Institute of Civil Engineering (SAICE), South African Institute of Engineering and Environmental Geologists (SAIEG), the and the Institute of Municipal Engineering of South Africa (IMESA).

Declaration of independence:

The author of this report is independent professional consultant with no vested interest in the project, other than remuneration for work associated with the compilation of this report.

Limitations of liability:

1. We have employed accepted geotechnical engineering procedures, and the opinions and conclusions expressed in the report are made in good faith in accordance with generally accepted principles and practices.
2. The contents of this report are valid as of the date of preparation. However, changes in the condition of the site can occur over time as a result or either natural processes or human activity. In addition, advancements in the practice of geotechnical engineering and changes in applicable practice codes may affect the validity of this report. Consequently, this report should not be relied upon after an eclipsed period of one year without a review by this firm for verification of validity. This warranty is in lieu of all other warranties, either expressed or implied.
3. Unless otherwise stated, the investigation did not include any specialist studies, including but not limited to the evaluation or assessment of any potential environmental hazards or groundwater contamination that may be present.
4. The investigation is conducted within the constraints of the budget and time and therefore limited information was available. Although the confidence in the information is reasonably high, some variation in the geotechnical conditions should be expected during and after construction. The nature and extent of variations across the site may not become evident until construction. If variations then become apparent this could affect the proposed project, and it may be necessary to re-evaluate recommendations in this report. Therefore, it is recommended that Outeniqua Geotechnical Services is retained to provide specialist geotechnical engineering services during construction in order to observe compliance with the design concepts, specifications and recommendations and to allow design changes in the event that subsurface conditions differ from those anticipated prior to the start of construction. Any significant deviation from the expected geotechnical conditions should be brought to the author's attention for further investigation.
5. The assessment and interpretation of the geotechnical information and the design of structures and services and the management of risk is the responsibility of the appointed engineer.

Table of Contents

1. Introduction and terms of reference

Enviroworks (Pty) Ltd was appointed by Khauta North Solar PV Facility RF (Pty) Ltd (the developer) to undertake a full Scoping and Environmental Impact Assessment (inclusive of specialist work) for the proposed construction of a 165 megawatt (MW) photovoltaic solar energy facility (PVSEF) and associated infrastructure (hereafter referred to as Khauta North PVSEF) on a site near Welkom in the Free State Province of South Africa (See **Figure 1**).

Outeniqua Geotechnical Services was appointed by Enviroworks on behalf of the developer to undertake a preliminary geotechnical investigation for the proposed project. The investigation was conducted to provide a baseline study of the geology and geotechnical nature of the site for the Environmental Impact Assessment (EIA) and the work was done in accordance with the requirements of the 2014 NEMA EIA regulations for specialist reports (refer to **Table 1**).

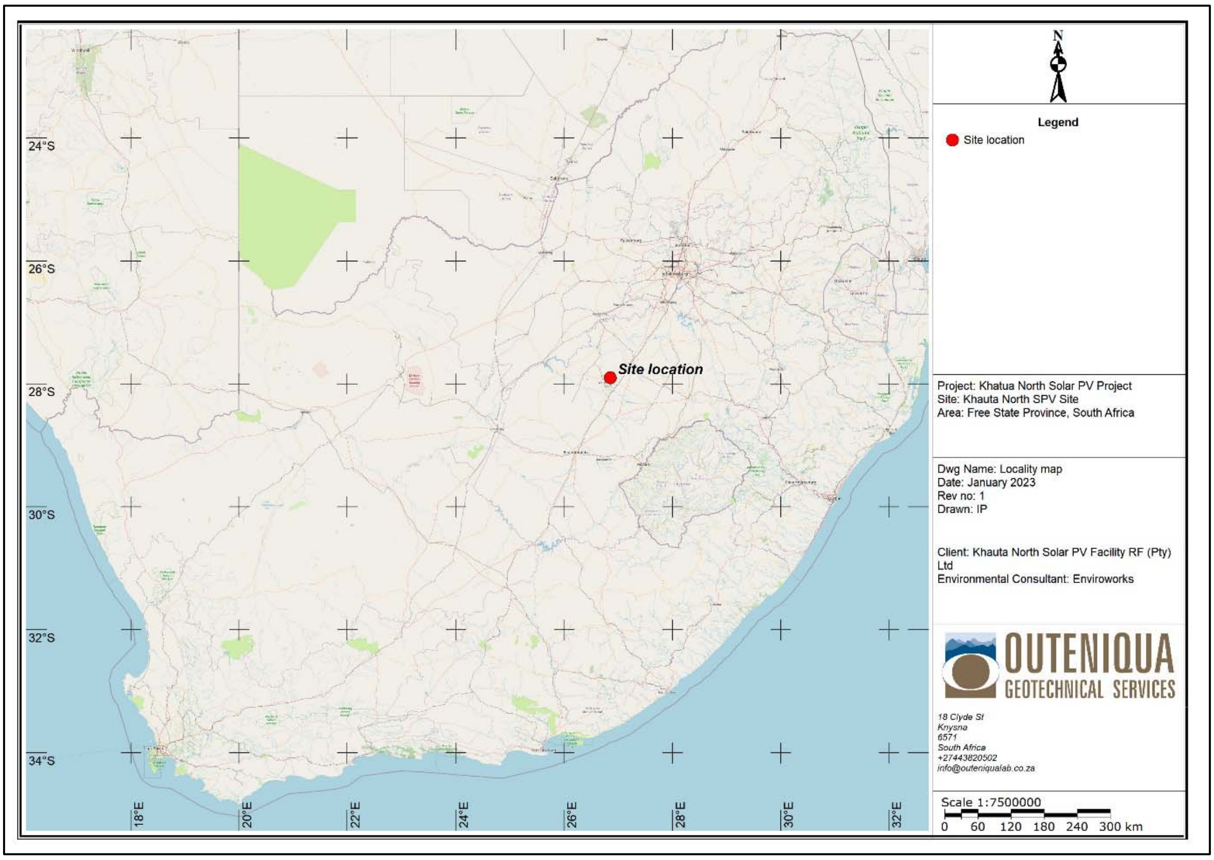

Figure 1: Locality map

Table 1: Specialist reporting requirements

	Content requirement of the 2014 EIA Regulations	Report section	Page
(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;	Preface & Appendix 3	i

	Content requirement of the 2014 EIA Regulations	Report section	Page
(b)	a declaration that the specialist is independent in a form as may be specified by the competent authority;	Preface	i
(c)	an indication of the scope of, and the purpose for which, the report was prepared;	Ch 1	1-3
(cA)	an indication of the quality and age of base data used for the specialist report;	Ch 3	3
(cB)	a description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change;	Ch 5	4-5
(d)	the duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment;	Ch 5	4-5
(e)	a description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used;	Ch 3	3
(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;	Ch 9	11-18
(g)	an identification of any areas to be avoided, including buffers;	Ch 10.1	18
(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;	Fig10	10
(i)	a description of any assumptions made and any uncertainties or gaps in knowledge;	Ch 4	4
(j)	a description of the findings and potential implications of such findings on the impact of the proposed activity or activities;	Ch 9	11-18
(k)	any mitigation measures for inclusion in the EMPr;	Ch 10	18-23
(l)	any conditions for inclusion in the environmental authorisation;	Ch 10	18-23
(m)	any monitoring requirements for inclusion in the EMPr or environmental authorisation;	Ch 10	18-23
(n)	a reasoned opinion— (i) 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 in the case of a closure activity, the closure plan;	Ch 9.4 Ch10	18 18-23
(o)	a description of any consultation process that was undertaken during the course of preparing the specialist report;	n/a	

	Content requirement of the 2014 EIA Regulations	Report section	Page
(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	

The detailed scope of work included the following:

- Desktop assessment of the baseline geology and geotechnical nature (soil and rock stratigraphy) of the site.
- Identification of potential development constraints (no-go areas e.g. problem soils, dolomitic areas etc.)
- Identification of potential impacts such as erosion and soil degradation, slope stability issues, etc.
- Preliminary evaluation of the geotechnical land use potential of the property for the proposed development at a feasibility level.
- No site visits were conducted at this stage of the project.

2. Information available

The following maps and plans were available for reference purposes:

- Topocadastral data (2021) for the area, obtained from the Chief Directorate: National Geospatial Information (NGI);
- Aerial photographs of the site obtained from the NGI, ESRI and Google Earth (2023);
- 1:250 000 Geological maps of the area, obtained from the Council for Geoscience;
- 1:1000000 Seismic Hazard Map of SA, obtained from the Council for Geoscience;
- Site layout plans of the proposed development, provided by Enviroworks.

3. Nature of the investigation

The aim of the investigation was to conduct a baseline study to characterise the geological and geotechnical nature of the site and to establish potential environmental impacts in accordance with NEMA EIA regulations. Furthermore, the study would facilitate the feasibility planning and design of the project. The scope of the investigation was designed to achieve technical standards of good practice with maximum economy in accordance with the initial stages of development.

A preliminary geotechnical investigation was undertaken in accordance with SAICE Code of Practice for Site Investigations (SAICE, 2010) for the proposed development, including a “desk-top” level review of available data. No site visit was undertaken for this preliminary level of investigation. The desk study included a review of published geological and topographic maps, aerial photographs, ortho-photographs, and any other relevant data from previous work on and around the site.

The investigation was conducted primarily to assess the general suitability of the site for the proposed development in terms of the location, topography, geology and geotechnical conditions, and to identify any potential "red flags", such as significant geological hazards. The investigation was conducted by an experienced and professionally-registered geotechnical specialist, but no detailed mapping or subsurface investigations, such as test pits or borehole drilling, were conducted as part of this preliminary investigation.

4. Limitations and gaps in knowledge

The scope of work for the investigation was limited to a desk-top study only. The scope of work did not extend into site-based work or any detailed investigations of the subsurface profile. The methods employed in this preliminary investigation were deemed to be in accordance with industry guidelines and codes of practice for studies of a preliminary or feasibility nature.

Gaps in knowledge included details of the proposed facility, including exact layouts of services, structures and associated engineering systems, which had yet to be finalised dependant on the outcome of the EIA process. Other gaps of knowledge included details of the engineering properties of the subsurface profile and the interaction between structures and the substrate. The confidence in the preliminary data obtained at this stage of the project was high but additional investigations were considered necessary for the engineering design to determine the geological profile, soil properties, groundwater levels, founding conditions for structures, etc.

No historical data pertaining to any geological hazards or recent events on or in the immediate vicinity of the site, such as recent seismic activity, landslides, flood events or major ground subsidence or erosion, was available. Furthermore, no information pertaining to the performance of any existing structures or current activity on the site was available.

5. Site description

The site identified for the proposed development of the PVSEF was rural farmland located on the following farm portions northeast of Riebeeckstad near Welkom in the Matjhabeng Local Municipality of the Free State Province (refer to **Figure 2&3**):

- Portion 0 of the Farm Kopje Alleen No. 81; and
- Portion 1 of the Farm Kopje Alleen No. 81.

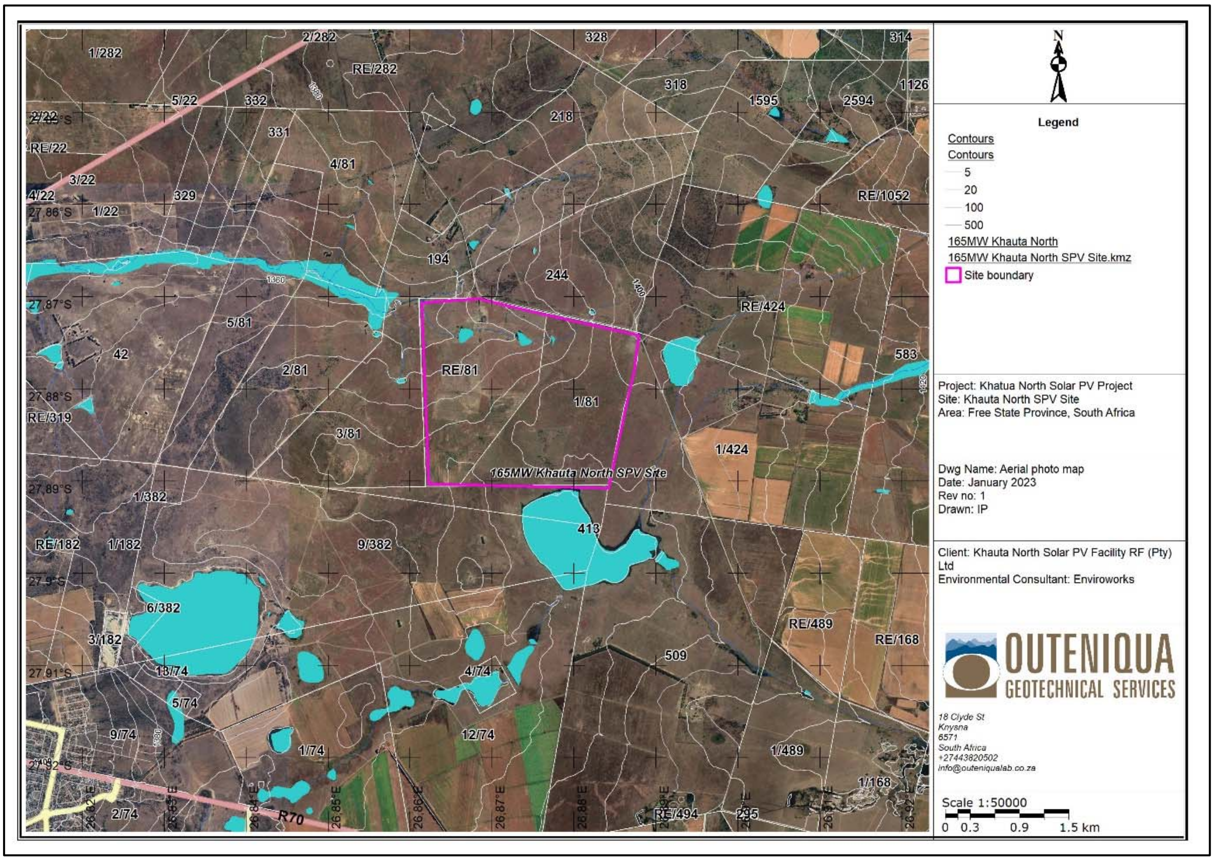

Figure 2: Aerial photo map of the proposed site

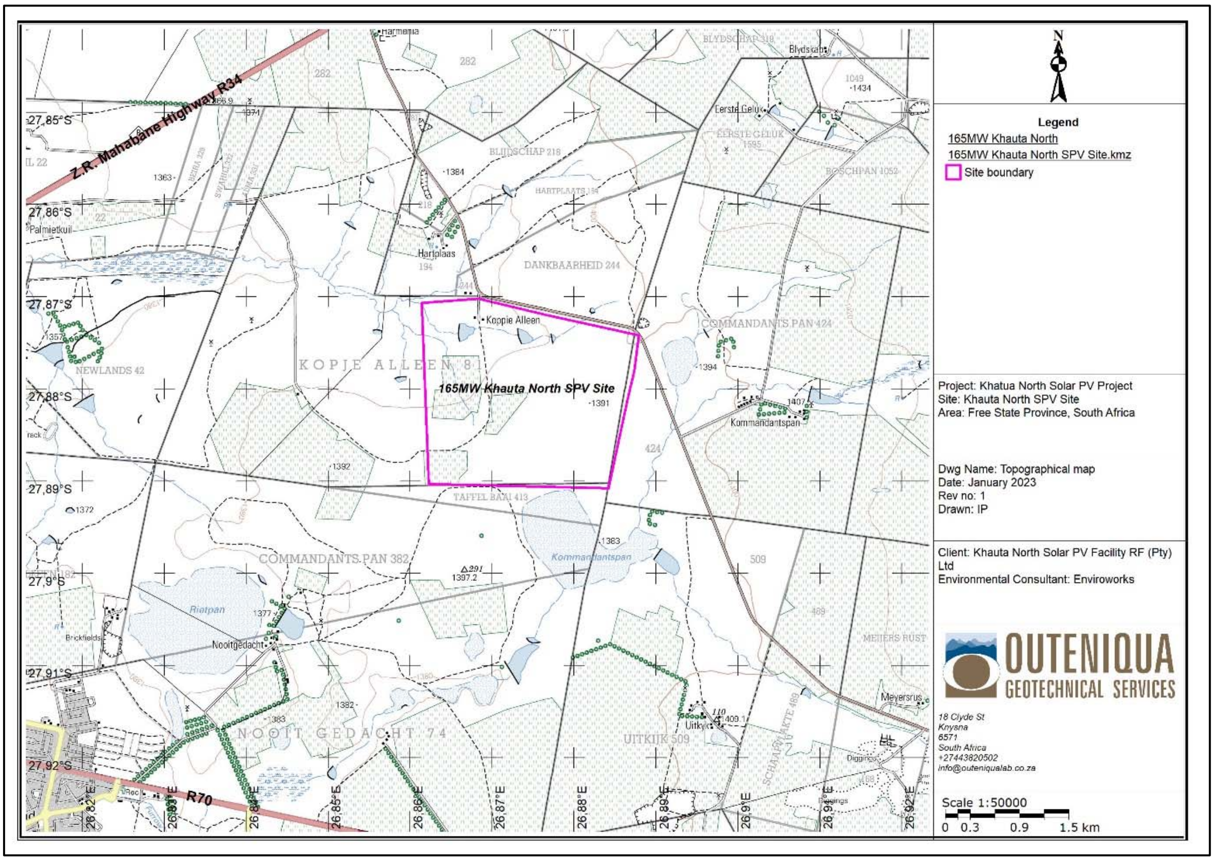

Figure 3: Topographic map showing the proposed site boundary

The broader site area was approximately 504Ha in extent, situated at an approximate altitude of 1370-1395m above mean sea level on very gently undulating plains and very low hills. The site drained towards the northwest into tributaries of the Sandspruit, which flowed west. The vegetation types were dominated by thorn trees and long dry grass (See **Figure 4**).

The climate of the region was classified under the Köppen system (Köppen, 1936) as “BSk - Tropical and Subtropical Steppe Climate” with hot summers with maximum daytime temperatures exceeding 30°C, and cold winters with minimum temperatures at or below freezing - See **Figure 5**. The Weinert climatic-N Value (Weinert, 1980) for the site area was 4.5 (moderate), indicating both chemical and mechanical weathering processes at play.

Figure 4: Typical topography and vegetation cover in the vicinity of the site (source: Google Earth)

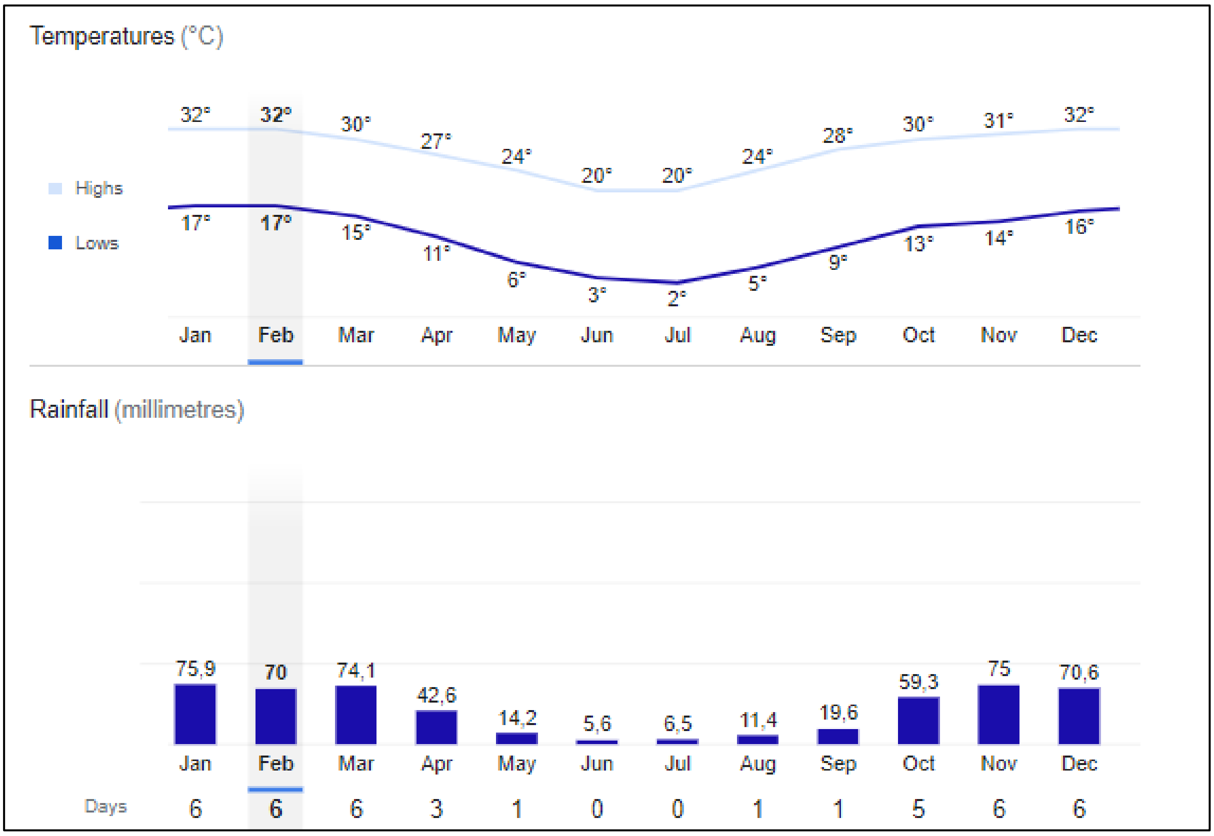

Figure 5: Climate data for the area (source: www.google.com)

6. Geology

The geological map of the area (see **Figure 6**) indicated that the northern portion of the site was underlain by mudstone, siltstone and shale of the Permian Volksrust Formation of the Ecca Group (orange/maroon on map) of the Karoo Supergroup, which dip gently to the east. Quaternary aeolian sand cover was mapped in the vicinity of the site (yellow (dotted) on map) and some small localised dolerite intrusions were indicated protruding through the Karoo sediments and soil cover to the north and south of the site (purple on map). The stratigraphy of the various sedimentary formations of the local geology was indicated in **Figure 7**.

The Welkom area had a well-established history of mining activity since the 1940's, which was dominated by Harmony's deep-level underground gold and uranium operations. Mining activity (either current or historical) in the vicinity of the site included a brick clay quarry (Superior Brick) approximately 4km beyond the SW corner of the site, and an abandoned underground gold mine (the old Welkom 1 Mine) and associated tailings storage facility approximately 10km southwest of the site. Brick clay mining (Cs) was indicated on the geological map of the site although there was no evidence of this on historical aerial photography.

No major geological faults were indicated on the map and according to the Seismic Hazard map of SA (Fernandez, et. al., 1992), the site was located in a zone of potentially high mining-induced seismic activity (see **Figure 8 & 9**) with maximum intensity of IV-V on the modified Mercalli Scale, or 4-4.5 on the Richter scale (rather strong, felt by all, minimal damage to buildings) and a maximum peak horizontal ground acceleration of 200cm/s^2 (0.2g), with a 10% probability of being exceeded at least once in a period of 50 years.

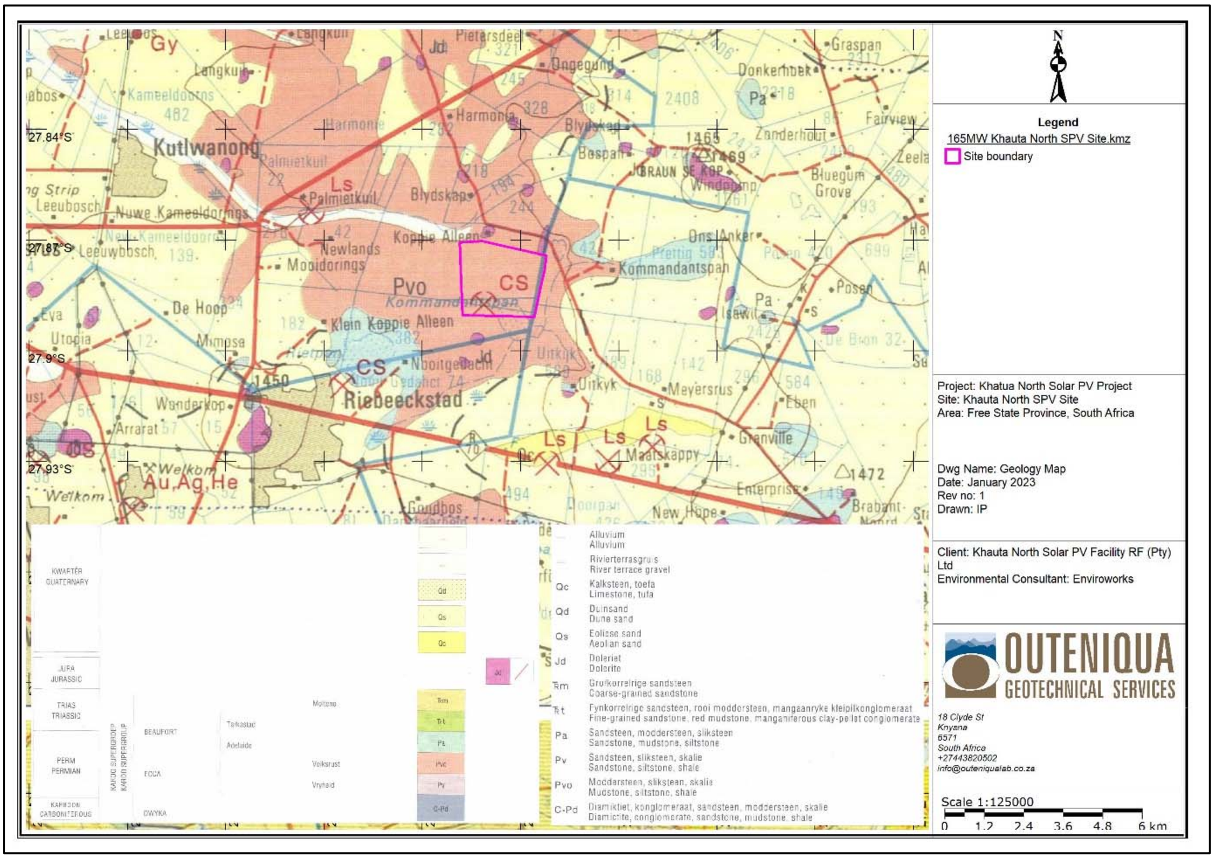

Figure 6: Geological map of the area

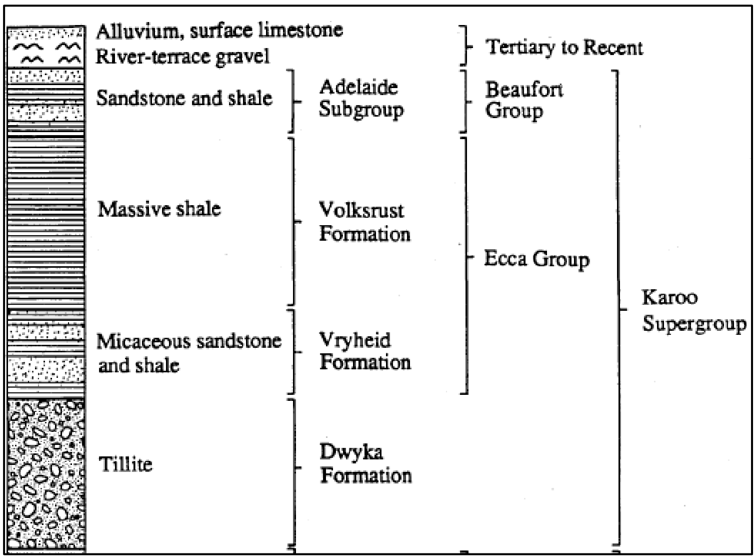

Figure 7: Stratigraphical column for the Welkom area

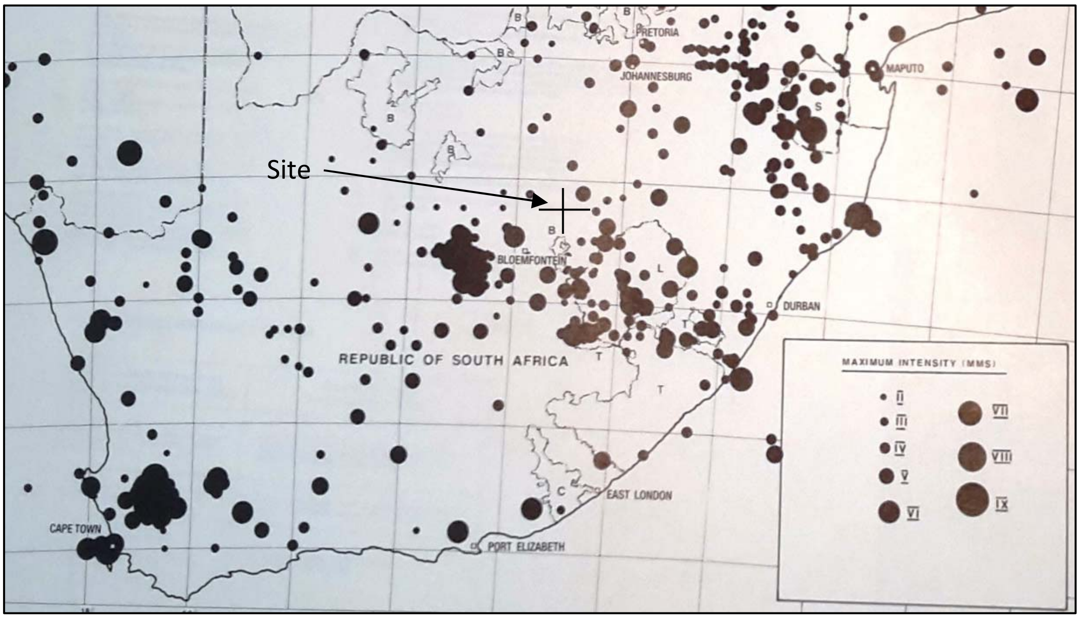

Figure 8: Seismic event map of SA

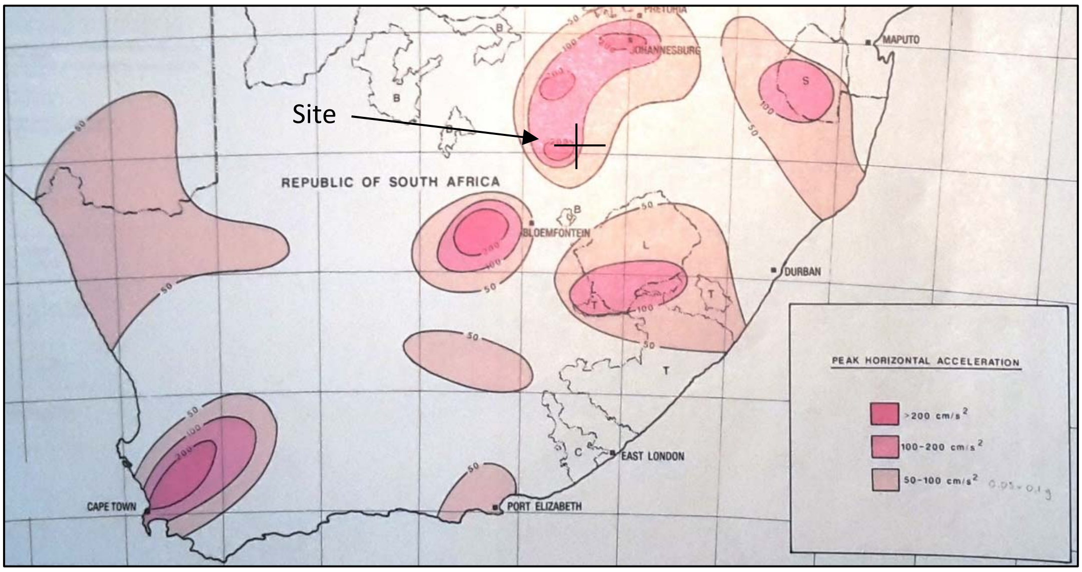

Figure 9: Peak horizontal ground acceleration map of SA

7. Geotechnical Evaluation

7.1 Geotechnical terrains

The site was broadly mapped according to the expected geotechnical characteristics, including soil type and thickness, slope gradients, surface water bodies, natural drainage lines, and areas with shallow groundwater or drainage problems such as marshes. See **Figure 10**.

Terrain 1 forms the central and southern portions of the site, and was characterised by low slope gradients with potentially slightly to moderately compressible and collapsible transported soils (aeolian/colluvial) and potentially active residual soil underlain by bedrock siltstone or sandstone, possibly within a shallow depth range (i.e. estimated 1.5-3m of surface). Terrain 1 was deemed to have a high development potential.

Terrain 2 lies in the northern portion of the site, and was characterised by natural drainage lines and/or surface water bodies with potentially problematic geotechnical conditions and low development potential.

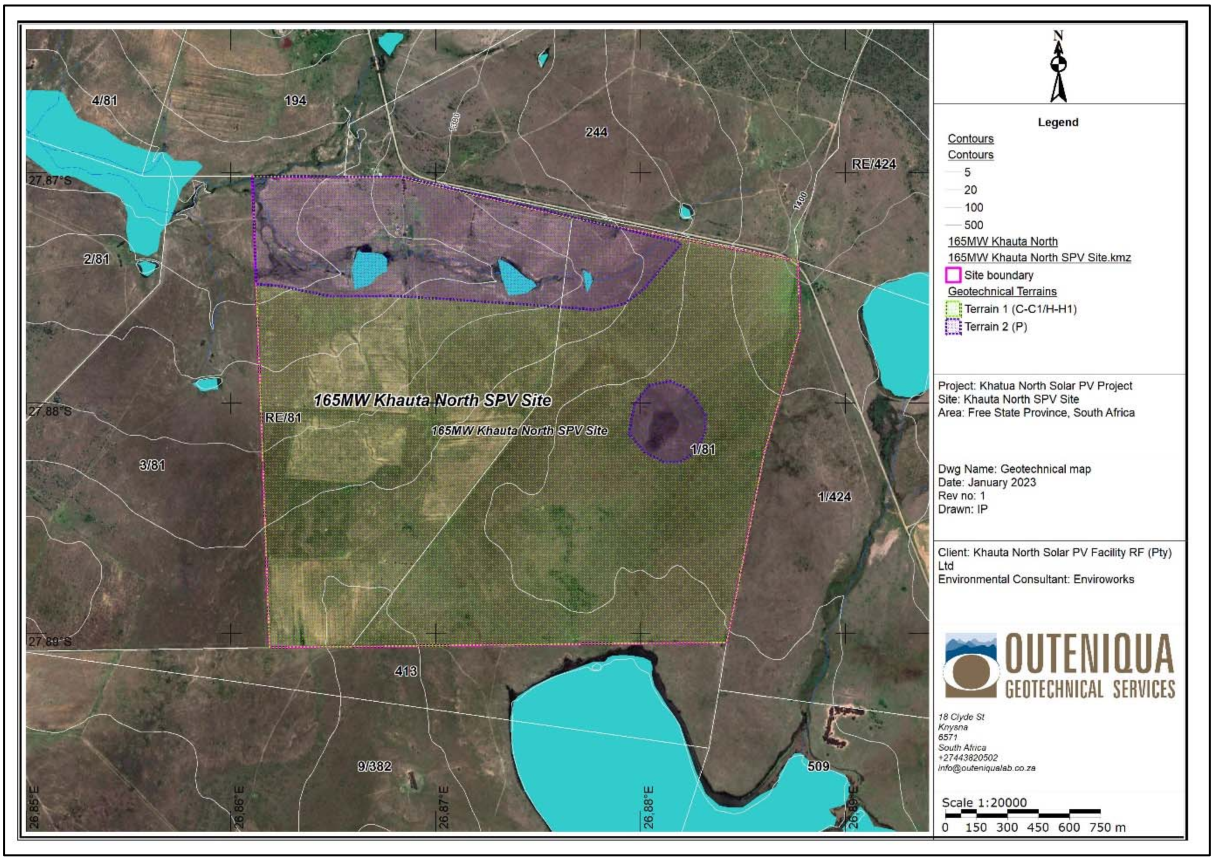

Figure 10: Geotechnical map of site

7.2 Proposed development and infrastructure

The proposed project entails the generation of up to a maximum export capacity of 165 MW to be achieved through several arrays of PV panels. The total footprint of the solar PV Facility including associated infrastructure will be approximately 87 hectares (ha). The proposed PV arrays would be mounted on light weight steel frames (fixed or tracking) which are connected to a on-site facility substation with underground or overhead electrical cabling. Associated infrastructure included a battery energy storage system (BESS), auxiliary buildings for general operation and maintenance purposes, water storage tanks, internal gravel roads and parking areas. No layout plans were available at the time of the investigation.

7.3 Foundations for structures

The proposed PV array structures would be supported on lightweight steel frame structures attached to the ground either on shallow pad foundations or driven or pre-bored steel piles, generally emplaced at a typical depth of 1.0-3.0m, depending on the underlying soil profile and geotechnical characteristics of the profile, which would have to be investigated during on-site testing.

7.4 Slope stability and erosion

The slope gradient on the site was low and therefore natural slope stability problems were not considered to be a significant risk. No severe erosion scars were apparent during the investigation and erosion was not considered to be a significant problem, although localised erosion was expected around the edges of drainage lines and surface water bodies identified in Terrain 2.

7.5 Excavations

Excavation classification would have to be determined after on-site testing.

7.6 Natural construction material sources

Sandstone and siltstone or shale rock of the Karoo Supergroup, or dolerite was deemed to be a potentially useful source of low-quality materials for gravel road surfacing and general backfilling material around structures and over pipe cradles. Material availability and quality would have to be determined during on-site testing.

8. Site classification

In accordance with SANS 10400-H Section 4.2, the applicable geotechnical site classifications are shown in **Table 2**.

Table 2: SANS10400-H site classification

Terrain unit	*Geotechnical Constraint*	*Expected movement (mm)*	*Site Classification*
1	Potentially compressible and/or collapsible soil	<10	C-C1
	Potentially active soil	<15	H-H1
2	Shallow groundwater or marshy ground conditions		P

9. Environmental assessment

9.1 Land-use potential and development constraints

Terrain 1, which comprised the majority of the site, was considered to be potentially suitable for the development of a solar energy facility with only minor to moderate geotechnical constraints expected, which would be taken into consideration in the engineering design.

The presence of natural drainage lines and surface waterbodies identified in Terrain 2 (as indicated in **Figure 10**) presented some constraints on the developable area, and this area was considered a “No-go” area for development purposes.

9.2 Potential impacts relating to the geological environment

Based on preliminary assessments of the geological nature of the site and the proposed activity, the project could potentially involve the following *negative direct* impacts:

a. Soil and/or bedrock degradation - Soil degradation is the negative alteration of the natural soil profile, usually directly or indirectly related to human activity, including erosion, excavation/removal, loosening, mixing, compaction and contamination/pollution or chemical alteration. Soil degradation negatively affects soil formation, natural weathering processes, moisture levels and soil stability. This could, in time, have a significant effect on agricultural potential and biodiversity (not assessed as part of this study). Soil erosion induced or increased by human activity is termed accelerated erosion and is an integral element of global soil degradation. Accelerated soil erosion is generally considered the most important impact in any development due to its potential impact on a local and regional scale (i.e. on and off site) and as a potential threat to global biodiversity. Soil erodability – the susceptibility of soil to erosion – is a complex variable, not only because it depends on soil chemistry, texture, and characteristics, but because it varies with time and other variables, such as mode of transport (i.e. wind or water). Erosion of soil due to water run-off is generally considered as being more important due to the magnitude of the potential impact over a relatively short period of time, which can be very difficult to control or reverse. Erosion potential is typically increased in areas where soil is loosened and vegetation cover is stripped (such is the case on most construction sites). Removal of vegetation (ground cover) may increase the risk of soil erosion, making the soil less fertile and less able to support the regeneration of vegetation in future. Generally speaking, unconsolidated or partly consolidated, fine-grained soils of low plasticity occurring along drainage lines, on moderate to steep slopes or at the base of steep slopes are most vulnerable to severe levels of erosion due to water run-off. Areas where these factors occur are typically classified as "highly erosion-sensitive" areas.

The activity may also lead to the following *negative indirect* impacts:

a. Dust pollution;
b. Siltation of watercourses adjacent to or away from the site or activity areas.

Negative impacts are dominantly related to the construction phase with insignificant additional impacts in the post construction and decommissioning phases, as explained below.

Construction Phase - The proposed photovoltaic (PV) technology typically involves minimal earthworks for structures, roads and electrical ducting. The construction phase typically takes 1-2 years.

The following activities were envisaged as part of the construction phase:

1. Site clearing and grubbing (with the exception of protected vegetation and sensitive areas);
2. Construction of site infrastructure, roads, electrical reticulation trenches;
3. Construction of array frame foundations;
4. Panel construction and transport to frames;
5. Erection of panels onto frames;
6. Electrical connection;
7. Construction of substation and control centre.

Operation Phase - The following activities were envisaged during the operational phase:

1. Cleaning panels;
2. Site road maintenance;
3. Mechanical maintenance of structures;

4. Preventive inspections.

Decommissioning Phase - The following activities were envisaged during the decommissioning phase:

1. Disassembling structures;
2. Removing equipment and infrastructure from site;
3. Rehabilitating soil, vegetation and surrounds.

The activity can also have positive impacts on the geological environment (either directly or indirectly), such as a reduced demand for non-renewable energy sources (such as coal, uranium) and an improvement in the status quo in terms of erosion due to improved storm water and roads engineering on the site (more specifically on highly degraded sites).

9.3 Impact assessment methodology

Direct, indirect, and cumulative negative impacts are assessed in terms of significance, based on the criteria given in **Table 3**.

Table 3: Impact assessment criteria

Evaluation component	***Ranking scale and description (criteria)***
MAGNITUDE of NEGATIVE IMPACT (at the indicated spatial scale)	10 - Very high: Bio-physical and/or social functions and/or processes might be severely altered. 8 - High: Bio-physical and/or social functions and/or processes might be considerably altered. 6 - Medium: Bio-physical and/or social functions and/or processes might be notably altered. 4 - Low : Bio-physical and/or social functions and/or processes might be slightly altered. 2 - Very Low: Bio-physical and/or social functions and/or processes might be negligibly altered. 0 - Zero: Bio-physical and/or social functions and/or processes will remain unaltered.
MAGNITUDE of POSITIVE IMPACT (at the indicated spatial scale)	10 - Very high (positive): Bio-physical and/or social functions and/or processes might be substantially enhanced. 8 - High (positive): Bio-physical and/or social functions and/or processes might be considerably enhanced. 6 - Medium (positive): Bio-physical and/or social functions and/or processes might be notably enhanced. 4 - Low (positive): Bio-physical and/or social functions and/or processes might be slightly enhanced. 2 - Very Low (positive): Bio-physical and/or social functions and/or processes might be negligibly enhanced. 0 - Zero (positive): Bio-physical and/or social functions and/or processes will remain unaltered.
Duration	5 - Permanent 4 - Long term: Impact ceases after operational phase/life of the activity > 60 years. 3 - Medium term: Impact might occur during the operational phase/life of the activity – 60 years. 2 - Short term: Impact might occur during the construction phase - < 3 years. 1 - Immediate
Extent	5 - International: Beyond National boundaries. 4 - National: Beyond Provincial boundaries and within National boundaries. 3 - Regional: Beyond 5 km of the proposed development and within Provincial boundaries.

	2 - Local: Within 5 km of the proposed development. 1 - Site-specific: On site or within 100 m of the site boundary. 0 - None
Irreplaceable loss of resources	5 – Definite loss of irreplaceable resources. 4 – High potential for loss of irreplaceable resources. 3 – Moderate potential for loss of irreplaceable resources. 2 – Low potential for loss of irreplaceable resources. 1 – Very low potential for loss of irreplaceable resources. 0 - None
Reversibility	5 – Impact cannot be reversed. 4 – Low potential that impact might be reversed. 3 – Moderate potential that impact might be reversed. 2 – High potential that impact might be reversed. 1 – Impact will be reversible. 0 – No impact.
Cumulative impacts	High: The activity is one of several similar past, present or future activities in the same geographical area, and might contribute to a very significant combined impact on the natural, cultural, and/or socio-economic resources of local, regional or national concern. Medium: The activity is one of a few similar past, present or future activities in the same geographical area, and might have a combined impact of moderate significance on the natural, cultural, and/or socio-economic resources of local, regional or national concern. Low: The activity is localised and might have a negligible cumulative impact. None: No cumulative impact on the environment.

The significance, which is determined through a synthesis of the characteristics described above, is then calculated by combining the criteria in the following formula:

SP (Significance Points) = (Magnitude + Duration + Extent + Irreplaceability + Reversibility) x Probability

The significance weightings for each potential impact were provided in **Table 4**.

Table 4: Definition of significance ratings

Significance Points	***Environmental Significance***	***Description***
125-150	Very high	An impact of very high significance will mean that the project cannot proceed, and that impacts are irreversible, regardless of available mitigation options.
100-124	High	An impact of high significance which could influence a decision about whether or not to proceed with the proposed project, regardless of available mitigation options.
75-99	Medium-High	If left unmanaged, an impact of medium-high significance could influence a decision about whether or not to proceed with a proposed project. Mitigation options should be relooked.
40-74	Medium	If left unmanaged, an impact of moderate significance could influence a decision about whether or not to proceed with a proposed project.
<40	Low	An impact of low is likely to contribute to positive decisions about whether or not to proceed with the project. It will have little real effect and is unlikely to have an influence on project design or alternative motivation.
+		A positive impact is likely to result in a positive consequence/effect, and is likely to contribute to positive decisions about whether or not to proceed with the project.

The results of the assessment were presented in **Table 5** below.

Table 5: Results of the impact assessment

Nature: Soil degradation (soil removal, mixing, compaction, etc) due to the construction of roads and structures (PV panels, buildings, substations, powerlines).		
	Without mitigation	***With mitigation***
Magnitude	Low (4)	Very Low (2)
Duration	Short term (2)	Short term (2)
Extent	Site-specific (1)	Site-specific (1)
Irreplaceability	Low (1)	Low (1)
Reversibility	Moderate (3)	High (2)
Probability	Definite (5)	Definite (5)
Significance rating	**55 (Medium)**	**40 (Low)**
Can impacts be mitigated?	Yes, by adhering to EMP and engineering specifications.	
Mitigation:	» Minimise excavations and disturbance areas. » Rehabilitate topsoil & vegetation around site after construction.	
Cumulative impacts:	» Soil degradation in the Welkom area has been significantly affected by mining activity, which is generally carries a higher significance. Further development of the area may have increasing impact on the natural soil but the additional cumulative impact of the proposed activity is considered minimal.	
Residual impacts:	» Minor loss of soil under roads and structures.	
Nature: Soil degradation due to pollution of soil by contaminants used on site during construction (e.g. fuel, oil, chemicals, cement).		
	Without mitigation	***With mitigation***
Magnitude	Low (4)	Very Low (2)
Duration	Short term (2)	Short term (2)
Extent	Site-specific (1)	Site-specific (1)
Irreplaceability	Low (1)	Low (1)
Reversibility	Moderate (3)	High (2)
Probability	Medium (3)	Low (2)
Significance rating	33 (Low)	16 (Low)
Can impacts be mitigated?	Yes, by adhering to EMP and engineering specifications.	

Mitigation:	» Provide contamination prevention systems on site. » Control use and disposal of potential contaminants or hazardous materials. » Remove contaminants and contaminated topsoil and replace topsoil in affected areas.	
Cumulative impacts:	» Soil degradation in the Welkom area has been significantly affected by mining activity, which is generally carries a higher significance. Further development of the area may have increasing impact on the natural soil but the additional cumulative impact of the proposed activity is considered minimal.	
Residual impacts:	» Negligible.	
Nature: Soil erosion by wind and/or water on construction areas		
	Without mitigation	***With mitigation***
Magnitude	Low (4)	Very Low (2)
Duration	Short term (2)	Short term (2)
Extent	Site-specific (1)	Site-specific (1)
Irreplaceability	Low (1)	Low (1)
Reversibility	Moderate (3)	High (2)
Probability	Medium (3)	Low (2)
Significance rating	33 (Low)	16 (Low)
Can impacts be mitigated?	Yes, by adhering to EMP and engineering specifications.	
Mitigation:	» Minimise size of the construction footprint/camp. » Restrict activity outside of construction camp areas. » Implement effective erosion control measures around site. » Carry out earthworks in phases across site to reduce the area of exposed ground at any one time. » Protect and maintain denuded areas and material stockpiles to minimise erosion and instability	
Cumulative impacts:	» Soil degradation in the Welkom area has been significantly affected by mining activity, which is generally carries a higher significance. Further development of the area may have increasing impact on the natural soil but the additional cumulative impact of the proposed activity is considered minimal.	
Residual impacts:	» Negligible.	
Nature: Degradation of watercourses due to siltation (silt-loading) due to erosion from site		
	Without mitigation	***With mitigation***
Magnitude	Low (4)	Very Low (2)

Duration	Short term (2)	Short term (2)
Extent	Site-specific (1)	Site-specific (1)
Irreplaceability	Low (1)	Low (1)
Reversibility	Low (4)	Low (4)
Probability	Medium (3)	Low (2)
Significance rating	36 (Low)	20 (Low)
Can impacts be mitigated?	Yes, by adhering to EMP and engineering specifications.	
Mitigation:	» Install anti-erosion measures such as silt fences, geosynthetic erosion protection, and/or flow attenuation along watercourses below construction sites. » Strictly control activity near water courses/natural drainage lines as sediment transport is higher in these areas. » Minimise increased run-off from hard surfaces (PV panels) by channelising and capturing rainwater for re-use (rainwater harvesting)	
Cumulative impacts:	» Soil degradation in the Welkom area has been significantly affected by mining activity, which is generally carries a higher significance. Further development of the area may have increasing impact on the natural soil but the additional cumulative impact of the proposed activity is considered minimal.	
Residual impacts:	» Negligible.	
Nature: Dust pollution due to wind erosion from site		
	Without mitigation	***With mitigation***
Magnitude	Low (4)	Very Low (2)
Duration	Short term (2)	Short term (2)
Extent	Site-specific (1)	Site-specific (1)
Irreplaceability	Low (1)	Low (1)
Reversibility	Low (4)	Low (4)
Probability	Medium (3)	Low (2)
Significance rating	36 (Low)	20 (Low)
Can impacts be mitigated?	Yes, by adhering to EMP and engineering specifications.	
Mitigation:	» Apply dust control measures such as straw bales or dampen dusty denuded areas.	

Cumulative impacts:	»	Soil degradation in the Welkom area has been significantly affected by mining activity, which is generally carries a higher significance. Further development of the area may have increasing impact on the natural soil but the additional cumulative impact of the proposed activity is considered minimal.
Residual impacts:	»	Negligible.

9.4 Impact statement

The most significant potential negative impacts on the geological environment are that of soil degradation. However, if these impacts are successfully mitigated the proposed activity will have an overall low negative impact on the environment.

An assessment of the cumulative impacts on soil degradation in the vicinity takes into account the nearby mining activities which have been a significant potential contributor to cumulative soil degradation in the area. In comparison, the proposed solar energy development is considered to be a relatively small contributor to the cumulative impact of the degradation of the local soil resource and this should not hinder its development.

10. Recommendations

The following recommendations have been provided as a guideline based on the information gained from the preliminary investigation. Although this level of investigation was deemed acceptable for environmental assessment, project feasibility and planning purposes, a detailed geotechnical investigation would have to be commissioned during the detailed design phase of the project.

10.1 Development potential layout

The proposed development is supported and the layout should consider the constraints and no-go areas identified in Chapter 9.1.

10.2 Earthworks and foundations

No electrical infrastructure or buildings are recommended within a buffer zone of at least 32m from the centreline of natural drainage lines where these occur on the site. Box or pipe culverts with properly designed wingwalls are recommended where access roads cross drainage lines. No buildings are recommended on slopes steeper than 1:5 unless special measures are taken to ensure stable foundations and excavations. Erosion is not considered to be a major risk in areas away from drainage lines but practical steps should be taken to minimise erosion of loosened soil or where vegetation is stripped, such as silt fences and stormwater control.

Single story masonry buildings, such as substation control rooms, maintenance buildings, etc would be generally suited to shallow spread footings or rafts, taking into account geotechnical information provided from detailed on-site testing.

PV array frames and overhead powerline structures would typically be founded on shallow spread (gravity) foundations, frictional driven piles or pre-manufactured steel piles cast into pre-bored holes (see **Figures 11 & 12**). The method would largely be dictated by the ground profile to be determined in detailed geotechnical investigations. Short frictional piles cast into a pre-bored hole would be more suitable in shallow very dense/stiff soils or rock, whereas driven piles would be more suitable in thicker granular soil profiles. The dominant forces in consideration in the design of foundations for PV arrays are horizontal forces and moments due to wind acting on the panels, which are then transferred into the frame and down into the ground. The foundations should be deep enough or heavy enough to resist uplift forces and overturning moments. The founding conditions on the site would have to be investigated with subsurface testing to determine soil/rock profile and geotechnical properties.

Figure 11: Typical spread (gravity) foundation systems for PV panels (left) and overhead powerlines (right)

Figure 12: Driven piles for PV array frames

10.3 Roads, platforms and lay-down areas

Internal access roads will be required to service the panels and other infrastructure. Typically, access roads and platforms would be surfaced with gravel materials obtained from site or imported from commercial sources if the insitu subgrade is poor or unfavourable. In areas where the subgrade soils are poor (soft silty sandy), such as near drainage lines, imported gravel material may be required. Geotechnical investigations would be required to investigate and identify potential sources of natural materials on site.

10.4 Environmental Management Programme (EMP) guidelines for earthworks

Negative impacts can be mitigated to a large degree by the implementation of an appropriate and effective EMP. The following generic guidelines relate specifically to the earthworks contract.

10.4.1 Earthworks

- Prior to earthworks (including site clearance) starting on the site, a plant search and rescue operation should be undertaken as per the requirements set out in the EMP.
- All earthworks shall be undertaken in such a manner to minimise the extent of any impacts caused by such activities.
- Defined access routes to and from the area of operations as well as around the area of operation shall be adhered to.
- No equipment associated with the activity shall be allowed outside of these areas unless expressly permitted by the Environmental Control Officer (ECO).
- Mechanical methods of rock breaking, including Montabert-type breakers and jackhammers, have noise and dust impacts, and must be addressed in the EMP.
- Residents shall be notified at least one week prior to these activities commencing, and their concerns addressed.
- Chemical breaking shall require a method statement approved by the Engineer’s Representative (ER).

10.4.2 Topsoil

- Prior to construction, the topsoil areas to be disturbed should be stripped to a depth to be confirmed by the ER and set aside for spreading to all areas to be reinstated after the construction. Temporary topsoil stock piles must be covered with net, shade cloth or straw bales to protect them.
- Once all grades have been finalised and prepared, topsoil should be spread evenly to all affected areas to be re-vegetated.

10.4.3 Erosion and Sedimentation Control

- During construction, the contractor shall protect areas susceptible to erosion by installing necessary temporary and permanent drainage works as soon as possible and by taking other measures necessary to prevent the surface water from being concentrated in streams and from scouring the slopes, banks or other areas.
- A method statement shall be developed and submitted to the ER to deal with erosion issues prior to bulk earthworks operations commencing.
- Any erosion channels developed during the construction period or during the vegetation establishment period shall be backfilled and compacted and the areas restored to a proper condition.

- Stabilisation of cleared areas to prevent and control erosion shall be actively managed. The method of stabilisation shall determine in consultation with the ECO. Consideration and provision shall be made for the following methods (or combination):
  - Brush cut packing
  - Mulch or chip cover
  - Straw stabilising
  - Watering
  - Planting/sodding
  - Hand seed-sowing
  - Hydroseeding
  - Soil binders and anti erosion compounds
  - Gabion bolsters & mattresses for flow attenuation
  - Geofabric
  - Hessian cover
  - Log/ pole fencing
- Traffic and movement over stabilised areas shall be restricted and controlled and damage to stabilised areas shall be repaired and maintained to the satisfaction of the ECO.
- Anti-erosion compounds shall consist of all organic or inorganic material to bind soil particles together and shall be a proven product able to suppress dust and erosion. The application rate shall conform to the manufacturer's recommendations. The material used shall be approved by the ECO.

10.4.4 Drilling and Jack-Hammering

- The contractor shall submit a method statement detailing his proposals to prevent pollution during drilling operations. This shall be approved by the site manager prior to the onset of any drilling operations.
- The contractor shall take all reasonable measures to limit dust generation as a result of drilling operations.
- Noise and dust nuisances shall comply with the applicable standards according to the Occupational Health and safety (Act No. 85 of 1993).
- The Contractor shall ensure that no pollution results from drilling operations, either as a result of oil and fuel drips, or from drilling fluid.
- All affected parties shall be informed at least one week prior to the onset of the proposed drilling/jackhammering operations, and their concerns addressed.
- Drill coring with water or coolant lubricants shall require a method statement approved by the Site Manager.
- Any areas or structures damaged by the drilling and associated activities shall be rehabilitated by the contractor to the satisfaction of the site manager.

10.4.5 Trenching

- Trenching shall be kept to a minimum using single trenches for multiple service provision.
- The planning and selection of trench routes shall be undertaken in liaison with the ER and cognisance shall be given to minimising the potential for soil erosion.
- Trench routes with permitted working areas shall be clearly defined and marked with painted stakes prior to excavation.
- The stripping and separation of topsoil shall occur as stipulated by the ER. Soil shall be stockpiled for use as backfilling as directed by the ER.

- Trench lengths shall be kept as short as practically possible before backfilling and compacting.
- Trenches shall be backfilled to the same level as (or slightly higher to allow for settlement) the surrounding land surface to minimise erosion. Excess soil shall be stockpiled in an area approved by the engineer.
- Immediately after backfilling, trenches and associated disturbed working areas shall be planted with a suitable plant species and regularly watered. Where there is a particularly high erosion risk, a fabric such as Geojute (biodegradable) shall be used in addition to planting.

10.4.6 Dust

- The contractor shall be solely responsible for the control of dust arising from the contractor's operations and for any costs against the employer for damages resulting from dust.
- The contractor shall take all reasonable measures to minimise the generation of dust as a result of construction activities to the satisfaction of the site manager.
- Removal of vegetation shall be avoided until such time as soil stripping is required and similarly exposed surfaces shall be re-vegetated or stabilised as soon as is practically possible.
- Excavation, handling and transport of erodible materials shall be avoided under high wind conditions or when a visible dust plume is present.
- During high wind conditions the site manager will evaluate the situation and make recommendations as to whether dust damping measures are adequate, or whether working will cease altogether until the wind speed drops to an acceptable level.
- Where possible, soil stockpiles shall be located in sheltered areas where they are not exposed to the erosive effects of the wind. Where erosion of stockpiles becomes a problem, erosion control measures shall be implemented at the discretion of the site manager.
- Vehicle speeds shall not exceed 40km/h along dust roads or 20km/h when traversing unconsolidated and non-vegetated areas.
- Appropriate dust suppression measures shall be used when dust generation as unavoidable, e.g. dampening with water, particularly during prolonged periods of dry weather in summer. Such measures shall also include the use of temporary stabilising measures (e.g. chemical soil binders, straw, brush packs, clipping etc.)
- Straw stabilisation shall be applied at a rate of one bale/ 10m2 and harrowed into the top 100mm of top material for all completed earthworks.

10.4.7 Imported Materials and Stockpiles

- Imported materials shall be free of weeds, litter and contaminants.
- Sources of imported material shall be listed and approved by the ER on site.
- The contractor shall provide samples to the ER for approval.
- Stockpile areas shall be approved by the ER before any stockpiling commences.

11. Conclusions

The preliminary geotechnical investigation has established a baseline study of the local geology of the site and provided high-level development constraints for project planning. Potential environmental impacts relating to the geology of the site were also assessed and found to be generally low. The investigation has indicated that the majority of the site is highly suitable for the proposed development of a PVSEF. Some general recommendations have been provided project planning and feasibility, but further site investigations will be required to investigate the subsurface conditions for engineering design purposes.

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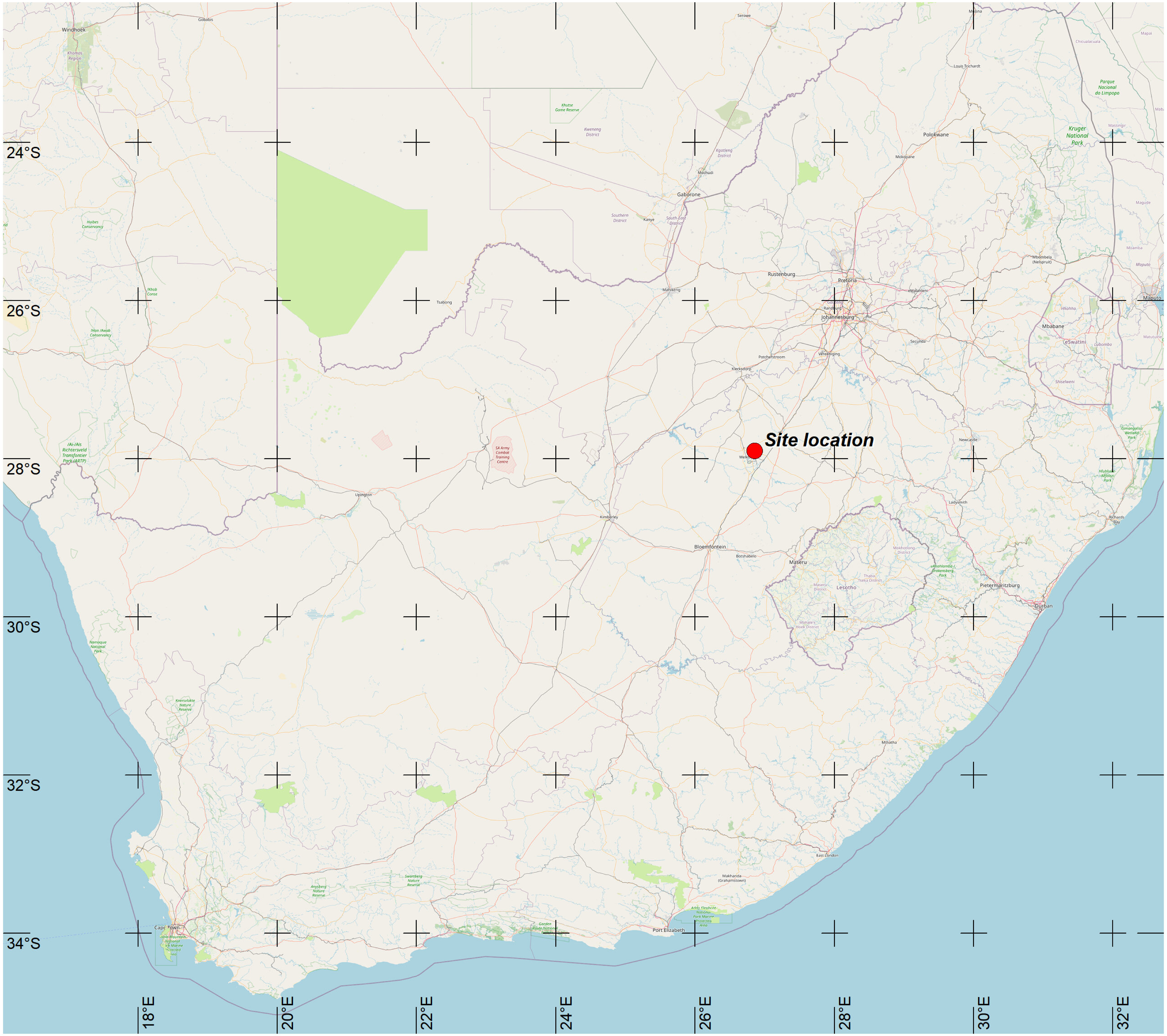
Appendix 1

Maps



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Legend

Site location

Project: Khatua North Solar PV Project
Site: Khauta North SPV Site
Area: Free State Province, South Africa

Dwg Name: Locality map
Date: January 2023
Rev no: 1
Drawn: IP

Client: Khauta North Solar PV Facility RF (Pty) Ltd
Environmental Consultant: Enviroworks

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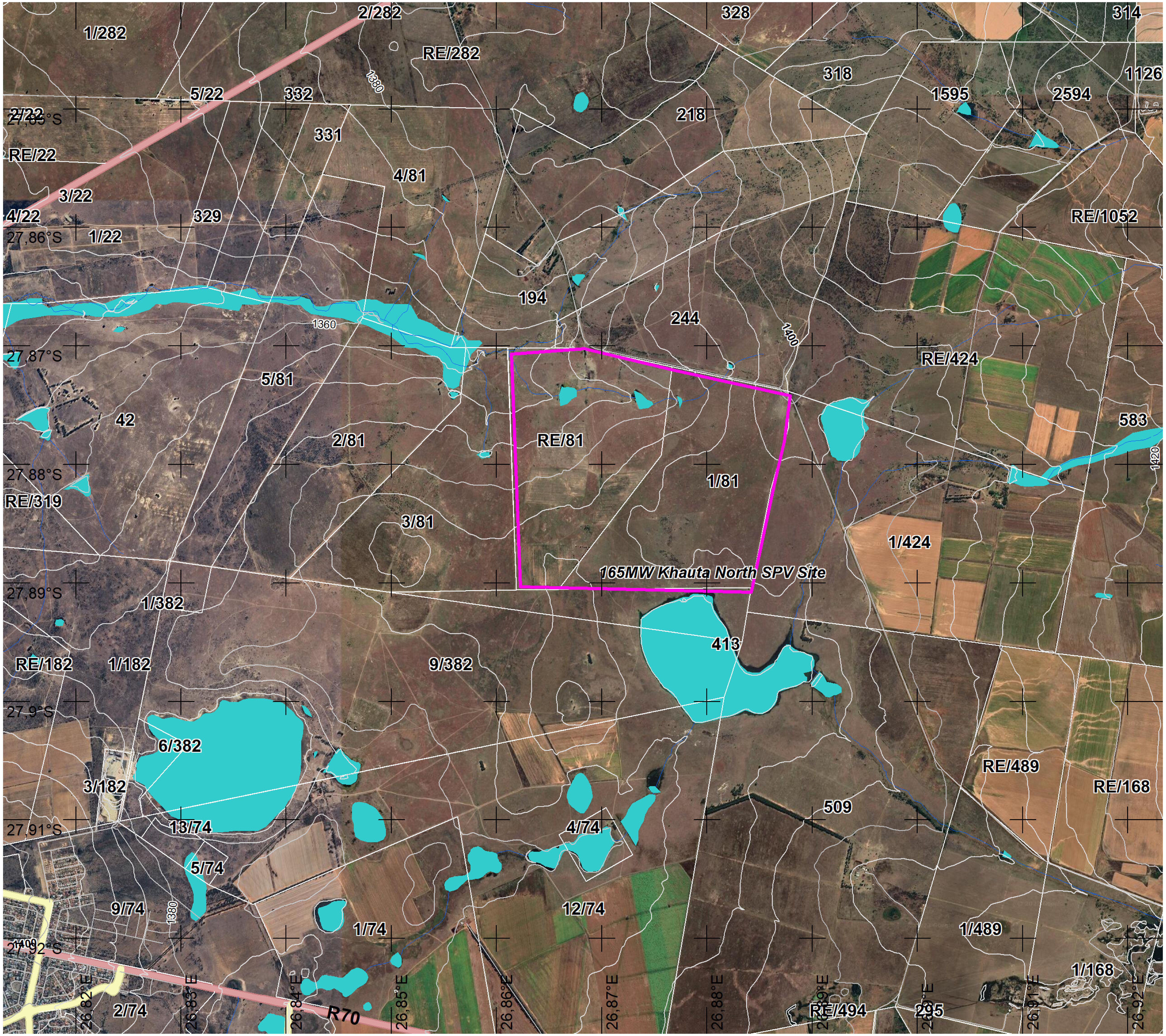

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Legend

Contours

Contours

5

20

100

500

165MW Khauta North

165MW Khauta North SPV Site.kmz

Site boundary

Project: Khatua North Solar PV Project
Site: Khauta North SPV Site
Area: Free State Province, South Africa

Dwg Name: Aerial photo map
Date: January 2023
Rev no: 1
Drawn: IP

Client: Khauta North Solar PV Facility RF (Pty) Ltd
Environmental Consultant: Enviroworks

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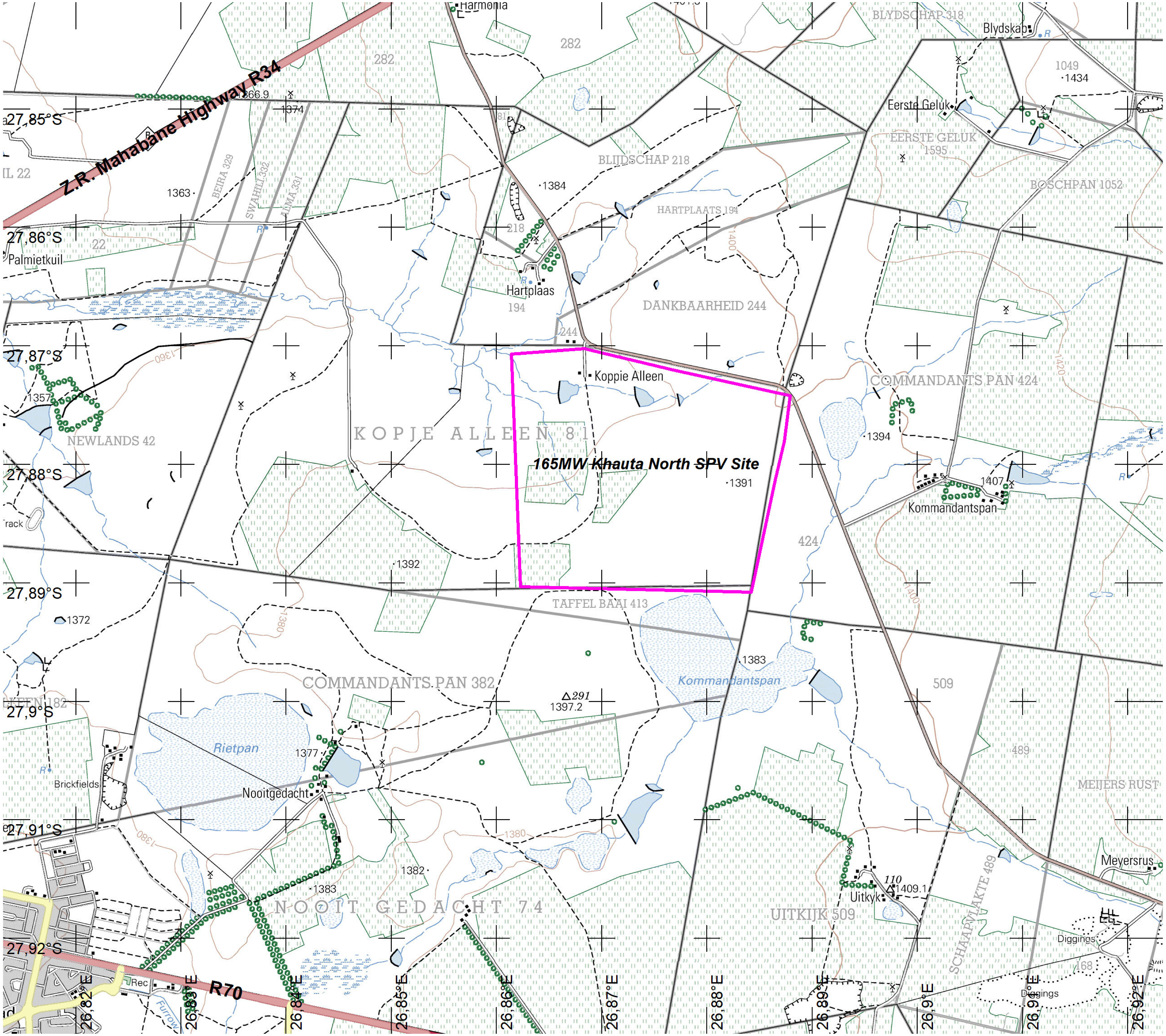

Legend

165MW Khauta North

165MW Khauta North SPV Site.kmz

Site boundary

Project: Khatua North Solar PV Project
Site: Khauta North SPV Site
Area: Free State Province, South Africa

Dwg Name: Topographical map
Date: January 2023
Rev no: 1
Drawn: IP

Client: Khauta North Solar PV Facility RF (Pty) Ltd
Environmental Consultant: Enviroworks

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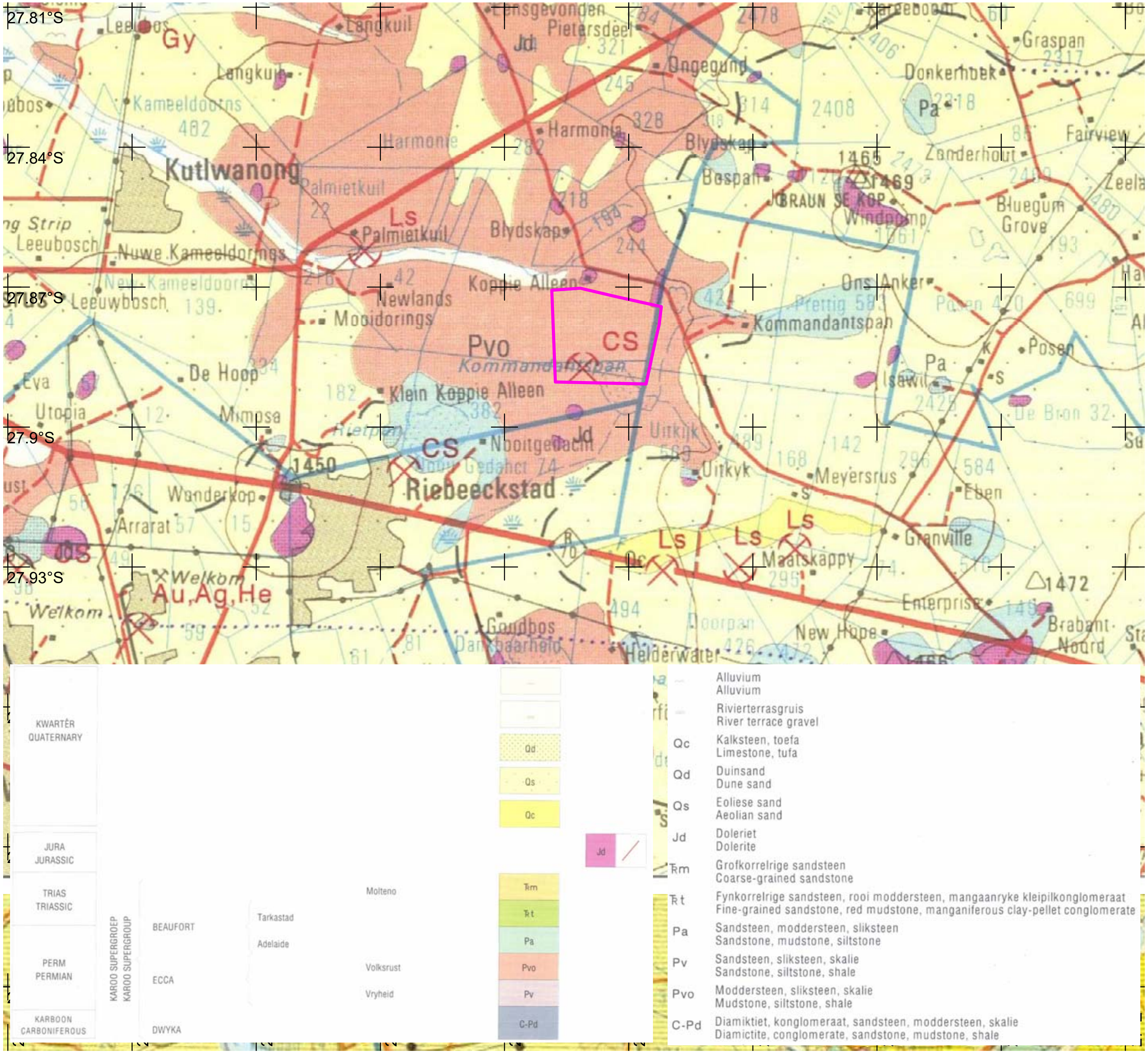

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165MW Khauta North SPV Site.kmz

Site boundary

Project: Khatua North Solar PV Project
Site: Khauta North SPV Site
Area: Free State Province, South Africa

Dwg Name: Geology Map
Date: January 2023
Rev no: 1
Drawn: IP

Client: Khauta North Solar PV Facility RF (Pty) Ltd
Environmental Consultant: Enviroworks

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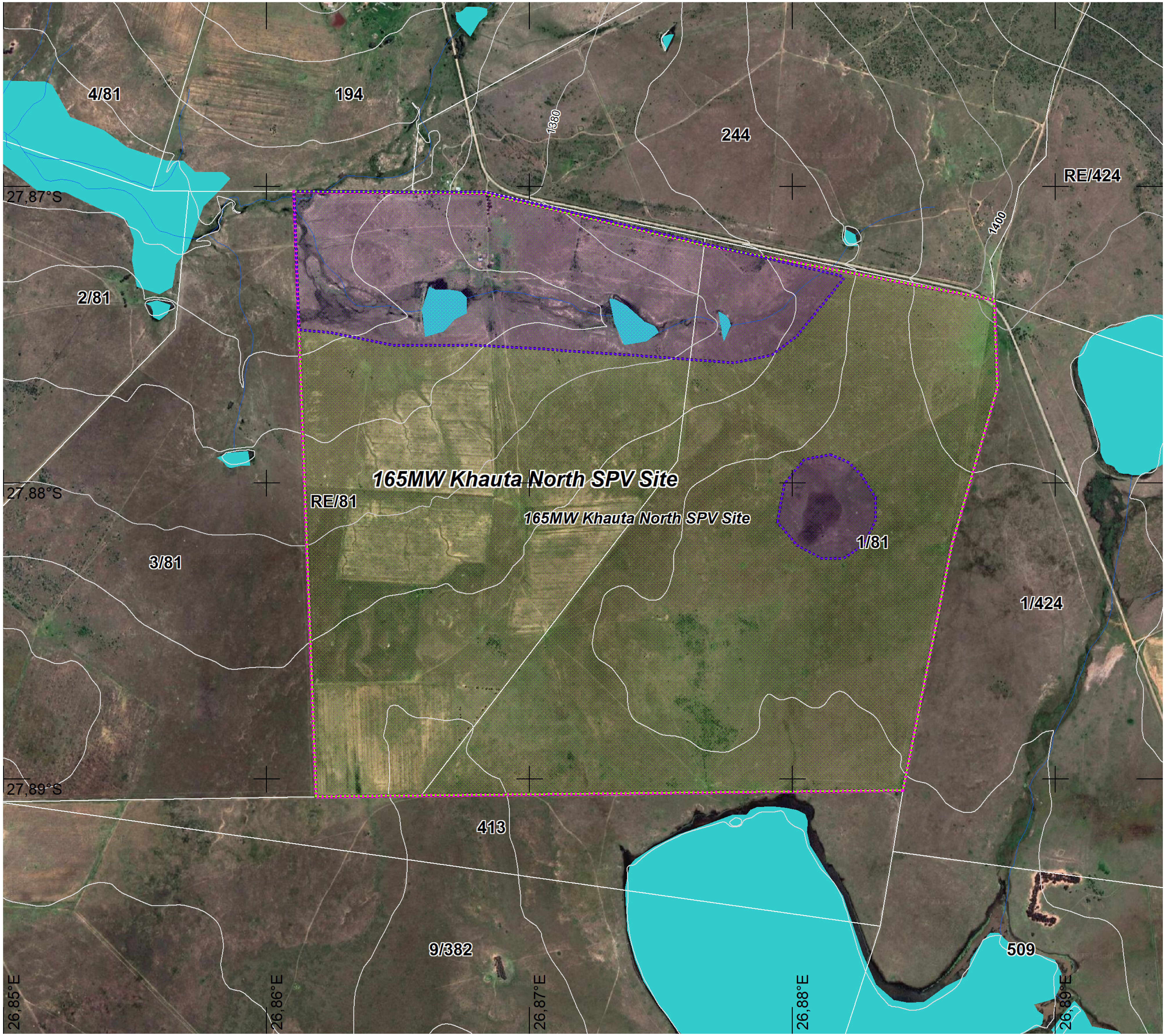

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Legend

Contours

Contours

5

20

100

500

165MW Khauta North

165MW Khauta North SPV Site.kmz

Site boundary

Geotechnical Terrains

Terrain 1 (C-C1/H-H1)

Terrain 2 (P)

Project: Khatua North Solar PV Project
Site: Khauta North SPV Site
Area: Free State Province, South Africa

Dwg Name: Geotechnical map
Date: January 2023
Rev no: 1
Drawn: IP

Client: Khauta North Solar PV Facility RF (Pty) Ltd
Environmental Consultant: Enviroworks

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