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ECOLOGY & BIODIVERSITY

PROPOSED VREDE SOLAR ENERGY FACILITY NEAR KROONSTAD, FREE STATE PROVINCE

FRESHWATER RESOURCE ASSESSMENT: EIA PHASE

Version: 1.1

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Author: Gerhard Botha

PROPOSED VREDE SOLAR ENERGY FACILITY NEAR KROONSTAD, FREE STATE PROVINCE

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Authors: Mr. Gerhard Botha

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I. DECLARATION OF CONSULTANTS INDEPENDENCE

- act/ed as the independent specialist in this application;
- regard the information contained in this report as it relates to my specialist input/study to be true and correct, and
- do not have and will not have any financial interest in the undertaking of the activity, other than remuneration for work performed in terms of the NEMA, the Environmental Impact Assessment Regulations, 2014 and any specific environmental management Act;
- have and will not have any vested interest in the proposed activity proceeding;
- have disclosed, to the applicant, EAP and competent authority, any material information that has or may have the potential to influence the decision of the competent authority or the objectivity of any report, plan or document required in terms of the NEMA, the Environmental Impact Assessment Regulations, 2014 and any specific environmental management Act;
- have provided the competent authority with access to all information at my disposal regarding the application, whether such information is favourable to the applicant or not; and
- am aware that a false declaration is an offense in terms of regulation 48 of GN No. R. 326.

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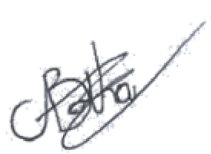
Field of expertise: Fauna & flora, terrestrial biodiversity, wetland ecology, aquatic and wetland, aquatic biomonitoring, and wetland habitat evaluations. BSc (Hons) Zoology and Botany, MSc Botany (Phytosociology) from 2011 to present.



April 2021

II. STATEMENT OF WORK

- This study has been executed in accordance with and meet the responsibilities in terms of:
  - NEMA, the Environmental Impact Assessment Regulations, 2014 (specifically in terms of regulation 13 of GN No. R. 326);
  - The "newly" Gazetted Protocols 3(a),(c) and (d) in terms of Section 24(5)(a) and 24(5)(h) of NEMA (Published on the 20th of March 2020);
  - The Aquatic Biodiversity Protocol published in GN NO. 1105 of 30 October 2020

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Field of expertise: Fauna & flora, terrestrial biodiversity, wetland ecology, aquatic and wetland, aquatic biomonitoring, and wetland habitat evaluations. BSc (Hons) Zoology and Botany, MSc Botany (Phytosociology) from 2011 to present.

Refer to Appendix 3 for curriculum vitae, Appendix 4 for relevant work experience and Appendix 5 for SACNASP Registration.

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PROPOSED VREDE SOLAR ENERGY FACILITY NEAR KROONSTAD, FREE STATE PROVINCE

FRESHWATER RESOURCE ASSESSMENT: EIA PHASE

1. INTRODUCTION

Client

Savannah Environmental (Pty) Ltd. on behalf of South Africa Mainstream Renewable Power Developments (Pty) Ltd.

Project

the 100 MWac Vrede Photovoltaic (PV) Solar Energy Facility (SEF), Battery Energy Storage System (BESS) and associated infrastructure located near the town of Kroonstad in the Moqhaka Local Municipality (Fezile Dabi District) of the Free State Province of South Africa

Proposed Activity

South Africa Mainstream Renewable Power Developments (Pty) Ltd is proposing the construction and operation of the 100 MWac Vrede Photovoltaic (PV) Solar Energy Facility (SEF), Battery Energy Storage System (BESS) and associated infrastructure located near the town of Kroonstad in the Moqhaka Local Municipality (Fezile Dabi District) of the Free State Province of South Africa (Figure 1). The total size of the project area is approximately 263ha whilst the development footprint itself will cover 217ha, inclusive of the substation (3.3ha).

The properties investigated include:

» Remaining extent of the farm Vrede No. 1152 (main & grid site);
» Portion 1 of the farm Uitval No. 1104 (main site);
» Remaining Extent of the farm Gesukkel No. 1153 (grid site); and
» Remaining Extent of the farm Geduld No. 1156 (grid site).

The Vrede SEF is proposed on the following properties:

» Remaining extent of the farm Vrede No. 1152; and
» Portion 1 of the farm Uitval No. 1104.

The grid connection infrastructure is proposed on the following properties:

- Remaining extent of the farm Vrede No. 1152;
- Remaining Extent of the farm Gesukkel No. 1153; and
- Remaining Extent of the farm Geduld No. 1156.

*** Please take not that even though the proposed grid connection have been mentioned above, the assessment of this infrastructure will be done in a separate Environmental Basic Assessment Report. This Environmental Scoping Report deals exclusively with the SEF and associated components.**

As mentioned, the proposed SEF is envisaged to have a generating capacity of up to 100MW and would include the following infrastructure:

- Solar Arrays:
- Solar Panel Technology - Mono and Bifacial Photovoltaic (PV) Modules;
- Mounting System Technology – single axis tracking, dual axis tracking or fixed axis tracking PV;
- Underground cabling (up to 33kV)
- Centralised inverter stations or string inverters; Power Transformers;
- Building Infrastructure
- Offices;
- Operational control centre;
- Operation and Maintenance Area / Warehouse / workshop;
- Ablution facilities;
- Battery Energy Storage System;
- Substation building.
- Electrical Infrastructure
- 33/132kV Independent Power Producer (IPP) onsite substation including associated equipment and infrastructure
- Underground cabling and overhead power lines (up to 33kV)
- Associated Infrastructure:
- Access roads and Internal gravel roads;
- Fencing and lighting;
- Lightning protection
- Permanente laydown area;
- Temporary construction camp and laydown area;
- Telecommunication infrastructure;
- Concrete batching plant (if required);
- Stormwater channels; and water pipelines.

Access to the SEF will be via the S172 gravel road which links the farming area with the P99/1 route.

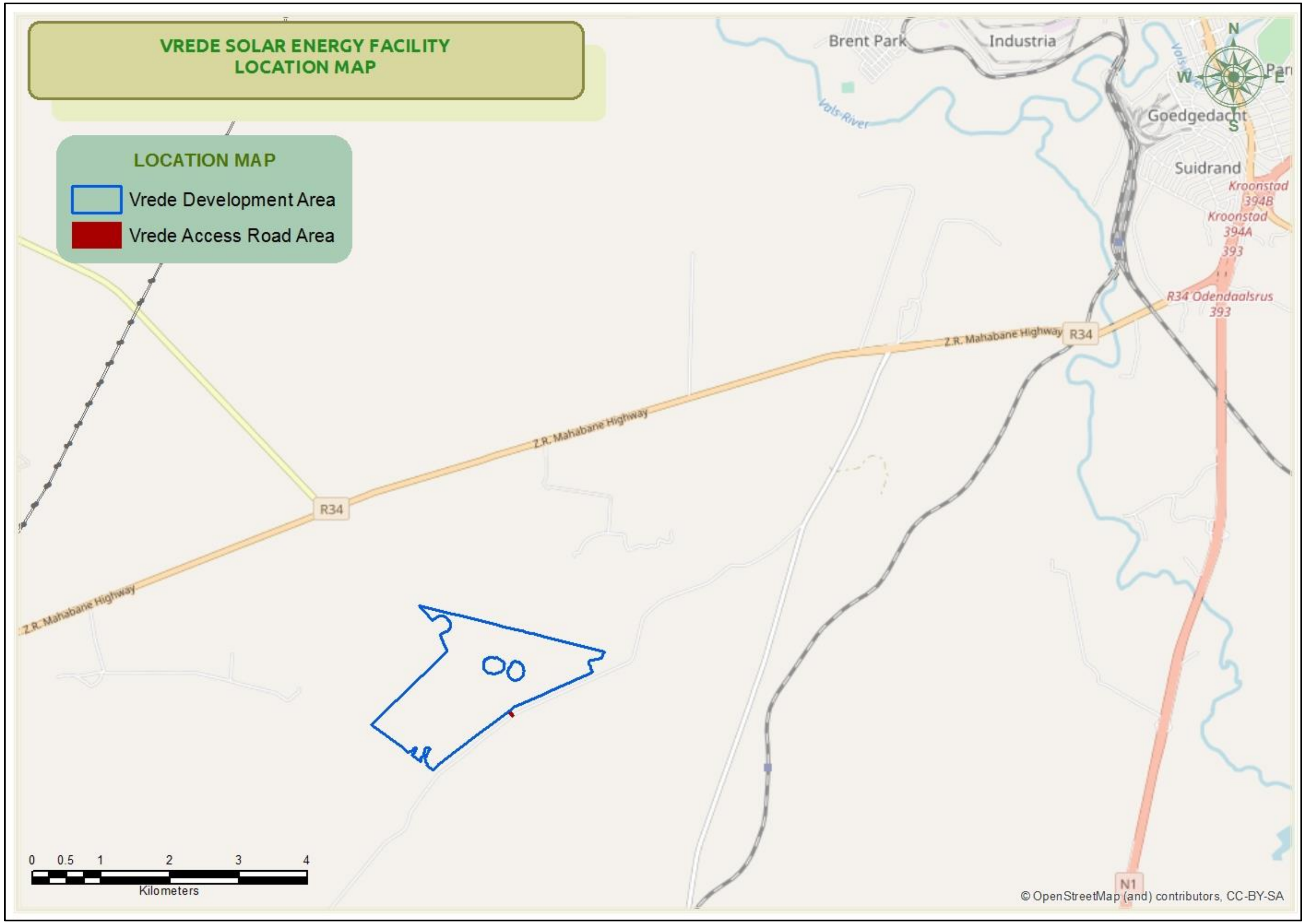


Figure 1: Proposed location of the Vrede SEF

Terms of reference

The primary objective of the specialist freshwater resource assessment was to provide information to guide the proposed Solar PV Facility development with respect to the potential impacts on the affected freshwater ecosystems within the project site. The focus of this study was solely on the specific Hydrogeomorphic Units (HGMs), within a radius of 500m of the proposed footprint and which will likely be impacted by the proposed development.

The focus of the work involved the undertaking of a specialist assessment of freshwater resource features, which included the following tasks:

- Desktop identification and delineation of potential freshwater resource areas affected by the proposed development, or occurring within a 500m radius of the proposed development using available imagery, contour information and spatial datasets in a Geographical Information System (GIS);
- Undertaking a rapid water resource screening and risk assessment to determine which desktop delineated/mapped watercourses/wetlands are likely to be measurably affected by the proposed activities. This was used to flag watercourses/wetlands for further infield assessments as well as identify those watercourses/wetlands to be unaffected and not require further assessment (i.e. wetlands/rivers within adjacent catchments, upstream or some distance downstream of the predicted impact zone);
- Site-based (detailed in-field) delineation of the outer wetland boundary of wetland/watercourse areas within the project focal area and which were flagged during the desktop screening/risk assessment;
- Classification of wetlands and riparian areas and assessment of conservation significance based on available data sets;
- Description of the biophysical characteristics of the delineated freshwater habitats based on onsite observations and sampling (i.e. hydrology, soils, vegetation, existing impacts etc.);
- Baseline functional assessment of wetland habitats based on field investigations, involving the:
  - PES (Present Ecological State/Condition) of the delineated wetland units;
  - EIS (Ecological Importance and Sensitivity) of the delineated wetland units;
  - Direct and indirect ecosystem services (functions) importance of the delineated wetland units only.
- Impact assessment and identification of mitigation measures to reduce the significance of potential aquatic impacts for both the construction and operational phases of the pipeline project. For this section the same methodology and layout approach within the existing report was followed in order to maintain uniformity and coherence between the two reports.
- Compilation of a specialist wetland assessment report detailing the methodology and findings of the assessment, together with relevant maps and GIS information.

Conditions of this report

Findings, recommendations and conclusions provided in this report are based on the authors' best scientific and professional knowledge and information available at the time of compilation. No form of this report may be amended or extended without the prior written consent of the author. Any recommendations, statements or conclusions drawn from or based on this report must clearly cite or make reference to this report. Whenever such recommendations, statements or conclusions form part of a main report relating to the current investigation, this report must be included in its entirety.

Relevant legislation

The link between ecological integrity of freshwater resources and their continued provision of valuable ecosystem goods and services to burgeoning populations is well-recognised, both globally and nationally (Rivers-Moore et al., 2007). In response to the importance of freshwater aquatic resources, protection of wetlands and rivers has been campaigned at national and international levels. A strong legislative framework which backs up South Africa's obligations to numerous international conservation agreements creates the necessary enabling legal framework for the protection of freshwater resources in the country. Relevant environmental legislation pertaining to the protection and use of aquatic ecosystems (i.e. wetlands and rivers) in South Africa has been summarized below.

South African Constitution 108 of 1996

» Section 24 of Chapter 2 of the Bill of Rights No. 108 of 1996 states that everyone has the right to:
  (a) to an environment that is not harmful to their health or well-being; and
  (b) to have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that—
    (i) prevent pollution and ecological degradation;
    (i) promote conservation; and
    (ii) secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development.

National Environmental Management Act 107 of 1998

» Wetlands and other watercourses defined in the NWA are also protected in the National Environmental Management Act (Act 107 of 1998), (NEMA). The act lists several activities that require authorisation before they can be implemented. NEMA lists various activities that require authorisation when located within 32 m or less from the edge of a wetland or other watercourse type.

National Water Act (Act No. 36 of 1998)

According to the National Water Act (Act No. 36 of 1998), a water resource is defined as: "a watercourse, surface water, estuary, or aquifer. A watercourse in turn refers to

(a) a river or spring;
(b) a natural channel in which water flows regularly or intermittently;
(c) a wetland, lake or dam into which, or from which, water flows; and
(d) any collection of water which the Minister may, by notice in the Gazette, declare to be a watercourse. Reference to a watercourse includes, where relevant, its bed and banks."

A wetland is defined as: "land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances support or would support vegetation typically adapted to life in saturated soil.

Chapter 4 of the Act deals with the regulation of the use of water and the requirements for controlled activities, general authorisations, and licenses. In general, a water use must be licensed unless: it is listed in Schedule 1 of the Act as an existing lawful water use, or is permissible under a general authorisation, or if a responsible authority waives the need for a license.

According to the Department of Water and Sanitation (DWS), any activity that falls within the temporary zone of a wetland or the 1:100 year floodline (whichever is greater) qualifies as a Section 21 water use activity (depending on the use) and will thus require either a general authorization or Water Use License (WUL). According to the NWA, an application for a WUL should be submitted to the DWS if any of the above activities are to be undertaken.

Section 21 of the National Water Act (NWA Act No. 36 of 1998) covers the following activities, which might be applicable to the proposed project. According to Section 21 of the NWA and in relation to the river ecosystem, the following activity is considered a use, and therefore requires a water use license:

21 (c) impeding or diverting the flow of water in a watercourse;
21 (i) altering the bed, banks, course or characteristics of a watercourse;

In terms of Section 22 (1), a person may only undertake the abovementioned water uses if it is appropriately authorised:

22(1) A person may only use water

(a) without a licence

(i) if that water use is permissible under Schedule 1;
(ii) if that water use is permissible as a continuation of an existing lawful use; or

(iii) if that water use is permissible in terms of a general authorisation issued under section 39;

(b) if the water use is authorised by a licence under this Act; or

(c) if the responsible authority has dispensed with a licence requirement under subsection (3).

Other pieces of legislation that may also be of some relevance to freshwater resources include:

- The National Forests Act No. 84 of 1998;
- The Natural Heritage Resources Act No. 25 of 1999;
- The National Environmental Management: Protected Areas Act No. 57 of 2003;
- Minerals and Petroleum Resources Development Act No. 28 of 2002;

2. METHODOLOGY

Assessment Approach and Philosophy

The delineation and classification of freshwater resources were conducted using the standards and guidelines produced by the DWS (DWAF, 2005 & 2007) and the South African National Biodiversity Institute (SANBI, 2009). These methods are contained in the attached Appendix 1, which also includes wetland definitions, wetland conservation importance, and Present Ecological State (PES) assessment methods used in this report.

In addition to these guidelines, the general approach to freshwater habitat assessment was furthermore based on the proposed framework for wetland assessment as proposed within the Water Research Commission's (WRC) report titled: "Development of a decision-support framework for wetland assessment in South Africa and a Decision-Support Protocol for the rapid assessment of wetland ecological condition" (Ollis *et.* al., 2014). A schematic illustration of the proposed decision-support framework for wetland assessment in South Africa is provided in Figure 3 below.

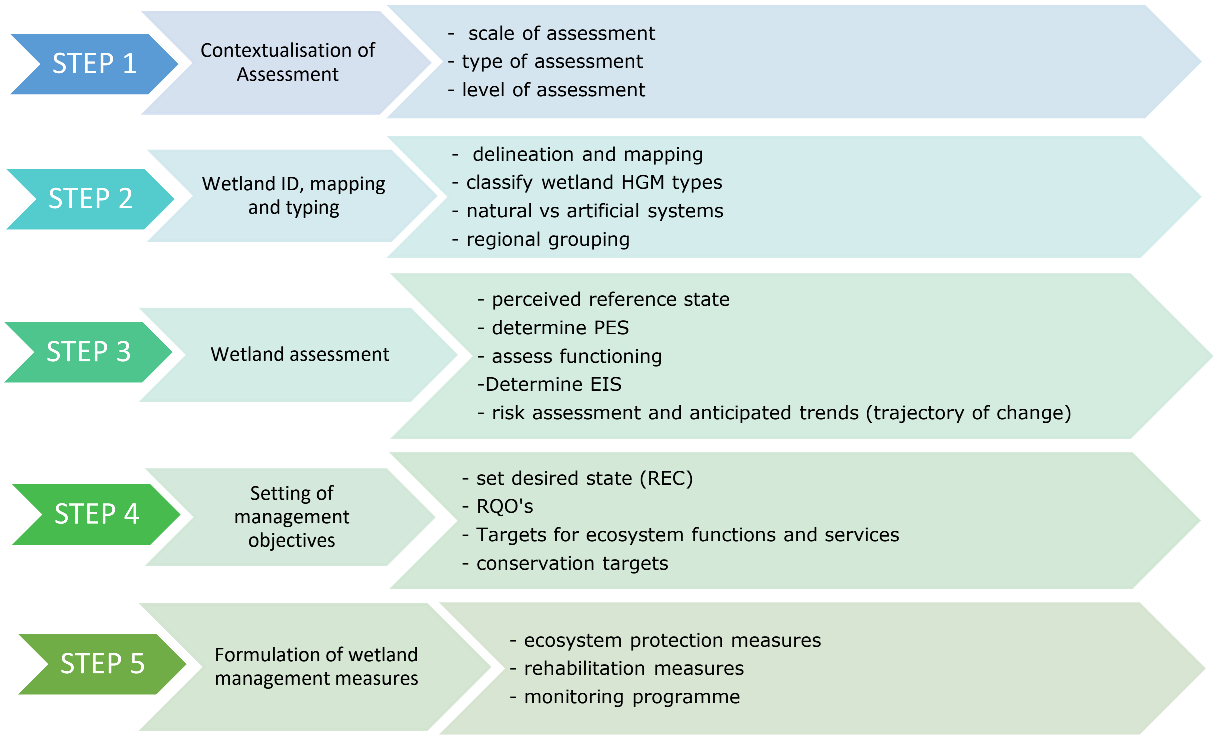


Figure 2: Proposed decision support framework for wetland assessment in South Africa (after Ollis et al., 2014)

Data scouring and review

Data sources from the literature and GIS spatial information was consulted and used where necessary in the study and include the following (also refer to Table 1):

Vegetation:

» Vegetation types and their conservation status were extracted from the South African National Vegetation Map (Mucina and Rutherford 2006) as well as the National List of Threatened Ecosystems (2011), where relevant.

» Critical Biodiversity Areas for the site and surroundings were extracted (CBA Map obtained from the SANBI Database).

» The IUCN conservation status of the species in the list was also extracted from the database and is based on the Threatened Species Programme, Red List of South African Plants (Version 2017.1).

» Nkurenkuru Ecology and Biodiversity, 2021. Proposed Vrede Solar Energy Facility Near Kroonstad, Free State Province: *Terrestrial Ecological Study and Assessment.* Unpublished report Prepared by Nkurenkuru Ecology and Biodiversity for Savannah Environmental. April 2021.

» Kooij, M.S., Scheepers, J.C., Bredenkamp, G.J. & Theron, G.K. (1992). The Vegetation of the Kroonstad Area: A description of the Grassland Communities. *S.Afr.J.Bot*. **58(3)**: 155-164.
» Kooij, M.S., Scheepers, J.C., Bredenkamp, G.J. & Theron, G.K. (1991). The Vegetation of the Kroonstad Area, Orange Free State I: Vlei and Bottomland Communities. *S.Afr.J.Bot*. **57(4)**: 213-219.
» Fuls, E.R., Bredenkamp, G.J. & Van Rooyen, N. (1992). The Hydrophilic Vegetation of the Vredefort – Kroonstad – Lindley – Heilbron Area, Northern Orange Free State. *S.Afr.J.Bot*. **58(4)**: 231-235

Ecosystem:

» Freshwater and wetland information were extracted from the National Freshwater Ecosystem Priority Areas assessment, NFEPA (Nel et al. 2011). This includes rivers, wetlands, and catchments defined under the study.
» Important catchments and protected areas expansion areas were extracted from the National Protected Areas Expansion Strategy 2008 (NPAES).

Table 1: Data coverages used to inform the ecological and freshwater resource assessment.

	Data/Coverage Type	Relevance	Source
Biophysical Context	**1:50 000 Relief Line** (5m Elevation Contours GIS Coverage)	Desktop mapping of terrain and habitat features as well as drainage network.	National Geo-Spatial Information (NGI)
	1:50 000 River Line (GIS Coverage)	Highlight potential on-site and local rivers and wetlands and map local drainage network.	CSIR (2011)
	Free State Province Land-Cover (from SPOT5 Satellite imagery circa 2009)	Shows the land-use and disturbances/transformations within and around the impacted zone.	DETEA (2009)
	South African Vegetation Map (GIS Coverage)	Classify vegetation types and determination of reference primary vegetation.	Mucina *et al.* (2018)
	NFEPA: river and wetland inventories (GIS Coverage)	Highlight potential on-site and local rivers and wetlands.	CSIR (2011)
	NBA 2018 National Wetland Map 5 (GIS Coverage)	Highlight potential on-site and local wetlands	SANBI (2018)
	NBA 2018 Artificial Wetlands (GIS Coverage)	Highlight potential on-site and local artificial wetlands	SANBI (2018)
	DWA Eco-regions (GIS Coverage)	Understand the regional biophysical context in which water resources within the study area occur	DWA (2005)
Conservation and	**NFEPA: River, wetland and estuarine FEPAs** (GIS Coverage)	Shows location of national aquatic ecosystems conservation priorities.	CSIR (2011)
	National Biodiversity Assessment – Threatened Ecosystems (GIS Coverage)	Determination of national threat status of local vegetation types.	SANBI (2011)

	Terrestrial Critical Biodiversity Areas of the Fee State (GIS Coverage)	Determination of provincial terrestrial conservation priorities and biodiversity buffers.	DESTEA (2015)
	Strategic Water Source Areas for Surface Water (SWSA-sw) (GIS Coverage)	Shows the location of the development area relative to areas that contribute significantly to the overall water supply of the country	CSIR (2017)

Baseline Freshwater Resource Assessment

The methods of data collection, analysis and assessment employed as part of the baseline freshwater habitat assessment are briefly discussed in this section. The assessments undertaken as part of this study are listed in Table 2 below along with the relevant published guidelines and assessment tools / methods / protocols utilised. A more comprehensive description of the methods listed below is included in Appendix 1.

Table 2: Summary of methods used in the assessment of delineated freshwater resources.

Method/Technique	Reference for Methods / Tools Used
Freshwater Resource Delineation	A Practical Field Procedure for Identification and Delineation of Wetland and Riparian Areas' (DWAF, 2005).
Freshwater Resource Classification	National Wetland Classification System for Wetlands and other Aquatic Ecosystems in South Africa (Ollis et al, 2013)
Freshwater Resource Condition/PES	Wetland Management Series: WET-HEALTH. A technique for rapidly assessing wetland health (Macfarlane *et al*. 2008)
Freshwater Resource Functions and Services	Wetland Management Series: WET-EcoServices. A technique for rapidly assessing ecosystem services supplied by wetlands (Kotze *et al.* 2008)
Freshwater Ecological Importance and Sensitivity (EIS)	EIS (Ecological Importance and Sensitivity) assessment tool (DWAF 1999c; Rountree & Malan, 2013)
Buffers for rivers and watercourses	The national Preliminary Guideline for the Determination of Buffer Zones for River, Wetlands and Estuaries (MacFarlane *et al.,* 2014).

Sampling Limitations and Assumptions

- While disturbance and transformation of habitats can lead to shifts in the type and extent of ecosystems, it is important to note that the current extent and classification are reported on here.
- The delineation of the outer boundary of wetland areas is based on several indicators, including topography (macro-channel features), the soil wetness and form and vegetation indicators. The boundaries mapped in this specialist report, therefore, represent the approximate boundary of riparian habitat as evaluated by an assessor familiar and well-practiced in the delineation technique.
- The accuracy of the delineation is based solely on the recording of the relevant onsite indicators using a GPS. GPS accuracy will, therefore, influence the accuracy of the mapped sampling points and therefore resource boundaries and an error of 3 – 5m can

be expected. All soil/vegetation/terrain sampling points were recorded using a Garmin etrex Touch 35 Positioning System (GPS) and captured using Geographical Information Systems (GIS) for further processing.

» Any freshwater resources that fall outside of the affected catchment (but still within the 500m DWS regulated area) and are not at risk of being impacted by the specific activity were not delineated or assessed. Such features were flagged during a baseline desktop assessment before the site visit.
» Sampling by its nature means that generally not all aspects of ecosystems can be assessed and identified.
» While every care is taken to ensure that the data presented are qualitatively adequate, inevitably conditions are never such that that is possible. The nature of the vegetation, seasonality, human intervention etc. limit the veracity of the material presented.
» No water sampling and analysis was undertaken.
» The vegetation information provided is based on onsite/ infield observations and not formal vegetation plots. As such, the species list provided only gives an indication of the dominant and/or indicator wetland/riparian species and thus only provides a general indication of the composition of the vegetation communities.
» No faunal sampling and/or faunal searches were conducted and the assessment was purely wetland and riverine habitat based.
» Probably the most significant potential limitation associated with such a sampling approach is the narrow temporal window of sampling.
  - Ideally, a site should be visited several times, during different seasons to ensure that the full complement of plant and animal species present is captured.
  - However, this is rarely possible due to time and cost constraints and therefore, the representation of the species sampled at the time of the site visit should be critically evaluated.
  - The site was sampled at the end of the wet season and is regarded as an acceptable (optimal) time for such a study.
  - The footprint was covered in detail with the result that the results are considered highly reliable and it is unlikely that there are any significant species or features present that were not recorded.

Baseline Assessment – Limitations and Assumptions

» All assessment tools utilised within this study were applied only to the resources and habitats located within the development footprint as well as the 500m DWS "regulated area" around the footprint area, and which are at risk of being impacted by the proposed development. Any resource located outside of the DWS "regulated area" and which is not a risk of being impacted was not assessed.
» It should be noted that the most appropriate assessment tools were selected for the analysis of the specific features and resources that may potentially be impacted by the proposed development. The selection was based on the assessment practitioner's knowledge and experience of these tools and their attributes and shortcomings.

» Furthermore, it should be noted that these assessment techniques and tools are currently the most appropriate currently available tools and techniques to undertake assessments of freshwater resources, the area however rapid assessment tools that rely on qualitative information and expert judgment. While these tools have been subjected to peer review processes, the methodology for these tools is ever-evolving and will likely be further refined in the near future. For the purposes of this assessment, the assessments were undertaken at rapid levels with somewhat limited field verification. It, therefore, provides an indication of the PES of the portions of the affected systems rather than providing a definitive measure.
» The PES, EIS and functional assessments undertaken are largely qualitative assessment tools and thus the results are open to professional opinion and interpretation. We have made an effort to substantiate all claims where applicable and necessary.
» The assessment of impacts and recommendation of mitigation measures was informed by the site-specific ecological concerns arising from the field survey and based on the assessor's working knowledge and experience with similar development projects.
» The impact descriptions and assessment are based on the author's understanding of the proposed development based on the site visit and information provided.
» Evaluation of the significance of impacts with mitigation takes into account mitigation measures provided in this report and standard mitigation measures to be included in the Environmental Management Programme (EMPr).

GIS (Mapping/Spatial Analysis)

Data sources from the literature and GIS spatial information have been consulted and used where necessary in the study.

A National Aeronautics and Space Administration (NASA) Shuttle Radar Topography Mission (SRTM) (V3.0, 1 arcsec resolution) Digital Elevation Model (DEM) have been obtained from the United States Geological Survey (USGS) Earth Explorer website. Basic desktop terrain analysis have been performed on this DEM using ArcGis (10.4.1) software that encompassed a slope, landforms and channel network analyses in order to detect potential outcrops, ridges, landscape depressions and drainage networks.

The above-mentioned spatial data along with Google Earth Imagery (Google Earth ©) have been utilized to identify and delineate habitat/ecosystem features/units.

Additional existing data layers that will be incorporated into the scoping phase assessment, in order to determine important (sensitive) terrestrial and freshwater entities are summarised below in Table 1:

Table 3: Data coverages used to inform the ecological and freshwater resource assessment.

	Data/Coverage Type	Relevance	Source
Biophysical Context	**1:50 000 Relief Line** (5m Elevation Contours GIS Coverage)	Desktop mapping of terrain and habitat features as well as drainage network.	National Geo-Spatial Information (NGI)
	1:50 000 River Line (GIS Coverage)	Highlight potential on-site and local rivers and wetlands and map local drainage network.	CSIR (2011)
	Free State Province Land-Cover (from SPOT5 Satellite imagery circa 2009)	Shows the land-use and disturbances/transformations within and around the impacted zone.	DETEA (2009)
	South African Vegetation Map (GIS Coverage)	Classify vegetation types and determination of reference primary vegetation.	Mucina *et al.* (2018)
	NFEPA: river and wetland inventories (GIS Coverage)	Highlight potential on-site and local rivers and wetlands.	CSIR (2011)
	NBA 2018 National Wetland Map 5 (GIS Coverage)	Highlight potential on-site and local wetlands	SANBI (2018)
	NBA 2018 Artificial Wetlands (GIS Coverage)	Highlight potential on-site and local artificial wetlands	SANBI (2018)
	DWA Eco-regions (GIS Coverage)	Understand the regional biophysical context in which water resources within the study area occur	DWA (2005)
Conservation and Distribution Context	**NFEPA: River, wetland and estuarine FEPAs** (GIS Coverage)	Shows location of national aquatic ecosystems conservation priorities.	CSIR (2011)
	National Biodiversity Assessment – Threatened Ecosystems (GIS Coverage)	Determination of national threat status of local vegetation types.	SANBI (2011)
	Terrestrial Critical Biodiversity Areas of the Fee State (GIS Coverage)	Determination of provincial terrestrial conservation priorities and biodiversity buffers.	DESTEA (2015)
	SAPAD – South Africa Protected Areas Database (GIS Coverage)	Shows the location of protected areas within the region	http://egis.environment.gov.za DEA (2020)
	SACAD – South Africa Conservation Areas Database (GIS Coverage)	Shows the location of conservation areas within the region	http://egis.environment.gov.za DEA (2020)
	Strategic Water Source Areas for Surface Water (SWSA-sw) (GIS Coverage)	Shows the location of the development area relative to areas that contribute significantly to the overall water supply of the country	CSIR (2017)

3. CONSERVATION AND FUNCTIONAL IMPORTANCE OF AQUATIC ECOSYSTEMS

Water affects every activity and aspiration of human society and sustains all ecosystems. "Freshwater ecosystems" refer to all inland water bodies whether fresh or saline, including rivers, lakes, wetlands, sub-surface waters, and estuaries (Driver et al., 2011). South Africa's freshwater ecosystems are diverse, ranging from sub-tropical in the north-eastern part of the country, to semi-arid and arid in the interior, to the cool and temperate rivers of the fynbos. Wetlands and rivers form a fascinating and essential part of our natural heritage and are often referred to as the "kidneys" and "arteries" of our living landscapes and this is particularly true in semi-arid countries such as South Africa (Nel et al., 2013). Rivers and their associated riparian zones are vital for supplying freshwater (South Africa's most scarce natural resource) and are important in providing additional biophysical, social, cultural, economic, and aesthetic services (Nel et al., 2013). The health of our rivers and wetlands is measured by the diversity and health of the species we share these resources with. Healthy river ecosystems can increase resilience to the impacts of climate change, by allowing ecosystems and species to adapt as naturally as possible to the changes and by buffering human settlements and activities from the impacts of extreme weather events (Nel et al., 2013). Freshwater ecosystems are likely to be particularly hard hit by rising temperatures and shifting rainfall patterns, and yet healthy, intact freshwater ecosystems are vital for maintaining resilience to climate change and mitigating its impact on human wellbeing by helping to maintain a consistent supply of water and for reducing flood risk and mitigating the impact of flash floods. We, therefore, need to be mindful of the fact that without the integrity of our natural river systems, there will be no sustained long-term economic growth or life (DEA et al., 2013).

Freshwater ecosystems, including rivers and wetlands, are also particularly vulnerable to anthropogenic or human activities, which can often lead to irreversible damage or longer-term, gradual/cumulative changes to freshwater resources and associated aquatic ecosystems. Since channelled systems such as rivers, streams, and drainage lines are generally located at the lowest point in the landscape; they are often the "receivers" of wastes, sediment, and pollutants transported via surface water runoff as well as subsurface water movement (Driver et al., 2011). This combined with the strong connectivity of freshwater ecosystems means that they are highly susceptible to upstream, downstream, and upland impacts, including changes to water quality and quantity as well as changes to aquatic habitat & biota (Driver et al., 2011). South Africa's freshwater ecosystems have been mapped and classified into National Freshwater Ecosystem Priority Areas (NFEPAs). This work shows that 60% of our river ecosystems are threatened and 23% are critically endangered. The situation for wetlands is even worse: 65% of our wetland types are threatened, and 48% are critically endangered (Driver et al., 2011). Recent studies reveal that less than one-third of South Africa's main rivers are considered to be in an ecologically 'natural' state, with the principal threat to freshwater systems being human activities, including river regulation, followed by catchment transformation (Rivers-Moore & Goodman, 2009). South Africa's freshwater fauna also display high levels of threat: at least one-third of freshwater fish indigenous to South Africa are reported as threatened, and a recent southern African study on the conservation status of major freshwater-dependent taxonomic groups (fishes, molluscs, dragonflies, crabs, and vascular plants) reported far higher levels of threat in South Africa than in the rest of the region (Darwall *et al*., 2009). Clearly, urgent attention is required to ensure that representative natural examples of the different ecosystems that make up the natural heritage of this country for current and future generations to come. The degradation of South African rivers and wetlands is a concern now recognized by Government as requiring urgent action and the protection of freshwater resources, including rivers and wetlands, is considered fundamental to the sustainable management of South Africa's water resources in the context of the reconstruction and development of the country.

4. DESKTOP ECOLOGICAL ANALYSIS

Land use and Land Cover

The Free State Province Land-Cover dataset (2009) were queried as part of the desktop study (Figure 3). Land-cover is a critical information component for a wide range of regional and local planning and management activities, especially in terms of resource conservation and environmental monitoring. The Free State Province Land-Cover dataset I a digital, seamless, vegetation and land-cover map of the entire Free State Province, suitable for 1:50 000 scale (or coarser) GIS modelling applications. This dataset was developed using 2009 SPOT5 satellite imagery. Furthermore, this vegetation and land-cover dataset is compatible with the latest South African land-cover classification standards. In addition to the land-cover data, a comprehensive set of digital aerial reference photographs, acquired as part of the land-cover map accuracy verification field survey process has been supplied as a geo-referenced GIS database.

According to this dataset approximately 60% of the entire development area is located on cultivated fields (dryland), whist approximately 35% of the project site can be regarded as a natural form of grassland. Furthermore, approximately 4% of the project site is covered by wetlands.

Due to the relatively large scale of the map 1:50 000 and the fact that this land cover map was compiled back in 2009, variations in the land-use and vegetation cover may be present or may have changed of a period of time. As such, current (and historical) available areal and satellite imagery was analysed at a much closer elevation, of between 770 and 3.5km.

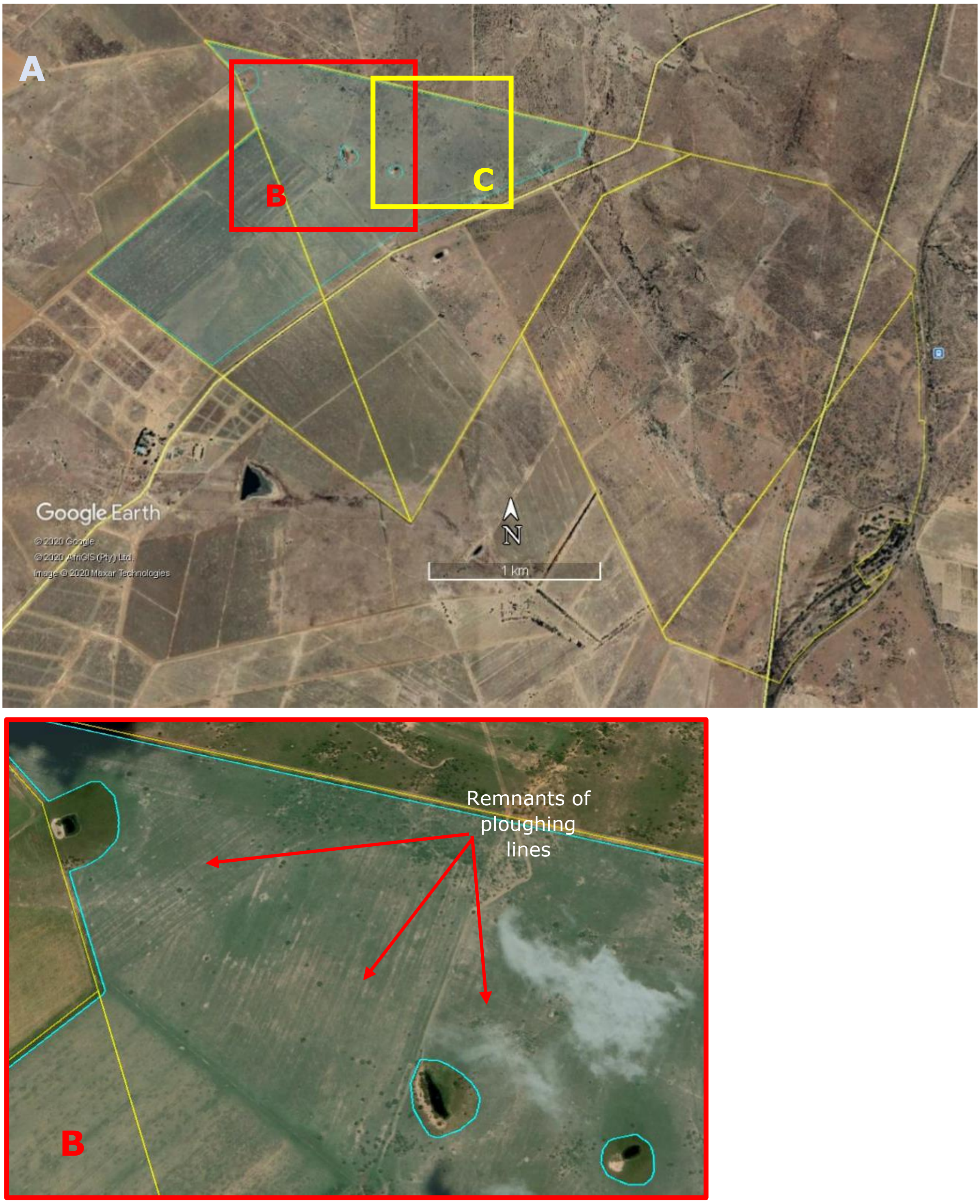
The results of this spatial analysis were as follows:

Land cover and land-use changes often indicate major impacts on biodiversity, especially if those changes show the loss of natural habitat due to urban sprawl, cultivation, etc.

The affected properties are predominantly used for agricultural purposes, in the past mainly for dryland cultivation, and to a lesser extent for livestock farming (predominantly cattle). However, cultivation practices have been abandoned within the project area for a relative long period of time. Game farming have also become much more prominent within the region over the last decade (wide variety of game species including rare antelope and big game such as buffalo).

Currently (and for a long period of time), no cultivation activities are taking place. Approximately 60% of the development area appears to be fallow lands, most recently abandoned (<20 years) and is now used as pastures for cattle. Historically cultivated land (> 30 years), covers an area of approximately 18% (of the development area) and appears to have been re-established by grasses and low shrubs (plagioclimax grassland), with the only evidence, from available spatial data, being feint ploughing contour lines (Figure 2). These areas are also now likely being utilised as grazing. Subsequently, approximately 78% of the development area has been, at some point in time, subjected to ploughing (soil and vegetation disturbance) and cultivation. Only approximately 20% natural veld remain comprising of grasslands with varying coverage/density of shrubs.

Furthermore, natural wetland features cover approximately 2% of the project area, comprising mostly of valley-bottom and depression wetlands. Small earth dam structures have been created within some of the wetlands, in an attempt to concentrate and store surface water for longer periods of time within these wetland features.


A
B
C
Google Earth
1 km
N
Remnants of ploughing lines
B

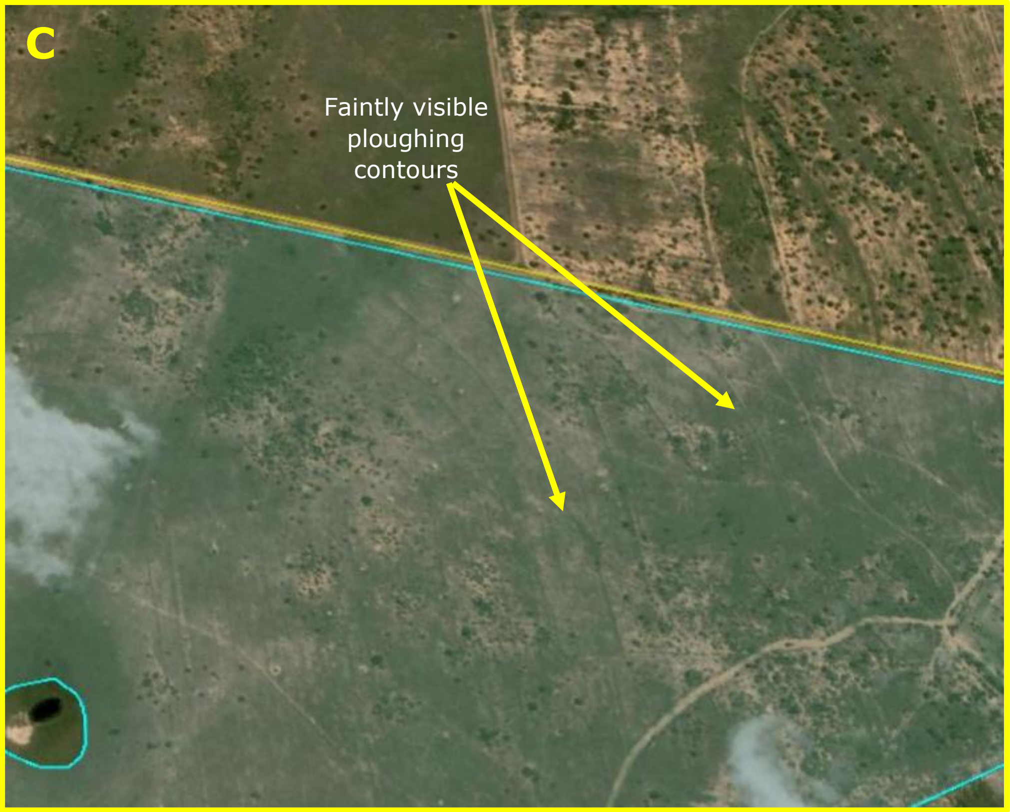


Figure 3 (A-C) Evidence of historical cultivation (>10years) within areas that have been mapped as natural grassland within the Free State Province Land Cover dataset as well as within the Critical Biodiversity Area data sets.

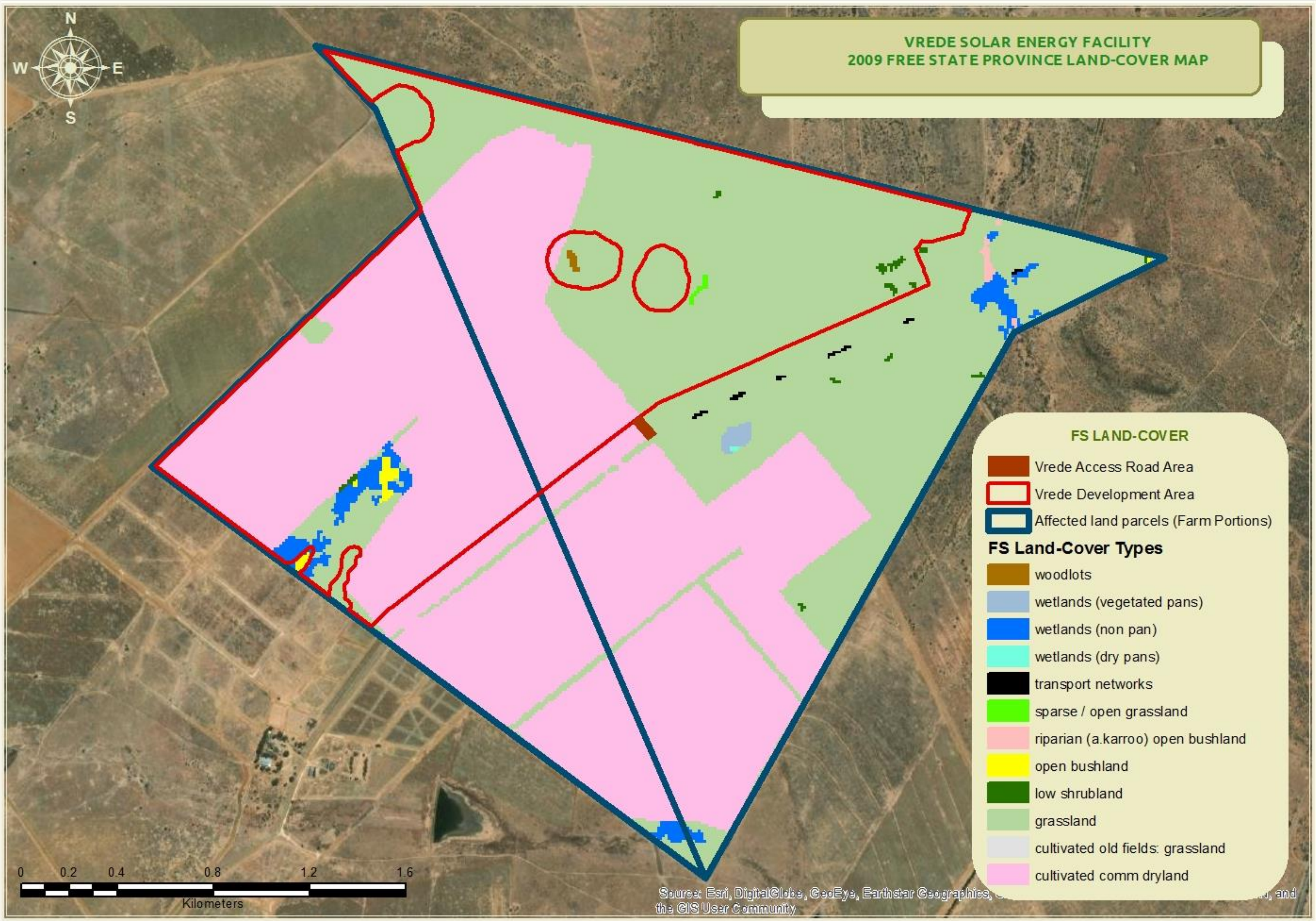


Figure 4: 2009 Free State Province Land-Cover Map

Regional/Local Biophysical Setting

The development footprint is located on Portion 1 of the farm Uitval No. 1104 and the Remaining Extent of the farm Vrede No. 1152, situated approximately 18.3km (south-west) from the town of Kroonstad (central) (Figure 1) within the Moqhaka Local Municipality and the Fezile Dabi District Municipality in the Free State Province. The site is accessible via an existing gravel road (P99/1 route) which provides access to the properties off of the secondary road (S172 route) which is located east of the project site linking Kroonstad with Hennenman.

The Vrede Solar Energy Facility will have a generating capacity of up to 100MW and will cover a development footprint of approximately 217 ha.

Land use within the project site is mostly for farming. Farming practices consist of livestock farming (cattle) farming with some "free" roaming small game. Due to moderate to moderate-low land capability of the dominant soil forms within the project site, crop production has been systematically abandoned over the past 30-20years, with the historically cultivated areas converted to grazing field (pastures). Small, fractured patches of natural vegetation have remained in areas that have never been ploughed. In terms of the surrounding landscape, most farmers have followed a similar route, where unproductive lands have been converted to grazing field. However, rainfed annual crop production is still a common practice within some of the properties to the west, and especially to the south. Pivot irrigation is a less common land use practice within the area. Most "natural" vegetation within the surrounding properties are used for cattle farming, however the breeding of scarce and large game has become increasingly popular within the area, especially to the north and east of the affected properties. The neighbouring property to the south has a relative intensive lion breeding programme.

Prominent anthropogenic features within the region include the P99/1 gravel road, S172 secondary route, smaller dirt and twin track routes, cattle and game fences (mostly electrified), homesteads, kraals, cattle feeding and watering points, reservoirs and small farm dams (mostly instream) and power lines. Apart from these anthropogenic features, most of the region is poorly developed and, as mentioned, predominantly used for livestock, game and cultivation farming.

The site lies in an area considered to be a local steppe climate (BSk according to Köppen-Geiger Climate Classification). The site thus falls within a cold semi-arid region arid area, with a mean annual temperature of 16.6°C and a mean annual precipitation of 545mm (predominantly mid-summer). The driest month is July with 7mm whilst the greatest amount of precipitation occurs in December with an average of 107mm. January is the warmest month of the year with an average temperature of 22.4°C, whilst the coldest month is June with an average temperature of 8.8°C. The first occurrence of frost may be experienced as early as the onset of May and marks the end of the growing season (average frost incidence of 43 days a year).

The development site occurs predominantly within the Quaternary Catchment C60H whilst a portion of the northern half of the development site falls within Quaternary Catchment C60G (Middle Vaal Management Area), which is drained by the Vals River and associated tributaries including the Diepstruit stream traversing the north eastern corner of the development site, flowing mostly in a northern direction and feeding directly into the Vals River (Figure 5). Other prominent watercourses draining the region include the Blomesprui and Otterspruit.

The Hydrological Characteristics of project site are summarised as follows:

» Mean Annual Precipitation = 545 mm;
» Mean Annual Runoff = 10.3 – 25.8mm; and
» Mean Annual Evaporation = 1 600 – 1 700mm

The Vrede Solar project is located within the Highveld ecoregion (Kleynhans *et al.*, 2005). The Highveld ecoregion comprises high lying plains with a moderate to low relief, as well as various grassland vegetation types (with moist types to the west and south). Several large rivers have their sources in this region, including the Vet, Modder, Riet, Vaal, Olifants, Steelpoort, Marico, Crocodile (west), Crocodile (east) and the Great Usutu River.

According to Partridge *et al*. (2010) the Highveld Geomorphic Province is an extensive grassland region occupying the eastern interior plateau and is mostly drained by the tributaries of the Vaal River. South of the Vaal River the province is underlain by near-horizontal Karoo strata (intruded by dolerite dykes and sills). Much of the province is, gently undulating and is dominated by the late Cretaceous African erosion surface, which remains intact on many of the broad interfluves (Partridge & Maud, 1987). The dominant drainage direction is westerly, partly because of the influence of the pre-Karoo topography, and partly because of warping along the Griqualand–Transvaal axis, whose activity was largely contemporaneous with uplift of the Ciskei–Swaziland axis (Partridge & Maud, 1987). The shallow, open valleys reflect minor incision in the early Miocene Post-African I cycle. Many of the Highveld rivers have incised their channel beds to just below the bedrock surface and are strongly influenced by the relationship between the softer Karoo shales and sandstones and the position and breaching of dolerite sills and dykes (Tooth *et al.,* 2004). Meandering patterns are typical within the sandstones and shales (above local hydraulic barriers usually dolerite dykes and sills), while straight channels occur where the rivers breach the dolerite (Tooth *et al.,* 2002, 2004).

The sub-Province Southern Highveld is drained by south-bank Vaal River tributaries. The rivers rise in the Eastern Escarpment Hinterland in the south before flowing northwest into the Vaal River valley. The valley cross-sectional profiles are broader than in the North-eastern Highveld, but narrower than those of the North-western Highveld. There is also a broad trend from north to south, with narrower valley cross-sectional profiles and flatter slopes in the north and broader valley forms and steeper slopes in the south. Significantly, however, the average valley slopes are flatter than in the other two sub-provinces. The sub-province is therefore characterised predominantly by BF[1] and WF sediment storage surrogate descriptors. With the exception of the Wilge River (which has a logarithmic BFC[2]), the concave longitudinal profiles are predominantly exponential.

Wetlands within the region are mostly depression (pan) wetlands within the relatively flat plains where a slight change in geomorphology and underlying geology may result in the collection of water and saturated soil conditions. Most of the pans are endorheic. The more undulating and steeper slopes to the north and south contain a higher diversity of wetland types due to the greater variation in geomorphology resulting in different drainage systems. Seepages are a common feature along the steeper slopes where the underlying bedrock is typically near the surface. Most of these seepages are typically groundwater fed. Benchlands or discrete areas of mostly level or nearly level high ground, interrupting the surrounding steeper slopes, typically contain wetland flats which are usually groundwater fed. Channelled valley-bottom wetlands are typically associated with the higher reaches and tributaries of the watercourses whilst some floodplain wetlands are associated with the lower and more gradual reaches of the Vals and Vet Rivers.

A summary of the biophysical features and the setting of the project site and surroundings are summarised in Table 4.

Table 4: Summary of the biophysical setting of the proposed SEF footprint.

<table>
<tr><th>Biophysical Aspect</th><th colspan="2">Desktop Biophysical Details</th><th>Source</th></tr>
<tr><td colspan="4">Physiography</td></tr>
<tr><td>Landscape Description</td><td colspan="2">A relative flat plains-dominated landscape with a small isolated koppies/outcrop located north-east of the development footprint. As already described, large tracts of land have been transformed for cultivation purposes. These plains are typically dominated by low-tussock grasslands with a prominent karroid element. Shrubby trees, such as Acacia karroo (also known as Vachellia karroo) may also be a common feature, especially near watercourses and wetland areas. Depression wetlands are a common feature within this landscape, as well as valley-bottom wetlands (usually channelled), which tend to drain in a north-eastern/eastern direction towards the Blomspruit River.</td><td>Google Earth</td></tr>
<tr><td>Dominant Land Type</td><td colspan="2">Bd21</td><td>ARC</td></tr>
<tr><td rowspan="2">Dominant Terrain Type</td><td>Symbol</td><td>Description</td><td rowspan="2">ARC</td></tr>
<tr><td>A2</td><td>Level plains or plateaus with a local relief between 30-90m</td></tr>
<tr><td>Geomorphic Province</td><td colspan="2">Southern Highveld</td><td>Partridge et al., 2010</td></tr>
</table>

[1] BF & WF: Sediment storage surrogate descriptor indicative of high sediment storage capability.
[2] BFCs: Macro-reach Best Fit Curves

Geology	Mudrock and subordinate sandstone of the Adelaide Subgroup (Beaufort Group). Occasional dolerite sills may also be present.	ARC & SA Geological Dataset
Soils (General)	Soils with a plinthic catena characterised by loamy red yellow and greyish sand with a high base status	ARC
Prominent Soil Forms	Avalon, Westleigh, Valsrivier. The lower lying areas such as depressions, valley bottom wetlands and watercourses are typically characterised by Dundee, Bonheim and Valsrivier soil types	ARC
Susceptibility to Wind Erosion	**Class:** 3a (Wind), & 1 (Water) **Description:** Land with moderate wind erosion susceptibility and a low susceptibility to water erosion. Generally, level to gently sloping. Soils have a favourable erodibility index.	ARC
Climate		
Köppen-Geiger Climate Classification	BSk (Cold semi-arid climate)	Climate-data.org
Mean annual temperature	16.6°C	Climate-data.org
Warmest Month & Av. Temp.	January: 22.4°C	Climate-data.org
Coldest Month & Av. Temp.	June: 8.8°C	Climate-data.org
Rainfall Seasonality	Mid-summer (January – February)	DWAF, 2007
Mean annual precipitation	545 mm	Schulze, 1997
Mean annual runoff	10.3 mm up to 25.8mm	Schulze, 1997
Mean annual evaporation	1 600 – 1 700 mm	Schulze, 1997
Surface Hydrology		
DWA Ecoregions	**Level 1:** Highveld **Level 2:** 11.08	DWA, 2005
Wetland vegetation group	Dry Highveld Grassland (Group 3 & 4)	CSIR, 2011
Water management area	Middle Vaal WMA (09)	DWA
Quaternary catchment	**Name (Symbol):** C60H (Primary), C60G & C60F	DWA
Main collecting river(s) in the catchment	Tributaries of the Vals River including Blomespruit to the east and Otterspruit to the west.	CSIR, 2011
Closest river to the project site	Tributary of the Otterspruit (~3.8km to the west).	Google Earth
Geomorphic Class	**Symbol / Description / Slope (%)** V4 / Upper foothills / 0.005 – 0.019 V4, V2 / Lower foothills / 0.001 - 0.005 **Description** Watercourses to the west correspond more with Lower Foothill systems, whist the watercourses to the east are more typical of Upper Foothill systems. » Upper Foothill systems tend to be moderately steep streams dominated by bedrock or boulders. Reach types may include plain-bed, pool-riffle or pool-rapid reach types. Length of pools and riffles/rapids are usually similar. Narrow flood plain of sand, gravel or cobble often present. » Lower Foothill systems typically have lower gradient mixed bed alluvial channels with sand and gravel dominating the bed, locally may be bedrock controlled.	CSIR, 2011

	Reach types typically include pool-riffle or pool-rapid, sand bars common in pools. Pools of significantly greater extent than rapids or riffles. Flood plan often present.	
Vegetation Overview		
Biome	Grassland Biome (Dry Highveld Grassland Bioregion)	Mucina & Rutherford, 2018
Vegetation Types	» Western portion of the project site including the SEF footprint: Vaal-Vet Sandy Grassland. » Eastern portion of the project site including north-eastern most corner of the SEF footprint: Central Free State Grassland	Mucina & Rutherford, 2018
Vegetation & Landscape Feature	Vaal-Vet Sandy Grassland: Plainns-dominated landscape with some scattered, slightly irregular undulating plains and hills. Mainly low-tussock grasslands with and abundant karroid element. Dominance of *Themeda triandra* is an important feature of this vegetation unit. Locally low cover of *T. triandra* and the associated increase in *Elionurus muticus, Cymbopogon pospischilii* and *Aristida congesta* is attributed to heavy grazing. Central Free State Grassland: Undulating plains supporting short grassland, in natural condition dominated by *Themeda triandra* while *Eragrostis curvula* and *E. chloromelas* become dominant in degraded habitats. Dwarf karoo bushes establish in severely degraded clayey bottomlands. Overgrazed and trampled low-lying areas with heavy clayey soils are prone to *Acacia karroo* (also known as *Vachellia karroo*) encroachment.	Mucina & Rutherford, 2006

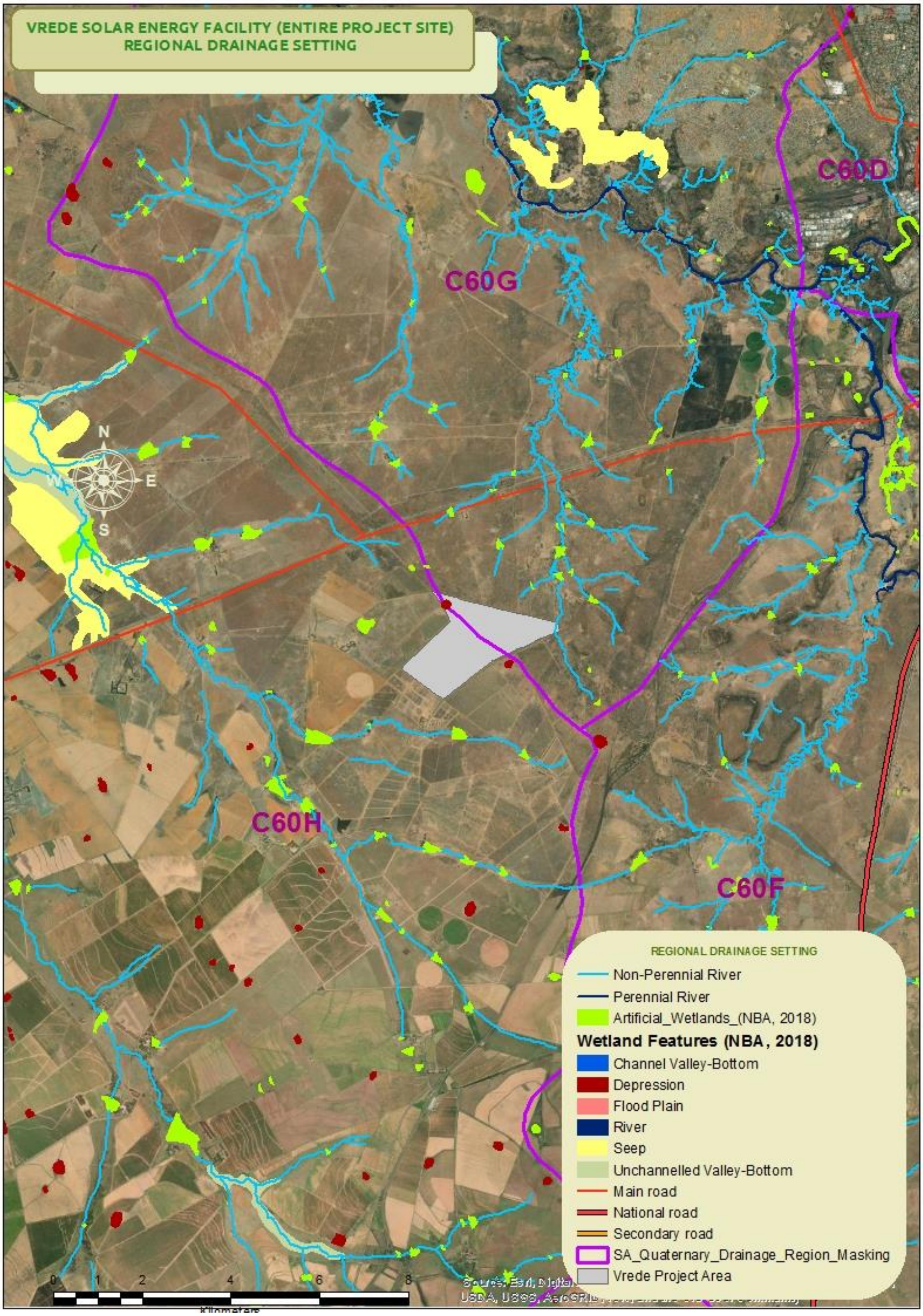


Figure 5: Regional drainage setting.

Conservation Planning / Context

Understanding the conservation context and importance of the study area and surroundings is important to inform decision making regarding the management of the aquatic resources in the area. In this regard, national, provincial, and regional conservation planning information available and was used to obtain an overview of the study site (Table 5).

Table 5: Summary of the conservation context details for the study area.

Conservation Planning Dataset		Relevant Conservation Feature	Location in Relationship to Project Site	Conservation Planning Status
NATIONAL LEVER	Strategic Water Source Areas for groundwater (SWSA-gw)	Areas with high groundwater availability and of national importance	Located within the Kroonstad SWSA-gw	Located within important groundwater recharge area.
	Vegetation Types	Vaal-Vet Sandy Grassland	Vegetation of Study Area	Endangered
		Central Free State Grassland	Vegetation of Study Area	Least Threatened
	Threatened Ecosystems	Vaal-Vet Sandy Grassland Ecosystem	Ecosystems of Study Area	Endangered
	National Freshwater Ecosystem Priority Area	River FEPA	Located outside of any River FEPAs	Not Classified
		Wetland FEPA	No Wetland FEPAs located within project site.	Not Classified
PROVINCIAL AND REGIONAL LEVEL CONSERVATION PLANNING CONTEXT	NCBSP: Critical Biodiversity Areas	Ecological Support Areas ESA1	Corridors/linkages between the upland (terrestrial) areas and important water resource features such as the Vals and Blomspruit Rivers. No ESA1 located within the SEF footprint.	ESA
		Critical Biodiversity Areas CBA1	Natural areas of Vaal-Vet Sandy Grassland which are regarded as irreplaceable and essential in meeting the biodiversity conservation targets as set out for the Free State Province North-eastern and north-western portions of SEF footprint falls within CBAs	CBA1

Strategic Water Source Areas (SWSAs)

Strategic Water Source Areas (SWSAs) are defined as areas of land that either:

» supply a disproportionate (i.e. relatively large) quantity of mean annual surface water runoff in relation to their size and so are considered nationally important;
» have high groundwater recharge and where the groundwater forms a nationally important resource;
» areas that meet both criteria mentioned above.

They include transboundary Water Source Areas that extend into Lesotho and Swaziland.

The project site is located outside of any SWSA for surface water but is located within a SWSA for groundwater; namely the Kroonstad SWSA-gw (Figure 7).

Due to the nature of the Solar PV developments and their associated infrastructure (limited use of chemicals, hazardous and toxic materials), it is unlikely that such a development will have a significant impact on groundwater quality. However, Solar PV developments may slightly influence local infiltration and subsequently ground water recharge. This impact can however, be successfully mitigated through careful planning and with effective mitigation measures in place.

National Level of Conservation Priorities (Threatened Ecosystems)

The vegetation types of South Africa have been categorised according to their conservation status which is, in turn, assessed according to the degree of transformation and rates of conservation. The status of a habitat or vegetation type is based on how much of its original area still remains intact relative to various thresholds. On a national scale these thresholds are, as depicted in the table below, determined by the best available scientific approaches (Driver *et al*. 2005). The level at which an ecosystem becomes Critically Endangered differs from one ecosystem to another and varies from 16% to 36% (Driver *et al*. 2005).

Table 6: Determining ecosystem status (from Driver et al. 2005). *BT = biodiversity target (the minimum conservation requirement.

Habitat remaining (%)			
	80–100	least threatened	LT
	60–80	vulnerable	VU
	*BT–60	endangered	EN
	0–*BT	critically endangered	CR

The National List of Ecosystems that are Threatened and in need of protection (GN1002 of 2011), published under the National Environment Management: Biodiversity Act (Act No. 10 of 2004), lists national vegetation types that are afforded protection on the basis of rates of transformation. The threshold for listing in this legislation is higher than in the

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scientific literature, which means there are fewer ecosystems listed in the National Ecosystem List versus in the scientific literature.

According to current layout the bulk of the SEF footprint is located within the endangered Vaal-Vet Sandy Grassland (Figure 6), with only a small portion of the north-eastern corner falling within the Central Free State Grassland. However, as described earlier (Land cover and Land Use Section), more than 50% of the development footprint is located within transformed areas whist only 17% of the footprint is located in what appears to be grassland largely consistent to that of Vaal-Vet Sandy Grassland.

No azonal vegetation units (aquatic) have been identified within the development footprint or within close proximity to the development footprint

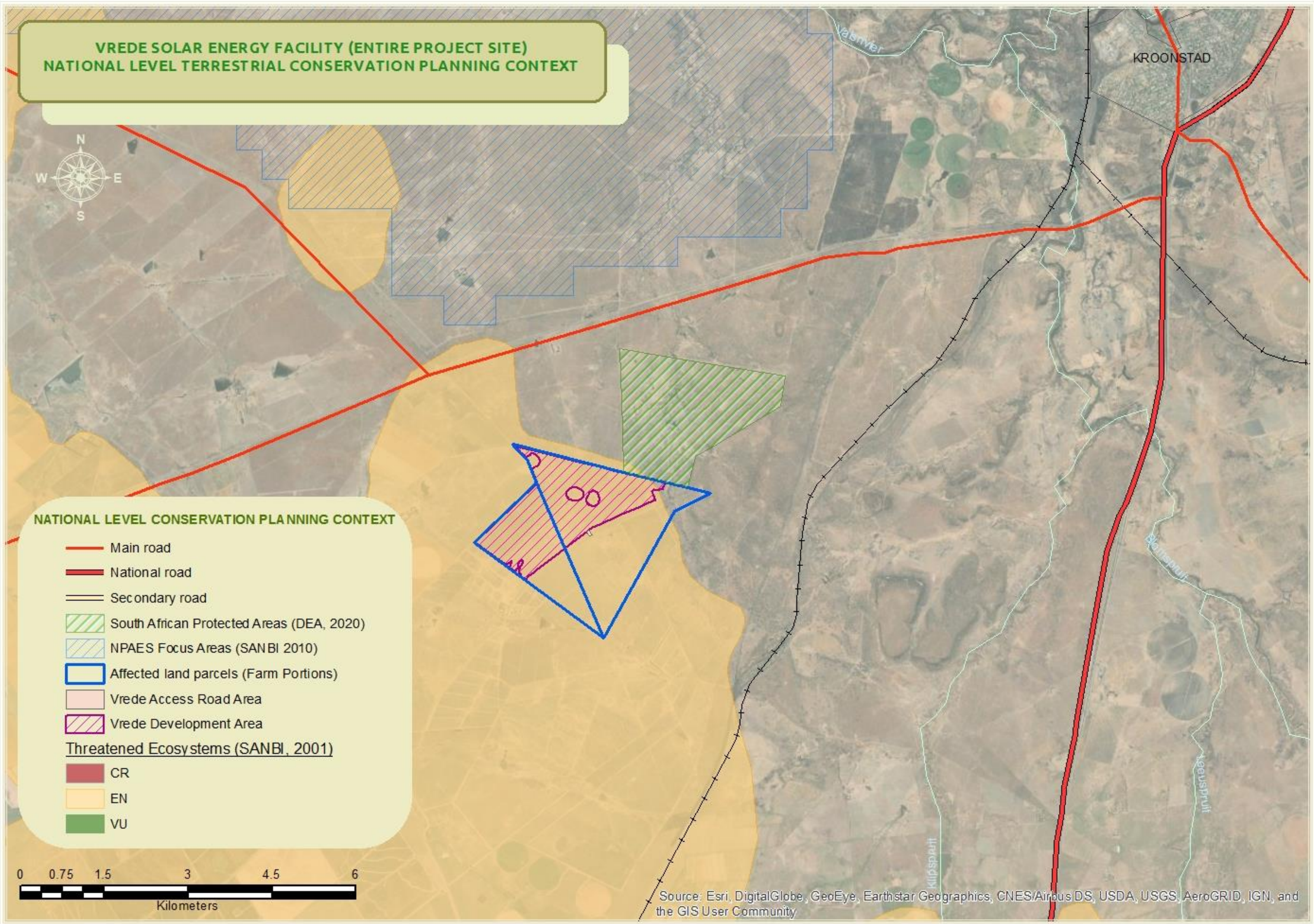

Figure 6: National Level Terrestrial Conservation Planning Context

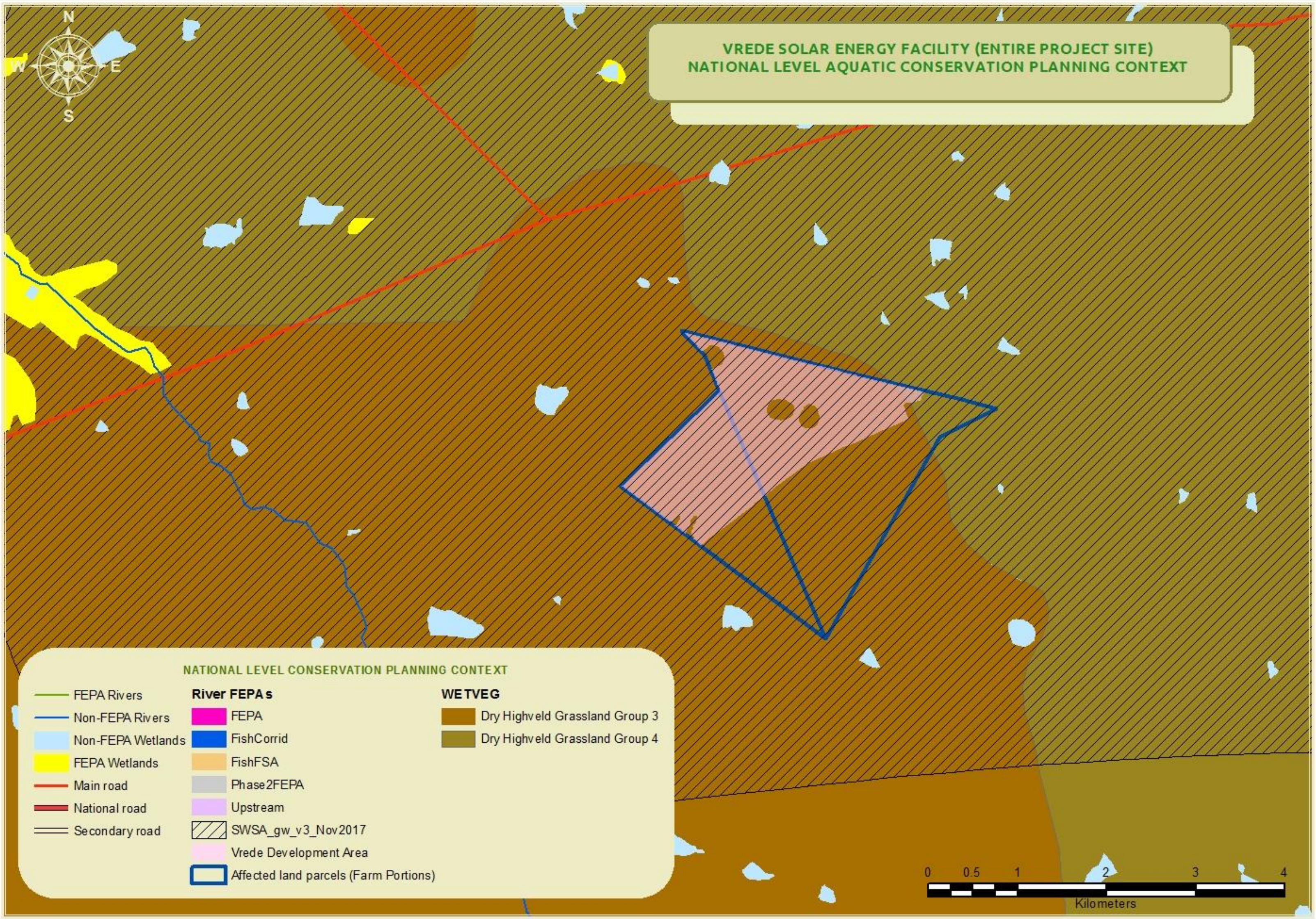

Figure 7: National Level Aquatic Conservation Planning Context.

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Critical Biodiversity Areas and Broad Scale Ecological Processes

The SEF footprint falls within the planning domain of the Free State Province Biodiversity Conservation Assessment which maps Critical Biodiversity Areas and Ecological Support Areas within the Free State Province. The CBA map indicates the most efficient selection and classification of land portions requiring safeguarding in order to maintain ecosystem functioning and meet national biodiversity objectives. According to these maps, the majority of the footprint falls within degraded areas whilst the north-eastern and north-western portions of the footprint is located within CBA1 (Figure 8). A small portion of the project site, to the east, extends into an ESA1, however this area is located outside of the proposed footprint. These terrestrial CBA features will not be dealt with or assessed within this study/report as this forms part of the terrestrial biodiversity assessment.

National Freshwater Ecosystem Priority Areas (2011) Database

The National Freshwater Ecosystems Priority Areas (NFEPA) (2011) database provides strategic spatial priorities for conserving South Africa's freshwater ecosystems and supports the sustainable use of water resources. The spatial priority areas are known as Freshwater Ecosystem Priority Areas (FEPAs).

FEPAs were identified based on:

» Representation of ecosystem types and flagship free-flowing rivers.
» Maintenance of water supply areas in areas with high water yield.
» Identification of connected ecosystems.
» Preferential identification of FEPAs that overlapped with"
  - Any free-flowing river
  - Priority estuaries identified in the National Biodiversity Assessment 2011.
  - Existing protected areas and focus areas for protected area expansion identified in the National Protected Area Expansion Strategy.

A review of the NFEPA coverage for the study area (Figure 7) revealed that no River FEPAs are located within the development footprint or the project site. Furthermore, the NFEPA coverage for the project site shows that now Wetland FEPAs are located within the SEF footprint as well as project site.

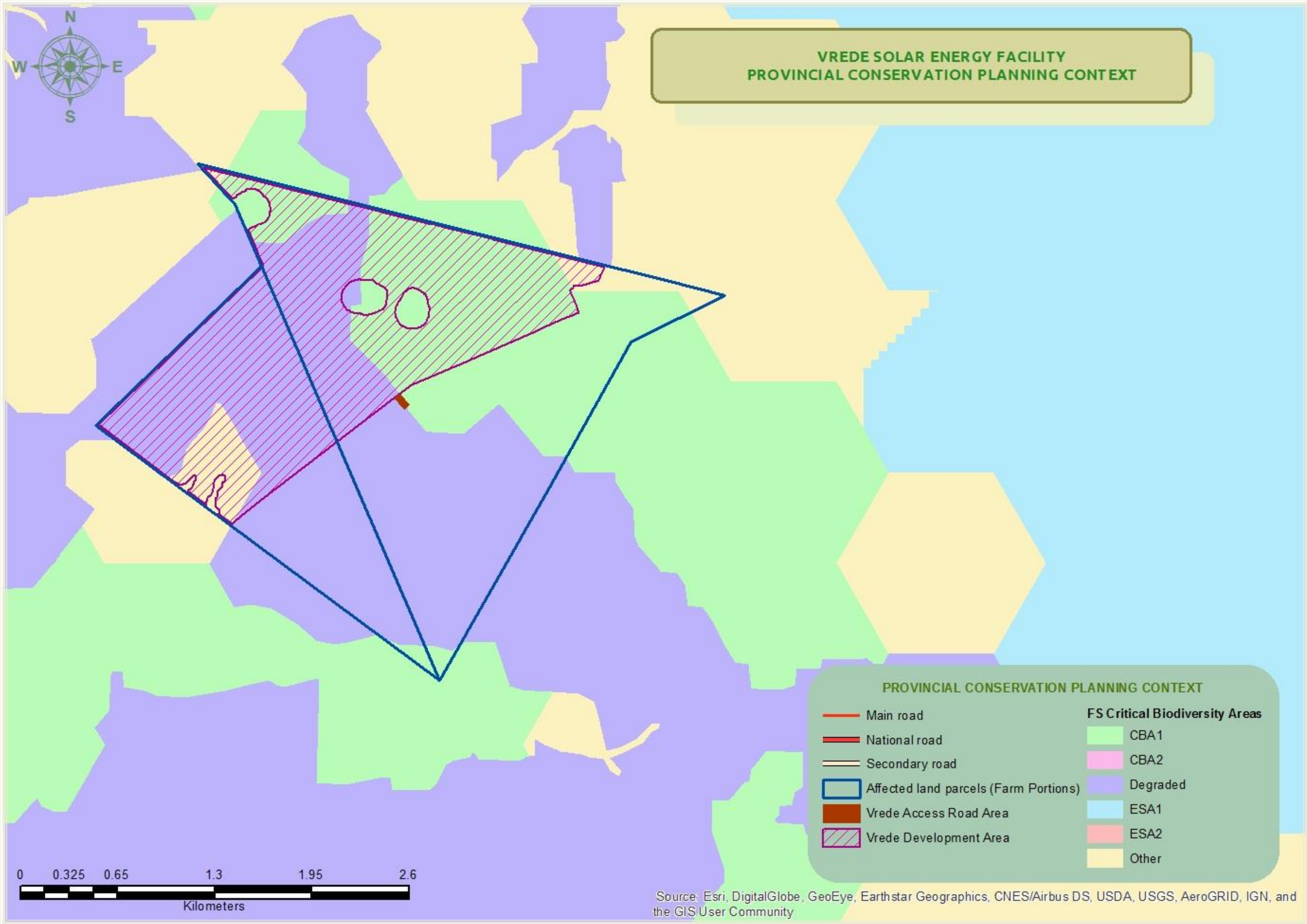

Figure 8: Provincial Level Conservation Planning Context – CBA Map (Free State Province Biodiversity Conservation Assessment).

Freshwater Resource Screening Assessment

This Risk screening assessment was undertaken during the scoping phase and was somewhat refined following an initial site visit in mid-March (18th March 2021).

As mentioned, in terms of the NFEPA (2011) and the NBAs 2018 National Wetlands Map 5 the project area contains a few small natural endorheic depression (pans) features and some numerous small earth dam/reservoir structures (artificial wetlands). Most of these small dams have been constructed within the natural depression features in an attempt to deepen portions of the wetlands in order to collect store surface water for longer periods of time. According to the NFEPA Wetland coverage no wetland features are located within the SEF footprint, whilst the NBAs National Wetland coverage also indicates no wetlands within the footprint, but shows two small depression wetlands located just outside of the footprint.

However, following a desktop mapping exercise wherein all available Geo-spatial resources were closely analysed numerous wetland features were identified within the project site as well as the DWS 500m regulated area (Figure 9).

A total of five (5) natural wetland features have been identified, most of which were depression wetlands. The valley-bottom (VB) wetlands appears to be channelled and drains in a northern direction towards the Vals River. This delineated channelled VB wetland can be regarded as the primary drainage feature within the project area.

The presence and extent of all wetland features, at risk of being potentially impacted by the development (refer to risk screening section below) will be confirmed, and their boundaries adjusted where needed, following an infield delineation (using all wetland indicators) of these features during the EIA phase. Furthermore, these wetland features' Present Ecological State (PES), their Ecological Sensitivity and Importance (EIS) as well their recommended buffer areas will be determined during the EIA phase.

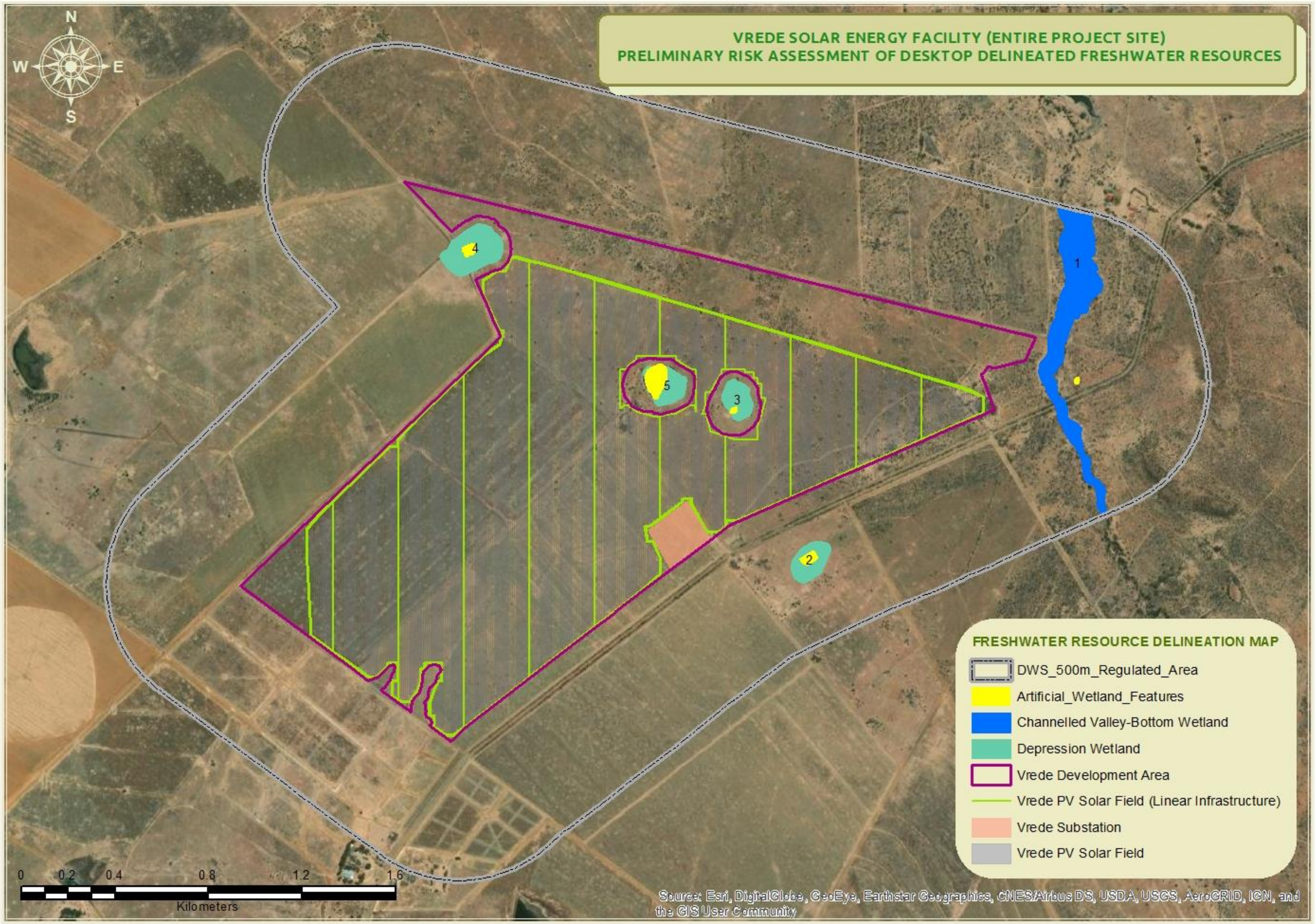

Figure 9: Desktop delineated freshwater resources (Map of entire project site).

Desktop Wetland Risk Screening

As described within the previous section, water resources (wetland) within a radius of 500m around the proposed project site was mapped and classified at a desktop level. Following the delineation exercise a desktop rating of risk associated with the proposed activities has been done. This has been undertaken to guide field assessments and inform water use identification for the proposed project. Several water resources were identified and rated and include wetland features in the form of endorheic depression wetlands, seepages and valley bottom wetlands that fall within the 500m regulated area.

Typically, the main risks associated with the construction and operations of the proposed activities are:

» Direct physical modification / destruction of surface water resources within/in the vicinity of the development footprint.
» Direct physical loss and/or modification of surface water resources within the development footprint, both planned and accidental;
» Direct physical alteration of flow characteristics of wetlands within the development site and associated erosion and sedimentation impacts;
» Alteration of catchment / surface water processes / hydrological inputs and associated erosion and sedimentation impacts; and
» Surface runoff contamination and local watercourse water quality deterioration.

The risk ratings for each of the mapped water resources are presented in Table 7 and Figure 10 below. The proposed activities pose a potential high risk to four (4) wetland features (three depression wetlands and the channelled VB wetland), and a low risk to one depression wetland which is located outside of the development footprint and on the other side of the P99/1 gravel road, cutting off/intercepting drainage from the project area towards this depression wetland feature.

Note: The risk ratings provided relates to the likelihood that a water resources unit may be measurably negatively affected to inform the legal processes. Thus, this is essentially risk screening, **not a risk assessment and risk ratings are not a representation of impact intensity/magnitude of the change. Also take not that this is does not form part of the DWS Risk Assessment and these values can not be used towards that.**

Table 7: Preliminary risk ratings for the mapped wetland units including rationale.

Risk Class	Water Resource Number	Water Resource	Rationale
High	1	Channelled Valley-Bottom Wetland	These are all surface water resource features located within the development footprint, or located in very close proximity to the footprint.
	3	Depression Wetland	
	4	Depression Wetland	
	5	Depression Wetland	
Low	1	Seepage Wetland	These are all surface water features located quite some distance from the development area, with the footprint located either some distance outside of these features' catchment areas or some distance downstream. Subsequently the likelihood of risk of impact, posed by the development, on these features are low.
	2	Depression Wetland	

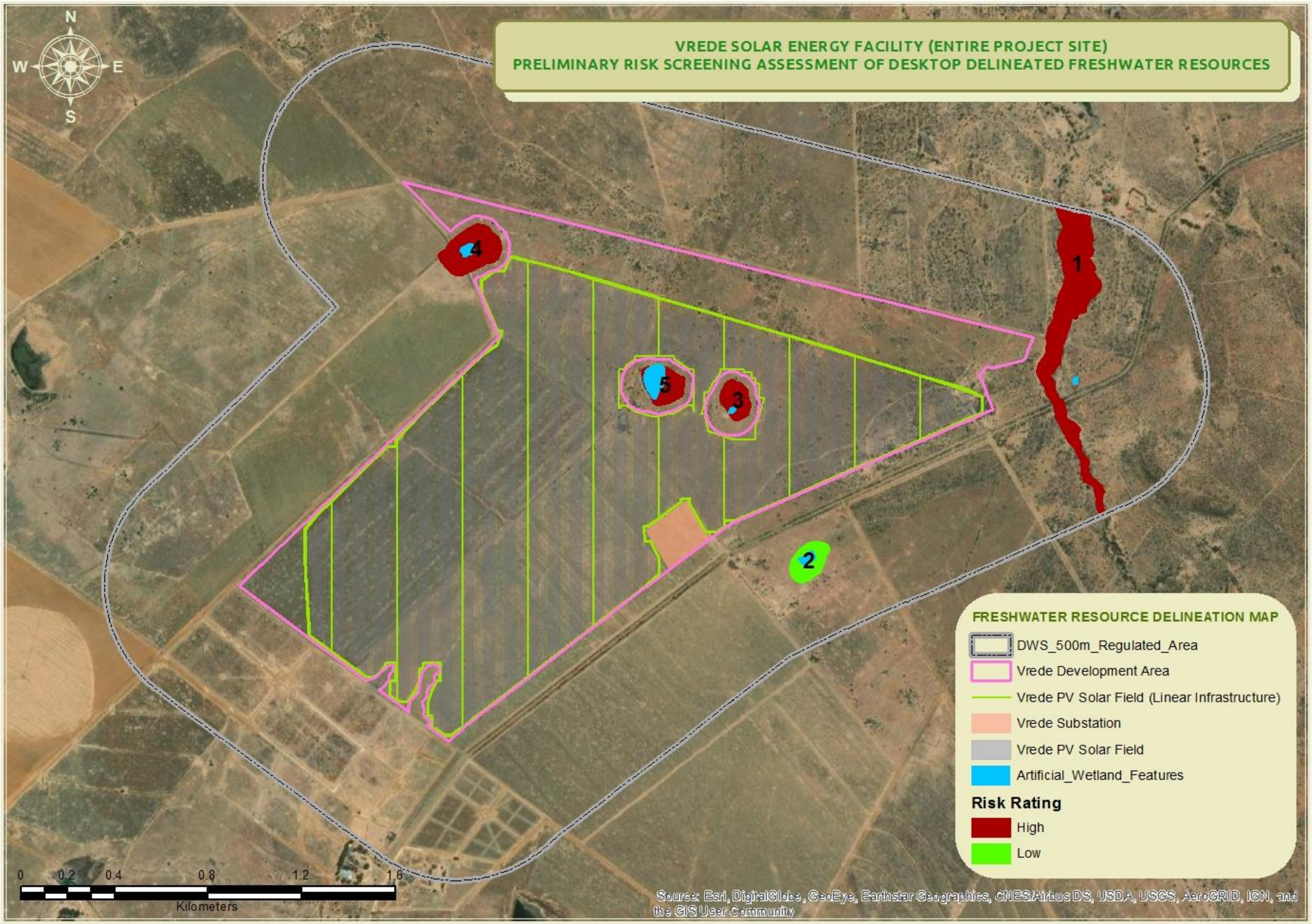

Figure 10: Risk Screening of delineated freshwater resources.

5. BASELINE ASSESSMENT RESULTS

The baseline habitat assessment, informed by on-site data collection, focused primarily on wetland units rated as being at **Moderate to High risk** of being impacted by the proposed activities (as per section above). This section sets out the findings of the baseline assessment of those water resources units and includes:

» Delineation, Classification & Habitat Descriptions;
» Present Ecological State (PES) Assessment;
» Ecological Importance and Sensitivity (EIS) Assessment;

The on-site / in-field assessment of the wetlands indicators was conducted by Gerhard Botha from Nkurenkuru Biodiversity and Ecology on the 7th to the 10th of April 2021.

On the Vrede Solar Energy Facility project site, there are three depression wetland features, and a channelled valley-bottom wetland running across the north-eastern corner of the site and which terminates into the Vals River to the north. A seepage wetland feeds into the valley-bottom wetland (within the project area).

All of the freshwater resource features on and around the site are mostly, naturally, ephemeral, however artificial (anthropogenically) modifications to the morphology of most of the wetlands has resulted in portions of these wetland resource features becoming seasonally inundated (for an extended period of time).

A dominant feature of the channelled valley bottom wetland is the patches of woody riparian habitats interrupted with grassy riparian fringes lining the outer edges of these valley bottom wetlands. The height and density of the forb and tree/shrub layer is highly variable throughout the extent of the valley-bottom wetland. The depression wetlands as well as the seepage wetland comprise of a large temporarily saturated zone with a small seasonally saturated zone and an artificially created permanent saturated zone (only in the case of the depression wetlands, this zone is absent within the seepage wetland) and is dominated by a dense, moderate to tall graminoid cover (obligate and facultative wetland grasses and sedges).

Ultimately, five (5) freshwater resource features were identified and delineated within the development area and include; <u>three</u> depression wetland, <u>one</u> seepage wetland and one channelled valley-bottom wetland (Figures 11).

Classification, Delineation and Description of Surface Water Resource Features

Surface Water Resource Delineation

The water body delineation and classification were conducted using the standards and guidelines produced by the DWS (DWAF, 2005 & 2007) and the South African National Biodiversity Institute (2009).

For the DWS definitions of different hydrological features refer to Appendix 1.

Soil and vegetation sampling in conjunction with the recording of topographical features enabled the delineation of five wetland units at risk of being impacted by the proposed development.

Depression Wetlands:

Soil and vegetation sampling in conjunction with the recording of topographical features enabled the delineation of five wetland units at risk of being impacted by the proposed development.

Wetland ecosystems are in general the dominant drainage features in this landscape and comprise predominantly of ephemeral depressions (endorheic) hydrogeomorphic (HGM) units. Depression wetlands, also known as pans, form within shallowed-out basins within the flatter landscape areas and are generally closed systems that are inward draining (endorheic).

Three such depression wetlands were identified and delineated within the development footprint. Such depression wetlands make up the majority of the lentic (non-flowing) systems of the greater landscape. These depression wetlands are, as mentioned endorheic, i.e. isolated from other surface water ecosystems, usually with inflowing surface water but no outflow. There is generally little or no direct connection with groundwater, and these depressions tend to be fed by unchanneled overland flow and interflow following rainfall events. Interflow is the lateral movement of water, usually derived from precipitation, that occurs in the upper part of the unsaturated zone between the ground surface and the water table. This water generally enters directly into a wetland or other aquatic ecosystem, without having occurred first as surface runoff, or it returns to the surface at some point down-slope from its point of infiltration.

Endorheic pans are the most common wetland type in arid and semi-arid environments (Allan *et al.*, 1995), and are generally thought to form as a result of the synergy of a number of factors and processes, including low rainfall, sparse vegetation, flat to gently sloping topography, disrupted drainage, geology (e.g. dolerite sills and dykes) grazing and deflation.

Naturally, inundation periods for these wetlands, would have been short-lived (few weeks up to about two months) following sufficient precipitation. However, in an attempt to store surface water for longer periods (water source for livestock), portions of these depression wetlands have been artificially deepened. These portions are now seasonally inundated and may stay inundated for extended periods of time. This modification to the morphology and hydrology of the wetland have resulted in an alteration in the local vegetation cover as well. The depression wetland is covered by moderate to tall graminoid and forb layer, with graminoids, especially moisture loving (hydrophytic and mesophytic), grasses being the most prominent.

Seepage Wetland:

A single seepage wetland has been identified within the project area. Seepage wetlands tend to be located on gently (as in the case of this delineated seep) to steeply sloping land and is dominated by colluvial (gravity driven), unidirectional movement of water and material down-slope. Seeps are often located on the side-slopes of a valley but they do not, typically extend onto a valley-floor. This specific seepage wetland is located on a fairly gently slope, just above the valley-floor, which contains a channelled valley-bottom wetland and into which this seepage wetland feeds into.

Seepage wetlands are characterized by their association with geological formations (litologies) and topographic positions that either cause groundwater to discharge to the land surface or rain-derived water to seep down-slope as subsurface interflow. In the case of this seepage wetland, the wetland owes its presence to the fact that the water table intersects the land surface along the slope, resulting in groundwater discharge directly to the land surface as well as presence of a relatively impervious subsoil layer (clay) which impedes the infiltration of rain-derived water into the ground.

Thus, water inputs are primarily via subsurface flows from an up-slope direction. Water movement through the seep is mainly in the form of interflow, with diffuse overland flow often being significant during and after rainfall events. Furthermore, the seep is connected to a valley-bottom wetland and water tends to seep into the valley-bottom wetland through a combination of diffuse surface flow and interflow.

Inundation periods for this wetland is very short-lived (a matter of days) following sufficient precipitation. Furthermore, soil saturation is mainly temporary with a small portion being seasonally saturated. The seep is covered by an overall moderate tall grass and forb layer, especially moisture loving (mesophytic), grasses dominating the wetland.

Channelled Valley-bottom Wetland (CVB)

A single channelled valley-bottom wetland has been identified within the north-eastern portion of the project area. CVB systems are characterised by their location within moderately well-defined valley floors with the presence of an active channel, but without typical diagnostic floodplain features. Flows within these systems are characteristically confined within a define channel. In terms of this CVB wetland the channel within the upper reaches is predominantly relative narrow and shallow, however trampling, overgrazing and erosion have locally scoured the channels, deepening sections of these channels and in some areas have created deeper pools. The effect of channel deepening and widening becomes much more pronounced downstream, especially north of the R34 route where erosion has had a significant impact on the morphology of this wetland

Dominant water inputs to these wetlands are from the watercourse/channel flowing through the wetland, predominantly as surface flow resulting from flooding, or as a form of overland flow from adjacent hillslopes and other smaller watercourses and valley-bottom wetlands, with substantially less groundwater discharge. Water generally exits a channelled valley-bottom wetland in the form of diffuse surface or subsurface flow in the adjacent river (in this case the Vals River), with infiltration into the ground and evapotranspiration of water also being potentially significant.

Inundation periods for this wetland is highly variable (laterally and longitudinally). In terms of the impacted portion of the wetland, inundation of the channel is typically fairly short-lived (few weeks) following sufficient precipitation. However, inundation within the eroded channels and pools may be seasonally. Inundation of the wetland areas adjacent to the channel is very seldom and erratic.

The channel and deeper pools tend to be more sparsely covered by a short to medium vegetation cover, comprising of a mixture of hydrophytic sedges and forbs. The terrace sections (seasonal and mostly temporary saturated zones) of the CVB wetland is however densely covered by medium to tall grasses and some forbs. Patches of woody riparian trees and shrubs can be found occasionally along lining the outer boundary of the CVB wetland, and in some areas these woody elements may encroach into the CVB wetland. Tree/shrub and forb density and height is highly variable along this CVB wetland.

Table 8: Summary of delineated freshwater resource features.

HGM Unit	Summary		
Depression Wetlands	Size	Wetland 3	1.695 ha
		Wetland 4	3.926 ha
		Wetland 5	2.310 ha
	Slope	Wetland 3	1.5% (Max: 2.8%)
		Wetland 4	1.1% (Max: 2.6%)
		Wetland 5	1.6% (Max: 3.2%)
	Elevation	Wetland 3	1430 - 1433m (Av. 1432m)
		Wetland 4	1432 – 1345m (Av. 1434m)
		Wetland 5	1429 – 1432m (Av. 1431m)
	Landscape Unit	Valley Floor	
	Outflow Drainage	No outflow (Endorheic)	
	Inflow Drainage	Unchanneled overland flow and interflow	
	Hydroperiod	All tree hydro-geomorphic zones are present: » Permanent saturated zone (smallest portion of the wetland) » Seasonal saturated zone » Temporary saturated zone (largest portion of wetland) Inundation: » Was naturally intermittent » Artificial deepening of a portion of these wetlands have resulted in these deeper areas being seasonally intermittent.	
	Drainage Direction	Various directions	
	Sediment	<u>Permanent Saturated Zone:</u> Katspruit » Orthic A Horizon: Dark greyish brown horizon with greyish brown to grey coloured clay fractions and greyish coatings on sand particles. Bleached horizon reflects reducing soil conditions and a greater degree of saturation with water in this horizon. » Gley Horizon: Diffuse transition from Grey to light grey. A result of continuous duration of saturation with stagnant and reduced water. Marked accumulation of clay within the horizon due to illuviation from upslope areas. Form in terrain positions subjected to vertical, and especially lateral in-flow of water and where subsurface water permeability to adjacent soil is low, limiting out-flow of water. <u>Seasonal Saturated Zone:</u> Sepane	

		» Orthic A Horizon: Greyish Brown horizon with greyish brown to grey coloured clay fractions and greyish coatings on sand particles. Bleached horizon along with an abundance (40%) of fairly large red to dark orange mottles reflect reducing soil conditions and a greater degree of seasonal saturation with water in this horizon. » Pedocutanic Horizon: Moderately structured soils with distinct cutans on the ped surface and a sandy clay loam texture. Cutanic character is the result of the illuviation of fine material manifested as prominent clay cutans on most ped surfaces. Fairly abundant (25%) red and dark orange mottles. » Gley Horizon: Diffuse transition from light brownish grey to light grey). Few mottles (10%), mainly small light orange to yellow. <u>Temporary Saturated Zone:</u> Sepane » Orthic A Horizon: Greyish Brown horizon with very little few mottles (1%) » Pedocutanic Horizon: Light yellowsh brown to brownish grey moderately structured soils with distinct cutans on the ped surface and a sandy clay loam texture. Moderately low abundance (5%) of small red mottles. Fairly abundant red and dark orange mottles. » Gley Horizon: Diffuse transition from light brownish grey to light grey. Few mottles (7%), mainly small light orange to yellow.	
	Key Plant Species	Permanent Saturated and Seasonally Inundated Zone	*Eleocharis limosa, Aponogeton rehmannii, Utricularia stellaris, Potamogeton crispus, Persicaria decipiens, Paspalum distichum*
		Permanent Saturated and Temporary Inundated Zone	*Paspalum distichum, Leptochloa fusca, Persicaria decipeins, Eleocharis limosa*
		Seasonal Saturated Zone	*Echinochloa holubii, Eragrostis planiculmis, Helichrysum aureonitens, Cyperus denudatus, Leptochloa fusca, Gnaphalium filagopsis, Verbena bonariensis, V. officinalis, Setaria incrassata*
		Temporary Saturated Zone	*Eragrostis plana, Eragrostis chloromelas, Themeda triandra, Helichrysum aureonitens, Verbena officinalis, Cynodon dactylon, Eragrostis curvula, Panicum coloratum, Gomphocarpus fruticosus, Arctotis arctoides, Conyza bonariensis, Eragrostis gummiflua*
Seepage Wetland	Size	1.6868 ha	
	Slope	1.8% (Max: 3.2%)	
	Elevation	1397 - 1403m (Av. 1400m)	
	Landscape Unit	Footslope	
	Outflow Drainage	Unchanneled overland- and interflow into channeled valley-bottom wetland	
	Inflow Drainage	Via subsurface flows from an up-slope direction	
	Hydroperiod	Saturation Period: Intermittently Inundation Period: Very seldomly inundated	
	Drainage Direction	Eastward towards the CVB wetland.	
	Sediment	<u>Seasonal Saturated Zone:</u> Sepane	

		» Orthic A Horizon: Greyish Brown horizon with greyish brown to grey coloured clay fractions and greyish coatings on sand particles. Bleached horizon along with an abundance (40%) of fairly large red to dark orange mottles reflect reducing soil conditions and a greater degree of seasonal saturation with water in this horizon. » Pedocutanic Horizon: Moderately structured soils with distinct cutans on the ped surface and a sandy clay loam texture. Cutanic character is the result of the illuviation of fine material manifested as prominent clay cutans on most ped surfaces. Fairly abundant (25%) red and dark orange mottles. » Gley Horizon: Diffuse transition from light brownish grey to light grey). Few mottles (10%), mainly small light orange to yellow. <u>Temporary Saturated Zone:</u> Tukulu » Orthic A Horizon: Brown horizon with very little few mottles (2%) » Neocutanic Horizon: Overall pale brown (variegated soil colours) weakly structured subsoil. Associated with materials of colluvial origin located in footslopes that have been subjected to an intermediate stage of pedogenic alteration. Colour variegations in neocutanic horizons are usually the result of illuvial material that coats weak structural units. Moderately low abundance (4%) of small red mottles. Gley Horizon: Diffuse transition from light brownish grey to light grey. Few mottles (7%), mainly small light orange to yellow.	
	Key plant species	Seasonal Saturated Zone	*Eragrostis planiculmis, Pennisetum spacelatum, Setaria incrassata, Senecio inornatus, Eragrostis plana, Paspalum dilatatum, Themeda triandra, Setaria pallide-fusca, Sporobolus africanus*
		Temporary Saturated Zone	*Eragrostis plana, Eragrostis planiculmis, Themeda triandra, Cynodon dactylon, Eragrostis chloromelas*
Channeled Valley-Bottom Wetland	Size (Potential area of impact)	10 ha	
	Slope (Potential area of impact)	0.6% (Max: 3.3%)	
	Elevation	1394 - 1409m (Av. 1400m)	
	Landscape Unit	Valley floor	
	Outflow Drainage	Mainly channeled surface flow.	
	Inflow Drainage	Surface flow and interflow	
	Hydroperiod	Saturation Period: Permanent saturated pools, Seasonally Saturated channels and terraces fringe channels, Temporary Saturated terraces. Inundation Period: Intermittently within channels and seasonally within deeper pools.	
	Drainage Direction	Northwards towards the Vals River	
	Sediment	<u>Permanent Saturated Zone:</u> Rensburg <u>Seasonal Saturated Zone:</u> Katspruit (Vertic horizon overlying a Gley subsurface); Idutywa (Orthic A horizon overlying a Prismacutanic and then Gleyic horizon) <u>Temporary Saturated Zone:</u> Sepane (Orthic A horizon overlying a Peducutanic and then Gleyic Horizon)	

	Key plant species	Permanent Saturated and Seasonally Inundated pools/depression within channels	*Marsilea macrocarpa, Schonoplectus muricinux, Leersia hexandra, Persicaria decipeins, Paspalum distichum, Echinchloa holubii*
		Seasonally Saturated Channels	*Verbena officinalis, Paspalum dilatatum, Cynodon dactylon, Haplocarpa scaposa, Cypersus eragrostis,*
		Permanent Saturated and Seasonally Inundated pools/depression within channels	
		Temporary Saturated Zone	Paspalum dilatatum, Echinochloa holubii, Verbena officinalis, Eragrostis plana, Setaria incrassata, Seatria pallide-fusca, Eragrostis planiculmis, Pennisetum sphacelatum, Sporobolus africanus
		Riparian Zone	*Celtis africana, Searsia pyrioides, Sida dregei, Pavonia senegalensis, Pentharrhinum insipidum, Gleditsia triacanthos, Ziziphus mucronata, Acacia karoo, Asparagus laricinus, Setaria verticillata, Cynodon dactylon, Bidens bipinnata, Achyranthes aspera*

Present Ecological State

Wetlands form at the interface between terrestrial and aquatic environments, and between groundwater and surface-water systems. The complex interaction of inflows and outflows of water, sediment, nutrients and energy over time is what shapes the physical template of the wetland and understanding theses fluxes and interactions considered is fundamentally important in developing an understanding the occurrence, morphology and dynamics of different wetland systems (Ellery et al., 2009).

The current health or Present Ecological State (PES) of wetlands was assessed using the WET-Health tool (Macfarlane et al. 2008) which was applied at a rapid level 1 assessment level. WET-Health assesses wetland condition or PES based on an understanding of both catchment and on-site impacts. The approach to assessing wetland PES essentially works by comparing a wetland in its current state with the estimated baseline/reference state of the wetland.

The results of the wetland PES assessment are presented in Table 9.

» The depression wetlands (W3-5) as well as the channelled valley bottom wetland (W1) (W6) have been assessed as being 'Moderately Modified' ('C' PES) which implies *a moderate change in ecosystem processes and loss of natural habitats has taken place but the natural habitat remains predominantly intact*.
» The seepage wetland (W6) has been assessed as being largely natural with few modifications ('B' PES) which implies *that a slight change in ecosystem processes is discernible and a small loss of natural habitats and biota may have taken place.*

Key existing impacts affecting the condition of the various wetland units include:

» Depression wetland:
    - Alteration to a portion of the wetlands morphology: Portions have been artificially (anthropogenically) deepened in order to store water for longer periods of time (water source for cattle). The overburden material has been stockpiled within the boundaries of the wetlands and has also contributed to the modification of the morphology;
    - These deepened areas have led to a slight local change in the inundation period extent of the hydro-morphological zones as well as the plant species cover within the inundated area.
    - Especially the permanent and seasonally saturated zones have been subjected to trampling.
    - All of these wetlands are exposed frequent grazing with some local signs of overgrazing.
    - Disturbed areas are subjected to the invasion of numerous weedy and herbaceous invasive alien plants such as *Salsola kali, Alternanthera pungens,*

Tribulus terrestris, Cirsium vulgare, Schkuria pinnata, Tagetes minuta, Xanthium spinosum, Datura stramonium and Verbena aristigera,
- Outside of these disturbed areas, the "natural" areas also contain some invasive alien plants such as Verbena bonariensis and especially *V. officinalis*. Other alien and weedy plants frequently observed include; *Conyza bonariensis, Tagetes minuta, Verbena aristigera and Paspalum dilatatum,*
- Historically ploughing/cultivation activities have encroached slightly into portions of the temporary zones; however, these practices have been abandoned, and a plagioclimax grassland has since established within these areas.

» Seepage Wetland:
- Long term selective grazing and occasional overgrazing have impacted the grass composition slightly.
- A power line spans across this wetland with a few pylons located within the wetland.
- Alien invasive plants such as Verbena bonariensis and especially V. officinalis have established within this area although the current level of invasion is regarded as low.
- Indigenous shrubs such *as Acacia (Vachellia karoo)* and *Asparagus laricinus* have become slightly encroaching although level is regarded as low.

» Channelled Valley-Bottom Wetland:
- Trampling and erosion have impacted the channel morphology and resulted in the formation of small depression where water tend to be collected and stored for period of time.
- Trampling by livestock and erosion have also resulted in a modification of the vegetation composition and structure of the channels.
- Infilling associated with the gravel road have also impacted the local wetland morphology as well as the distribution and retention of waterflow upstream and downstream of the road, however the significance of this impact is regarded as moderate-low.
- The establishment of alien invasive plants is regarded as a significant, especially *Gleditsia triacanthos* which is locally abundant. Other invasive alien plant species recorded within this wetland include; *Verbena bonariensis* and *V. offincialis.*

Table 9: Summary of the Present Ecological Scores (PES) of the affected Hydrogeomorphic units.

Hydro-geomorphic Unit	Hydrology	Geomorphology	Vegetation	Overall PES
Depression Wetlands (W3-5)	C: Moderately Modified (PES Score: 2.7)	C: Moderately Modified (PES Score: 2.4)	B: Largely Natural (PES Score 1.8)	C: Moderately Modified (PES Score: 2.3)
Seepage Wetland (W6)	A: Natural (PES Score: 0.8)	B: Largely Natural (PES Score: 1.3)	B: Largely Natural (PES Score 1.7)	B: Largely Natural (PES Score: 1.2)

Channelled Valley-Bottom Wetland (W1)	C: Moderately Modified (PES Score: 2.9)	C: Moderately Modified (PES Score: 3.7)	D: Largely Modified (PES Score: 4.6)	C: Moderately Modified (PES Score: 3.7)

Ecological Importance and Sensitivity (EIA) Assessment

The Ecological Importance and Sensitivity (EIS) of a wetland is an expression of the importance of the aquatic resource for the maintenance of biological diversity and ecological functioning on local and wider scales; whilst Ecological Sensitivity (or fragility) refers to a system's ability to resist disturbance and its capability to recover from disturbance once it has occurred (Kleynhans & Louw, 2007).

Ecological Importance and Sensitivity is a concept introduced in the reserve methodology to evaluate a wetland in terms of:

» Ecological Importance;
» Hydrological Functions; and
» Direct Human Benefits

A summary of the EI&S importance assessment scores and ratings for wetlands is provided in Table 10 below and indicates the following:

» The channelled Valley-Bottom (W1) is considered to be of 'High' EIS, linked with its relative high importance in providing biodiversity maintenance and water quality enhancement services primarily as well as its moderate-low sensitivity to external impacts. Wetland unit 1 provides a valuable corridor for movement (fauna and likely avifauna) as well as hydrological connectivity with important lower lying aquatic and wetland ecosystems as well as with surrounding terrestrial (primary and secondary) grasslands. Furthermore, water quality enhancement and maintenance are vital for functionality and services provided by important downstream ecosystems.
» The depression wetlands (W3-5) is also considered to be of 'High' EIS, primarily due to their association with the endangered Vaal-Vet Sandy Grassland as well as their sensitivity to external impacts as well as their low to moderate importance in providing biodiversity maintenance.
» The seepage wetland (W6) is considered to be of 'Moderate' EIS, linked with its high sensitivity to external impacts as well as its high importance in terms of water quality enhancement services. Due to this wetland's association (hydrological connection) with the lower lying channelled valley-bottom wetland which is regarded as a high EIS system, this wetland features have been upgraded to High sensitive and importance.
» No red listed, CITES or nationally protected species were recorded within any of the wetlands.
» However, the following provincially protected species were recorded: *Crinum bulbispermum* (W1), *Boophone disticha* (W3-5), *Ammocharis caronica* (W1, W3-6) and *Schizocarphus nervosus* (W3 – 6).

- *Hypoxis hemerocallidea* (W1, W3-5) was also recorded within some of the wetlands and even though this species is neither provincially nor nationally protected this species is prone to illegal collection and harvesting and populations may subsequently be vulnerable to such activities. Subsequently local populations of this species are regarded as locally important.
- The depression wetlands as well as the seasonally saturated zones of the channelled valley bottom wetland are regarded as suitable habitat for Giant Bullfrog - *Pyxicephalus adspersus* (Vulnerable) with a moderate likelihood of occurrence.
- Dense grass covered wetland areas (all wetlands delineated) and the fringing natural terrestrial vegetation is also furthermore regarded as suitable habitat for Serval – *Leptailurus serval* (Near Threatened) with a high likelihood of occurrence.
- All three depression wetlands are located within T-CBA1, according to the terrestrial critical biodiversity areas for the Free State (2015)
- All wetland units occurring within Critical Biodiversity Areas (CBA), were rated as 'High' with regards to protected status.

Table 10: Score sheet for determining the ecological importance and sensitivity for the identified wetland units.

DETERMINANT		IMPORTANCE SCORES (0-4) AND RATINGS		
		Depression Wetlands (W3-5)	**Seepage Wetland (W6)**	**Channelled Valley-Bottom Wetland (W1)**
PRIMARY DETERMINANTS	Rare & Endangered Species	3	1	3
	Populations of Unique Species	1	1	1
	Species/taxon Richness	3	2	3
	Diversity of Habitat Types or Features	2	2	4
	Migration route/breeding and feeding site for wetland species	2	2	2
	Sensitivity to Changes in the Natural Hydrological Regime	4	4	3
	Sensitivity to Water Quality Changes	3	4	3
	Flood Storage, Energy Dissipation & Particulate/Element Removal	1	3	1
MODIFYING DETERMINANTS	Protected Status	4	4	4
	Ecological Integrity	3	3	2
TOTAL		26	26	26
MEDIAN		3	2.5	3
OVERALL ECOLOGICAL SENSITIVITY & IMPORTANCE		**B High**	**C Moderate**	**B High**

Wetland Buffer Zones

Buffers represent zones in which construction or habitat degradation would risk direct or indirect impacts on aquatic features and local hydrology. The main objective of the establishment and protection of buffers around aquatic features is to ensure that these features are protected from direct and indirect impacts.

The national Preliminary Guideline for the Determination of Buffer Zones for River, Wetlands and Estuaries (MacFarlane *et al.,* 2014) was used to determine a desktop-level buffer width, which was based on the types of impacts associated with above-ground construction and operation of power infrastructure. The generic buffer for this type of activity is **55 m** for all aquatic ecosystems located in an area with moderate low rainfall and with low rainfall intensity (MacFarlane *et al.,* 2014).

It is recommended that this generic buffer be reduced to the following, specifically due to the flat terrain (i.e. a flatter slope will mean that water flowing across the buffer will flow slowly, thus increasing the chance of sediment and pollutants settling out, and increasing the effectiveness of the buffer):

» Aquatic features of high sensitivity: 30m buffer

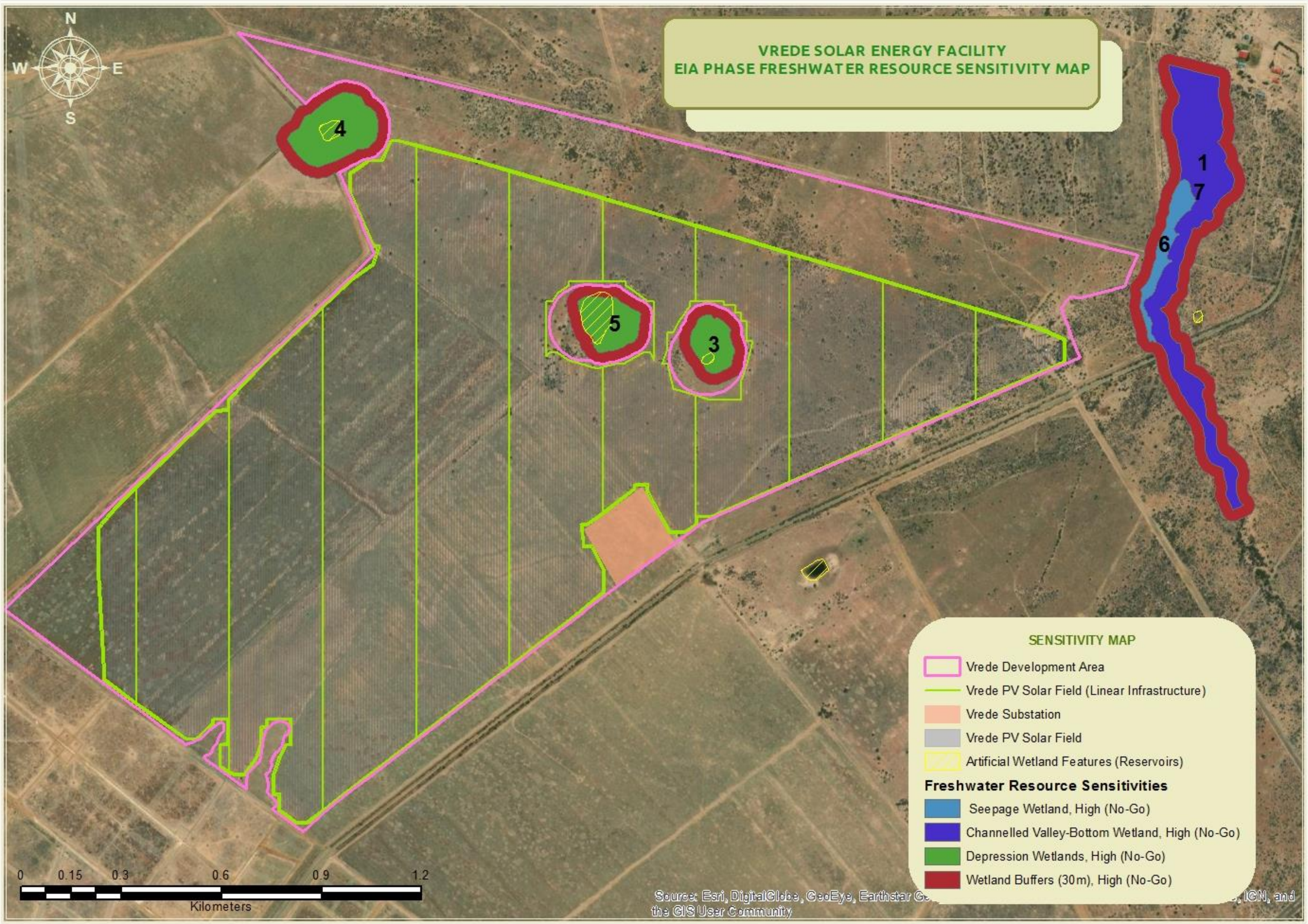

Figure 11: Ecological Importance and Sensitivity Map.

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6. ASSESSMENT OF PROPOSED IMPACTS

Identification of Potential Impacts and Associated Activities

All freshwater resources as well as their associated buffer areas have been excluded from the development footprint and as such direct impacts during construction, operation and decommission is highly unlikely. However, there is a slight potential for indirect loss of / or damage to some of the freshwater resources. This may potentially lead to localised loss of freshwater resources and may potentially lead to downstream impacts that affect a greater extent of freshwater resources or impact on function and biodiversity. Where these habitats are already stressed due to degradation and transformation, the loss may lead to increased vulnerability (susceptibility to future damage) of the habitat. Physical alteration to wetlands can have an impact on the functioning of those wetlands. Consequences may include:

- increased loss of soil;
- loss of/or disturbance to indigenous wetland vegetation;
- loss of sensitive wetland habitats;
- loss or disturbance to individuals of rare, endangered, endemic and/or protected species that occur in wetlands;
- fragmentation of sensitive habitats;
- impairment of wetland function;
- change in channel morphology in downstream wetlands, potentially leading to further loss of wetland vegetation; and
- reduction in water quality in wetlands downstream.

Impact of proposed PV solar facility and substation

Construction and Planning Phase

SEFs require an initial high intensity disturbance of a fairly large surface area including the clearance of the vegetation cover and the levelling of earth on different terraces where necessary and the compaction of local soil within the development footprint. Concrete foundations for the framework on which the PV panels will be mounted. Soil disturbance, vegetation clearance and hardened surfaces will also be associated with the construction of access and internal roads within the PV solar facility. The internal substation would also need to be constructed within the site. Temporary laydown and storage areas would need to be placed within the site for the construction works.

In terms of the proposed substation, the location of the substation is well located, a fair distance from any freshwater resource feature, and close to the P99/1 route.

Subsequently, it is unlikely that the construction of the substation will have any impact of freshwater resources.

In terms of the location of the PV solar field, according to the current layout, the valley-bottom wetland and associated seepage wetland is located outside of the proposed PV solar field (~320m to the south-west) and potential impacts on these wetland features would likely be of an indirect nature, however these impacts are likely to be fairly small due to the distance of the footprint area from these wetlands. Potential impacts on these wetland features include the increase in surface runoff and sediments carried into these wetland features, subsequently potentially impacting local hydrological character of these wetlands (e.g. water quality and hydro-geomorphological character), due to a reduction in roughage, soil compaction/hardening and disturbance within the PV solar footprint area (portion of footprint area falls within the wetland resources' catchment areas).

In terms of the delineated depression wetland, the current layout of the PV solar field will avoid construction within all of these wetland features, however the development will still none the less occur in relative close proximity to these wetlands. Subsequently, according to the current layout, potential impacts on these wetlands will mostly be of an indirect nature and may include:

- The increase in surface runoff and sediments carried into these wetland features, subsequently potentially impacting local hydrological character of these wetlands (e.g. water quality and hydro-geomorphological character).
- Change in vegetation structure and composition due a change in the hydro-geomorphological character (increase in inundated area and the permanent and seasonal saturated zones, to the cost of the temporary saturated zone.
- The potential spread of erosion from the source (within the development footprint area), into the wetland features, subsequently disturbing wetland soils, vegetation cover and local biota.

Direct impacts on these wetland features may include:

- A direct loss of terrestrial habitat fringing the wetland resources may lead to the loss of valuable foraging habitat for wetland fauna (amphibians).
- Fracturing and isolation of wetland features.

There is also the potential for some water quality impacts associated with the batching of concrete, from hydrocarbon spills or associated with the other construction activities on the site. Only a limited amount of water is utilised during construction for the batching of cement and other construction activities.

Generally, with mitigation measures in place, including the micro-placing of infrastructure, outside of any sensitive features (freshwater resource features and associated buffer areas), impacts will be localised, short-term and of low intensity and is expected to have a moderate-low to low overall significance in terms of its impact on the identified aquatic ecosystems in the area.

Operation Phase:

During the operation phase the facility will operate continuously, mostly unattended and with low maintenance required for the duration of the SEFs life (±20 years). The SEF is likely to be monitored and controlled remotely, with maintenance only taking place when required.

The PV panels as well as the hard surfaces created by the development may lead to increased runoff (reduction in infiltration) and the potential interception and channelling of surface runoff, particular on surfaces with a steeper gradient. This may potentially lead to:

- A modification to the water input characteristic (input in quantity and a change in water input pattern);
- Increased erosion;
- Sedimentation of the downslope areas; and
- Impairment of wetland functions and services

Subsequently, a localised long-term impact (more than 20 years) of low intensity (depending on the distance between the PV panels and the freshwater features) could be expected that would have a very low overall significance post-mitigation in terms of its impact on the identified freshwater resource features in the area.

Decommission Phase:

During decommissioning, the potential freshwater impacts will be very similar to that of the Construction Phase, although the potential for water quality and flow related risks will be lower.

Cumulative impacts

Existing solar energy projects that were considered in terms of their potential cumulative terrestrial ecological impacts that are in an approximate 30 km radius of the Vrede Solar Energy Facility illustrated below in Figure 12. Only two other PV Solar projects are located within the 30 km radius and as such the cumulative impacts in the area is expected to be relatively low at this point.

Of the three renewable energy facilities, the 75MW PV solar farm located to the east of Riebeeckstad is located within the C4 secondary catchment primarily drained by the Vet River and associated tributaries, whilst the proposed Vrede and Rondavel Solar Energy

Facilities is located within the C6 secondary catchment (Vals River and associated tributaries). Subsequently the SEF near Riebeeckstad will not contribute to the cumulative impact on the Vals River's catchment and subsequently the only SEFs likely to contribute to cumulative impacts, are the Vrede and Rondavel SEFs and as such only these two SEFs were taken into account.

Apart from these two SEFs, no other renewable energy project is currently planned within the Vals Rivers' catchment area and as such the expected cumulative impact on this freshwater resource will be very small.

A Freshwater Resource Study and Assessments was also undertaken, as part of the EIA process, for the proposed Rondavel SEF and this study also recommend the avoidance of any freshwater resource features and furthermore has also recommended aquatic buffers. The conclusion drawn from the Rondavel SEF is very similar to that drawn for this study in that the proposed layouts of these facilities indicated limited impacts on their aquatic environments as the proposed structures for the most part, have avoided the delineated wetlands. Based on the findings of the Rondavel study the relevant specialist found no objection to the authorisation of any of SEF inclusive of provided recommended mitigation measures and alternatives.

Probably the most significant potential impact associated with these projects are the modification of roughage (vegetation cover) and the creation of compacted and hard engineered surfaces with the catchment areas, leading to:

- Reduced infiltration; and
- The increase in surface runoff and sediments carried into downstream freshwater resource features.

For these projects concerned, the micro-placing of infrastructure in order to avoid direct impacts on delineated freshwater resources, and to accommodate for recommended buffers, are highly possible and will allow for the avoidance of freshwater resource features, furthermore, reducing the impacts on the aquatic ecosystems.

Both of the projects have indicated that this is their intention with regard to mitigation, i.e. selecting the best possible layout to minimise the local and regional impacts.

Subsequently it can be concluded that the cumulative impact of the proposed project would not be significant provided mitigation measures are implemented.

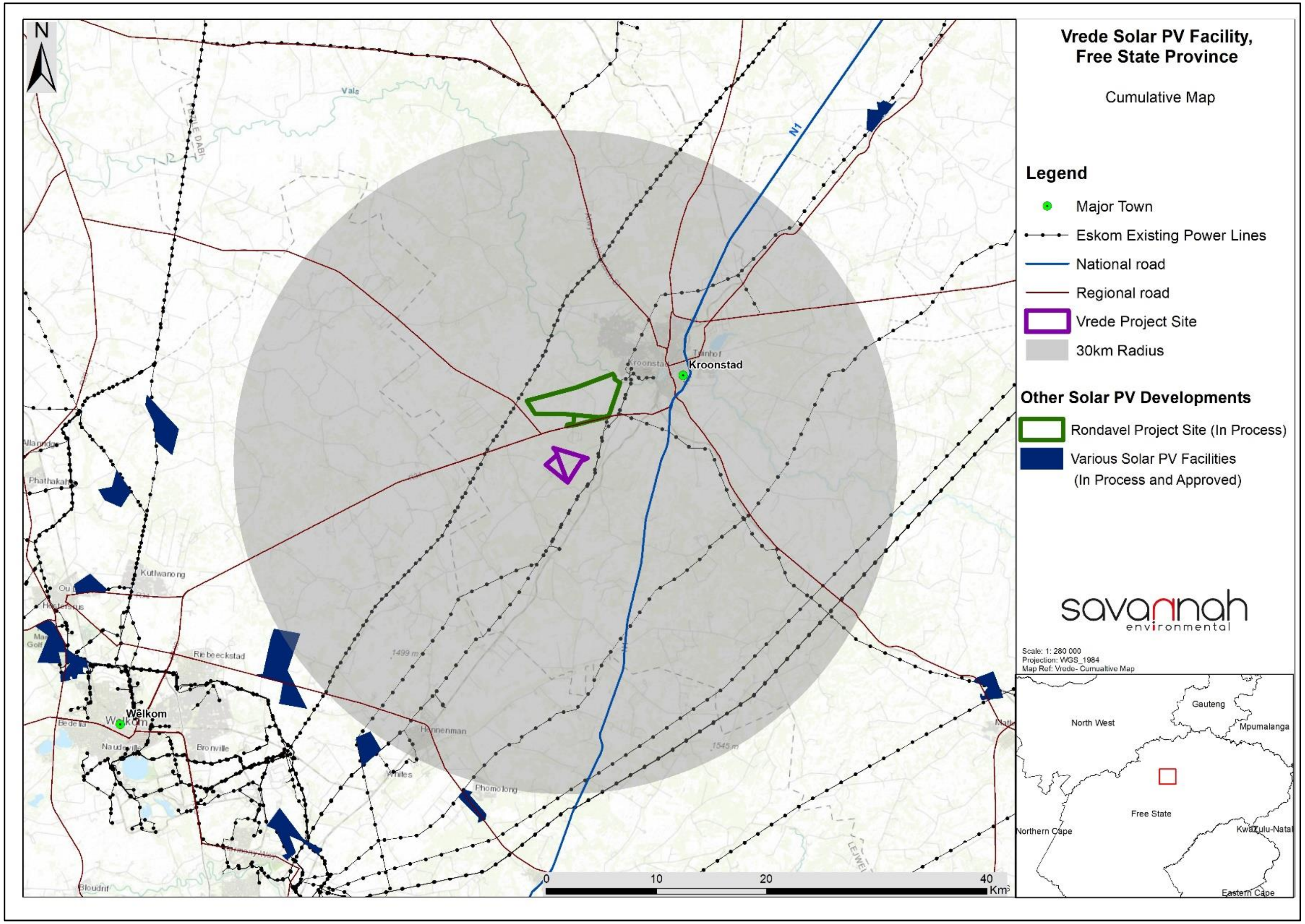

Figure 12: The location of the Vrede Solar PV Facility in relation to other renewable energy projects within a radius of 30km from the Vrede Solar PV Facility (Map provided by Savannah Environmental).

Assessment of Impacts

Impact 1: *Indirect loss of wetland habitats during the construction, operation and decommissioning phase (applicable to all wetland features).*

Impact Nature: This refers to the indirect physical destruction or disturbance of wetland habitat caused by vegetation clearing and disturbance of habitat within their catchments. This may result in the formation of erosion features within the catchment area which may potentially spread into the lower lying wetland habitats, or the deposition of sediments within these habitats. This in turn may result in the disturbance/removal of wetland vegetation and soil and expose these areas to the encroachment/colonisation by invasive alien plants and alteration of geomorphological profiles (including stream beds and banks). Possible ecological consequences associated with this impact may include:

» Reduction in representation and conservation of freshwater ecosystem/habitat types;
» Reduction in the supply of ecosystem goods & services;
» Reduction/loss of habitat for aquatic dependent flora & fauna; and
» Reduction in and/or loss of species of conservation concern (i.e. rare, threatened/endangered species).

These disturbances will be the greatest during the construction and again in the decommissioning phases as the related disturbances could result in loss and/or damaged vegetation.

	Without Mitigation	**With Mitigation**
Extent	Development footprint as well as neighbouring areas (3)	Local (1)
Duration	Long-term (4)	Long-term (4)
Magnitude	Moderate (5)	Small (2)
Probability	Probable (3)	Improbable (2)
Significance	**Medium (36)**	**Low (14)**
Status	Negative	Negative
Reversibility	Low – Destruction of wetland vegetation will not be remedied easily.	Low – Destruction of wetland vegetation will not be remedied easily.
Irreplaceable loss of resources	Local loss of resources	No loss of resources
Can impacts be mitigated?	Yes, to a large extent	
Mitigation:	» All wetland features and their associated buffer areas should be regarded as No-Go areas for all construction activities. » The recommended buffer areas between the delineated freshwater resource features and proposed project activities should be maintained. » Vegetation clearing within the development footprint to be kept to a minimum. No unnecessary vegetation to be cleared. » Vegetation clearing should occur in in a phased manner to minimise erosion and/or run-off. » Avoid placing any construction camps, laydown areas, or any buildings or storage facilities within the wetland features as well as their buffer areas.	

	» Any areas disturbed during the construction phase should be encouraged to rehabilitate as fast and effective as possible and were deemed necessary by the ECO or Contractor's EO, artificial rehabilitation (e.g. re-seeding with collected or commercial indigenous seed mixes) should be applied in order to speed up the rehabilitation process in critical areas (e.g. steep slopes and unstable soils). » Existing roads should be used as far as possible » Where new roads need to be constructed, the existing road infrastructure should be rationalised and any unnecessary roads decommissioned and rehabilitated to reduce the level of disturbance. » During the construction and operational /decommissioning phase, monitor the development footprint and wetland areas to see if erosion issues arise and if any erosion control is required. ▪ Any areas disturbed during the construction phase should be encouraged to rehabilitate as fast and effective as possible and were deemed necessary by the Contractor's EO, artificial rehabilitation (e.g. re-seeding with collected or commercial indigenous seed mixes) should be applied in order to speed up the rehabilitation process in critical areas (e.g. steep slopes and unstable soils). ▪ All alien plant re-growth must be monitored and should it occur these plants should be eradicated. ▪ Road infrastructure and cable alignments should coincide as far as possible to minimise the impact. ▪ During decommissioning, disturbance to the freshwater ecosystems should be avoided as far as possible. ▪ Disturbed areas may need to be rehabilitated and revegetated. ▪ Mitigation and follow up monitoring of residual impacts (alien vegetation growth and erosion) may be required. » An effective storm water management plan should be compiled by a suitable specialist and the effectivity of the plan should be regularly assessed and revised if necessary.
Residual Impacts	» Locally altered vegetation structure, » Without the implementation of mitigation measures, possible impact on the remaining catchment due to changes in run-off characteristics in the development site.

Impact 2: *Impact on wetland systems through the increase in surface runoff on wetland form and function during the operational and decommissioning phases*

Impact Nature: The proposed PV Power Project will involve the addition of hardened areas through the establishment of solar panel foundations while some compaction of soils may occur due to site works. Service roads have the potential to further increase areas of hardening as do the temporary construction area. The substation and additional support buildings will increase hardened surfaces. The aforementioned will increase the runoff generated on site due to the addition of areas of hard surfaces and could lead to increased flood peaks downstream with increased flood risk and erosion risk, potentially reducing or disturbing important/sensitive downstream wetland habitats.		
	Without Mitigation	**With Mitigation**
Extent	Development footprint as well as neighbouring areas (3)	Local (2)
Duration	Long-term (4)	Medium-term (3)

Magnitude	Moderate (5)	Small (2)
Probability	Highly Probable (5)	Probable (3)
Significance	**Medium (60)**	**Low (21)**
Status	Negative	Negative to Neutral
Reversibility	Low – Destruction of wetland vegetation will not be remedied easily.	Low – Destruction of wetland vegetation will not be remedied easily.
Irreplaceable loss of resources	Local loss of resources	No loss of resources
Can impacts be mitigated?	Yes – to a large extent, mainly through avoidance of highly sensitive areas and associated buffers and through the implementation of an effective storm water management plan.	
Mitigation:	» All wetland features and their associated buffer areas should be regarded as No-Go areas for all construction activities. » The recommended buffer areas between the delineated freshwater resource features and proposed project activities should be maintained. » Vegetation clearing within the development footprint to be kept to a minimum. No unnecessary vegetation to be cleared. » Vegetation clearing should occur in in a phased manner to minimise erosion and/or run-off. » Infrastructure footprint and associated area of disturbance should be minimised as far as practically possible » Any storm-water within the site must be handled in a suitable manner, i.e. trap sediments, and reduce flow velocities » Stormwater from hard stand areas, buildings and substation must be managed using appropriate channels and swales when located within steeper areas. » The runoff should be dissipated over a broad area covered by natural vegetation or managed using appropriate channels and swales. » Storm water run-off infrastructure must be maintained to mitigate both the flow and water quality impacts of any storm water leaving the Solar PV site. » The existing road infrastructure should be utilised as far as possible to minimise the overall disturbance » Where new roads need to be constructed, the existing road infrastructure should be rationalised and any unnecessary roads decommissioned and rehabilitated in order to reduce total area of hardened, bare areas within the property. » No stormwater runoff must be allowed to discharge directly into freshwater resource features along roads, and flows should thus be allowed to dissipate over a broad area covered by natural vegetation.	
Residual Impacts	A potential residual impact is the modification to the extent of inundation as well as to the hydro-geomorphological zones (increase in permanent and seasonal saturated zones) resulting in an alteration to the vegetation composition. However, this impact is unlikely.	

Impact 3: *Increase in sedimentation and erosion during the construction, operational and decommissioning phase*

Impact Nature: For the construction and decommissioning phases this refers to the alteration in the physical characteristics of freshwater resource features as a result of increased turbidity and sediment deposition, caused by soil erosion and earthworks, within the wetland features' catchments, that are associated with construction activities. Possible ecological consequences associated with this impact may include:

- Deterioration in freshwater ecosystem integrity; and
- Reduction/loss of habitat for aquatic dependent flora & fauna.

This may furthermore, influence water quality

The proposed development will require clearing of existing vegetation and disturbance of soils, specifically for the installation of foundations for PV modules, access roads, electrical cabling, substation, buildings and laydown areas. The solar panels will increase shading of the surface and may result in a decrease in vegetation cover. Disturbed or exposed soils will increase the likelihood of soil erosion and subsequent potential sedimentation of downstream water courses during significant rainfall events. The study by Cook and McCuen (2013) found that the runoff from individual solar panels resulted in greater kinetic energy which increased potential soil erosion below panels (this potential erosion may be enhanced by panel maintenance which includes regular washing). The site is, however, located in a low rainfall area of South Africa which will reduce the potential impact with the mild topography also reducing the erosivity of runoff.

	Without Mitigation	**With Mitigation**
Extent	Local & downstream (3)	Local (1)
Duration	Long-term (4)	Very Short Duration (1)
Magnitude	Moderate (6)	Minor (4)
Probability	Highly Probable (4)	Improbable (2)
Significance	**Medium (52)**	**Low (12)**
Status	Negative	Slightly negative
Reversibility	Moderate	High
Irreplaceable loss of resources	Local and potential loss of downstream resources	Unlikely
Can impacts be mitigated?	Yes, to a large extent	
Mitigation:	» All wetland features and their associated buffer areas should be regarded as No-Go areas for all construction activities. » The recommended buffer areas between the delineated freshwater resource features and proposed project activities should be maintained. » Vegetation clearing to be kept to a minimum. No unnecessary vegetation to be cleared. » Vegetation clearing should occur in in a phased manner to minimise erosion and/or run-off. » Any erosion problems observed to be associated with the project infrastructure should be rectified as soon as possible and monitored thereafter to ensure that they do not re-occur. » All bare areas, as a result of the development, should be revegetated with locally occurring species, to bind the soil and limit erosion potential.	

	» Site rehabilitation should aim to restore surface drainage patterns, natural soil and vegetation as far as is feasible. » An erosion control management plan should be utilised to prevent erosion » Any storm-water within the site must be handled in a suitable manner, i.e. trap sediments, and reduce flow velocities » Stormwater from hard stand areas, buildings and substation must be managed using appropriate channels and swales when located within steep areas. » Erosion control measures such as silt fences (for areas of works) and gravel strips may be considered at the impact zone where water falls from the solar panels onto the soil surface (due to deterioration in natural grassland because of poor maintenance or lack of solar radiation). » Storm water run-off infrastructure must be maintained to mitigate both the flow and water quality impacts of any storm water leaving the Solar PV site. » The existing road infrastructure should be utilised as far as possible to minimise the overall disturbance created by the proposed Solar PV Facility. » Silt traps should be used where there is a danger of topsoil eroding and entering lower lying wetland resources. » Construction of gabions and other stabilisation features to prevent erosion, if deemed necessary. » No stormwater runoff must be allowed to discharge directly into any wetland feature along roads, and flows should thus be allowed to dissipate over a broad area covered by natural vegetation. » Containers carrying batteries (if present) should be regularly checked for leaks. If leaks are found, these containers should be repaired, replaced immediately with leaked chemicals cleaned up as soon as possible. » Store hydrocarbons off site where possible, or otherwise implement hydrocarbon storage using impermeable floors with appropriate bunding, sumps and roofing. » Handle hydrocarbons carefully to limit spillage. » Ensure vehicles are regularly serviced so that hydrocarbon leaks are limited. » Designate a single location for refuelling and maintenance, outside of any freshwater resource features. » Keep a spill kit on site to deal with any hydrocarbon leaks. » Remove soil from the site which has been contaminated by hydrocarbon spillage.
Residual Impacts	Altered morphology. Due to the extent and nature of the development this residual impact is unlikely to occur.

Cumulative Impacts

All existing (authorised) renewable energy projects located within an approximate radius of the 30km of the Vrede Solar Energy Facility were taken into account (Figure 12).

Cumulative Impact 1: *Compromise ecological processes as well as ecological functioning of important freshwater resource habitats*

Impact Nature: Transformation of intact freshwater resource habitat could potentially compromise ecological processes as well as ecological functioning of important habitats and would contribute to habitat fragmentation and potentially disruption of habitat connectivity and furthermore impair their ability to respond to environmental fluctuations. This is especially of relevance for larger watercourses and wetlands serving as important groundwater recharge and floodwater attenuation zones, important microhabitats for various organisms and important corridor zones for faunal movement		
	Overall impact of the proposed project considered in isolation	**Cumulative impact of the project and other projects within the area**
Extent	Local (1)	Local and Downstream areas (3)
Duration	Long Term (4)	Long Term (4)
Magnitude	Small (1)	Moderate (6)
Probability	Improbable (2)	Improbable (2)
Significance	Low (12)	Low (26)
Status	Neutral	Slightly Negative
Reversibility	Moderate to Low	Moderate to Low
Irreplaceable loss of resources	No	Limited loss of local resources
Can impacts be mitigated?	Yes	
Mitigation	» All wetland features and their associated buffer areas should be regarded as No-Go areas for all construction activities. » The recommended buffer areas between the delineated freshwater resource features and proposed project activities should be maintained. » Vegetation clearing to be kept to a minimum. No unnecessary vegetation to be cleared. » The potential stormwater impacts of the proposed developments areas should be mitigated on-site to address any erosion or water quality impacts. » Good housekeeping measures as stipulated in the EMPr for the project should be in place where construction activities take place to prevent contamination of any freshwater features. » Where possible, infrastructure should coincide with existing infrastructure or areas of disturbance (such as existing roads). » Disturbed areas should be rehabilitated through reshaping of the surface to resemble that prior to the disturbance and vegetated with suitable local indigenous vegetation.	

7. CONCLUSION AND RECOMMENDATIONS

Nkurenkuru Ecology and Biodiversity was appointed by Savannah Environmental (Pty) Ltd to undertake freshwater resource and biodiversity study and assessment for the proposed Vrede Solar Energy Facility. The proposed PV energy facility will cover an area of approximately 214 ha and will have a generating capacity of up to 100MW. The proposed facility will be located within the Remaining extent of the farm Vrede No. 1152, and Portion 1 of the farm Uitval No. 1104. The affected property is located 18.3km (south-west) from the town of Kroonstad (central) within the Moqhaka Local Municipality and the Fezile Dabi District Municipality in the Free State Province.

This study has been commissioned to meet the requirements of the EIA process in the form of an Environmental Impact Assessment as set out by the National Environmental Management Act (1998) and a Water Use Licence Application as set out by the National Water Act (Act 36 of 1998). Furthermore, this study should and has been done in accordance with the "newly" Gazetted Protocols 3(a),(c) and (d) in terms of Section 24(5)(a) and 24(5)(h) of NEMA (Published on the 20th of March 2020); and meet the requirements as set out within the Aquatic Biodiversity Protocol published in GN NO. 1105 of 30 October 2020.

According to the guidelines specified within GN509 of 2016 all wetlands within a radius of 500m of the facility footprint were identified and those with a high and moderate risk of being impacted was delineated, mapped and classified.

On the Vrede Solar Energy Facility project site, there are three depression wetland features, and a channelled valley-bottom wetland running across the north-eastern corner of the site and which terminates into the Vals River to the north. A seepage wetland feeds into the valley-bottom wetland (within the project area).

All of the freshwater resource features on and around the site are mostly, naturally, ephemeral, however artificial (anthropogenically) modifications to the morphology of most of the wetlands has resulted in portions of these wetland resource features becoming seasonally inundated (for an extended period of time).

A dominant feature of the channelled valley bottom wetland is the patches of woody riparian habitats interrupted with grassy riparian fringes lining the outer edges of these valley bottom wetlands. The height and density of the forb and tree/shrub layer is highly variable throughout the extent of the valley-bottom wetland. The depression wetlands as well as the seepage wetland comprise of a large temporarily saturated zone with a small seasonally saturated zone and an artificially created permanent saturated zone (only in the case of the depression wetlands, this zone is absent within the seepage wetland) and is dominated by a dense, moderate to tall graminoid cover (obligate and facultative wetland grasses and sedges).

Catchment Context (Regional Hydrological Setting):

- The project site is located within the Middle Vaal Management Area (WMA) and within the DWS Quaternary catchments C60H and C60G.
- The development site occurs predominantly within the Quaternary Catchment C60H.

- The proposed development area is situated within the Southern Highveld Geomorphic Sub- Province (Partridge et al., 2010).
- Wetlands within the region are mostly depression (pan) wetlands within the relatively flat plains where a slight change in geomorphology and underlying geology may result in the collection of water and saturated soil conditions. Most of the pans are endorheic. The more undulating and steeper slopes to the north and south contain a higher diversity of wetland types due to the greater variation in geomorphology resulting in different drainage systems. Seepages are a common feature along the steeper slopes where the underlying bedrock is typically near the surface. Most of these seepages are typically groundwater fed. Benchlands or discrete areas of mostly level or nearly level high ground, interrupting the surrounding steeper slopes, typically contain wetland flats which are usually groundwater fed. Channelled valley-bottom wetlands are typically associated with the higher reaches and tributaries of the watercourses whilst some floodplain wetlands are associated with the lower and more gradual reaches of the Vals and Vet Rivers.
- A review of the NFEPA coverage for the study area revealed that no River FEPAs are located within the development footprint or the project site. Furthermore, the NFEPA coverage for the project site shows that now Wetland FEPAs are located within the SEF footprint as well as project site.
- However, according to the NBAs 2018 National Wetlands Map 5 the development footprint area contains a small endorheic depression (pans) features located in the north-western corner of the development footprint.

Assessment of Depression Wetland Feature

- Soil and vegetation sampling in conjunction with the recording of topographical features enabled the delineation of five wetland features namely; three depression wetlands, one seepage wetland and one channelled valley-bottom wetland.
- All of these wetland features were found to be excluded from the development footprint.
- The findings of the baseline wetland assessment suggest the following Present Ecological Status' for the delineated wetland features:
  - All tree depression wetlands: C (Moderately Modified)
  - Seepage wetland: B (Largely Natural)
  - Channelled Valley Bottom Wetland: C (Moderately Modified)
- Following the Ecological Importance and Sensitivity (EIS) assessment, it was found that the depression wetlands as well as the channelled valley-bottom wetland are considered to ecologically important and sensitive (Class B: High EI&S). The seepage wetland was found to be of moderate ecological importance and sensitivity (Class C: Moderate EI&S). However, due to this wetland's association (hydrological connection) with the lower lying channelled valley-bottom wetland which is regarded as a high EIS system, this wetland features have been upgraded to High sensitive and importance.

- According to the DWA Buffer Tool a buffer zone of 30m for these wetland features are recommended.
- These wetland features as well as their associated buffers are regarded as No-Go areas for all activities, and must be maintained in a similar condition.

General Recommendations

- All wetland features along with their associated 30m buffers are regarded as No-Go areas and these wetland features along with their buffers should be maintained in similar natural conditions.An effective storm water management plan should be compiled by a suitable specialist and the effectivity of the plan should be regularly assessed and revised if necessary.
- Vegetation clearing within the development footprint to be kept to a minimum. No unnecessary vegetation to be cleared.
- Vegetation clearing should occur in in a phased manner to minimise erosion and/or run-off.
- Any storm-water within the site must be handled in a suitable manner, i.e. trap sediments, and reduce flow velocities
- Stormwater from hard stand areas, buildings and substation must be managed using appropriate channels and swales when located within steeper areas.
- The runoff should be dissipated over a broad area covered by natural vegetation or managed using appropriate channels and swales.
- Storm water run-off infrastructure must be maintained to mitigate both the flow and water quality impacts of any storm water leaving the Solar PV site.
- No stormwater runoff must be allowed to discharge directly into freshwater resource features along roads, and flows should thus be allowed to dissipate over a broad area covered by natural vegetation.
- During the construction and operational /decommissioning phase, monitor the development footprint and wetland areas to see if erosion issues arise and if any erosion control is required.
  - Any erosion problems observed to be associated with the project infrastructure should be rectified as soon as possible and monitored thereafter to ensure that they do not re-occur.
  - All bare areas, as a result of the development, should be revegetated with locally occurring species, to bind the soil and limit erosion potential.
  - Site rehabilitation should aim to restore surface drainage patterns, natural soil and vegetation as far as is feasible.
  - An erosion control management plan should be utilised to prevent erosion
  - Any storm-water within the site must be handled in a suitable manner
  - All alien plant re-growth must be monitored and should it occur these plants should be eradicated.

- Mitigation and follow up monitoring of residual impacts (alien vegetation growth and erosion) may be required.

» Containers carrying batteries (if present) should be regularly checked for leaks. If leaks are found, these containers should be repaired, replaced immediately with leaked chemicals cleaned up as soon as possible.
» Store hydrocarbons off site where possible, or otherwise implement hydrocarbon storage using impermeable floors with appropriate bunding, sumps and roofing.
» Handle hydrocarbons carefully to limit spillage.
» Ensure vehicles are regularly serviced so that hydrocarbon leaks are limited.
» Designate a single location for refuelling and maintenance, outside of any freshwater resource features.
» Keep a spill kit on site to deal with any hydrocarbon leaks.
» Remove soil from the site which has been contaminated by hydrocarbon spillage.

In addition, all impacts were determined low negative with the implementation of mitigation measures, with no remaining high or moderate significance impacts determined for the project post-mitigation. In addition, all cumulative impacts were determined low in isolation as well as low in the broader project context. With these recommendations and mitigation measures in place, impacts on the surface water resource integrity and functioning can be reduced to a sufficiently low level This would be best achieved by incorporating the recommended management & mitigation measures into an Environmental Management Programme (EMPr) for the site, together with appropriate rehabilitation guidelines and ecological monitoring recommendations.

Based on the outcomes of this study it is my considered opinion that the proposed Vrede Solar Energy Facility project detailed in this report could be authorised from a surface water resource perspective.

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9. APPENDICES

Appendix 1: Survey Methods

The assessment was initiated with a survey of the pertinent literature, past reports and the various conservation plans that exist for the study region. Maps and Geographical Information Systems (GIS) were then employed to ascertain, which portions of the proposed development, could have the greatest impact on the wetlands and associated habitats.

A three day site visit was then conducted to ground-truth the above findings, thus allowing critical comment of the development when assessing the possible impacts and delineating the wetland areas.

» The following equipment were utilized during field work.
  - Canon EOS 450D Camera
  - Garmin Etrex Legend GPS Receiver
  - Bucket Soil Auger
  - Munsell Soil Colour Chart (2000)
  - Braun-Blanquet Data Form (for vegetation recording and general environmental recordings).

Wetland and riparian areas were then assessed on the following basis:

» Identification and delineation of wetlands and riparian areas according to the the procedures specified by DWAF (2005a).
» Vegetation type – verification of type and its state or condition based, supported by species identification using Germishuizen and Meyer (2003), Vegmap (Mucina and Rutherford, 2006 as amended) and the South African Biodiversity Information Facility (SABIF) database.
» Plant species were further categorised as follows:
  - Terrestrial: species are not directly related to any surface or groundwater base-flows and persist solely on rainfall.
  - Facultative: species usually found in wetlands (inclusive of riparian systems) (67 – 99% of occurrences), but occasionally found in terrestrial systems (non-wetland) (DWAF, 2005)
  - Obligate: species that are only found within wetlands (>99% of occurrences) (DWAF, 2005).
» Assessment of the wetland type based on the NWCS method discussed below and the required buffers.
» Mitigation or recommendations required.

Data sources consulted

The following date sources and GIS spatial information provided in the table below was consulted to inform the assessment. The data type, relevance to the project and source of the information has been provided.

Table 11: Information and data coverages used to inform the wetland assessment

Data/Coverage Type	Relevence	Source

Colour Aerial Photography (2009)	Mapping of wetlands and other features	National Geo-Spatial Information
Latest Google Earth™ imagery	To supplement available aerial photography	Google Earth™ On-line
Proposed power line routes and substation locations.	Shows location to the porposed powerline routes and impacted zone	Client
NFEPA wetland Coverage	Shows location fo FEPA river and wetland sites.	CSIR (2011)
National Land-Cover	Shows the land-use and disturbances/transformations within and around the impacted zone.	DEA (2015)
SA National Land-Cover	Shows the expected land caracteristics including land form & shape, geology, soil types and slope gradients.	AGIS (2014)
Quaternary Drainage Regions	Indicates the drainage region and major tributaries and water sources.	DWS (2009)
Present Ecological State of watercourses	Shows the present ecological state of the affected non-perennial watercourses	Kleynhans (1999)

National Wetland Classification System (NWCS 2010)

Since the late 1960's, wetland classification systems have undergone a series of international and national revisions. These revisions allowed for the inclusion of additional wetland types, ecological and conservation rating metrics, together with a need for a system that would allude to the functional requirements of any given wetland (Ewart-Smith et al., 2006). Wetland function is a consequence of biotic and abiotic factors, and wetland classification should strive to capture these aspects.

The South African National Biodiversity Institute (SANBI) in collaboration with a number of specialists and stakeholders developed the newly revised and now accepted National Wetland Classification Systems (NWCS 2010). This system comprises a hierarchical classification process of defining a wetland based on the principles of the Hydrogeomorphic (HGM) approach at higher levels, with including structural features at the finer or lower levels of classification (SANBI 2009).

Wetlands develop in a response to elevated water tables, linked either to rivers, groundwater flows or seepage from aquifers (Parsons, 2004). These water levels or flows then interact with localised geology and soil forms, which then determines the form and function of the respective wetlands. Water is thus the common driving force, in the formation of wetlands (DWAF, 2005). It is significant that the HGM approach has now been included in wetland classification as the HGM approach has been adopted throughout the water resources management realm with regard the determination of the Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS) and WET-Health assessments for aquatic environments. All of these systems are then easily integrated using the HGM approach in line with the Eco-classification process of river and wetland reserve determinations used by the Department of Water Affairs.

The NWCS process is provided in more detail in the methods section of the report, but some of the terms and definitions used in this document are present below:

Definition Box Present

Ecological State is a term for the current ecological condition of the resource. This is assessed relative to the deviation from the Reference State. Reference State/Condition is the natural or pre-impacted condition of the system. The reference state is not a static condition, but refers to the natural dynamics (range and rates of change or flux) prior to development. The PES is determined per component - for rivers and wetlands this would be for the drivers: flow, water quality and geomorphology; and the biotic response indicators: fish, macroinvertebrates, riparian vegetation and diatoms. PES categories for every component would be integrated into an overall PES for the river reach or wetland being investigated. This integrated PES is called the EcoStatus of the reach or wetland.

EcoStatus is the overall PES or current state of the resource. It represents the totality of the features and characteristics of a river and its riparian areas or wetland that bear upon its ability to support an appropriate natural flora and fauna and its capacity to provide a variety of goods and services. The EcoStatus value is an integrated ecological state made up of a combination of various PES findings from component EcoStatus assessments (such as for invertebrates, fish, riparian vegetation, geomorphology, hydrology and water quality).

Reserve: The quantity and quality of water needed to sustain basic human needs and ecosystems (e.g. estuaries, rivers, lakes, groundwater and wetlands) to ensure ecologically sustainable development and utilisation of a water resource. The Ecological Reserve pertains specifically to aquatic ecosystems.

Reserve requirements: The quality, quantity and reliability of water needed to satisfy the requirements of basic human needs and the Ecological Reserve (inclusive of instream requirements).

Ecological Reserve determination study: The study undertaken to determine Ecological Reserve requirements.

Licensing applications: Water users are required (by legislation) to apply for licenses prior to extracting water resources from a water catchment.

Ecological Water Requirements: This is the quality and quantity of water flowing through a natural stream course that is needed to sustain instream functions and ecosystem integrity at an acceptable level as determined during an EWR study. These then form part of the conditions for managing achievable water quantity and quality conditions as stipulated in the Reserve Template. **Water allocation process** (compulsory licensing): This is a process where all existing and new water users are requested to reapply for their licenses, particularly in stressed catchments where there is an over-allocation of water or an inequitable distribution of entitlements. **Ecoregions** are geographic regions that have been delineated in a top-down manner on the basis of physical/abiotic factors. • NOTE: For purposes of the classification system, the 'Level I Ecoregions' for South Africa, Lesotho and Swaziland (Kleynhans et al. 2005), which have been specifically developed by the Department of Water Affairs & Forestry (DWAF) for rivers but are used for the management of inland aquatic ecosystems more generally, are applied at Level 2A of the classification system. These Ecoregions are based on physiography, climate, geology, soils and potential natural vegetation.

Wetland definition

Although the National Wetland Classification System (SANBI, 2009) is used to classify wetland types it is still necessary to understand the definition of a wetland. Wetland definitions as with classification systems have changed over the years. Terminology currently strives to characterise a wetland not only on its structure (visible form), but also to relate this to the function and value of any given wetland.

The Ramsar Convention definition of a wetland is widely accepted as "**areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres**" (Davis 1994). South Africa is a signatory to the Ramsar Convention and therefore its extremely broad definition of wetlands has been adopted for the proposed NWCS, with a few modifications.

Whereas the Ramsar Convention included marine water to a depth of six metres, the definition used for the NWCS extends to a depth of ten metres at low tide, as this is recognised seaward boundary of the shallow photic zone (Lombard et al., 2005). An additional minor adaptation of the definition is the removal of the term 'fen' as fens are considered a type of peatland. The adapted definition for the NWCS is, therefore, as follows (SANBI, 2009):

WETLAND: an area of marsh, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed ten metres.

This definition encompasses all ecosystems characterised by the permanent or periodic presence of water other than marine waters deeper than ten metres. The only legislated definition of wetlands in South Africa, however, is contained within the National Water Act (Act No. 36 of 1998) (NWA), where wetlands are defined as "land which is transitional between terrestrial and aquatic systems, where the water table is usually at, or near the surface, or the land is periodically covered with shallow water and which land in normal circumstances supports, or would support, vegetation adapted to life in saturated soil." This definition is consistent with more precise working definitions of wetlands and therefore includes only a subset of ecosystems encapsulated in the Ramsar definition. It should be noted that the NWA definition is not concerned with marine systems and clearly distinguishes wetlands from estuaries, classifying the later as a watercourse (SANBI, 2009). The DWA is however reconsidering this position with regard the management of estuaries due to the ecological needs of these systems with regard to water allocation. Table 12 provides a comparison of the various wetlands included within the main sources of wetland definition used in South Africa.

Although a subset of Ramsar-defined wetlands was used as a starting point for the compilation of the first version of the National Wetland Inventory (i.e. "wetlands", as defined by the National Water Act, together with open waterbodies), it is understood that subsequent versions of the Inventory include the full suite of Ramsar-defined wetlands in order to ensure that South Africa meets its wetland inventory obligations as a signatory to the Convention (SANBI, 2009).

Wetlands must therefore have one or more of the following attributes to meet the above definition (DWAF, 2005):

» A high-water table that results in the saturation at or near the surface, leading to anaerobic conditions developing in the top 50cm of the soil.
» Wetland or hydromorphic soils that display characteristics resulting from prolonged saturation, i.e. mottling or grey soils
» The presence of, at least occasionally, hydrophilic plants, i.e. hydrophytes (water loving plants).

It should be noted that riparian systems that are not permanently or periodically inundated are not considered true wetlands, i.e. those associated with the drainage lines.

Table 12: Comparison of ecosystems considered to be 'wetlands' as defined by the proposed NWCS, the National Water Act (Act No. 36 of 1998), and ecosystems are included in DWAF's (2005) delineation manual.

Ecosystem	NWCS "wetland"	National Water Act wetland	DWAF (2005) delineation manual
Marine	YES	NO	NO
Estuarine	YES	NO	NO
Waterbodies deeper than 2 m (i.e. limnetic habitats often describe as lakes or dams)	YES	NO	NO
Rivers, channels and canals	YES	NO[3]	NO
Inland aquatic ecosystems that are not river channels and are less than 2 m deep	YES	YES	YES
Riparian[4] areas that are permanently / periodically inundated or saturated with water within 50 cm of the surface	YES	YES	YES3
Riparian areas that are not permanently / periodically inundated or saturated with water within 50 cm of the surface	NO	NO	YES[5]

Wetland importance and function

South Africa is a Contracting Party to the Ramsar Convention on Wetlands, signed in Ramsar, Iran, in 1971, and has thus committed itself to this intergovernmental treaty, which provides the framework for the national protection of wetlands and the resources they could provide. Wetland conservation is now driven by the South African National Biodiversity Institute, a requirement under the National Environmental Management: Biodiversity Act (No 10 of 2004).

Wetlands are among the most valuable and productive ecosystems on earth, providing important opportunities for sustainable development (Davies and Day, 1998). However, wetlands in South Africa are still rapidly being lost or degraded through direct human induced pressures (Nel et al., 2004).

The most common attributes or goods and services provided by wetlands include:

[3] Although river channels and canals would generally not be regarded as wetlands in terms of the National Water Act, they are included as a 'watercourse' in terms of the Act.
[4] According to the National Water Act and Ramsar, riparian areas are those areas that are saturated or flooded for prolonged periods would be considered riparian wetlands, opposed to non –wetland riparian areas that are only periodically inundated and the riparian vegetation persists due to having deep root systems drawing on water many meters below the surface.
[5] The delineation of 'riparian areas' (including both wetland and non-wetland components) is treated separately to the delineation of wetlands in DWAF's (2005) delineation manual.

» Improve water quality;
» Impede flow and reduce the occurrence of floods;
» Reeds and sedges used in construction and traditional crafts;
» Bulbs and tubers, a source of food and natural medicine;
» Store water and maintain base flow of rivers;
» Trap sediments; and
» Reduce the number of water borne diseases.

In the past wetland conservation, has focused on biodiversity as a means of substantiating the protection of wetland habitat. However not all wetlands provide such motivation for their protection, thus wetland managers and conservationists began assessing the importance of wetland function within an ecosystem.

Table 13 summarises the importance of wetland function when related to ecosystem services or ecoservices (Kotze et al., 2008). One such example is emergent reed bed wetlands that function as transformers converting inorganic nutrients into organic compounds (Mitsch and Gosselink, 2000).

Table 13: Summary of direct and indirect ecoservices provided by wetlands from Kotze et al., 2008.

Wetland benefits (goods and services)	**Indirect benefits**	Hydrological benefits	Water purification
			Sustained stream flow
			Flood reduction
			Ground water recharge/discharge
			Erosion control
		Biodiversity conservation – integrity & irreplaceability	
		Chemical cycling	
	Direct benefits	Water supply	
		Provision of harvestable resources	
		Socio-cultural significance	
		Tourism and recreation	
		Education and research	

Relevant wetland legislation and policy

Locally the South African Constitution, seven (7) Acts and two (2) international treaties allow for the protection of wetlands and rivers. These systems are protected from the destruction or pollution by the following:

» Section 24 of The Constitution of the Republic of South Africa;
» Agenda 21 – Action plan for sustainable development of the Department of Environmental Affairs and Tourism (DEAT) 1998;
» The Ramsar Convention, 1971 including the Wetland Conservation Programme (DEAT) and the National Wetland Rehabilitation Initiative (DEAT, 2000);

- National Environmental Management Act (NEMA), 1998 (Act No. 107 of 1998) inclusive of all amendments, as well as the NEM: Biodiversity Act;
- National Water Act, 1998 (Act No. 36 of 1998);
- Conservation of Agricultural Resources Act, 1983 (Act No. 43 of 1983); and
- Minerals and Petroleum Resources Development Act, 2002 (Act No. 28 of 2002).
- Nature and Environmental Conservation Ordinance (No. 19 of 1974)
- National Forest Act (No. 84 of 1998)
- National Heritage Resources Act (No. 25 of 1999)

Apart from NEMA, the Conservation of Agricultural Resources Act (CARA), 1983 (Act No. 43 of 1983) will also apply to this project. The CARA has categorised a large number of invasive plants together with associated obligations of the land owner. A number of Category 1 & 2 plants were found at all of the sites investigated, thus the contractors must take extreme care further spread of these plants doesn't occur. This should be done through proper stockpile management (topsoil) and suitable rehabilitation of disturbed areas after construction.

An amendment of the National Environmental Management was promulgated late December 2011, namely the Biodiversity Act or NEM:BA (Act No 10 of 2004), which lists 225 threatened ecosystems based on vegetation type (Vegmap, 2006 as amended). Should a vegetation type or ecosystem be listed, actions in terms of NEM:BA are triggered.

Other policies that are relevant include:

- Provincial Nature Conservation Ordinance (PNCO) – Protected Flora. Any plants found within the sites are described in the ecological assessment.
- National Freshwater Ecosystems Priority Areas – CSIR 2011 draft. This mapping product highlights potential rivers and wetlands that should be earmarked for conservation on a national basis.

National Wetland Classification System method

During this study, due to the nature of the wetlands and watercourses observed, it was decided that the newly accepted National Wetlands Classification System (NWCS) be adopted. This classification approach has integrated aspects of the HGM approached used in the WET-Health system as well as the widely accepted eco-classification approach used for rivers.

The NWCS (SANBI, 2009) as stated previously, uses hydrological and geomorphological traits to distinguish the primary wetland units, i.e. direct factors that influence wetland function. Other wetland assessment techniques, such as the DWAF (2005) delineation method, only infer wetland function based on abiotic and biotic descriptors (size, soils & vegetation) stemming from the Cowardin approach (SANBI, 2009).

The classification system used in this study is thus based on SANBI (2009) and is summarised below:
The NWCS has a six-tiered hierarchical structure, with four spatially nested primary levels of classification (Figure 15). The hierarchical system firstly distinguishes between Marine, Estuarine and Inland ecosystems (**Level 1**), based on the degree of connectivity the particular systems has with the open ocean (greater than 10 m in depth). **Level 2** then categorises the regional wetland setting using a combination of biophysical attributes at the landscape level, which operate at a broad bioregional scale. This is opposed to specific attributes such as soils and vegetation. **Level 2** has adopted the following systems:

» Inshore bioregions (marine)
» Biogeographic zones (estuaries)
» Ecoregions (Inland)

Level 3 of the NWCS assess the topographical position of inland wetlands as this factor broadly defines certain hydrological characteristics of the inland systems. Four landscape units based on topographical position are used in distinguishing between Inland systems at this level. No subsystems are recognised for Marine systems, but estuaries are grouped according to their periodicity of connection with the marine environment, as this would affect the biotic characteristics of the estuary.

Level 4 classifies the hydrogeomorphic (HGM) units discussed earlier. The HGM units are defined as follows:

(i) Landform – shape and localised setting of wetland
(ii) Hydrological characteristics – nature of water movement into, through and out of the wetland
(iii) Hydrodynamics – the direction and strength of flow through the wetland.

These factors characterise the geomorphological processes within the wetland, such as erosion and depositing, as well as the biogeochemical processes.

Level 5 of the assessment pertains to the classification of the tidal regime within the marine and estuarine environments, while the hydrological and inundation depth classes are determined for the inland wetlands. Classes are based on frequency and depth of inundation, which are used to determine the functional unit of the wetlands and are considered secondary discriminators within the NWCS.

Level 6 uses of six descriptors to characterise the wetland types on the basis of biophysical features. As with Level 5, these are non-hierarchal in relation to each other and are applied in any order, dependent on the availability of information.

The descriptors include:
(i) Geology;

(ii) Natural vs. Artificial;
(iii) Vegetation cover type;
(iv) Substratum;
(v) Salinity; and
(vi) Acidity or Alkalinity.

It should be noted that where sub-categories exist within the above descriptors, hierarchical systems are employed, thus are nested in relation to each other.

The HGM unit (Level 4) is the **focal point of the NWCS**, with the upper levels (Figure 15 – Inland systems only) providing means to classify the broad bio-geographical context for grouping functional wetland units at the HGM level, while the lower levels provide more descriptive detail on the particular wetland type characteristics of a particular HGM unit. Therefore Level 1 – 5 deals with functional aspects, while Level 6 classifies wetlands on structural aspects.

In the past wetland conservation, has focused on biodiversity as a means of substantiating the protection of wetland habitat. However not all wetlands provide such motivation for their protection, thus wetland managers and conservationists began assessing the importance of wetland function within an ecosystem.

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Level 1:
System » Connectivity to open ocean

WETLAND/AQUATIC ECOSYSTEM CONTEXT	
LEVEL 2: REGIONAL SETTING	LEVEL 3: LANDSCAPE UNIT
DWA Level 1 Ecoregions or NFEPA WetVeg Groups or Other spatial frameworks	Valley floor
	Slope
	Plain
	Bench (Hilltop/Saddle/Shelf)

FUNCTIONAL UNIT	
LEVEL 4: HYDROGEOMORPHIC (HGM) UNIT	LEVEL 5: HYDROLOGICAL REGIME
River	Perenniality
Floodplain wetland	Period and depth of inundation and Period of saturation
Channelled valley-bottom wetland	
Unchannelled valley-bottom wetland	
Depression	
Seep	
Wetland flat	

WETLAND/AQUATIC ECOSYSTEM CHARACTERISTICS
LEVEL 6: DESCRIPTORS
Natural vs. Artificial Salinity pH Substratum type Vegetation type Geology

Figure 13: Basic structure of the National Wetland Classification System, showing how 'primary discriminators' are applied up to Level 4 to classify Hydrogeomorphic (HGM) Units, with 'secondary discriminators' applied at Level 5 to classify the hydrological regime, and 'descriptors' applied at Level 6 to categorise the characteristics of wetlands classified up to Level 5 (From SANBI, 2009).

Wetland condition and conservation importance assessment

Wetland functional assessment

» ***WET-Health Assessment (Wetland integrity/Present Ecological State)***

The Wet-Health tool (Macfarlane *et al.* 2008) was used to assess the Present Ecological State (PES) of wetlands by highlighting specific impacts within wetlands and within wetland catchment areas. For the purposes of this study, a Level 1 assessment was undertaken. While this is a rapid assessment, it is regarded as adequate to inform an assessment of existing impacts on wetland condition.

The WET-Health tool provides an appropriate framework for undertaking an assessment to indicate the functional importance of the wetland system that could be impacted by the proposed development. The assessment also helps to identify specific impacts thereby highlighting issues that should be addressed through mitigation and rehabilitation activities. The Level 1 assessment, approach relies on a combination of desktop and on-site indicators to assess various aspects of wetland condition, including:
Hydrology: defined as the distribution and movement of water through a wetland and its soils.
Geomorphology: defined as the distribution and retention patterns of sediment within the wetland.
Vegetation: defined as the vegetation structural and compositional state.

Each of these modules follows a broadly similar approach and is used to evaluate the extent to which anthropogenic changes have impacted upon wetland functioning or condition. While the impacts considered vary considerably across each module, a standardized scoring system is applied to facilitate the interpretation of results (Table 14). Scores range from 0 indicating no impact to a maximum of 10 which would imply that impacts had totally destroyed the functioning of a particular component.

Table 14: Guideline for interpreting the magnitude of impacts on wetland integrity (after Macfarlane *et al*. 2008)

IMPACT CATEGORY	DESCRIPTION	SCORE
None	No discernible modification or the modification is such that it has no impact on this component of wetland integrity.	0 – 0.9
Small	Although identifiable, the impact of this modification on this component of wetland integrity is small.	1 – 1.9
Moderate	The impact of this modification on this component of wetland integrity is clearly identifiable, but limited	2 – 3.9
Large	The modification has a clearly detrimental impact on this component of wetland integrity. Approximately 50% of wetland integrity has been lost.	4 – 5.9
Serious	The modification has a highly detrimental effect on this component of wetland integrity. Much of the wetland integrity has been lost but remaining integrity is still clearly identifiable.	6 – 7.9

Critical	The modification is so great that the ecosystem processes of this component of wetland integrity are almost totally destroyed, and 80% or more of the integrity has been lost.	8 - 10

Impact scores obtained for each of the modules reflect the degree of change from natural reference conditions. Resultant health scores fall into one of six health categories (A-F) on a gradient from "unmodified/natural" (Category A) to "severe/complete" deviation from natural" (Condition F) as depicted in Table 15, below. This classification is consistent with DWAF categories used to evaluate the present ecological state of aquatic ecosystems.

Table 15: Guideline for interpreting the magnitude of impacts on wetland integrity (after Macfarlane *et al*. 2008)

PES CATEGORY	DESCRIPTION	RANGE
A	Unmodified, natural.	0 – 0.9
B	Largely natural with few modifications. A slight change in ecosystem processes is discernible and a small loss of natural habitat and biota may have taken place.	1 – 1.9
C	Moderately modified. A moderate change in ecosystem processes and loss of natural habitats has taken place but the natural habitat remains predominantly intact.	2 – 3.9
D	Largely modified. A large change in ecosystem processes and loss of natural habitat and biota and has occurred.	4 – 5.9
E	The change in ecosystem processes and loss of natural habitat and biota is great but some remaining natural habitat features are still recognizable	6 – 7.9
F	Modifications have reached a critical level and the ecosystem processes have been modified completely with an almost complete loss of natural habitat and biota	8 - 10

An overall wetland health score is calculated by weighting the scores obtained for each module and combining them to give an overall combined score using the following formula:

» **Overall health rating**
 = [(Hydrology*3)+(Geomorphology*2)+(Vegetation*2)]/7

This overall score assists in providing an overall indication of wetland health/functionality which can in turn be used for recommending appropriate management measures.

Appendix 2: Assessment of Impacts

The Environmental Impact Assessment methodology assists in the evaluation of the overall effect of a proposed activity on the environment. This includes an assessment of the significant direct, indirect, and cumulative impacts. The significance of environmental impacts is to be assessed by means of the criteria of extent (scale), duration, magnitude (severity), probability (certainty) and direction (negative, neutral or positive).

» The **nature**, which includes a description of what causes the effect, what will be affected and how it will be affected.

» The **extent**, wherein it is indicated whether the impact will be local (limited to the immediate area or site of development) or regional, and a value between 1 and 5 was assigned as appropriate (with 1 being low and 5 being high).
» The **duration**, wherein it was indicated whether:
  - the lifetime of the impact will be of a very short duration (0 – 1 years) – assigned a score of 1;
  - the lifetime of the impact will be of a short duration (2 – 5 years) – assigned a score of 2;
  - medium-term (5 -15 years) – assigned a score of 3;
  - long term (> 15 years) – assigned a score of 4; or
  - permanent – assigned a score of 5;
» The **magnitude**, quantified on a scale from 0 – 10, where 0 is small and will have no effect on the environment, 2 is minor and will not result in an impact on processes, 4 is low and will cause a slight impact on processes, 6 is moderate and will result in processes continuing but in a modified way, 8 is high (processes are altered to the extent that they temporarily cease), and 10 is very high and results in complete destruction of patterns and permanent cessation of processes.
» The **probability** of occurrence, which describes the likelihood of the impact actually occurring. Probability was estimated on a scale of 1 -5, where 1 is very improbable (probably will not happen), 2 is improbable (some possibility, but low likelihood), 3 is probable (distinct possibility), 4 is highly probable (most likely) and 5 is definite (impact will occur regardless of any prevention measures).
» The **significance**, was determined through a synthesis of the characteristics described above and can be assessed as **LOW**, **MEDIUM** or **HIGH**; and
» the **status**, which was described as either positive, negative or neutral.
» the degree of which the impact can be reversed,
» the degree to which the impact may cause irreplaceable loss of resources,
» the degree to which the impact can be mitigated.

The significance was calculated by combining the criteria in the following formula:

S=(E+D+M)P where;

» S = Significance weighting
» E = Extent
» D = Duration
» M = Magnitude
» P = Probability

The significance weightings for each potential impact are as follows;

» < 30 points: **LOW** (i.e. where the impact would not have a direct influence on the decision to develop in the area),

- 30 – 60 points: **MEDIUM** (i.e. where the impact could influence the decision to develop in the area unless it is effectively mitigated),
- > 60 points: **HIGH** (i.e. where the impact must have an influence on the decision process to develop in the area).

Appendix 3. Specialist CV.

CURRICULUM VITAE:

Gerhard Botha

Name:	:	Gerhardus Alfred Botha
Date of Birth	:	11 April 1986
Identity Number	:	860411 5136 088
Postal Address	:	PO Box 12500 Brandhof 9324
Residential Address	:	3 Jock Meiring Street Park West Bloemfontein 9301
Cell Phone Number	:	084 207 3454
Email Address	:	gabotha11@gmail.com
Profession/Specialisation	:	Ecological and Biodiversity Consultant
Nationality:	:	South African
Years Experience:	:	8
Bilingualism	:	Very good – English and Afrikaans

Professional Profile:

Gerhard is a Managing Director of Nkurenkuru Ecology and Biodiversity (Pty) Ltd. He has a BSc Honours degree in Botany from the University of the Free State Province and is currently completing a MSc Degree in Botany. He began working as an environmental specialist in 2010 and has since gained extensive experience in conducting ecological and biodiversity assessments in various development field, especially in the fields of conventional as well as renewable energy generation, mining and infrastructure development. Gerhard is a registered Professional Natural Scientist (Pr. Sci. Nat.)

Key Responsibilities:

Specific responsibilities as an Ecological and Biodiversity Specialist include, inter alia, professional execution of specialist consulting services (including flora, wetland and fauna studies, where required), impact assessment reporting, walk through surveys/ground-truthing to inform final design, compilation of management plans, compliance monitoring and audit reporting, in-house ecological awareness training to on-site personnel, and the development of project proposals for procuring new work/projects.

Skills Base and Core Competencies

- Research Project Management
- Botanical researcher in projects involving the description of terrestrial and coastal ecosystems.
- Broad expertise in the ecology and conservation of grasslands, savannahs, karroid wetland, and aquatic ecosystems.
- Ecological and Biodiversity assessments for developmental purposes (BAR, EIA), with extensive knowledge and experience in the renewable energy field (Refer to Work Experiences and References)
- Over 3 years of avifaunal monitoring and assessment experience.
- Mapping and Infield delineation of wetlands, riparian zones and aquatic habitats (according to methods stipulated by DWA, 2008) within various South African provinces of KwaZulu-Natal, Mpumalanga, Free State, Gauteng and Northern Cape Province for inventory and management purposes.
- Wetland and aquatic buffer allocations according to industry best practice guidelines.
- Working knowledge of environmental planning policies, regulatory frameworks, and legislation
- Identification and assessment of potential environmental impacts and benefits.
- Assessment of various wetland ecosystems to highlight potential impacts, within current and proposed landscape settings, and recommend appropriate mitigation and offsets based on assessing wetland ecosystem service delivery (functions) and ecological health/integrity.
- Development of practical and achievable mitigation measures and management plans and evaluation of risk to execution
- Qualitative and Quantitative Research
- Experienced in field research and monitoring
- Working knowledge of GIS applications and analysis of satellite imagery data
- Completed projects in several Provinces of South Africa and include a number of projects located in sensitive and ecological unique regions.

Education and Professional Status

Degrees:

- *2015:* Currently completing a M.Sc. degree in Botany (Vegetation Ecology), University of the Free State, Bloemfontein, RSA.
- *2009:* B.Sc. Hons in Botany (Vegetation Ecology), University of the Free State, Bloemfontein, RSA.
- *2008:* B.Sc. in Zoology and Botany, University of the Free State, University of the Free State, Bloemfontein, RSA.

Courses:

- *2013*: Wetland Management (ecology, hydrology, biodiversity, and delineation) – University of the Free State accredited course.
- *2014*: Introduction to GIS and GPS (Code: GISA 1500S) – University of the Free State accredited course.

Professional Society Affiliations:

- The South African Council of Natural Scientific Professions: Pr. Sci. Nat. Reg. No. 400502/14 (Botany and Ecology).

Employment History

- December 2017 – Current: Nkurenkuru Ecology and Biodiversity (Pty) Ltd
- 2016 – November 2017: ECO-CARE Consultancy

- *2015 - 2016*: Ecologist, Savannah Environmental (Pty) Ltd
- *2013 – 2014*: Working as ecologist on a freelance basis, involved in part-time and contractual positions for the following companies
  - Enviroworks (Pty) Ltd
  - GreenMined (Pty) Ltd
  - Eco-Care Consultancy (Pty) Ltd
  - Enviro-Niche Consulting (Pty) Ltd
  - Savannah Environmental (Pty) Ltd
  - Esicongweni Environmental Services (EES) cc
- *2010 - 2012*: Enviroworks (Pty) Ltd

Publications

Publications:

- Botha, G.A. & Du Preez, P.J. 2015. A description of the wetland and riparian vegetation of the Nxamasere palaeo-river's backflooded section, Okavango Delta, Botswana. S. *Afr. J. Bot*., **98**: 172-173.

Congress papers/posters/presentations:

- Botha, G.A. 2015. A description of the wetland and riparian vegetation of the Nxamasere palaeo-river's backflooded section, Okavango Delta, Botswana. 41st Annual Congress of South African Association of Botanists (SAAB). Tshipise, 11-15 Jan. 2015.
- Botha, G.A. 2014. A description of the vegetation of the Nxamasere floodplain, Okavango Delta, Botswana. 10st Annual University of Johannesburg (UJ) Postgraduate Botany Symposium. Johannesburg, 28 Oct. 2014.

Other

- Guest speaker at IAIAsa Free State Branch Event (29 March 2017)
- Guest speaker at the University of the Free State Province: Department of Plant Sciences (3 March 2017):

References:

- Christine Fouché
  Manager: GreenMined (Pty) LTD
  Cell: 084 663 2399
- Professor J du Preez
  Senior lecturer: Department of Plant Sciences
  University of the Free State
  Cell: 082 376 4404

Appendix 4. Specialist's Work Experience and References

Nkurenkuru
ECOLOGY & BIODIVERSITY

WORK EXPERIENCES

&

References

Gerhard Botha

ECOLOGICAL RELATED STUDIES AND SURVEYS

Date Completed	Project Description	Type of Assessment/Study	Client
2019	Sirius Three Solar PV Facility near Upington, Northern Cape	Ecological Assessment (Basic Assessment)	Aurora Power Solutions
2019	Sirius Four Solar PV Facility near Upington, Northern Cape	Ecological Assessment (Basic Assessment)	Aurora Power Solutions
2019	Lichtenburg 1 100MW Solar PV Facility, Lichtenburg, North-West Province	Ecological Assessment (Scoping and EIA Phase Assessments)	Atlantic Renewable Energy Partners
2019	Lichtenburg 2 100MW Solar PV Facility, Lichtenburg, North-West Province	Ecological Assessment (Scoping and EIA Phase Assessments)	Atlantic Renewable Energy Partners
2019	Lichtenburg 3 100MW Solar PV Facility, Lichtenburg, North-West Province	Ecological Assessment (Scoping and EIA Phase Assessments)	Atlantic Renewable Energy Partners
2019	Moeding Solar PV Facility near Vryburg, North-West Province	Ecological Assessment (Basic Assessment)	Moeding Solar
2019	Expansion of the Raumix Aliwal North Quarry, Eastern Cape Province	Fauna and Flora Pre-Construction Walk-Through Assessment	GreenMined
2018	Kruisvallei Hydroelectric 22kV Overhead Power Line, Clarens, Free State Province	Faunal and Flora Rescue and Protection Plan	Zevobuzz
2018	Kruisvallei Hydroelectric 22kV Overhead Power Line, Clarens, Free State Province	Fauna and Flora Pre-Construction Walk-Through Assessment	Zevobuzz
2018	Proposed Kruisvallei Hydroelectric Power Generation Scheme in the Ash River, Free State Province	Ecological Assessment (Basic Assessment)	Zevobuzz
2018	Proposed Zonnebloem Switching Station (132/22kV) and 2X Loop-in Loop-out Power Lines (132kV), Mpumalanga Province	Ecological Assessment (Basic Assessment)	Eskom
2018	Clayville Thermal Plant within the Clayville Industrial Area, Gauteng Province	Ecological Comments Letter	Savannah Environmental
2018	Iziduli Emoyeni Wind Farm near Bedford, Eastern Cape Province	Ecological Assessment (Re-assessment)	Emoyeni Wid Farm Renewable Energy
2018	Msenge Wind Farm near Bedford, Eastern Cape Province	Ecological Assessment (Re-assessment)	Amakhala Emoyeni Renewable Energy

2017	H2 Energy Power Station near Kwamhlanga, Mpumalanga Province	Ecological Assessment (Scoping and EIA phase assessments)	Eskom
2017	Karusa Wind Farm (Phase 1 of the Hidden Valley Wind Energy Facility near Sutherland, Northern Cape Province)	Ecological Assessment (Re-assessment)	ACED Renewables Hidden Valley
2017	Soetwater Wind Farm (Phase 2 of the Hidden Valley Wind Energy Facility near Sutherland, Northern Cape Province)	Ecological Assessment (Re-assessment)	ACED Renewables Hidden Valley
2017	S24G for the unlawful commencement or continuation of activities within a watercourse, Honeydew, Gauteng Province	Ecological Assessment	Savannah Environmental
2016 - 2017	Noupoort CSP Facility near Noupoort, Northern Cape Province	Ecological Assessment (Scoping and EIA phase assessments)	Cresco
2016	Buffels Solar 2 PV Facility near Orkney, North West Province	Ecological Assessment (Scoping and EIA phase assessments)	Kabi Solar
2016	Buffels Solar 1 PV Facility near Orkney, North West Province	Ecological Assessment (Scoping and EIA phase assessments)	Kabi Solar
2016	132kV Power Line and On-Site Substation for the Authorised Golden Valley II Wind Energy Facility near Bedford, Eastern Cape Province	Ecological Assessment (Basic Assessment)	Terra Wind Energy
2016	Kalahari CSP Facility: 132kV Ferrum–Kalahari–UNTU & 132kV Kathu IPP–Kathu 1 Overhead Power Lines, Kathu, Northern Cape Province	Fauna and Flora Pre-Construction Walk-Through Assessment	Kathu Solar Park
2016	Kalahari CSP Facility: Access Roads, Kathu, Northern Cape Province	Fauna and Flora Pre-Construction Walk-Through Assessment	Kathu Solar Park
2016	Karoshoek Solar Valley Development – Additional CSP Facility including tower infrastructure associated with authorised CSP Site 2 near Upington, Northern Cape Province	Ecological Assessment (Scoping Assessment)	Emvelo
2016	Karoshoek Solar Valley Development –Ilanga CSP 7 and 8 Facilities near Upington, Northern Cape Province	Ecological Assessment (Scoping Assessment)	Emvelo
2016	Karoshoek Solar Valley Development –Ilanga CSP 9 Facility near Upington, Northern Cape Province	Ecological Assessment (Scoping Assessment)	Emvelo
2016	Lehae Training Academy and Fire Station, Gauteng Province	Ecological Assessment	Savannah Environmental
2016	Metal Industrial Cluster and Associated Infrastructure near Kuruman, Northern Cape Province	Ecological Assessment (Scoping Assessment)	Northern Cape Department of Economic Development and Tourism
2016	Semonkong Wind Energy Facility near Semonkong, Maseru District, Lesotho	Ecological Pre-Feasibility Study	Savannah Environmental
2015 - 2016	Orkney Solar PV Facility near Orkney, North West Province	Ecological Assessment (Scoping and EIA phase assessments)	Genesis Eco-Energy
2015 - 2016	Woodhouse 1 and Woodhouse 2 PV Facilities near Vryburg, North West Province	Ecological Assessment (Scoping and EIA phase assessments)	Genesis Eco-Energy
2015	CAMCO Clean Energy 100kW PV Solar Facility, Thaba Eco Lodge near Johannesburg, Gauteng Province	Ecological Assessment (Basic Assessment)	CAMCO Clean Energy
2015	CAMCO Clean Energy 100kW PV Solar Facility, Thaba Eco Lodge near Johannesburg, Gauteng Province	Ecological Assessment (Basic Assessment)	CAMCO Clean Energy

2015	Sirius 1 Solar PV Project near Upington, Northern Cape Province	Fauna and Flora Pre-Construction Walk-Through Assessment	Aurora Power Solutions
2015	Sirius 2 Solar PV Project near Upington, Northern Cape Province	Fauna and Flora Pre-Construction Walk-Through Assessment	Aurora Power Solutions
2015	Sirius 1 Solar PV Project near Upington, Northern Cape Province	Invasive Plant Management Plan	Aurora Power Solutions
2015	Sirius 2 Solar PV Project near Upington, Northern Cape Province	Invasive Plant Management Plan	Aurora Power Solutions
2015	Sirius 1 Solar PV Project near Upington, Northern Cape Province	Plant Rehabilitation Management Plan	Aurora Power Solutions
2015	Sirius Phase 2 Solar PV Project near Upington, Northern Cape Province	Plant Rehabilitation Management Plan	Aurora Power Solutions
2015	Sirius 1 Solar PV Project near Upington, Northern Cape Province	Plant Rescue and Protection Plan	Aurora Power Solutions
2015	Sirius Phase 2 Solar PV Project near Upington, Northern Cape Province	Plant Rescue and Protection Plan	Aurora Power Solutions
2015	Expansion of the existing Komsberg Main Transmission Substation near Sutherland, Northern Cape Province	Ecological Assessment (Basic Assessment)	ESKOM
2015	Karusa Wind Farm near Sutherland, Northern Cape Province)	Invasive Plant Management Plan	ACED Renewables Hidden Valley
2015	Proposed Karusa Facility Substation and Ancillaries near Sutherland, Northern Cape Province	Ecological Assessment (Basic Assessment)	ACED Renewables Hidden Valley
2015	Eskom Karusa Switching Station and 132kV Double Circuit Overhead Power Line near Sutherland, Northern Cape Province	Ecological Assessment (Basic Assessment)	ESKOM
2015	Karusa Wind Farm near Sutherland, Northern Cape Province)	Plant Search and Rescue and Rehabilitation Management Plan	ACED Renewables Hidden Valley
2015	Karusa Wind Energy Facility near Sutherland, Northern Cape Province	Fauna and Flora Pre-Construction Walk-Through Assessment	ACED Renewables Hidden Valley
2015	Soetwater Facility Substation, 132kV Overhead Power Line and Ancillaries, near Sutherland, Northern Cape Province	Ecological Assessment (Basic Assessment)	ACED Renewables Hidden Valley
2015	Soetwater Wind Farm near Sutherland, Northern Cape Province)	Invasive Plant Management Plan	ACED Renewables Hidden Valley
2015	Soetwater Wind Energy Facility near Sutherland, Northern Cape Province	Fauna and Flora Pre-Construction Walk-Through Assessment	ACED Renewables Hidden Valley
2015	Soetwater Wind Farm near Sutherland, Northern Cape Province	Plant Search and Rescue and Rehabilitation Management Plan	ACED Renewables Hidden Valley
2015	Expansion of the existing Scottburgh quarry near Amandawe, KwaZulu-Natal	Botanical Assessment (for EIA)	GreenMined Environmental
2015	Expansion of the existing AFRIMAT quarry near Hluhluwe, KwaZulu-Natal	Botanical Assessment (for EIA)	GreenMined Environmental
2014	Tshepong 5MW PV facility within Harmony Gold's mining rights areas, Odendaalsrus	Ecological Assessment (Basic Assessment)	BBEnergy
2014	Nyala 5MW PV facility within Harmony Gold's mining rights areas, Odendaalsrus	Ecological Assessment (Basic Assessment)	BBEnergy
2014	Eland 5MW PV facility within Harmony Gold's mining rights areas, Odendaalsrus	Ecological Assessment (Basic Assessment)	BBEnergy
2014	Transalloys circulating fluidised bed power station near Emalahleni, Mpumalanga Province	Ecological Assessment (for EIA)	Trans-Alloys
2014	Umbani circulating fluidised bed power station near Kriel, Mpumalanga Province	Ecological Assessment (Scoping and EIA)	Eskom
2014	Gihon 75MW Solar Farm: Bela-Bela, Limpopo Province	Ecological Assessment (for EIA)	NETWORX Renewables

2014	Steelpoort Integration Project & Steelpoort to Wolwekraal 400kV Power Line	Fauna and Flora Pre-Construction Walk-Through Assessment	Eskom
2014	Audit of protected *Acacia erioloba* trees within the Assmang Wrenchville housing development footprint area	Botanical Audit	Eco-Care Consultancy
2014	Rehabilitation of the N1 National Road between Sydenham and Glen Lyon	Peer review of the ecological report	EKO Environmental
2014	Rehabilitation of the N6 National Road between Onze Rust and Bloemfontein	Peer review of the ecological report	EKO Environmental
2011	Illegally ploughed land on the Farm Wolwekop 2353, Bloemfontein	Vegetation Rehabilitation Plan	EnviroWorks
2011	Rocks Farm chicken broiler houses	Botanical Assessment (for EIA)	EnviroWorks
2011	Botshabelo 132 kV line	Ecological Assessment (for EIA)	CENTLEC
2011	De Aar Freight Transport Hub	Ecological Scoping and Feasibility Study	EnviroWorks
2011	The proposed establishment of the Tugela Ridge Eco Estate on the farm Kruisfontein, Bergville	Ecological Assessment (for EIA)	EnviroWorks
2010 - 2011	National long-haul optic fibre infrastructure network project, Bloemfontein to Beaufort West	Vegetation Rehabilitation Plan for illegally cleared areas	NEOTEL
2010 - 2011	National long-haul optic fibre infrastructure network project, Bloemfontein to Beaufort West	Invasive Plant Management Plan	NEOTEL
2010 - 2011	National long-haul optic fibre infrastructure network project, Bloemfontein to Beaufort West	Protected and Endangered Species Walk-Through Survey	NEOTEL
2011	Optic Fibre Infrastructure Network, Swartland Municipality	Botanical Assessment (for EIA) - Assisted Dr. Dave McDonald	Dark Fibre Africa
2011	Optic Fibre Infrastructure Network, City of Cape Town Municipality	Botanical Assessment (for EIA) - Assisted Dr. Dave McDonald	Dark Fibre Africa
2010	Construction of an icon at the southernmost tip of Africa, Agulhas National Park	Botanical Assessment (for EIA)	SANPARKS
2010	New boardwalk from Suiderstrand Gravel Road to Rasperpunt, Agulhas National Park	Botanical Assessment (for EIA)	SANPARKS
2010	Farm development for academic purposes (Maluti FET College) on the Farm Rosedale 107, Harrismith	Ecological Assessment (Screening and Feasibility Study)	Agri Development Solutions
2010	Basic Assessment: Barcelona 88/11kV substation and 88kV loop-in lines	Botanical Assessment (for EIA)	Eskom Distribution
2011	Illegally ploughed land on the Farm Wolwekop 2353, Bloemfontein	Vegetation Rehabilitation Plan	EnviroWorks

WETLAND DELINEATION AND HYDROLOGICAL ASSESSMENTS

Date Completed	Project Description	Type of Assessment/Study	Client
In progress	Steynsrus PV 1 & 2 Solar Energy Facilities near Steynsrus, Free State Province	Wetland Assessment	Cronimet Mining Power Solutions
2019	Lichtenburg 1 100MW Solar PV Facility, Lichtenburg, North-West Province	Surface Hydrological Assessment (Scoping and EIA Phase)	Atlantic Renewable Energy Partners
2019	Lichtenburg 2 100MW Solar PV Facility, Lichtenburg, North-West Province	Surface Hydrological Assessment (Scoping and EIA Phase)	Atlantic Renewable Energy Partners
2019	Lichtenburg 3 100MW Solar PV Facility, Lichtenburg, North-West Province	Surface Hydrological Assessment (Scoping and EIA Phase)	Atlantic Renewable Energy Partners
2019	Moeding Solar PV Facility near Vryburg, North-West Province	Wetland Assessment (Basic Assessment)	Moeding Solar
2018	Kruisvallei Hydroelectric 22kV Overhead Power Line, Clarens, Free State Province	Wetland Assessment (Basic Assessment	Zevobuzz
2017	Nyala 5MW PV facility within Harmony Gold's mining rights areas, Odendaalsrus	Wetland Assessment	BBEnergy

2017	Eland 5MW PV facility within Harmony Gold's mining rights areas, Odendaalsrus	Wetland Assessment	BBEnergy
2017	Olifantshoek 10MVA 132/11kV Substation and 31km Power Line	Surface Hydrological Assessment (Basic Assessment)	Eskom
2017	Expansion of the Elandspruit Quarry near Ladysmith, KwaZulu-Natal Province	Wetland Assessment	Raumix
2017	S24G for the unlawful commencement or continuation of activities within a watercourse, Honeydew, Gauteng Province	Aquatic Assessment & Flood Plain Delineation	Savannah Environmental
2017	Noupoort CSP Facility near Noupoort, Northern Cape Province	Surface Hydrological Assessment (EIA phase)	Cresco
2016	Wolmaransstad Municipality 75MW PV Solar Energy Facility in the North West Province	Wetland Assessment (Basic Assessment)	BlueWave Capital
2016	BlueWave 75MW PV Plant near Welkom Free State Province	Wetland Delineation	BlueWave Capital
2016	Harmony Solar Energy Facilities: Amendment of Pipeline and Overhead Power Line Route	Wetland Assessment (Basic Assessment)	BBEnergy

AVIFAUNAL ASSESSMENTS

Date Completed	Project Description	Type of Assessment/Study	Client
2019	Sirius Three Solar PV Facility near Upington, Northern Cape	Avifauna Assessment (Basic Assessment)	Aurora Power Solutions
2019	Sirius Four Solar PV Facility near Upington, Northern Cape	Avifauna Assessment (Basic Assessment)	Aurora Power Solutions
2019	Moeding Solar PV Facility near Vryburg, North-West Province	Avifauna Assessment (Basic Assessment)	Moeding Solar
2018	Proposed Zonnebloem Switching Station (132/22kV) and 2X Loop-in Loop-out Power Lines (132kV), Mpumalanga Province	Avifauna Assessment (Basic Assessment)	Eskom
2017	Olifantshoek 10MVA 132/11kV Substation and 31km Power Line	Avifauna Assessment (Basic Assessment)	Eskom
2016	TEWA Solar 1 Facility, east of Upington, Northern Cape Province	Wetland Assessment (Basic Assessment	Tewa Isitha Solar 1
2016	TEWA Solar 2 Facility, east of Upington, Northern Cape Province	Wetland Assessment	Tewa Isitha Solar 2

ENVIRONMENTAL IMPACT ASSESSMENT

- Barcelona 88/11kV substation and 88kV loop-in lines – BA (for Eskom).
- Thabong Bulk 132kV sub-transmission inter-connector line – EIA (for Eskom).
- Groenwater 45 000 unit chicken broiler farm – BA (for Areemeng Mmogo Cooperative).
- Optic Fibre Infrastructure Network, City of Cape Town Municipality – BA (for Dark Fibre Africa (Pty) Ltd).
- Optic Fibre Infrastructure Network, Swartland Municipality – BA (for Dark Fibre Africa).
- Construction and refurbishment of the existing 66kV network between Ruigtevallei Substation and Reddersburg Substation – EMP (for Eskom).
- Lower Kruisvallei Hydroelectric Power Scheme (Ash river) – EIA (for Kruisvallei Hydro (Pty) Ltd).
- Construction of egg hatchery and associated infrastructure – BA (For Supreme Poultry).

- Construction of the Klipplaatdrif flow gauging (Vaal river) – EMP (DWAF).

ENVIRONMENTAL COMPLIANCE AUDITING AND ECO

- National long haul optic fibre infrastructure network project, Bloemfontein to Laingsburg – ECO (for Enviroworks (Pty) Ltd.).
- National long haul optic fibre infrastructure network project, Wolmaransstad to Klerksdorp – ECO (for Enviroworks (Pty) Ltd.).
- Construction and refurbishment of the existing 66kV network between Ruigtevallei Substation and Reddersburg Substation – ECO (for Enviroworks (Pty) Ltd.).
- Construction and refurbishment of the Vredefort/Nooitgedacht 11kV power line – ECO (for Enviroworks (Pty) Ltd.).
- Mining of Dolerite (Stone Aggregate) by Raumix (Pty) Ltd. on a portion of Portion 0 of the farm Hillside 2830, Bloemfontein – ECO (for GreenMined Environmental (Pty) Ltd.).
- Construction of an Egg Production Facility by Bainsvlei Poultry (Pty) Ltd on Portions 9 & 10 of the farm, Mooivlakte, Bloemfontein – ECO (for Enviro-Niche Consulting (Pty) Ltd.).
- Environmental compliance audit and botanical account of Afrisam's premises in Bloemfontein – Environmental Compliance Auditing (for Enviroworks (Pty) Ltd.).

OTHER PROJECTS:

- Keeping and breeding of lions (*Panthera leo*) on the farm Maxico 135, Ficksburg – Management and Business Plan (for Enviroworks (Pty) Ltd.)
- Keeping and breeding of lions (*Panthera leo*) on the farm Mooihoek 292, Theunissen – Management and Business Plan (for Enviroworks (Pty) Ltd.)
- Keeping and breeding of wild dogs (*Lycaon pictus*) on the farm Mooihoek 292, Theunissen – Management and Business Plan (for Enviroworks (Pty) Ltd.)
- Existing underground and aboveground fuel storage tanks, TWK AGRI: Pongola – Environmental Management Plan (for TWK Agricultural Ltd).
- Existing underground fuel storage tanks on Erf 171, TWK AGRI: Amsterdam – Environmental Management Plan (for TWK Agricultural Ltd).
- Proposed storage of 14 000 L of fuel (diesel) aboveground on Erf 32, TWK AGRI: Carolina – Environmental Management Plan (for TWK Agricultural Ltd).
- Proposed storage of 23 000 L of fuel (diesel) above ground on Portion 10 of the Farm Oude Bosch, Humansdorp – Environmental Management Plan (for TWK Agricultural Ltd).
- Proposed storage of 16 000 L of fuel (diesel) aboveground at Panbult Depot – Environmental Management Plan (for TWK Agricultural Ltd).
- Existing underground fuel storage tanks, TWK AGRI: Mechanisation and Engineering, Piet Retief – Environmental Management Plan (for TWK Agricultural Ltd).
- Existing underground fuel storage tanks on Portion 38 of the Farm Lothair, TWK AGRI: Lothair – Environmental Management Plan (for TWK Agricultural Ltd).

Appendix 5. SACNASP CERTIFICATE.

SACNASP
South African Council for Natural Scientific Professions

herewith certifies that

Gerhardus Alfred Botha

Registration number: 400502/14

is registered as a

Professional Natural Scientist

in terms of section 20(3) of the Natural Scientific Professions Act, 2003
(Act 27 of 2003)
in the following field(s) of practice (Schedule I of the Act)

Ecological Science	**28 January 2015**
Botanical Science	**19 November 2014**

28 January 2015		
Pretoria	President	Executive Director

Nkurenkuru
ECOLOGY & BIODIVERSITY