AQUATIC BIODIVERSITY ASSESSMENT, WETLAND DELINEATION AND ASSESSMENT FOR THE PROPOSED PROPOSED STEYNSRUS 10 MW PV SOLAR FACILITY, FREE STATE.

February 2023

Conducted for:

CRCerenwables Pty Ltd

Compiled by:

MORA Ecological Services
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DOCUMENT CONTROL

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- Arcus Consulting: May - November 2017, Avifaunal Specialist
- Centre for African Conservation Ecology (ACE), Nelson Mandela University: 2015 – 2016, Environmental Educator.
- South African National Biodiversity Institute (SANBI): May – December 2014, Zoological Systematics Technician.
- Department of Zoology, University of Venda: 2009 – 2013, Research Assistant
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DECLARATION BY THE SPECIALIST

I, Mokgatla Jerry Molepo , declare that:

• I act as the independent specialist in this application;

• I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;

• I declare that there are no circumstances that may compromise my objectivity in performing such work;

• I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, Regulations and any guidelines that have relevance to the proposed activity;

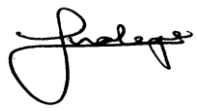
• I will comply with the Act, Regulations and all other applicable legislation;

• I have no, and will not engage in, conflicting interests in the undertaking of the activity;

• I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;

• all the particulars furnished by me in this form are true and correct; and

• I realise that a false declaration is an offence in terms of regulation 48 and is punishable in terms of section 24F of the Act.



Signature of the Specialist

MORA Ecological Services (Pty) Ltd

Name of Company

24/02/2023

Date

Key experience in specialist projects

Year	Project	Location:	Role(s)
2022	Avifaunal Impact Assessment for the proposed 132kV for Musina-Makhado Special Economic Zone North Site	Musina, Limpopo	Avifaunal Specialist/Ornithologist
2022	Avifaunal Impact Assessment for the proposed Khauta PV Solar including 44kV and 132kV Powerline	Welkom, Free State	Avifaunal Specialist/Ornithologist
2022	Avifaunal Impact Assessment for the proposed NAOS PV Solar including 132kV Powerline	Free State	Avifaunal Specialist/Ornithologist
2022	Preconstruction Avifaunal Assessment for the proposed Lichtenburg PV Solar including 132kV Powerline	Lichtenburg, North West	Avifaunal Specialist/Ornithologist
2022	Preconstruction Botanical Assessment for the proposed Lichtenburg PV Solar including 132kV Powerline	Lichtenburg, North West	Ecologist
2022	Biodiversity Assessment, Land Capability and Veld Condition Assessment for PPC Cement SA Slurry	Slurry, North West	Ecologist
2021	Avifaunal Impact Assessment for the proposed Upington-Aries 2x 400kV	Upington, Northern Cape	Avifaunal Specialist/Ornithologist
2021	Habitat Assessment Post Rehabilitation for PPC Cement SA Dwaalboom Factory	Dwaalboom, Limpopo	Ecologist
2021	Habitat Assessment Post Rehabilitation for Gibson Bay Wind Energy Farm	Humansdorp, Eastern Cape	Ecologist
2021	Wetland Rehabilitation for the sewer pipeline construction in Daveyton	Ekurhuleni East College Campus, Daveyton, Gauteng	Wetland Ecologist
2021	12 Months Wetland Rehabilitation Supervision for Ekangala Ext F Waterborne Sanitation Project	City of Tshwane Metropolitan Municipality, Ekangala, Gauteng	Aquatic Ecologist

List of abbreviations	
BAR	Basic Assessment Report
CBA	Critical Biodiversity Areas
DFFE	Department of Forestry, Fisheries and the Environment
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
ECO	Environmental Control Officer
ESO	Environmental Site Officer
EIA	Ecological Impact Assessment
EIS	Ecological Sensitivity and Importance
EMPr	Environmental Management Programme
ENPAT	Environmental Potential Atlas
ESA	Ecological Support Areas
GA	General Authorisation
HGM type	Hydrogeomorphic type
MAP	Mean Annual Precipitation
NEMA	National Environmental Management Act
NEMBA	National Environmental Management: Biodiversity Act
NFEPA	National Freshwater Ecosystem Priority Areas
NWA	National Water Act
NWM5	National Wetland Map version 5
MW	Megawatt
PA	Protected Areas
PES	Present Ecological State
PESC	Present Ecological Status Class
PV	Photovoltaic
SAAB	South African Association of Botanists
SACNASP	South African Council for Natural Scientific Professions
SANBI	South African National Biodiversity Institute
UVB	Unchannelled Valley Bottom
WUL	Water Use License

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1 BACKGROUND

1.1 Assignment

Contrarians Capital Holdings, hereafter referred to as the “applicant”, is proposing the development of a new Steynsrus 10MW Photovoltaic (PV) Solar Facility, within Moqhaka Local Municipality, in the Free State Province. The proposed PV Site is located on farm Arbeid 2154 and Weltevrede 2151. The associated infrastructure will include but not limited to the following: on-site substation and buildings, access roads, overhead power line, and associated structures. The power generated by the proposed Project will feed into the existing Eskom 132 kV distribution system.
MORA Ecological Services (Pty) Ltd was requested by CR Renewables as the appointed Environmental Assessment Practitioners, hereafter referred to as the “EAP” to conduct a terrestrial biodiversity and avifaunal impact assessment towards their pursuit of obtaining electricity generation rights by means of transforming land. Specialist studies are essential for obtaining the requisite environmental authorisations for the proposed project.

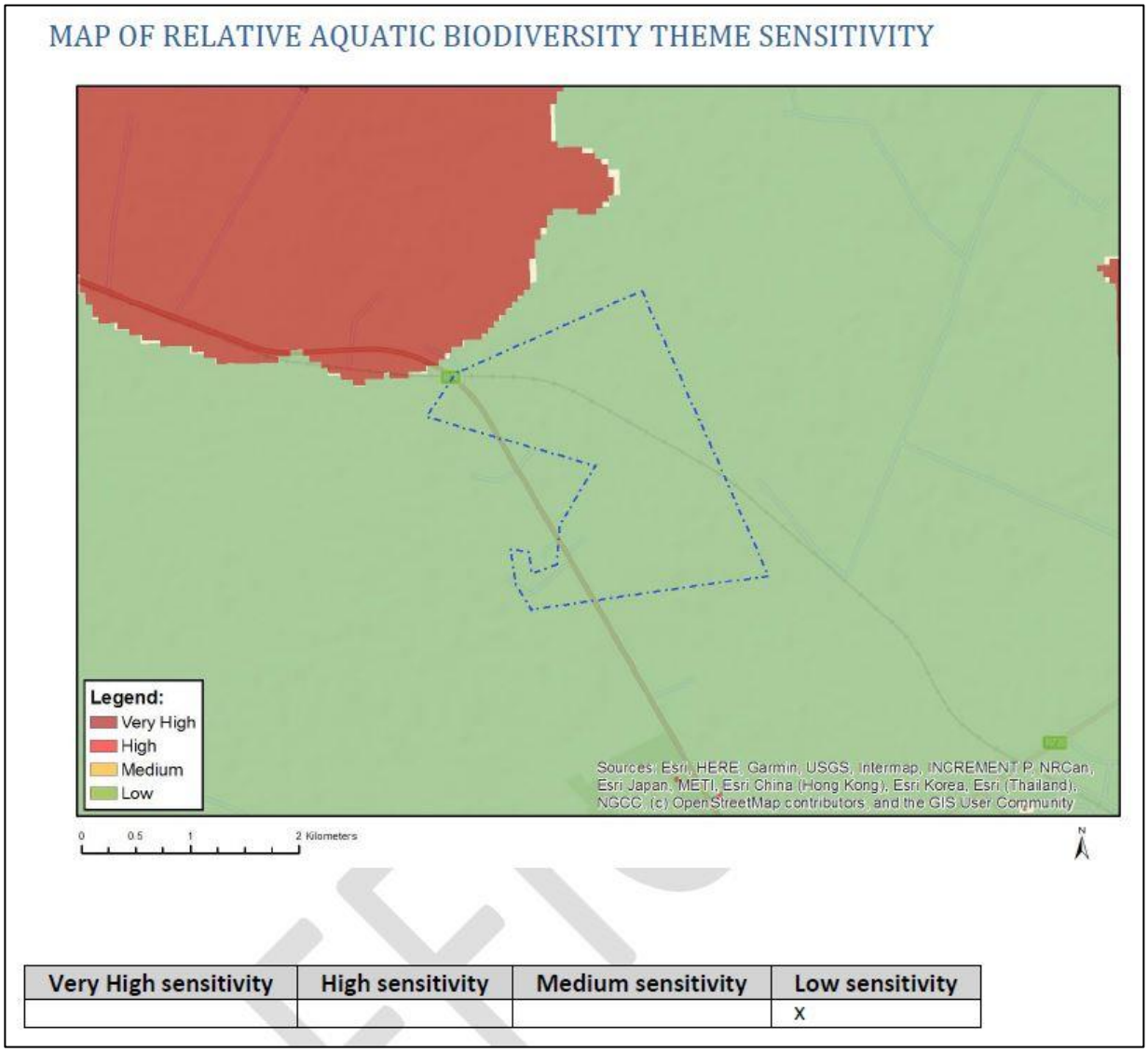
This report includes a detailed impact assessment of the proposed development on the watercourses or wetlands of the site. One of the main purposes was to compile a specialist report on the abovementioned aspects that will form part of the Water Use License (WUL) application, especially where the development will impede on wetlands, watercourses or other hydrological features. This assessment is essential as it will contribute to meeting the requirements of the National Environmental Management Act (NEMA), 1998 (Act No. 107 of 1998) in conjunction with Regulation 982 of December 2014, promulgated in terms of Section 24 (5) of NEMA and Chapter 4 of the National Water Act, Act 36 of 1998. The assignment is interpreted as follows:

Compile a study on the wetlands of the site as per the guidelines and criteria set by the Department of Water and Sanitation. The study includes a wetland / riparian delineation and functionality assessment (Present Ecological State Ecological Importance and Sensitivity and Wet-EcoServices), with descriptions of the anticipated impacts (risks) associated with the proposed development activities and mitigation to reduce impacts.

1.2 EIA Screening Tool

According to the national web-based environmental screening tool in terms of the National Environmental Management Act (NEMA), 1998 (Act No. 107 of 1998), the site has the following sensitivities:

- Aquatic Biodiversity: Low Sensitivity for the project area (solar PV park) (Figure 1).



Very High sensitivity	High sensitivity	Medium sensitivity	Low sensitivity
			X

Figure 1: Aquatic biodiversity theme sensitivity according to the Screening Tool.

A site assessment was therefore conducted to determine if the assessment was accurate and if the studies recommended must be conducted. After the site visit the following was concluded:

- The site has a Low-Medium sensitivity from an Aquatic biodiversity perspective.

1.3 Information sources

The following information sources were obtained for the study:

1) All relevant topographical maps, aerial photographs and information (previous studies and environmental databases) related to wetlands and watercourses in the study area;
2) Requirements regarding the wetland survey as stipulated in the following guidelines:
3) Practical field procedure for identification and delineation of wetlands and riparian areas (DWAF, 2005);
4) National Wetland Classification System for South Africa (SANBI, 2009);
5) WET-Health (Version 2.0): A refined suite of tools for assessing the present ecological state of wetland ecosystems (Macfarlane *et al*., 2020).
6) Ecological Importance & Sensitivity assessment (DWAF, 1999)
7) A technique for rapidly assessing ecosystem services supplied by wetlands and riparian areas (Kotze *et al*., 2020)
8) Guidelines regarding development in and around wetlands as stipulated by the Department of Water Affairs (DWA) and the Free State Department: Economic, Small Business Development, Tourism and Environmental Affairs;

1.4 REGULATIONS GOVERNING THIS REPORT

1.4.1 National Environmental Management Act, 1998 (Act No. 107 of 1998)

This report was prepared in terms of the National Environmental Management Act, 1998 (Act No. 107 of 1998) - Protocol for the specialist assessment and minimum report content requirements for environmental impacts on aquatic biodiversity, gazetted 20 March 2020 (Government Notice number 320).

The compliance statement (for a site with a low sensitivity in terms of the aquatic biodiversity) must contain, as a minimum, the following information:

1) contact details of the specialist, their SACNASP registration number, their field of expertise and a curriculum vitae;
2) a signed statement of independence by the specialist;
3) a statement on the duration, date and season of the site inspection and the relevance of the season to the outcome of the assessment;
4) a baseline profile description of biodiversity and ecosystems of the site;
5) the methodology used to verify the sensitivities of the aquatic biodiversity

features on the site including the equipment and modelling used where relevant;

6) in the case of a linear activity, confirmation from the aquatic biodiversity specialist that, in their opinion, based on the mitigation and remedial measures proposed, the land can be returned to the current state within two years of completion of the construction phase;
7) where required, proposed impact management outcomes or any monitoring requirements for inclusion in the EMPr;
8) a description of the assumptions made as well as any uncertainties or gaps in knowledge or data; and
9) any conditions to which this statement is subjected.

1.4.2 The National Water Act (Act No. 36 of 1998)

Chapter 4 of the National Water Act, Act 36 of 1998 specifies that:

> *"In general a water use must be licensed unless it is listed in Schedule I, is an existing lawful use, is permissible under a general authorisation, or if a responsible authority waives the need for a licence. The Minister may limit the amount of water which a responsible authority may allocate. In making regulations the Minister may differentiate between different water resources, classes of water resources and geographical areas."*

In section 21 of the NWA water uses are listed as:

1) Taking water from a water resource;
2) Storing water;
3) Impeding or diverting the flow of water in a watercourse;
4) Engaging in a stream flow reduction activity contemplated in section 36;
5) Engaging in a controlled activity identified as such in section 37(1) or declared under section 38(1);
6) Discharging waste or water containing waste into a water resource through a pipe, canal, sewer, sea outfall or other conduit;
7) Disposing of waste in a manner which may detrimentally impact on a water resource;
8) Disposing in any manner of water which contains waste from, or which has been heated in, any industrial or power generation process;
9) Altering the bed, banks, course or characteristics of a watercourse;

10) Removing, discharging or disposing of water found underground if it is necessary for the efficient continuation of an activity or for the safety of people; and
11) Using water for recreational purposes.

1.4.3 Conservation of Agricultural Resources Act (Act No. 43 of 1983)

This Act controls the utilisation and protection of wetlands, soil conservation and all matters relating thereto including prevention of veld fires, control of weeds and invader plants, prevention of water pollution resulting from farming practices and losses in biodiversity.

1.4.4 The National Environmental Management Act (NEMA) (Act No. 107 of 1998)

This Act embraces all three fields of environmental concern namely: resource conservation and exploitation; pollution control and waste management; and land-use planning and development. The environmental management principles include the duty of care for wetlands and special attention is given to management and planning procedures.

1.4.5 National Environmental Management: Biodiversity Act (10 of 2004)

The National Environmental Management: Biodiversity Act (10 of 2004), (NEMBA) was signed into law in mid-2004 and entered into effect on 1 September 2004. The Act provides for the consolidation of biodiversity legislation through establishing national norms and standards for the management of biodiversity across all sectors and by different management authorities.

Certain activities, known as Restricted Activities, are regulated on listed species using permits by a special set of regulations published under the Act. Restricted activities regulated under the act are keeping, moving, having in possession, importing and exporting, and selling.

1.5 Limitations and assumptions

Due to the scale of the remote imagery used (Google Earth Imagery), as well as the accuracy of the handheld GPS unit used to delineate wetland areas in the field, the delineated boundaries cannot be guaranteed beyond an accuracy of about 10m on the ground. Should greater accuracy of the riparian boundary mapping be required, the boundaries will need to be pegged in the field and mapped using conventional survey techniques.

2 INTRODUCTION

Wetlands provide a wide range of ecosystem services, such as water purification, flood attenuation and streamflow regulation, carbon storage, biodiversity maintenance, recreation and many others (Kotze *et al*., 2021). Wetlands are therefore important ecosystems and are protected by law.

2.1 Definitions

The National Water Act (no. 36 of 1998) (NWA) defines **wetlands** 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 typically adapted to life in saturated soil."*

Wetlands are also included in the definition of a watercourse within the NWA, which implies that whatever legislation refers to a watercourse, will also be applicable to wetlands. The National Water Act (36 of 1998), Section 1(1)(xxiv), defines a '**watercourse'** as:

> 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,*
>
> *and a reference to a watercourse includes, where relevant, its bed and banks."*

The NWA defines **riparian areas** as

> *"…the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterized by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent land areas…"*

General Notice 509 as published in the Government Gazette 40229 of 2016 as it relates to the NWA (Act 36 of 1998) states the following:

> In accordance with GN 509 of 2016, a **regulated area of a watercourse** for Section 21(c) and 21(i) of the NWA, 1998 is defined as:

- The outer edge of the 1 in 100-year flood line and/or delineated riparian habitat, whichever is the greatest distance, measured from the middle of the watercourse of a river, spring, natural channel, lake or dam.
- In the absence of a determined 1 in 100-year flood line or riparian area the area within 100 m from the edge of a watercourse where the edge of the watercourse is the first identifiable annual bank fill flood bench: or
- A 500 m radius from the delineated boundary (extent) of any wetland or pan.

3 BACKGROUND TO THE STUDY AREA

3.1 Location and description of activity

Contrarians Capital Holdings, hereafter referred to as the “applicant”, is proposing the development of a new Steynsrus 10MW Photovoltaic (PV) Solar Facility, within Moqhaka Local Municipality, in the Free State Province. The proposed PV Site is located on farm Arbeid 2154 and Weltevrede 2151. The associated infrastructure will include but not limited to the following: on-site substation and buildings, access roads, overhead power line, and associated structures. The power generated by the proposed Project will feed into the existing Eskom 132 kV distribution system.

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3.2 Climate

The climate of the area is noted to be generally temperate, with summer rain and dry winters. The area is a semi-arid ecosystem. The rainfall varies with a mean annual of 560 mm. The area is noted to have very cold winters, usually with frost. The highly variable summer rainfalls are evident on the drier parts of the region, i.e. towards the eastern region of the Dry Highveld Grassland.

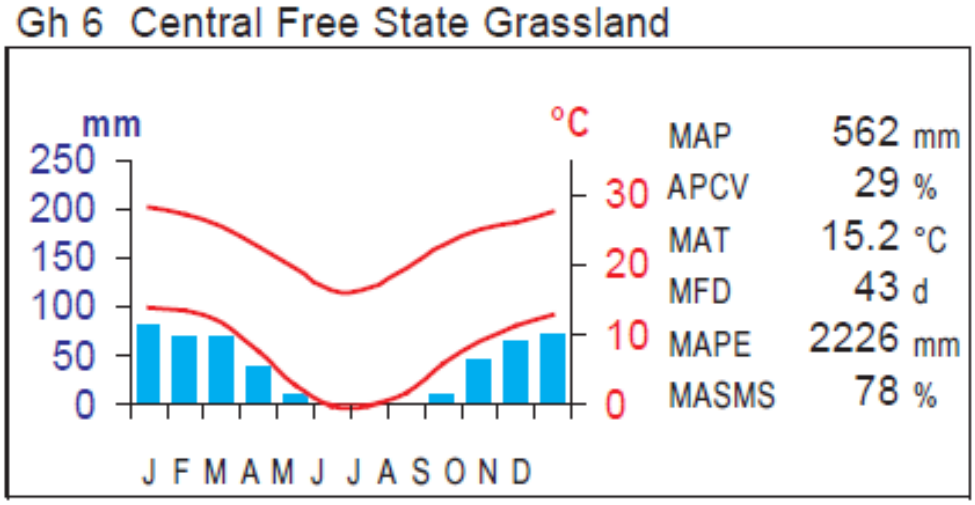


Figure 2: Climate diagram

3.3 Vegetation

The geographic region of the proposed Solar PV development falls on the Grassland biome (Figure 4). The Grassland biome is the second largest and comprises 27.9% of Southern Africa and spans across six provinces. The broad ecological unit of the Fezile Dabi District Municipality is represented by grassland ecosystems with seven vegetation types. The broad vegetation unit is classified as the Dry Highveld Grassland. The Dry Highveld Grassland Bioregion has a total area of 117 753 km^2 and approximately 32 717 km^2 (31.51%) of it has already been transformed.

Within the Dry Highveld Grassland, the proposed Solar PV development area falls under the Central Free State Grassland.

The project area is situated in the Grassland biome (Mucina & Rutherford, 2006), which is characterised by herbaceous vegetation of relatively short and simple structure that is dominated by graminoids, usually of the family Poaceae. Woody plants are rare (usually low to medium-sized shrubs) or absent or are confined to specific habitats, such as smaller escarpments or koppies. Core grassland areas usually have deep, fertile soils although a wide spectrum of soil types occur. Precipitation is strongly seasonal, and the growing season lasts approximately half the year (Mucina & Rutherford, 2006).

3.4 National Freshwater Ecosystem Priority Areas (NFEPAs)

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. "Freshwater ecosystems" refer to all inland water bodies whether fresh or saline, including rivers, lakes, wetlands, sub-surface waters and estuaries. Consistent with global trends, high levels of threat have been reported for freshwater ecosystems. According to the National Biodiversity Assessment 2018 nearly 80% of inland wetland ecosystem types in South Africa are threatened and approximately 75% of inland wetland ecosystem types are both threatened and under-protected (SANBI, 2019). South Africa's freshwater fauna also displays 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.

Urgent attention is needed to ensure that we conserve some representative natural examples of the different ecosystems that make up the natural heritage of this country for current and future generations. NFEPA responds to this need, providing strategic spatial priorities for conserving South Africa's freshwater ecosystems and supporting sustainable use of water resources (Driver et al., 2011)

3.5 National Wetland Map 5

The National Wetland Map version 5 (NWM5) shows the distribution of inland wetland ecosystem types across South Africa and includes estuaries and the extent of some rivers (CSIR, 2018).

There is one NWM5 wetland within the project boundary where the solar park is proposed to be developed, however the panels will not be located near waterbodies (Figure 4).

3.6 Critical Biodiversity Areas and Ecological Support Areas

Critical Biodiversity Areas are areas required to meet biodiversity targets for ecosystems, species and ecological processes, as identified in a systematic biodiversity plan. Ecological Support Areas are not essential for meeting biodiversity targets but play an important role in supporting the ecological functioning of Critical Biodiversity Areas and/or in delivering ecosystem services. Critical Biodiversity Areas and Ecological Support Areas may be terrestrial or aquatic.

The primary purpose of a map of Critical Biodiversity Areas and Ecological Support Areas is to guide decision-making about where best to locate development. It should inform land-use planning, environmental assessment and authorisations, and natural resource management, by a range of sectors whose policies and decisions impact on biodiversity. It is the biodiversity sector's input into multi-sectoral planning and decision-making processes (SANBI Biodiversity Advisor, 2017).

Most of the project area is degraded by agriculture. There is a section that falls into and ESA1, ESA2, Degraded and Other Natural Areas (see Figure 5) (Collins, 2015; Collins, 2016), which is mostly disturbed as well.

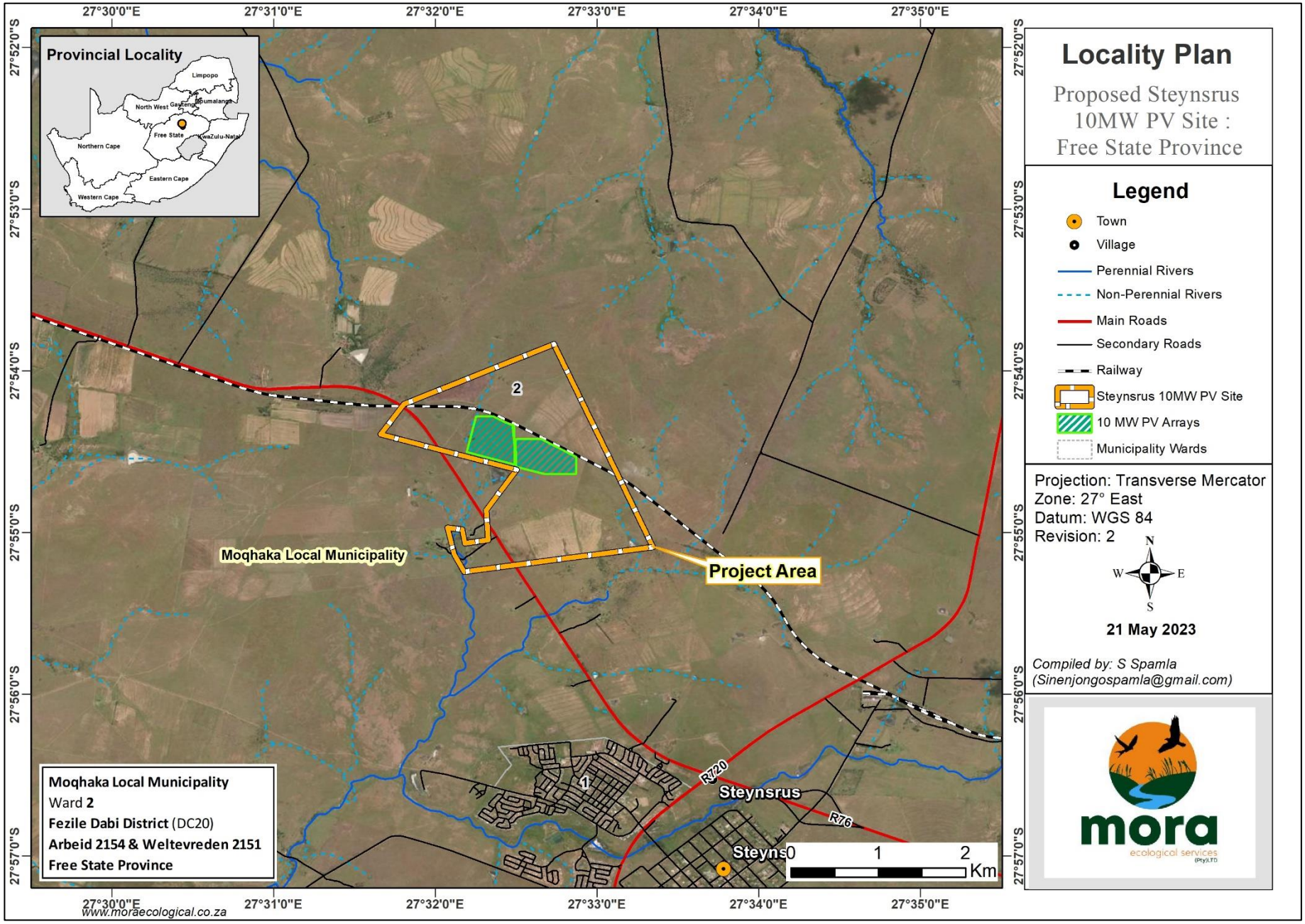


Figure 3: Locality Map

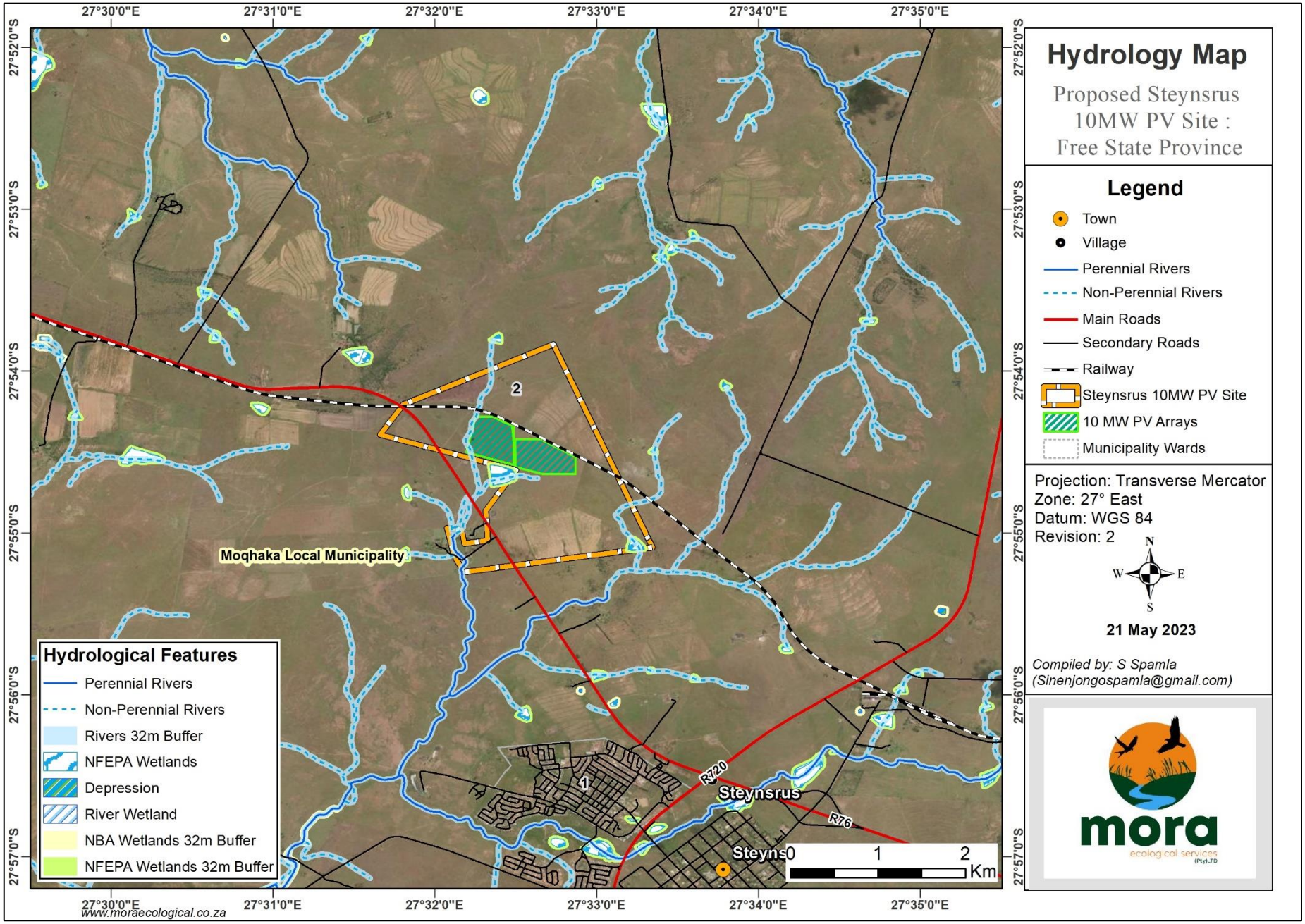


Figure 4: National Freshwater Ecosystem Priority Areas (NFEPA) wetlands and rivers

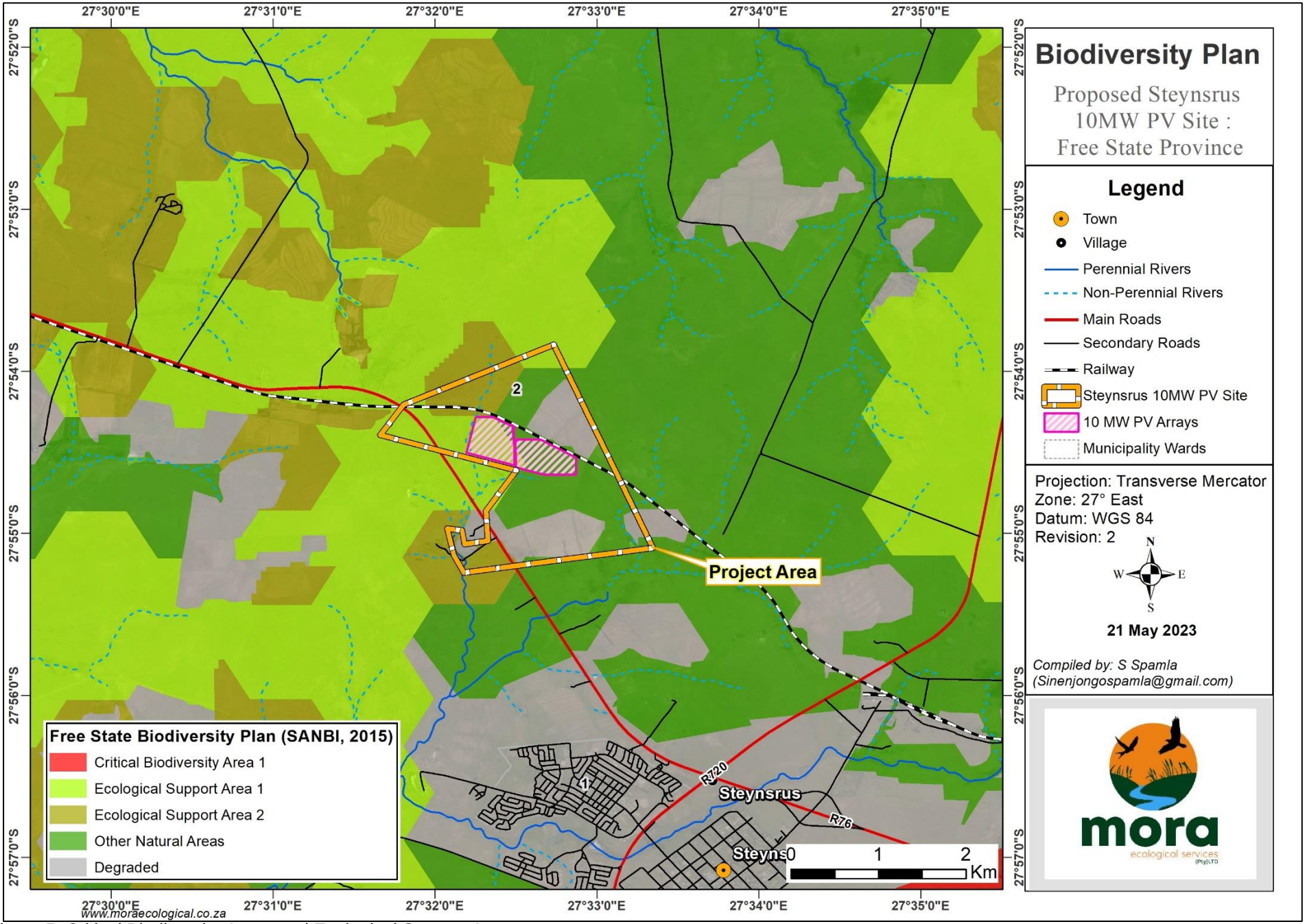


Figure 5: Critical Biodiversity Areas and Ecological Support Areas.

4 METHODS

4.1 Wetland classification

Wetlands can be classified into different hydrogeomorphic (HGM) types based on the geomorphic setting of the wetland in the landscape (e.g. valley bottom, floodplain, whether the wetland is open or closed), water source (surface water or groundwater), how water flows through the wetland (diffusely or channelled) and how water exits the wetland (Macfarlane *et al*., 2009). The HGM type of a wetland gives an indication of the structure and processes of the wetland.

4.2 Wetland delineation

Wetland delineation is essential to define the extent of a wetland. Wetland delineation procedures also determine the different zones of the wetland. Wetlands typically have three zones: the temporary, seasonal and permanent zones (Department of Water Affairs and Forestry, 2005). The wetland delineation approach developed by the Department of Water and Sanitation (previously known as the Department of Water Affairs and Forestry) is the accepted approach used by practitioners in South Africa and was therefore used for this report.

In order to identify the different wetland zones, two indicators are used namely vegetation and soil. Wetland soils (hydromorphic soils) have certain characteristics. When soil is saturated with water, anaerobic conditions persist, which leads to iron being dissolved and leached out of the soil. If the soil dries out (in the dry season for example) iron will accumulate, forming mottles. The level to which a soil is gleyed (have a grey colour due to the iron having been leached out) and the presence of mottles, indicates duration of the year that the soil is saturated with water. The permanent zone is mostly found in the centre of the wetland and is almost always saturated with water. Soils that are permanently waterlogged will be gleyed with no or little mottles, because it does not dry out and mottles are not formed. The permanent zone is surrounded by the seasonal zone, which is saturated with water for a significant duration of the rainy season. Seasonally waterlogged soils will also be gleyed, but to a lesser extent, with many mottles. The temporary zone surrounds the seasonal zone and is only saturated for short periods of the year, which is sufficient for soil to become gleyed to some extent. Few or no mottles form in the temporary zone (Department of Water Affairs and Forestry, 2005). Only the outer boundary of the wetland (temporary zone) was identified and delineated for this study.

Soil was augured to confirm the boundaries of the wetland. The wetland was mapped with a combination of the field data and satellite images. Vegetation is also an important indicator of wetlands, as most terrestrial plants are not adapted to live in waterlogged conditions. Wetland soils are low in oxygen, and plant roots needs oxygen to respire. Plants that do not have certain adaptations cannot live in wetland conditions. In anaerobic conditions (no or little oxygen) some nutrients become unavailable to plants and the concentration of certain elements can reach toxic levels. Plants adapted to these conditions are called hydrophytes and they can be used to indicate the presence and boundaries of a wetland (Department of Water Affairs and Forestry, 2005).

For the wetland delineation in this study more emphasis was placed on the vegetation. Findings were confirmed by means of soil auguring and then extrapolated with the help of satellite images.

4.3 WETLAND INTEGRITY ASSESSMENTS

4.3.1 Present Ecological Status (PES) of wetlands

WET-Health (Macfarlane *et al*., 2020) is designed to assess the PES of a wetland by scoring the perceived deviation from a theoretical reference condition, where the reference condition is defined as the un-impacted condition in which ecosystems show little or no influence of human actions. In thinking about wetland health or PES, it is thus appropriate to consider ‘deviation’ from the natural or reference condition, with the ecological state of a wetland taken as a measure of the extent to which human impacts have caused the wetland to differ from the natural reference condition (Macfarlane *et al*., 2020).

Whilst wetland features vary considerably from one wetland to the next, wetlands are all broadly influenced by their climatic and geological setting and by three core inter-related drivers, namely hydrology, geomorphology and water quality. The biology of the wetland (in which vegetation generally plays a central role) responds to changes in these drivers, and to activities within and around the wetland. The interrelatedness of these four components is illustrated schematically in Figure 6 below and forms the basis of the modular-based approach adopted in WET-Health Version 2 (Macfarlane *et al*., 2020).

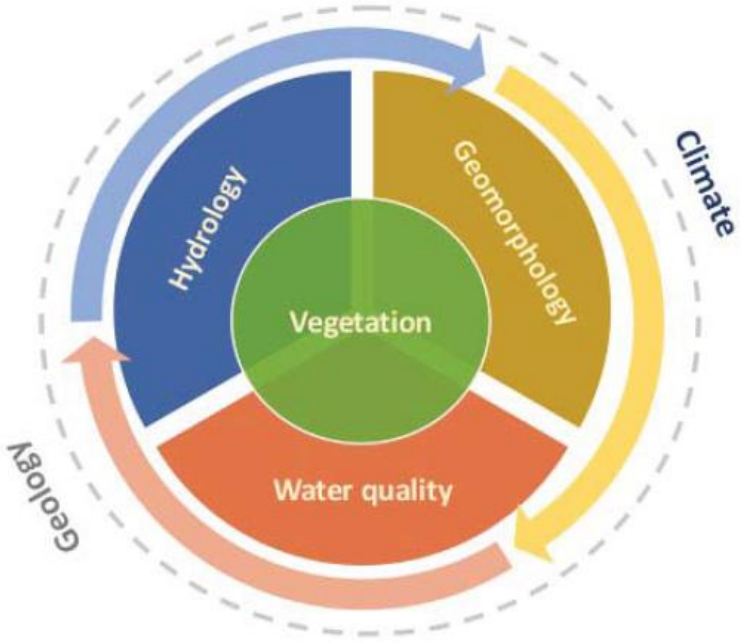


Figure 6: Diagram representing the four key components of Wetland PES considered in WET-Health Version 2 (Macfarlane *et al*., 2020).

The impact categories, scores, and associated present state categories are summarised in Table 2.

Table 1: Impact scores and categories of Present Ecological State used by WET-Health for describing the integrity of the wetland.

Impact Category	Description	Impact Score Range	Present Ecological State Category
None	Unmodified, or approximates natural condition	0 – 0.9	A
Small	Largely natural with few modifications, but with some loss of natural habitats	1 – 1.9	B
Moderate	Moderately modified, but with some loss of natural habitats	2 – 3.9	C
Large	Largely modified. A large loss of natural habitat and basic ecosystem function has occurred	4 – 5.9	D
Serious	Seriously modified. The losses of natural habitat and ecosystem functions are extensive	6 – 7.9	E
Critical	Critically modified. Modification has reached a critical level and the system has been modified completely with almost complete loss of natural habitat	8 – 10.0	F

4.3.2 Ecological Importance and Sensitivity (EIS)

The EIS was determined using the methodology developed by Rountree *et al*. (2013). It is a rapid scoring system to evaluate:

- Ecological Importance and Sensitivity
- Hydrological Functions; and
- Direct human benefits.

The highest score of the three derived scores (each with range 0 – 4) was then used to indicate the overall importance category of the wetland (Table 3).

Table 2: Description of the EIS Categories

EIS Category	Range of Mean	Recommended Ecological Management Class
Very High	3.1 to 4.0	A
High	2.1 to 3.0	B
Moderate	1.1 to 2.0	C
Low Marginal	< 1.0	D

4.3.3 Risk assessment matrix

A Risk Assessment, as required in terms of the General Authorisation Notice 509 of 2016 (Gazette No.40229), for any development proposed within the 1:100-year floodline. The risk assessment should be based on the following ratings (Table 3).

Risk Assessment was not undertaken for this project as the proposed solar facility falls outside the 1:100-year floodline.

Table 3. Risk rating tables and methodology for the risk assessment

SEVERITY

How severe does the aspects impact on the resource quality (flow regime, water quality, geomorphology, biota, and habitat)?

Insignificant / non-harmful	1
Small / potentially harmful	2
Significant / slightly harmful	3
Great / harmful	4
Disastrous / extremely harmful and/or wetland(s) involved	5
Where "or wetland(s) are involved" it means that the activity is located within the delineated boundary of any wetland. The score of 5 is only compulsory for the significance rating.	

SPATIAL SCALE

How big is the area that the aspect is impacting on?

Area specific (at impact site)	1
Whole site (entire surface right)	2
Regional / neighbouring areas (downstream within quaternary catchment)	3
National (impacting beyond secondary catchment or provinces)	4
Global (impacting beyond SA boundary)	5

DURATION

How long does the aspect impact on the resource quality?

One day to one month, PES, EIS and/or REC not impacted	1
One month to one year, PES, EIS and/or REC impacted but no change in status	2
One year to 10 years, PES, EIS and/or REC impacted to a lower status but can be improved over this period through mitigation	3
Life of the activity, PES, EIS and/or REC permanently lowered	4
More than life of the organisation/facility, PES and EIS scores, a E or F	5
PES and EIS (sensitivity) must be considered.	

FREQUENCY OF THE ACTIVITY

How often do you do the specific activity?

Annually or less	1
6 monthly	2
Monthly	3
Weekly	4
Daily	5

FREQUENCY OF THE INCIDENT/IMPACT

How often does the activity impact on the resource quality?

Almost never / almost impossible / >20%	1
Very seldom / highly unlikely / >40%	2
Infrequent / unlikely / seldom / >60%	3
Often / regularly / likely / possible / >80%	4
Daily / highly likely / definitely / >100%	5

LEGAL ISSUES

How is the activity governed by legislation?

No legislation	1
Fully covered by legislation (wetlands are legally governed)	5
Located within the regulated areas	

DETECTION
How quickly/easily can the impacts/risks of the activity be observed on the resource quality, people and property?

Immediately	1
Without much effort	2
Need some effort	3
Remote and difficult to observe	4
Covered	5

Risk scores, classes, and the appropriate authorization process (Extract from DWS, 2016)

Rating	Class	Management Description	Authorisation	Delegation
1 - 55	(L) Low Risk	Acceptable as is or consider requirement for mitigation. Impact to watercourses and resource quality small and easily mitigated. Wetlands are excluded.	GA	Regional Head
56 - 169	(M) Moderate Risk	Risk and impact on watercourses are notable and require mitigation measures on a higher level, which costs more and require specialist input. Wetlands are excluded.	WUL	Regional Head
170 - 300	(H) High Risk	Always involves wetlands. Watercourse(s) impacts by the activity are such that they impose a long-term threat on a large scale and lowering of the Reserve.	WUL	Director General

Calculations

Consequence = Severity + Spatial Scale + Duration
Likelihood = Frequency of Activity + Frequency of Incident + Legal Issues + Detection
Significance\Risk = Consequence X Likelihood
RISK ASSESSMENT MUST BE CONDUCTED BY A SACNASP REGISTERED PROFESSIONAL MEMBER AND THE ASSESSOR MUST: **1)CONSIDER BOTH CONSTRUCTION AND OPERATIONAL PHASES OF PROPOSED ACTIVITIES;** **2) CONSIDER RISKS TO RESOURCE QUALITY POST MITIGATION CONSIDERING MITIGATION MEASURES LISTED IN TABLES PROVIDED;** **3) CONSIDER THE SENSITIVITY (ECOLOGICAL IMPORTANCE AND SENSITIVITY – EIS) AND STATUS (PRESENT ECOLOGICAL STATUS - PES) OF THE WATERCOURSE AS RECEPTOR OF RISKS POSED;** **4) CONSIDER POSITIVE IMPACTS/RISKS REDUCTION AS A VERY LOW RISK IN THIS ASSESSMENT;** **5) INDICATE CONFIDENCE LEVEL OF SCORES PROVIDED IN THE LAST COLUMN AS A PERCENTAGE FROM 0 - 100%.**

5 RESULTS

5.1 WETLAND DELINEATION AND CLASSIFICATION

Figure 7 indicates the wetland delineation.

The wetlands in the project area are classified as:

1) Exorheic depression (artificial dams);
2) Channelled valley bottom wetland.

5.1.1 Exorheic depression (artificial dams)

The man-made dams in the project area represent depressions that are classified as exorheic depressions (Photograph 3). As the definition of an Inland System includes all inland aquatic ecosystems (i.e., not just wetlands), lakes and other open waterbodies are types of Inland Systems in terms of the Classification System, even if they are artificial such as dams. Man-made dams are therefore classified as aquatic systems since the landform characteristics of such systems fit the definition of a depression in that they typically have closed (or near closed) elevation contours and increase in depth from the perimeter to a central area of greatest depth. Lakes and other open waterbodies that have a maximum depth greater than two metres are called limnetic systems. The vegetation associated with the dams is mostly sedges and bulrushes depending on the depth of the water and the substrate. Species such as *Cynodon dactylon*, *Schoenoplectus brachyceras*, *Cyperus congestus, Cyperus Eragrostis* and *Persicaria decipiens* mostly grow in the wetlands.

5.1.2 Unchannelled valley bottom wetland

A valley-bottom wetland is a mostly flat wetland area located along a valley floor, often connected to an upstream or adjoining river channel (Ollis *et al*., 2013). Although valley-bottom wetlands are generally sites of sediment accumulation or temporary storage, as in the case of floodplain wetlands, the process of river-derived deposition is not nearly as important in these systems as it is in floodplain wetlands. As such, there tends to be few (if any) depositional features present within a valley-bottom wetland that can be ascribed to current riverine processes, although erosional features relating to riverine processes may be present. Valley-bottom wetlands are not formed by the process of flooding and large-scale sediment movement. Valley-bottom wetlands are either channelled or unchannelled (Ollis *et al*., 2013).

The valley-bottom wetland at the site is unchannelled. Unchannelled valley-bottom wetlands are characterised by their location on valley floors, an absence of distinct

channel banks, and the prevalence of diffuse flows. These wetlands are generally formed when a river channel loses confinement and spreads out over a wider area, causing the concentrated flow associated with the river channel to change to diffuse flow (i.e. the river becomes an unchannelled valley-bottom wetland).

The vegetation associated with these wetlands is dominated by grasses and sedges. Grass species include *Cynodon dactylon*, *Panicum schinzii*, *Aristida junciformis*, *Cymbopogon caesius* and *Setaria sphacelata* var. *sericea*.

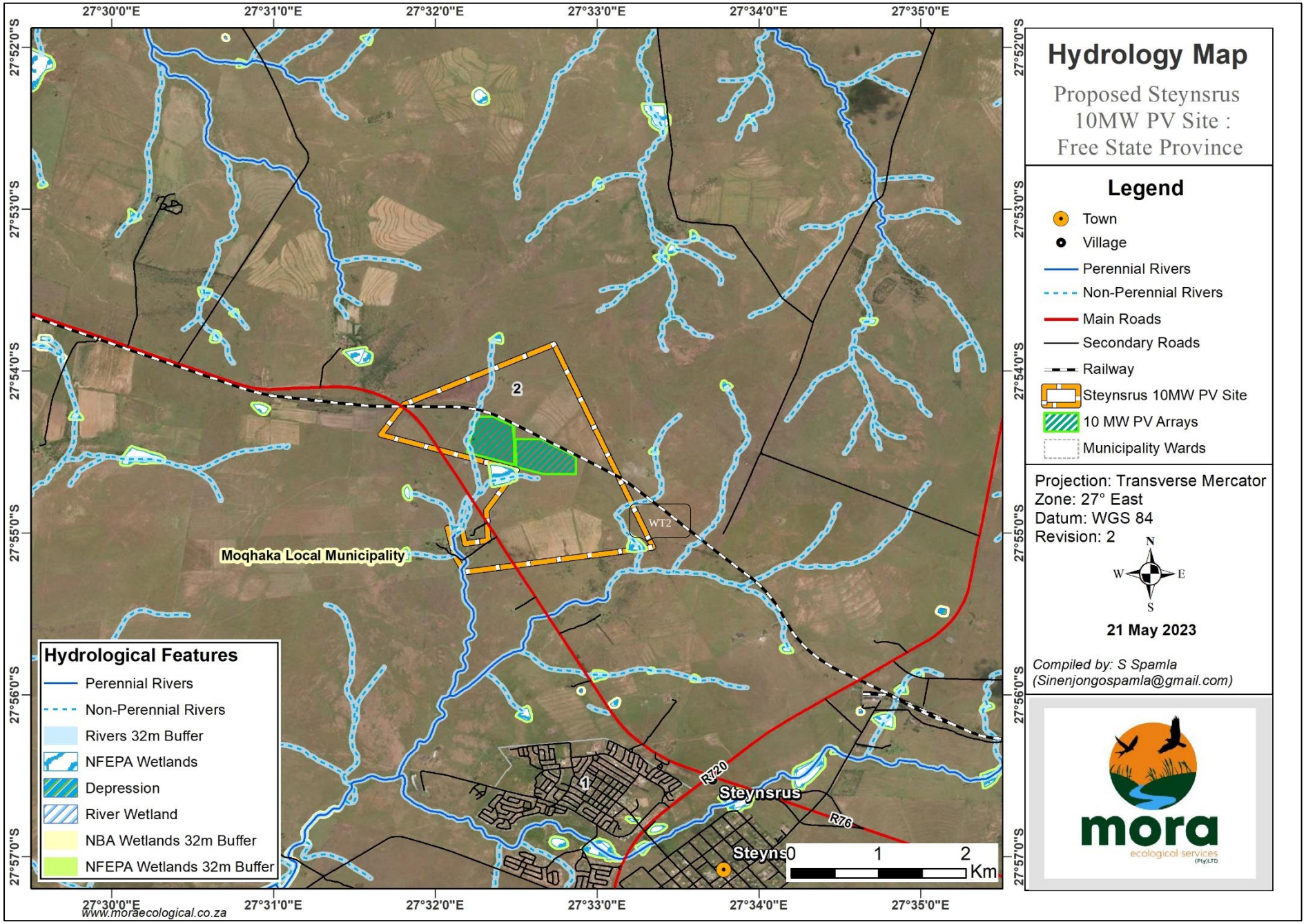


Figure 7: Wetland delineation map

Photograph 1: Farm dam located outside the study boundary.

Photograph 2: Channelled valley bottom wetland within the study area.

Photograph 3: Farm dam within the study area.

Photograph 4: Wetland soil showing dark coloration.

5.2 WETLAND INTEGRITY ASSESSMENTS

In determining the integrity of the drainage system, the condition of the site and the indirect and direct disturbances are considered. The impoundments, roads, alien invasive vegetation species, pollution, sedimentation and density roughness elements was taken into account in determining the PES and EIS of the wetland units on site.

5.2.1 WET-Health Assessment

Three modules, namely hydrology, geomorphology and vegetation, were assessed as a single unit for the HGM Units and subsequently an area weighted score was obtained for the HGM Units. The potential impacts of activities such as agriculture, drought and altered hydrological functions within the greater catchment were taken into consideration during the assessment. The results are summarised in Table 5 below.

Table 4: Summary of results of the WET-Health assessments conducted for the wetlands.

Summary of WET-Health assessment									
Wetland	**Hydrology**		**Geomorphology**		**Water Quality**		**Vegetation**		**Combined Ecological Category**
	Ecological Category	Trajectory of change	Ecological Category	Trajectory of change	Ecological Category	Trajectory of change	Ecological Category	Trajectory of change	Ecological Category
WT1	C	→	C	→	A	→	D	→	C
WT2	C	→	B	→	A	→	D	→	C

The PES Category for all two wetlands is a C, meaning that the functionality of the wetland is Moderately modified but with some loss of natural habitats. Based on the Trajectory of change, the wetlands PES is likely to remain stable over the next 5 years.

5.2.2 Ecosystem Services

Physical and hydrological features allow hydro-geomorphic units to perform specific ecosystems services. A Wet-EcoService evaluation was conducted for the hydro-geomorphic type found on site to determine the services as described in the methodology. The degree of disturbance and modification of wetlands results in a decrease in the ability to which they can perform these ecosystem services. The findings of the Wet-Ecoservice evaluation conducted is provided in Table 5 to 8 and Figure 8 below.

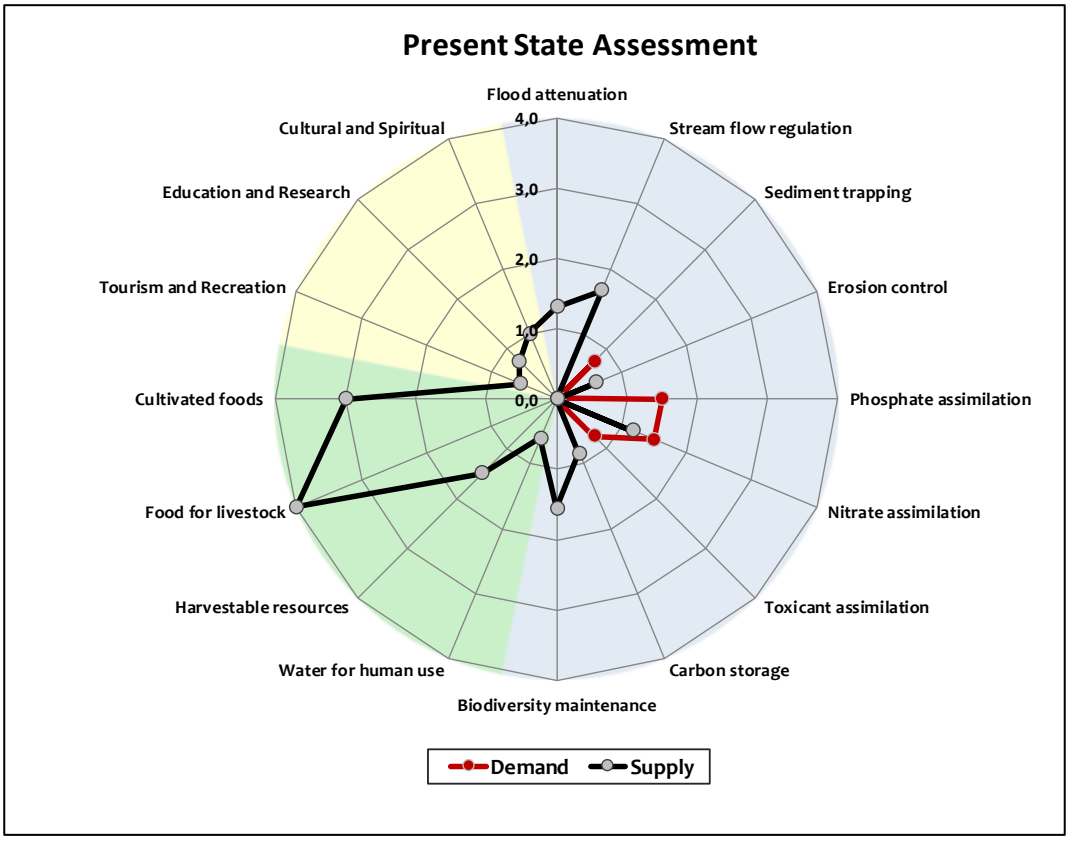
Table 5: Ecosystem Services for WT1

ECOSYSTEM SERVICE		Supply	Demand	Importance Score	Importance
REGULATING AND SUPPORTING SERVICES	Flood attenuation	1,3	0,0	0,0	Very Low
	Stream flow regulation	1,7	0,0	0,2	Very Low
	Sediment trapping	No scores	0,8	No scores	No scores
	Erosion control	0,6	0,0	0,0	Very Low
	Phosphate assimilation	No scores	1,5	No scores	No scores
	Nitrate assimilation	1,2	1,5	0,4	Very Low
	Toxicant assimilation	No scores	0,8	No scores	No scores
	Carbon storage	0,8	0,0	0,0	Very Low
	Biodiversity maintenance	1,6	0,0	0,0	Very Low
PROVISIONING SERVICES	Water for human use	0,6	0,0	0,0	Very Low
	Harvestable resources	1,5	0,0	0,0	Very Low
	Food for livestock	4,0	0,0	2,5	Moderately High
	Cultivated foods	3,0	0,0	1,5	Moderately Low
CULTURAL SERVICES	Tourism and Recreation	0,6	0,0	0,0	Very Low
	Education and Research	0,8	0,0	0,0	Very Low
	Cultural and Spiritual	1,0	0,0	0,0	Very Low

Table 6: Ecosystem services for WT2

ECOSYSTEM SERVICE		Supply	Demand	Importance Score	Importance
REGULATING AND SUPPORTING SERVICES	Flood attenuation	1,3	0,0	1,3	Low
	Stream flow regulation	3,0	0,0	1,5	Moderately Low
	Sediment trapping	2,3	1,0	1,3	Low
	Erosion control	1,7	0,3	0,4	Very Low
	Phosphate assimilation	1,4	1,0	0,4	Very Low
	Nitrate assimilation	2,0	1,0	1,0	Low
	Toxicant assimilation	2,1	1,0	1,1	Low
	Carbon storage	1,0	0,0	0,0	Very Low
	Biodiversity maintenance	1,4	1,5	0,7	Very Low
PROVISIONING SERVICES	Water for human use	2,4	0,0	0,9	Low
	Harvestable resources	1,0	0,0	0,0	Very Low
	Food for livestock	3,0	0,0	1,5	Moderately Low
	Cultivated foods	2,5	0,0	1,0	Low
CULTURAL SERVICES	Tourism and Recreation	0,9	0,0	0,0	Very Low
	Education and Research	1,3	0,0	0,0	Very Low
	Cultural and Spiritual	1,0	0,0	0,0	Very Low

WT1



WT2

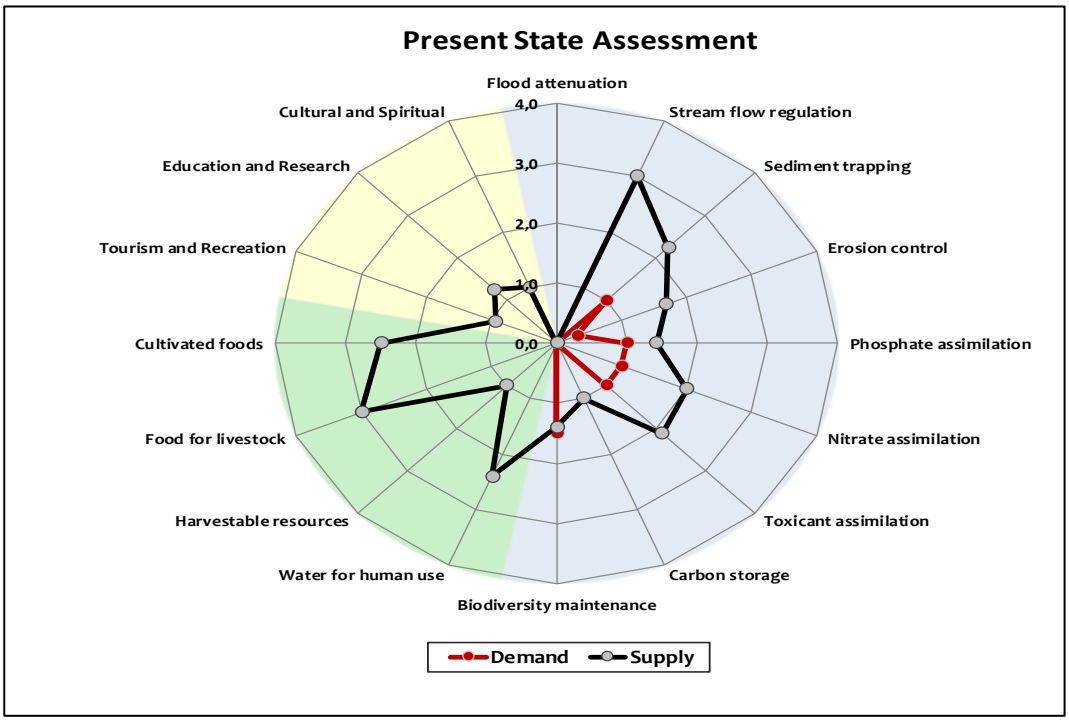


Figure 8: Results of the Ecosystem Services provided in graph format.

5.2.3 Ecological Importance and Sensitivity

The EIS assessment was applied to all wetland features within the study area in order to ascertain the levels of sensitivity and ecological importance of the features. The results of these assessments are summarised in Table 7 below.

Table 7: EIS scores obtained for the Wetlands (DWAF, 1999).

Ecological Importance and Sensitivity				
	WT2		**WT1**	
Determinant	**Score**	**Confidence**	**Score**	**Confidence**
Biotic determinants				
Rare and endangered biota	0	4	0	3
Unique biota	0	4	0	3
Intolerant biota	0	4	1	3
Species/taxon richness	1	3	2	3
Habitat (instream and riparian) determinants				
Diversity of aquatic habitat types or features	2	4	2	4
Refuge value of habitat types	1	4	2	4
Sensitivity of habitat to flow changes	1	3	1	3
Sensitivity to flow related water quality changes	1	3	2	3
Migration route/corridor for instream and riparian biota	0	4	1	4
National parks, Wilderness areas, Nature reserves Natural Heritage sites Natural areas	0	4	2	3
Total	6		13	
Average score	**0,6**		**1,3**	
Category	**Low / marginal**		**Moderate**	

The Ecological importance and sensitivity are respectively low / marginal (WT2), and moderate (WT1).

6 CUMULATIVE IMPACTS

The EIA Regulations (as amended in 2017) determine that cumulative impacts, “in relation to an activity, means the past, current and reasonably foreseeable future impact of an activity, considered together with the impact of activities associated with that activity, that in itself may not be significant, but may become significant when added to the existing and reasonably foreseeable impacts eventuating from similar or diverse activities.” Cumulative impacts can be incremental, interactive, sequential or synergistic.

The term "Cumulative Effect" has for the purpose of this project been defined as: the summation of effects over time which can be attributed to the operation of the Project itself, and the overall effects on the ecosystem of the Project Area that can be attributed to the Project and other existing and planned future projects.

6.1 Cumulative impact on wetlands

The cumulative impact of solar power park developments in the area on wetlands is not foreseen to be significant, as most of the development is proposed outside of major wetlands.

7 POTENTIAL IMPACTS OF THE PROPOSED DEVELOPMENT ON THE WETLANDS

The two Wetlands are located outside the PV panel footprints. However, the PV arrays located on the western side will be located on the edge of a watercourse. The impacts of the PV panel are not expected to be severe, as vegetation will not be cleared, and wetlands will not be traversed.

7.1 Compaction, Soil Erosion and Sedimentation

7.1.1 Description of impact:

This impact will be mostly on the depression wetlands and to a lesser extent on the unchannelled valley bottom wetlands. The use of heavy machinery during the construction process of the development will result in the compaction of soil, resulting in decreased infiltration of rainwater and increased surface run-off volumes and velocities leading to a greater erosion risk. The hardened surfaces of the road and compacted soils of the proposed development area will also lead to an increase in surface run-off during storms. This can lead to erosion in the cleared areas and sedimentation in the wetlands.

Soil erosion also promotes a variety of terrestrial ecological changes associated with disturbed areas, including the establishment of alien invasive plant species, altered plant community species composition and loss of habitat for indigenous fauna and flora.

7.1.2 Mitigation measures

- Compaction of soils must be limited and / or avoided as far as possible. Compaction will reduce water infiltration and will result in increased runoff and erosion. Where any disturbance of the soil takes place (have taken place in the past), these areas must be stabilised and any alien plants which establish must be cleared and follow-up undertaken for the duration of the construction and decommissioning phases. It is to be undertaken by the Internal Environmental Officer or the Environmental Control Officer. Where compaction becomes apparent, remedial measures must be taken (e.g., “ripping” the affected area).
- Reseed any areas where earthworks have taken place with indigenous grasses to prevent further erosion.
- Erosion control mechanisms must be established as soon as possible.
- A stormwater plan must be developed with the aid of an engineer to ensure that water runoff is diverted off the site without pooling and stagnation causing erosion. Financial provision for closure will include the estimated costs for erosion control post-construction and post-decommissioning.

- If compaction occurs, rectification can be done by application and mixing of manure, vegetation mulch or any other organic material into the area. Use of well cured manure is preferable as it will not be associated with the nitrogen negative period associated with organic material that is not composted.
- Vehicle traffic must not be allowed on the rehabilitated areas, except on allocated roads, due to adverse impacts of dispersive/compaction characteristics of soils and its implications on the long term.
- Appropriate design and mitigation measures must be developed and implemented to minimise impacts on the natural flow regime of the watercourse i.e., through placement of structures/supports and to minimise turbulent flow in the watercourse.
- The indiscriminate use of machinery within the wetland area will lead to compaction of soils and destruction of vegetation and must therefore be strictly controlled.
- Solar panels may not be placed within 32 m of the waterbodies.
- Perform scheduled maintenance to be prepared for storm events. Ensure that culverts have their maximum capacity, ditches are cleaned, and that channels are free of debris and brush than can block structures.

7.2 Disturbance of watercourse habitat and fringe vegetation

7.2.1 Description of impact:

Disturbance to the wetlands during construction and maintenance of the solar panels and associated power line may be inevitable as heavy vehicles will operate in the area. As habitat is disturbed, fauna and flora will be negatively impacted. Vegetation structure may change, affecting wetland properties and fauna.

7.2.2 Mitigation measures

- As far as possible, disturbance must be kept outside of the wetlands and their buffer zones.
- Existing access roads must be used where possible.

7.3 Soil and water pollution

7.3.1 Description of impact:

Construction work will also carry a risk of soil and water pollution, with large construction vehicles contributing substantially due to oil and fuel spillages. If not promptly dealt with, spillages or accumulation of waste matter can contaminate the soil and surface- or groundwater, leading to

potential medium/long-term impacts on fauna and flora.

7.3.2 Mitigation measures

- Ensure that all hazardous storage containers and storage areas comply with the relevant SABS standards to prevent leakage. Regularly inspect all vehicles for leaks. Re-fuelling must take place on a sealed surface area to prevent ingress of hydrocarbons into topsoil.
- No dumping of waste must take place within the wetlands or their buffer zones. If any spills occur, they must be cleaned up immediately.
- Contain all dirty water in the dirty water system and contain all dirty stormwater up to a 1:50 year flood line as a minimum. Ensure that all activities impacting on groundwater resources of the subject property are managed according to the relevant DWS Licensing regulations and groundwater monitoring and management requirements.
- Appropriate sanitary facilities must be provided for the duration of the proposed development and all waste removed to an appropriate waste facility.
- Excess waste or chemicals must be removed from site and discarded in an environmentally friendly way. The Environmental Control Officer (ECO) must enforce this rule rigorously.
- Hazardous chemicals to be stored on an impervious surface protected from rainfall and stormwater run-off.
- Spill kits must be on-hand to deal with spills immediately.
- All vehicles must be inspected for oil and fuel leaks on a regular basis. Vehicle maintenance yards on site must make provision for drip trays to capture spills. Drip trays must be emptied into a holding tank and returned to the supplier.
- Implement standard dust control measures, including periodic spraying (frequency will depend on many factors including weather conditions, soil composition and traffic intensity and must thus be adapted on an on-going basis) and chemical dust suppressants of construction areas and access roads, and ensure that these are continuously monitored to ensure effective implementation.
- A speed limit (preferably 40 km/hour) must be enforced on dirt roads.
- Limit pesticide use to non-persistent, immobile pesticides and apply in accordance with the label and application permit directions and stipulations for terrestrial and aquatic applications.

7.4 Spread and establishment of alien invasive species

7.4.1 Description of impact:

The construction almost certainly carries by far the greatest risk of alien invasive species being imported to the site, and the high levels of habitat disturbance also provide the greatest opportunities for such species to establish themselves, since most indigenous species are less tolerant of disturbance. The biggest risk is that seeds of noxious plants may be carried onto the site along with materials that have been stockpiled elsewhere at already invaded sites.

Continued movement of personnel and vehicles on and off the site, as well as occasional delivery of materials required for maintenance, will result in a risk of importation of alien species throughout the life of the project.

Furthermore, the spread of the alien invasive species through the area will be accelerated when seeds are carried by stormwater into the drainage features on the site that will cause environmental degradation and indigenous species to be displaced.

7.4.2 Mitigation measures

- Alien and invader vegetation must not be allowed to colonise the area. Control involves killing alien invasive plants present, seedlings and establishing an alternative plant cover to limit re-growth. The use of indigenous plants must be encouraged in the rehabilitated areas (stormwater canals). Control must begin prior to construction phase considering that small populations of invader plant species occur around the project area.
- Institute strict control over materials brought onto site, which must be inspected for seeds and steps taken to eradicate these before transport to the site. The contractor is responsible for the control of weeds and invader plants.
- Rehabilitate disturbed areas outside the development footprint as quickly as possible.
- Institute a monitoring programme during construction, undertaken by the IEO or the ECO, to detect alien invasive species early. Monitoring must be done periodically by the ECO.
- Institute an eradication/control programme for early intervention if invasive species are detected. The use of indigenous plants must be encouraged in the rehabilitated areas.

8 DISCUSSION & CONCLUSION

According to the NEMA screening tool the site has a low sensitivity from an aquatic biodiversity perspective. A site sensitivity verification was therefore conducted to determine if the assessment was accurate. After the site visit it was concluded that the site has a Low-Medium sensitivity from an Aquatic biodiversity perspective.

The wetland delineation and classification for the project was done according to the criteria set by the Department of Water Affairs and Forestry (2005) guidelines and the Classification System for Wetlands and other Aquatic Ecosystems in South Africa (Ollis *et al*., 2013). The soils and vegetation associated with wetlands and landscape were all used as parameters in identifying the wetlands.

Baseline soil information, landscape profile and vegetation were used to confirm wetland and terrestrial properties within the study area. Present Ecological State (PES) and Ecological Importance and Sensitivity are given in the table below:

Classification	PES	EIS
Depression	C: Moderately modified	D: Low / marginal
UVB1	C: Moderately modified	C: Moderate
UVB2	C: Moderately modified	C: Moderate

A risk matrix assessment was conducted for the wetlands on site in addition to the mitigation measures recommended to ensure the protection of the wetlands. Impacts relating to the proposed development on the wetlands / riparian zones are as follows:

- Soil Erosion and Sedimentation. Alteration of the amount of sediment entering the water resource and associated change in turbidity
- Disturbance of watercourse habitat and fringe vegetation
- Soil and water pollution
- Import and spread of alien invasive vegetation.

The impacts were all low and therefore a General Authorisation will be sufficient.

The development of proposed Solar PV Project can be supported from a wetland perspective, provided that the mitigation measures are implemented.

9 REFERENCES

Climate-data.org. 2022. Klerksdorp climate. https://en.climate-data.org/africa/south-africa/north-west/klerksdorp-1024/ Date of access: 28 March 2022.

Council for Scientific and Industrial Research. 2011. NFEPA rivers [vector geospatial dataset] 2011. Available from the Biodiversity GIS website, downloaded on 19 April 2021

Department of Water Affairs and Forestry. 1999. Ecological Importance & Sensitivity assessment method for river ecosystems [taken from Appendix R.7 of DWAF 1999].

Department of Water Affairs and Forestry. 2005. A practical field procedure for identification and delineation of wetlands and riparian areas. Pretoria: Department of Water Affairs and Forestry.

Department of Water and Sanitation. 2016. General Authorisation in terms of Section 39 of the National Water Act, 1998 (act no. 36 of 1998) for water uses as defined in Section 21(c) or Section 21(I). Notice 509 of 2016.

Driver, A., Nel, J.L., Snaddon, K., Murray, K., Roux, D.J., Hill, L., Swartz, E.R., Manuel, J. & Funke, N. 2011. Implementation Manual for Freshwater Ecosystem Priority Areas. South African National Biodiversity Institute, CSIR, The Freshwater Consulting Group, Water Research Commission, South African National Parks & South African Institute for Aquatic Biodiversity.

ENPAT. 2000. Environmental Potential Atlas. Department of Environmental Affairs and Tourism, Pretoria.

Kotze, D., Macfarlane, D.M. and Edwards, R. 2021. WET-EcoServices (Version 2): A technique for rapidly assessing ecosystem services supplied by wetlands and riparian areas. Water Research Commission, Pretoria.

Kleynhans C.J., Louw M.D., Graham M. 2008. Module G: EcoClassification and EcoStatus determination in River EcoClassification: Index of Habitat Integrity (Section 1, Technical manual) Joint Water Research Commission and Department of

Water Affairs and Forestry report. WRC Report No. TT 377-08

Macfarlane, D.M., Kotze, D.C., Ellery, W.N., Walters, D., Koopman, V., Goodman, P. & Goge, M. 2009. WET-Health: A technique for rapidly assessing wetland health. WRC Report No. TT 340/08. Water Research Commission: Pretoria.

Mills, G. & Hes, L. 1997. The Complete Book of Southern African Mammals. Struik Winchester, Cape Town.

Macfarlane D.M., Ollis D.J & Kotze D.C. 2020. WET-Health (Version 2.0): A refined suite of tools for assessing the present ecological state of wetland ecosystems. Technical guide Water Research Commission, Pretoria. WRC Report TT820/20 May 2020.

Mucina, L. & Rutherford, M.C. (eds) 2006. The vegetation of South Africa, Lesotho and Swaziland. Strelitzia 19. Pretoria: South African National Biodiversity Institute.

Mucina, L., Rutherford, M.C. & Powrie, L.W. (eds). 2005. Vegetation Map of South Africa, Lesotho and Swaziland, 1:1000000 scale sheet maps. Pretoria: South African National Biodiversity Institute.

Nel, J.L., Driver, A., Strydom, W.F., Maherry, A., Petersen, C., Hill, L., Roux, D.J., Nienaber, S., Van Deventer, H., Swartz, E. & Smith-Adao, L.B. 2011. Atlas Of Freshwater Ecosystem Priority Areas in South Africa: Maps to support sustainable development of water resources. Water Research Commission Report No. TT 500/11.

Ollis, D., Snaddon, K., Job, N. & Mbona, N. 2013. Classification System for Wetlands and other Aquatic Ecosystems in South Africa. USER MANUAL: Inland Systems. Pretoria: SANBI Biodiversity Series 22.

Rountree M.W., Malan H.L. and Weston BC. 2013. Manual for the Rapid Ecological Reserve Determination of Inland Wetlands (Version 2.0). WRC Report 1788/1/13. Water Research Commission, Pretoria

South African National Biodiversity Institute. 2006-2018. The Vegetation Map of

South Africa, Lesotho and Swaziland, Mucina, L., Rutherford, M.C. and Powrie, L.W. (Editors), Online, http://bgis.sanbi.org/Projects/Detail/186, Version 2018.

South African National Biodiversity Institute. 2018. National Biodiversity Assessment: Terrestrial ecosystem threat status and protection level layer [Vector] 2018. Available from the Biodiversity GIS website, downloaded on 13 January 2023.

South African National Biodiversity Institute (SANBI). 2019. National Biodiversity Assessment 2018: The status of South Africa's ecosystems and biodiversity. Synthesis Report. South African National Biodiversity Institute, an entity of the Department of Environment, Forestry and Fisheries, Pretoria

South Africa. 1983. Conservation of Agricultural Resources Act 43 of 1983.

South Africa. 1998. National Environmental Management Act 107 of 1998.

South Africa. 1998. National Forest Act 84 of 1998.

South Africa. 1998. National Water Act 36 of 1998.

South Africa. 2009. National Environmental Management: Biodiversity Act no 10 of 2004.

South Africa. 2016. National Environmental Management: Biodiversity Act no 10 of 2004. Alien and invasive species lists, 2020.

Van Oudtshoorn, F. 2004. Gids tot grasse van Suider-Afrika. 2de uitg. Pretoria: Briza Publications.

Van Wyk, B. & Malan, S. 1998. Field guide to wild flowers of the Highveld. Second addition, second impression. Cape Town: Struik Publishers.