RENEWSTABLE BOKAMOSO:

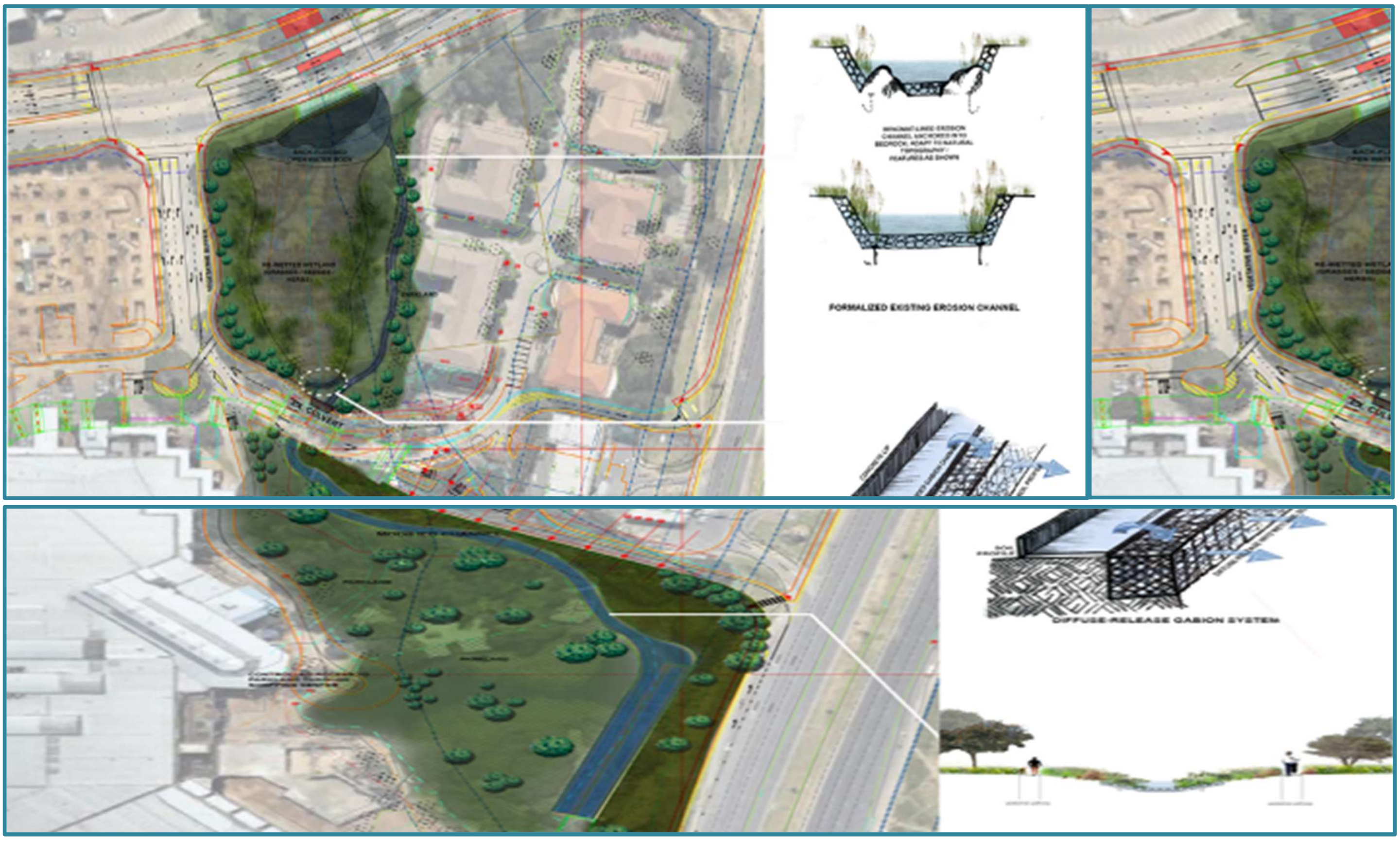
Wetland Baseline and Impact Assessment

Prepared for:

NSOVO ENVIRONMENTAL CONSULTING

Prepared by:

WaterMakers



July 2024

Declaration of Independence by Specialist

I, **WILLEM LUBBE**, in my capacity as a specialist consultant, hereby declare that I -

- act as an independent consultant;
- 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;
- declare that there are no circumstances that may compromise my objectivity in performing such work;
- do not have any financial interest in the undertaking of the activity, other than remuneration for the work performed in terms of the National Environmental Management Act, 1998 (Act 107 of 1998);
- have no, and will not engage in, conflicting interests in the undertaking of the activity;
- undertake to disclose, to the 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 National Environmental Management Act, 1998 (Act 107 of 1998);
- have expertise in conducting the specialist report relevant to this application, including knowledge of the National Environmental Management Act, 1998 (Act No. 107 of 1998), regulations and any guidelines that have relevance to the proposed activity;
- based on information provided to me by the project proponent and in addition to information obtained during the course of this study, have presented the results and conclusion within the associated document to the best of my professional ability;
- undertake to have my work peer reviewed on a regular basis by a competent specialist in the field of study for which I am registered; and
- as a registered member of the South African Council for Natural Scientific Professions, will undertake my profession in accordance with the Code of Conduct of the Council, as well as any other societies to which I am a member.

Willem Lubbe Pr.Sci.Nat
Wetland Specialist
SACNASP Reg. No. 004750

31/08/2023

Date

EXECUTIVE SUMMARY

HDF Energy proposes the development of a power plant that harnesses renewable energy from a Photovoltaic (PV) park and converts it into hydrogen using an electrolyser system. This hydrogen is stored in a compressed gas form. Subsequently, during periods when the photovoltaic park generates insufficient energy, the stored hydrogen is utilised to produce electricity for the grid through a fuel cell system. This innovative approach ensures a continuous and reliable power supply even when the PV park's energy production is inadequate. The proposed capacities generation consist of Renewstable® Bokamoso Power Plant.

Nsovo Environmental Consulting was contracted to review the area and conduct the Environmental Impact Assessment (EIA) on their behalf. Subsequently, WaterMakers was appointed by Nsovo Environmental Consulting as independent specialists to conduct the relevant wetland-related studies in order to facilitate the required environmental authorisation and water use licence processes. The present study represents the baseline and wetland impact assessment of the study and aims to inform responsible decision making with regards to the project

In order to enable an adequate description of potential wetland habitat and so as to ensure that the wetland study conducted is applicable for both an Environmental Authorisation as well as a Water Use Licence Application, the following approach was to be undertaken:

- Desktop assessment
- The wetland delineation should be conducted following the guidelines contained in the DWAF Guideline document entitled "A Practical Field Procedure for Identification and delineation of wetlands and riparian areas" (DWAF, 2008);
- Corroborate field and desktop data and classify confirmed wetlands into hydrogeomorphic units;
- Determine the functionality of wetlands, using a Level 2 Wet-EcoServices (Kotze *et al.*, 2005) assessment for wetlands within the study area;
- Determine the Present Ecological Status (PES) of identified wetlands within the study area through applying a Level 2 Wet-Health assessment (Macfarlane *et al*., 2008);
- Determine the Ecological Importance and Sensitivity (EIS) of identified wetlands by utilising methodology described by Rountree (2013);
- Determine and ground truth the NFEPA status of any wetlands on site, if any;
- Impact assessment for the proposed activities as well as potential mitigation measures.

A site visit to the area to be affected by the proposed activity was undertaken on the 31st of July as well as on the 23rd, 24th and 25th of August 2023. A detailed description of the methodology used to address the above Terms of Reference is provided in Appendix A.

Eight separate hydro-geomorphic units (HGM), comprising three HGM types, namely channelled valley bottom wetlands, hillslope seepage wetlands connected to a watercourse and depressions (pans), were delineated and classified within the study area and within one kilometre surrounding the study area.

Wetlands within the study area serve to improve habitat within and potentially downstream of the study area through the provision of various ecosystem services. Many of these functional benefits therefore contribute directly or indirectly to increased biodiversity within the study area as well as downstream of the study area through provision and maintenance of appropriate habitat and associated ecological processes

Combined area weighted Wet-Health results indicated that the wetlands from the study area have been moderately in most instances as a result of changes in water inputs (derived from its catchment) and water retention and distribution patterns within the wetlands units, as well as vegetation changes within the wetlands and surrounding catchments due to historic and current anthropogenic impacts, albeit relatively limited.

The valley bottom wetlands, were regarded as having a moderate to high Hydrological and Functional Importance as a result of the relatively intact nature and various important ecosystem services they provide. Direct human benefits were associated with the provision of natural resources as well as grazing opportunities afforded by most wetlands within the study area. Collectively, the valley bottom systems along with their supporting hillslope seepages, play an important role in contributing to good water quality and quantity to the downstream environment.

The moderate to high Ecological Importance and Sensitivity assigned to the hillslope seepage wetland units can be attributed to the relatively intact hydrological and geomorphological nature associated with the wetlands and their associated catchments. Most seepages have been heavily utilised for especially grazing which reduced the perceived biodiversity observed. However, as usual, further multiple seasonal biodiversity studies focused within wetland habitat would be required in order to increase the confidence levels with regards to the identification of species of conservation concern.

The depression wetland (pan) received low scores for the Hydrological and Functional Importance as well as their Ecological Importance and Sensitivity as a result of several anthropogenically driven impacts and incorporation into a cultivated productions area

The impact assessment identified the destruction of wetland habitat, surface water pollution including sedimentation as well as increased erosion, altered hydrological regimes, spread of invasive species and decreased downstream water quality as the major impacts during the construction and operational phase. Several general and specific mitigation measures were proposed in order to reduce negative impacts and incorporate some potentially positive impacts from the proposed development. Considering the erosive nature of the smectic clays on the terrain, erosion and sedimentation represents a very high risk on the study area, however, these aspects are very mitigatable through maintaining appropriate basal cover. It is thus essential to maintain a healthy diverse basal cover throughout the terrain, especially considering changes in micro climate due to increased shading of solar panels. These likely micro climate changes could potentially be beneficially utilised to help establish a higher ratio of increaser species through appropriate graminoid/veld management including seeding programs. Therefore, the most important mitigation measure was considered to be maintaining and improving the graminoid sward on terrain, leaving no cleared areas beneath or surrounding solar panels. Some other pertinent recommendations include:

- An appropriate wetland and terrestrial veld condition/basal cover monitoring and management program must be implemented prior to the start of the construction phase. It is recommended that local farmers familiar with local conditions and veld conservation techniques be incorporated in the management and utilisation of the grass sward on the terrain;

- Linear developments on terrain such as cabling must not concentrate surface and or subsurface flows, watercourses should receive surface and sub surface water diffusely as per the current hydrological regime. Keeping the graminoid layer intact and improving on veld condition and basal cover will assist a great deal towards achieving effective stormwater management. Where large areas of hardened surfaces are to be developed, SUDS based stormwater management plans must be developed for the specific terrain and approved by a suitably qualified wetland ecologist.
- The determined freshwater ecosystem buffer of a 35m must be implemented on all watercourses and be strictly enforced and appropriately managed.
- Active rehabilitation throughout the study area, but particularly in buffer zones and wetlands themselves should be initiated prior to the start of construction. Active rehabilitation to the graminoid layer within areas with low basal cover include reseeding, grazing exclusion, species diversification in order to be more resilient as well as increased monitoring for these sections. It is highly recommended that dense matts of *Pennisetum thunbergii* be planted within the buffer zones and any preferred drainage line or flow path, especially areas with low basal over and or areas exhibiting erosional processes, albeit even just slightly. The species seems to be very well adapted to the highly structured soils with inherently high swelling and shrinking properties typically leading to root pruning. The long rhizomes and high-density tufts that *Pennisetum thunbergii* forms increases the surface roughness and is ideal for erosion and run-off control. It is further recommended that these rehabilitation initiatives should take place well prior to construction to effect good establishment and afford the downstream freshwater resources the maximum protection.
- Watercourse crossings should be minimised and be designed perpendicular to the flow of the watercourse. Low-water bridges with permeable bases should be designed where appropriate and implemented in order to avoid concentrating flows. Flows exiting the bridge on the downstream side of the bridge should be diffused and span more than 80% of the width of the watercourse.
- Access roads must be designed in such a way to have a low impact on the veld condition/basal cover and hydrology of the terrain e.g. utilising grassed two tracks.

Considering all mitigation measures effectively and timeously implemented, flow regimes (including drivers), biota and water quality of the watercourses in the study area are unlikely to be observably affected or impacted, with no negative changes in watercourse PES, EIS or functionality of watercourses expected. However, a thorough wetland monitoring program must be designed and implemented prior to start of construction phase to ensure any negative impacts are detected and mitigated appropriately and timeously.

The DWS Risk Assessment Matrix, in terms of GA 509, calculated the significance of perceived impacts on the key drivers and receptors (hydrology, water quality, geomorphology, habitat and biota) of the freshwater resources assessed that is situated within 500m from the proposed development. These results are summarised in the tables presented in Appendix C. By assessing the severity, spatial scale, duration and frequency of the proposed infrastructure development, the risk to the potentially affected resource quality was determined to be low for all aspects during the construction and operational phases, assuming that all mitigation measures as proposed within the Impact assessment section of this report are adhered to. Considering all mitigation measures effectively and timeously implemented, flow regimes (including drivers), biota and water quality of the watercourses in the study area are unlikely to be observably affected or impacted, with no negative changes in watercourse PES, EIS or functionality of watercourses expected. However, a thorough wetland monitoring program must be designed and implemented prior to start of construction phase to ensure any negative impacts are detected and mitigated appropriately and timeously.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACRONYMS

CSIR	Council for Scientific and Industrial Research
DEA	Department of Environmental Affairs
DWA	Department of Water and Sanitation
DWS	Department of Water and Sanitation
EC	Ecological Category
FEPA	Freshwater Ecosystem Priority Area
GPS	Global Positioning System
HGM	Hydrogeomorphic
NBA	National Biodiversity Assessment
NFEPA	National Freshwater Ecosystem Priority Areas project
NWRS	National Water Resource Strategy
PES	Present Ecological State
SAIAB	South African Institute for Aquatic Biodiversity
SANBI	South African National Biodiversity Institute
SANParks	South African National Parks
VEGRAI	Vegetation Reponses Assessment Index
WMA	Water Management Areas
WRC	Water Research Commission
WWF	Worldwide Fund for Nature

1. INTRODUCTION

1.1 Project Description

HDF Energy proposes the development of a power plant that harnesses renewable energy from a Photovoltaic (PV) park and converts it into hydrogen using an electrolyser system. This hydrogen is stored in a compressed gas form. Subsequently, during periods when the photovoltaic park generates insufficient energy, the stored hydrogen is utilised to produce electricity for the grid through a fuel cell system. This innovative approach ensures a continuous and reliable power supply even when the PV park's energy production is inadequate. The proposed capacities generation consist of Renewstable® 78MVA Kwakhanya Power Plant as well as Renewstable® Bokamoso also a 78MVA Plant.

Nsovo Environmental Consulting was contracted to review the area and conduct the Environmental Impact Assessment (EIA) on their behalf. Subsequently, WaterMakers was appointed by Nsovo Environmental Consulting as independent specialists to conduct the relevant wetland-related studies in order to facilitate the required environmental authorisation and water use licence processes. The present study represents the baseline and wetland impact assessment of the study and aims to inform responsible decision making with regards to the project.

1.2 Scope of Work

In order to enable an adequate description of potential wetland habitat and so as to ensure that the wetland study conducted is applicable for both an Environmental Authorisation as well as a Water Use Licence Application, the following approach was to be undertaken:

- Desktop assessment
- The wetland delineation should be conducted following the guidelines contained in the DWAF Guideline document entitled “A Practical Field Procedure for Identification and delineation of wetlands and riparian areas” (DWAF, 2008);
- Corroborate field and desktop data and classify confirmed wetlands into hydrogeomorphic units;
- Determine the functionality of wetlands, using a Level 2 Wet-EcoServices (Kotze *et al.*, 2005) assessment for wetlands within the study area;
- Determine the Present Ecological Status (PES) of identified wetlands within the study area through applying a Level 2 Wet-Health assessment (Macfarlane *et al*., 2008);
- Determine the Ecological Importance and Sensitivity (EIS) of identified wetlands by utilising methodology described by Rountree (2013);
- Determine and ground truth the NFEPA status of any wetlands on site, if any;
- Impact assessment for the proposed activities as well as potential mitigation measures.

A site visit to the area to be affected by the proposed activity was undertaken on the 31st of July as well as on the 23rd, 24th and 25th of August 2023. A detailed description of the methodology used to address the above Terms of Reference is provided in Appendix A.

1.3 Assumptions and Limitations

During the course of the present study, the following limitations were experienced:

- In order to obtain definitive data regarding the biodiversity, hydrology and functioning of particular wetlands, studies should ideally be conducted over a number of seasons and over a number of years. The current study relied on information gained during a single field survey conducted during a single season, desktop information for the area, as well as professional judgment and experience;
- Wetland and riparian areas within transformed landscapes, such as urban and/or agricultural settings, or mining areas with existing infrastructure, are often affected by disturbances that restrict the use of available wetland indicators, such as hydrophytic vegetation or soil indicators (e.g. as a result of dense stands of alien vegetation, dumping, sedimentation, infrastructure encroachment and infilling). As such, wetland and riparian delineations as provided are based on indicators where available and the author's interpretation of the current extent and nature of the wetlands and riparian areas associated with the proposed activity;
- Some precision agricultural techniques such as topographical manipulation and soil redistribution ploughing were evident within the study area which in some instances could obscure pedological signs of wetness and hydric soil forms;
- Wetland and riparian assessments are based on a selection of available techniques that have been developed through the Department of Water and Sanitation (DWS). These methods are, however, largely qualitative in nature with associated limitations due to the range of interdisciplinary aspects that have to be taken into consideration. Current and historic anthropogenic disturbance within and surrounding the study area has resulted in soil profile disturbances as well as successional changes in species composition in relation to its original /expected benchmark condition;
- Delineations of wetland areas were largely dependent on the extrapolation of field indicator data obtained during field surveys, 5m contour data for the study area, and from interpretation of geo-referenced orthophotos and satellite imagery as well as historic aerial imagery data sets received from the National Department of Rural Development and Land Reform. As such, inherent ortho-rectification errors associated with data capture and transfer to electronic format are likely to decrease the accuracy of wetland boundaries in many instances; and
- Wetlands outside of the study area boundary was extrapolated using aerial imagery, although some sampling was done outside of the study boundaries in order to confirm findings and better interpret hydropedological characterisation of the study area.
- No other specialist studies were available at the time of writing this report to support findings for determining Ecological Importance and Sensitivity of watercourses. However, all watercourses within the study and within 500m from the study area were regarded as sensitive (with the exception of artificial wetland habitat).
- With regards to Ecological Importance and Sensitivity for pans, very little research has been conducted on the invertebrate biodiversity of endorheic and exhorheic depressions within South-Africa and therefore EIS within this report are based without any detailed aquatic assessment of invertebrate biodiversity.
- Although most of the main watercourses were described as wetlands (e.g. valley bottom wetlands0 large sections of these watercourses were dominated by riparian habitat ("non traditional riparian", thus riparian habitat dominated by graminoids). However, signs of wetness and hillslope driver processes were intermittently observed within these watercourses, a likely result of varying geology and intrusions between the dolerites. Therefore, a conservative approach was taken and classification were sided towards wetland classification as separating the various riparian versus wetland sections were not deemed practically or economically feasible.

- No hydropedological studies were available to confirm wetlands drivers and hydropedological responses associated with the terrain.
- A final impact assessment should be produced once the final lay-out, construction methodologies and operational management regimes pertaining to landscape maintenance are established.

2. GENERAL CHARACTERISTICS

2.1 Location

The proposed development is within the jurisdiction of Pixley Ka Seme Local Municipality which falls within the Gert Sibande District Municipality. The study site is located a few kilometres south of Amersfoort and adjacent (just north-east) of the Majuba Power Station (Figure 1). Approximate central co-ordinates for the study area are: 27° 4'34.73"S and 29°49'5.08"E

2.2 Biophysical Attributes

Climate

The climate for the study area was derived from recorded data (en.climate-data.org and worldweatheronline.com). The area around the study area receives seasonal summer rainfall and has generally very dry winters. Rainfall ranges between 620 – 750 mm, with the long term average around 650 mm. Most rain fall between November and March, peaking between December and February. Summer day temperatures fluctuate daily on average between 14°C and 25°C in January, but higher temperatures are experienced. The daily winter temperatures in July fluctuate on average between 1°C and 16°C. Incidence of frost is frequent which helps grasslands to persist.

2.2.2 Historic vegetation overview

Mpumalanga is known for its extensive grasslands and numerous wetlands, in which natural dominance of high shrubs and/or trees is largely prevented by frequent frost occurrences (and other factors) during winter, which tufted perennial grasses are better adapted to survive. Mpumalanga is host to approximately 21% of South Africa’s flora. The majority (64 %) of these plant species are soft herbs and bulbous plants (geophytes) situated in the grassland biome. The majority of these species remain dormant during winter or very dry seasons, and re-sprout during early summer if rains are sufficient.

The grassland biome is made up of a mosaic of many different vegetation types, which vary according to the prevailing abiotic conditions. According to the delineation of these vegetation types, as described and mapped for South Africa (in Mucina and Rutherford, 2006 and updated 2012 on BGIS), the study area was historically covered and surrounded with Amersfoort Highveld Clay Grassland as well as Eastern Temperate Freshwater Wetland (AZf 3) Vegetation (Mucina and Rutherford, 2006). Amersfoort Highveld Clay Grassland potentially include the following species:

Graminoids: *Aristida aequiglumis, A. congesta, A. junciformis subsp. galpinii, Brachiaria serrata, Cynodon dactylon, Digitaria monodactyla, D. tricholaenoides, Elionurus muticus, Eragrostis chloromelas, E. curvula, E. plana, E. racemosa, E. sclerantha, Heteropogon contortus, Loudetia simplex, Microchloa caffra,*

Monocymbium ceresiiforme, Setaria sphacelata, Sporobolus africanus, S. pectinatus, Themeda triandra, Trachypogon spicatus, Tristachya leucothrix, T. rehmannii, Alloteropsis semialata subsp. eckloniana.
Herbs*: Berkheya setifera , Haplocarpha scaposa , Justicia anagalloides , Pelargonium luridum, Acalypha angustata, Chamaecrista mimosoides, Dicoma anomala, Euryops gilfillanii, E. transvaalensis subsp. setilobus, Helichrysum aureonitens, H. caespititium, H. callicomum, H. oreophilum, H. rugulosum, Ipomoea crassipes, Pentanisia prunelloides subsp. latifolia, Selago densiflora, Senecio coronatus, Vernonia oligocephala, Wahlenbergia undulata.*
Geophytes: *Gladiolus crassifolius, Haemanthus humilis* subsp. *hirsutus, Hypoxis rigidula* var. *pilosissima, Ledebouria ovatifolia.*
Succulents: *Aloe ecklonis.*
Low Shrubs: *Anthospermum rigidum* subsp. *pumilum, Stoebe plumosa*.

Eastern Temperate Freshwater Wetlands are found on flat or gently undulating landscapes or shallow depressions filled with (temporary) water bodies such as pans, periodically flooded vleis, and edges of calmly flowing rivers that support zoned systems of aquatic and hygrophilous vegetation where grasslands are temporarily flooded. Dominant Taxa that can be expected in the different zones in wetlands include:

Marshes:
Graminoids: *Cyperus congestus, Agrostis lachnantha, Carex acutiformis, Eleocharis palustris, Eragrostis plana, E. planiculmis, Fuirena pubescens, Helictotrichon turgidulum, Hemarthria altissima, Imperata cylindrica, Leersia hexandra, Paspalum dilatatum, P. urvillei, Pennisetum thunbergii, Schoenoplectus decipiens, Scleria dieterlenii, Setaria sphacelata, Andropogon appendiculatus, A. eucomus*.
Herbs: *Centella asiatica, Ranunculus multifidus, Berkheya radula, B. speciosa, Berula erecta subsp. thunbergii, Centella coriacea, Chironia palustris, Equisetum ramosissimum, Falckia oblonga, Haplocarpha lyrata, Helichrysum difficile, H. dregeanum, H. mundtii, Hydrocotyle sibthorpioides, H. verticillata, Lindernia conferta, Lobelia angolensis, L. flaccida, Mentha aquatica, Monopsis decipiens, Pulicaria scabra, Pycnostachys reticulata, Rorippa fluviatilis var. fluviatilis, Rumex lanceolatus, Senecio inornatus, S. microglossus, Sium repandum, Thelypteris confluens, Wahlenbergia banksiana.*
Geophytes: *Cordylogyne globosa, Crinum bulbispermum, Gladiolus papilio, Kniphofia ensifolia, K. fluviatilis, K. linearifolia, Neobolusia tysonii, Satyrium hallackii* subsp. *hallackii.*

Reed and sedge beds:
Graminoids: *Phragmites australis, Schoenoplectus corymbosus, Typha capensis, Cyperus immensus. Carex rhodesiaca.*

Water bodies:
Aquatic Herbs: *Aponogeton junceus, Ceratophyllum demersum, Lagarosiphon major, L. muscoides, Marsilea capensis, Myriophyllum spicatum, Nymphaea lotus, N. nouchali var. caerulea, Nymphoides thunbergiana, Potamogeton thunbergii.*
Carnivorous Herb: *Utricularia inflexa.*
Herb: *Marsilea farinosa* subsp. *farinosa*. (Mucina & Rutherford, 2006).

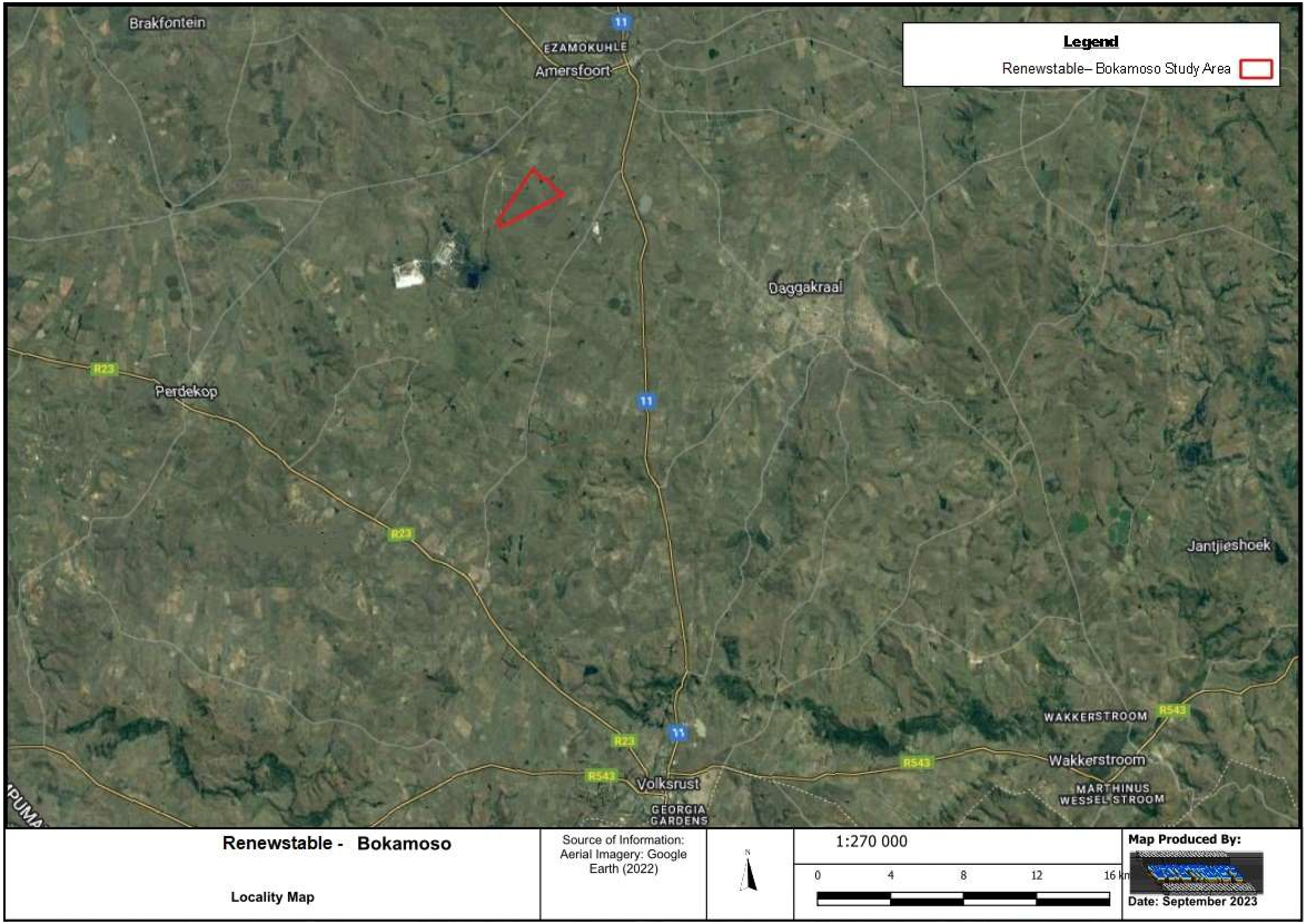


Figure 1: Locality map for the study area

2.2.3 Geology

Geology underlying the study area is made up of dolerite from Karoo Dolerite Suite of the Jurassic era, which in turn overlays the bluish grey-dark grey mudstone and shales as well as subordinate siltstone of the Volksrust formation (Ecca Group, Karoo Supergroup) from the Permian era. The dolerite intrusions are indicated on the 1:250,000 Geological map for the study area (2628 Frankfort; Department of Mines – Geological Survey (Figure 2).

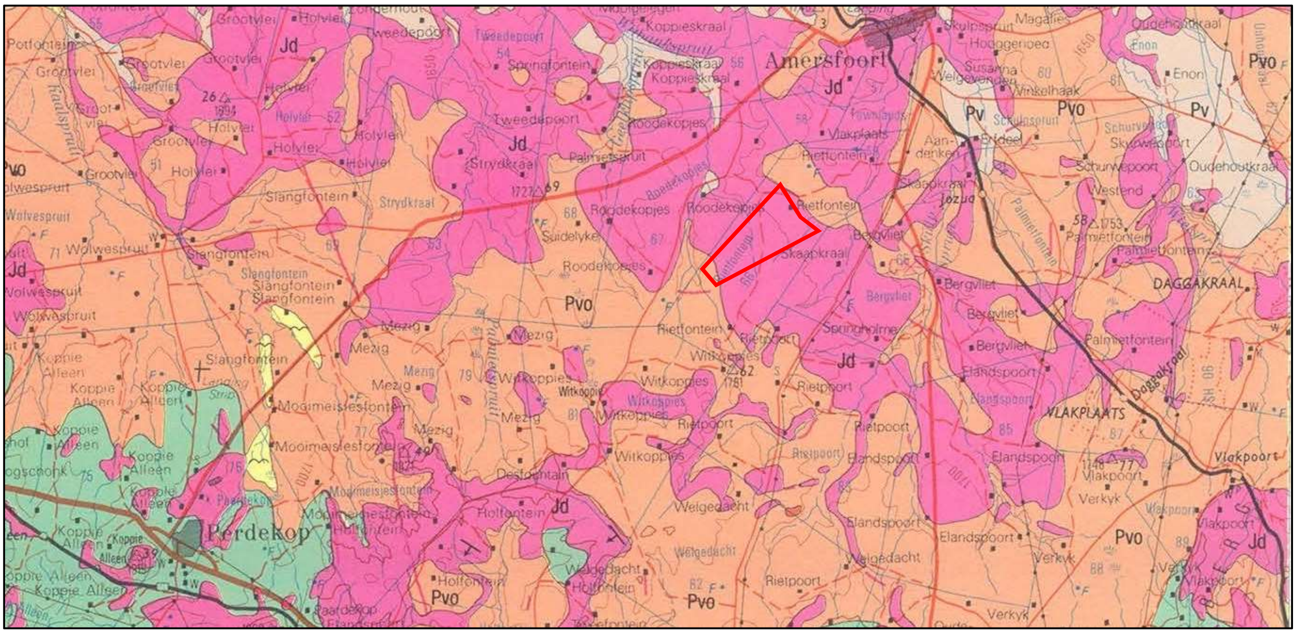


Figure 2: Geology of the study area (2728 Frankfort 1:250 000; Department of Mines – Geological Survey) with the approximate study area indicate by red polygon of the map inset

2.2.4 Associated Aquatic Ecosystems and Drainage

The NWRS-1 (National Water Resource Strategy, Version 1) originally established 19 Water Management Areas (WMA) within South Africa and proposed the establishment of the 19 Catchment Management Agencies to correspond to these areas. In rethinking the management model and based on viability assessments with respect to water resources management, available funding, capacity, skills and expertise in regulation and oversight, as well as to improve integrated water systems management, the original 19 designated WMAs have been consolidated into nine WMAs. Renewstable Kwakhanya and Bokamoso is situated in Quaternary catchments C11E and C11J in the Upper Vaal Water Management Area (WMA) which is situated in the north eastern part of South Africa, in the Mpumalanga Province. The western side of the study area drains into the Geelklipspruit whereas the eastern section off the study area drains into the Skulpspruit. Both Geelklipspruit and Skulpspruit eventually drains into the Vaal River approximately 30km north of the study area.

2.2.5 National Freshwater Ecosystem Priority Areas

The National Freshwater Ecosystem Priority Areas (NFEPA) project represents a multi-partner project between the Council for Scientific and Industrial Research (CSIR), South African National Biodiversity Institute

(SANBI), Water Research Commission (WRC), Department of Water Affairs (DWA; now Department of Water and Sanitation, or DWS), Department of Environmental Affairs (DEA), Worldwide Fund for Nature (WWF),

South African Institute of Aquatic Biodiversity (SAIAB) and South African National Parks (SANParks). More specifically, the NFEPA project aims to:

- Identify Freshwater Ecosystem Priority Areas (hereafter referred to as 'FEPAs') to meet national biodiversity goals for freshwater ecosystems; and
- Develop a basis for enabling effective implementation of measures to protect FEPAs, including free-flowing rivers.

The first aim uses systematic biodiversity planning to identify priorities for conserving South Africa's freshwater biodiversity, within the context of equitable social and economic development. The second aim comprises a national and sub-national component. The national component aims to align DWS and DEA policy mechanisms and tools for managing and conserving freshwater ecosystems. The sub-national component aims to use three case study areas to demonstrate how NFEPA products should be implemented to influence land and water resource decision-making processes at a sub-national level (Driver et al., 2011). The project further aims to maximize synergies and alignment with other national level initiatives such as the National Biodiversity Assessment (NBA) and the Cross-Sector Policy Objectives for Inland Water Conservation.

Based on current outputs of the NFEPA project (Nel et al., 2011; Figure 3), no FEPA wetlands or wetland clusters were located within the study area or within several kilometres from the study area. (Figure 3).

2.2.6 Wetland Vegetation Group

According to Nel et al. (2011), the study area falls within the Mesic Highveld Grassland Group 8 wetland vegetation group. According to Macfarlane et al. (2014), the Mesic Highveld Grassland Group 8 wetland vegetation group is regarded as being Least Threatened (Macfarlane et al., 2014).

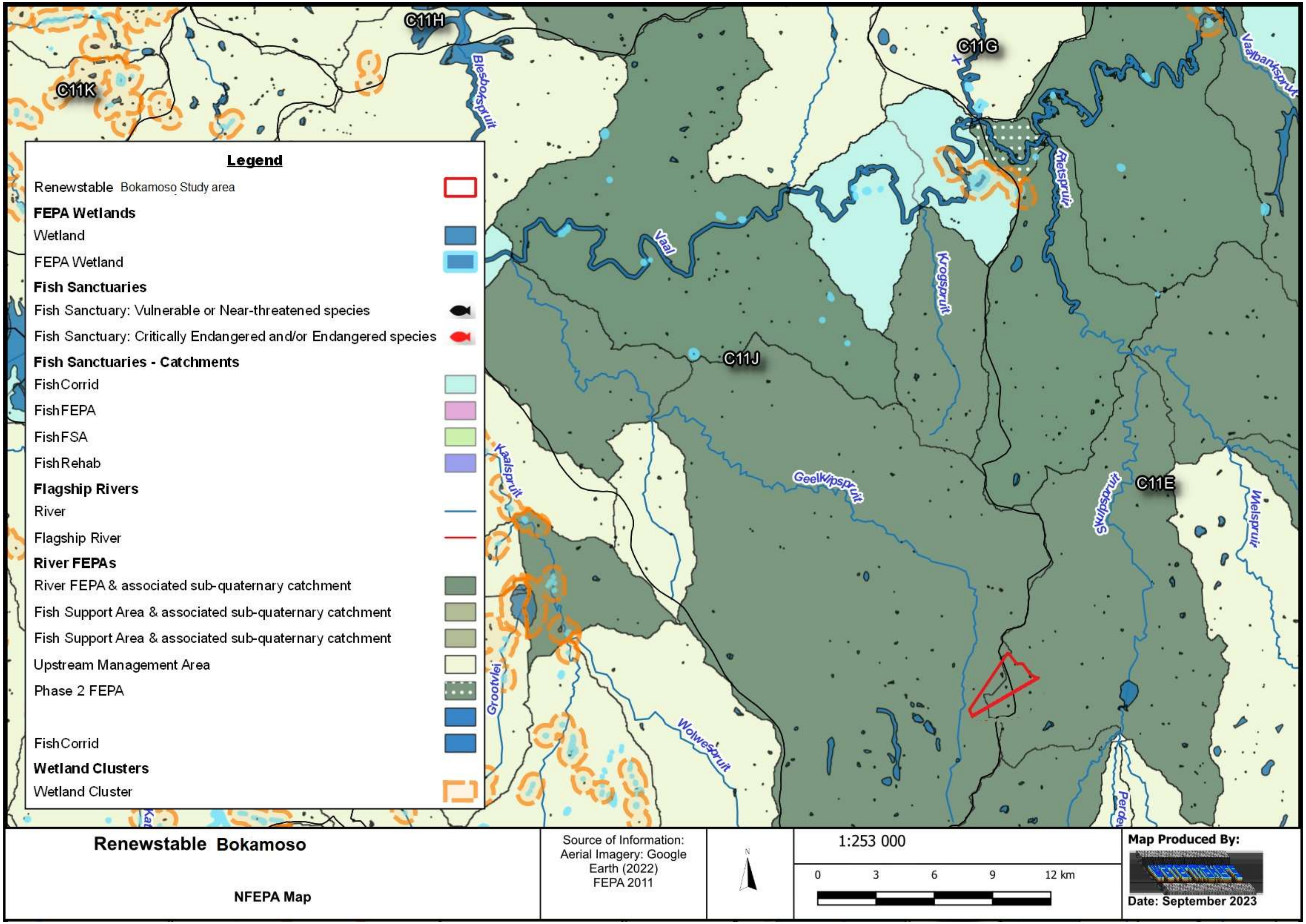


Figure 3: NFEPA map indicating closest FEPA features in relation to the study area.

3. ASSOCIATED WETLANDS

3.1 Wetland soils and hydropedological response of terrain

According to the Department of Water Affairs and Forestry (2005), the permanent zone of a wetland will always have either Champagne, Katspruit, Willowbrook or Rensburg soil forms present, as defined by the Soil Classification Working Group (1991). The seasonal and temporary zones of the wetlands will have one or more of the following soil forms present (signs of wetness incorporated at the form level): Kroonstad, Longlands, Wasbank, Lamotte, Estcourt, Klapmuts, Vilafontes, Kinkelbos, Cartref, Fernwood, Westleigh, Dresden, Avalon, Glencoe, Pinedene, Bainsvlei, Bloemdal, Witfontein, Sepane, Tukulu, Montagu. Alternatively, the seasonal and temporary zones will have one or more of the following soil forms present (signs of wetness incorporated at the family level): Inhoek, Tsitsikamma, Houwhoek, Molopo, Kimberley, Jonkersberg, Groenkop, Etosha, Addo, Brandvlei, Glenrosa, Dundee (Department of Water Affairs and Forestry, 2005). Hydric soil forms identified within the study area included the soil forms Avalon, Bainsvlei, Bloemdal, Dresden, Glencoe, Glenrosa, Katspruit, Rensburg, Longlands, Westleighs, Tukula, Kroonstad, Sepane and Wasbank.

The site’s geology comprises igneous dolerite which dominates the site and gives rise to typically dark coloured well-structured soils. Topsoil horizons were dominated by smectic vertic and melanic horizons leading to Arcadia, Bonheim and Mayo terrestrial soil forms dominating many sections of the landscape. The bluish grey-dark grey mudstone and shales also had a significant influence on some sections of the landscape giving rise to clayey soils albeit grey in all instances (which made it very difficult to distinguish and pick up on gleyed soils, pertinent to wetland delineation differentiation).

Poorly drained soils were observed within the lower lying positions of the landscape which included valley bottom and hillslope seepage wetlands and comprising mostly of the Rensburg and Willowbrook soil forms (Figure 4). The Katspruit soil form also contains a G horizon with marked gleyed features indicative of a permanent wetland zone, the Katspruit soil form was mostly observed in hillslope seepage habitat in the eastern section the study area.

Figure 4: Rensburg soil form in the study area

Terrestrial soils within the majority of the wetland catchment were well to very well structured, likely leading to high surface runoff during precipitation events, which was also likely why very few interflow soils were observed within the study area. The smectic high shrinking and swelling properties contained in many sections of the study area are also highly erosive and requires plants adopted to the root pruning effect of these soils (Figure 5).

Figure 5: A simple cattle path tuning into an erosion gully due the smectic properties of soils dominating the study area, this should serve as a warning to construction approaches within the study area

Avalon, Katspruit, Rensburg and Willowbrook soil forms were regarded as hydric soil forms associated with wetland habitat.

According to the DWAF (2005), soil wetness indicators (i.e. identification of redoximorphic features) are the most important indicator of wetland occurrence due to the fact that soil wetness indicators remain in wetland soils in most instances, even if they are degraded or desiccated. It is important to note that the presence or absence of redoximorphic features within the upper 500mm of the soil profile alone is sufficient to identify the soil as being hydric (a wetland soil), or non-hydric (non-wetland soil) (Collins, 2005). Redoximorphic features were present within soil profiles of the disturbed valley bottom wetland as well as within the hillslope seepage wetland including black, orange and red mottles and rhizospheres (Figure 5).

Redoximorphic features are the result of the reduction, translocation and oxidation (precipitation) of iron and manganese oxides that occur when soils are saturated for sufficiently long periods of time to become anaerobic. Redoximorphic features typically occur in three types (Collins, 2005):

- **A reduced matrix** - i.e. an *in situ* low chroma (soil colour), resulting from the absence of Fe^{3}+ ions which are characterised by "grey" colours of the soil matrix (Figure 6).
- **Redox depletions** - the "grey" (low chroma) bodies within the soil where Fe - Mn oxides have been stripped out, or where both Fe-Mn oxides and clay have been stripped. Iron depletions and clay depletions can occur.
- **Redox concentrations** - Accumulation of iron and manganese oxides (also called mottles). These can occur as:

- Concretions - harder, regular shaped bodies;
- Mottles - soft bodies of varying size, mostly within the matrix, with variable shape appearing as blotches or spots of high chroma colours (Figure 6); and,
- Pore linings – zones of accumulation that may be either coatings on a pore surface, or impregnations of the matrix adjacent to the pore. They are recognised as high chroma colours that follow the route of plant roots, and are also referred to as oxidised rhizospheres

Figure 6: Reduced matrix (grey) with orange and yellow mottles as well as black manganese concretions observable within an augered soil sample from the permanent zone of a hillslope seepage wetland northwest of terrain.

Landscapes within the study were largely dominated by soils that will class as responsive soils according to van Tol, and Le Roux (2019), the hydropedological grouping of South African soil forms Overland flow- will thus dominate on these responsive soils, both as infiltration excess in the arcadia and saturation in the Rensburg. The smectitic clay swells when saturated, causing a dramatic decrease in infiltration. The low infiltration then causes the overland flow. The Gley horizon under the Vertic horizons could be cause by returnflow from intrusions and small recharge areas. Ponding is highly likely on these soils due to the slow infiltration and water then accumulates in micro depressions on low gradient micro-topography.

3.2 Wetland Vegetation

According to the Department of Water Affairs and Forestry (2005), vegetation is regarded as a key component to be used in the delineation procedure for wetlands. Vegetation also forms a central part of the wetland definition in the National Water Act (Act 36 of 1998). Using vegetation as a primary wetland indicator however, requires undisturbed conditions (Department of Water Affairs and Forestry, 2005). A cautionary approach must therefore be taken as vegetation alone cannot be used to delineate a wetland, as several species, while common in wetlands, can occur extensively outside of wetlands. When examining plants within a wetland, a distinction between hydrophilic (vegetation adapted to life in saturated conditions) and upland species must be kept in mind.

There is typically a well-defined 'wetness' gradient that occurs from the centre of a wetland to its edge that is characterized by a change in species composition between hydrophilic plants that dominate within the wetland to upland species that dominate on the edges of, and outside the wetland (Department of Water Affairs and Forestry, 2005). It is important to identify the vegetative indicators which determine the three wetness zones (temporary, seasonal and permanent) which characterize wetlands. Each zone is characterized by different plant species which are uniquely suited to the soil wetness within that zone.

Areas identified within the study area with permanent zonation and associated high water tables contained hydrophylic plants such as *Typha capensis, Persicaria lapathifolia, Persicaria* sp., *Phragmites australis*, as well as grasses and sedges such as *Hemarthria altissima* and *Agrostis lachnanta. Typha capensis, Persicaria lapathifolia* and *Phragmites australis* were able to grow in water of up to 50cm deep while areas with standing water of up to 20cm was dominated by graminoids and geophytes such as *Schoenoplectus brachyceras, Berkheya sp, Lobelia angolensis*. *Agrostis lachnanta*, an obligatory wetland species, was present in all three wetland zones but flourished more abundantly in seasonal zones. Temporary and seasonal wetland zones were dominated by grass species such as *Eragrostis curvula, E. cloromelas, Eragrostis* spp., *Pennisetum clandestinum, Cynodon dactylon, Andropogeon eucomus* as well as sedges such as *Bulbostylis* sp., *Pycereus* sp*.* A stand of Populus sp. was observed within hillslope seepage habitat of the study area (Figure 7).

Figure 7: Hillslope seepage naturally dominated by graminoids, not the clumps of *Populus* sp. on the very far right of the picture

Identified riparian habitats associated with the study area were dominated by graimnoids such as*, Agrostis* sp*., Eragrostis plana, Arisitada junciformis, Eragrostis curvula, Erogrostis chloromelas Eragrostis* spp., *Paspalum dilatum* and *Themeda triandra.* Although many of the above species was also found within terrestrial habitat, individuals within the riparian habitat grew with a lot more vigour than their terrestrial counterparts.

3.3 Delineated Wetland Areas

According to the National Water Act (Act no 36 of 1998), 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 supports or would support vegetation typically adapted to life in saturated soil*." Wetlands typically occur on the interface between aquatic and terrestrial habitats and therefore display a gradient of wetness – from permanent, to seasonal, to temporary zones of wetness - which is represented in their plant species composition, as well as their soil characteristics. It is important to take cognisance of the fact that not all wetlands have visible surface water. An area which has a high water table at or just below the surface of the soil is as much a wetland as a pan that only contains water for a few weeks during the year.

Hydrophytes and hydric soils are subsequently used as the two main wetland indicators. The presence of these two indicators is symptomatic of an area that has sufficient saturation to classify the area as a wetland. Terrain unit, which is another indicator of wetland areas, refers to the land unit in which the wetland is found.

In practice all indicators should be used in any wetland assessment/delineation exercise, the presence of redoximorphic features being most important, with the other indicators being confirmatory. An understanding of the hydrological processes active within the area is also considered important when undertaking a wetland assessment. Indicators should be 'combined' to determine whether an area is a wetland and to delineate the boundary of a wetland. According to Department of Water Affairs and Forestry (2005), the more wetland indicators that are present the higher the confidence of the delineation. In assessing whether an area is a wetland, the boundary of a wetland or a non- wetland area should be considered to be the point where indicators are no longer present. Classification for the purpose of the current project therefore focused on classifying watercourses according to the most dominant hydrological and geomorphological drivers, especially in terms of relating potential impacts of the potential development on especially the watercourses associated with the study area. Wetland boundaries determined within the study area focused on identifying terrain units, soil forms, perceived organic content and the presence of vegetation species that are adapted to saturated conditions.

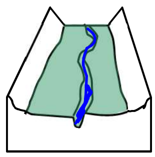
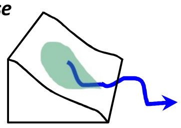
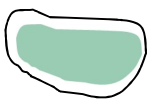
Eight separate hydro-geomorphic units (HGM), comprising three HGM types, namely channelled valley bottom wetlands, hillslope seepage wetlands connected to a watercourse and depressions (pans), were delineated and classified within the study area and within one kilometer surrounding the study area (Figure 11). HGM 1, a hillslope seepage was subdivided into three hydrogeomorphic units (HGM 1a, HGM 1b and HGM 1c) as a result of variability of terrain units and soils observed within the hillslope seepage complex. HGM 1a was supported by subsurface return flows and contained permanent and seasonal hydrological signatures. HGM 1b consisted of a more temporary / ephemeral system which is likely hydrologically mostly supported by surface run-off. HGM 1c consist of a 'saddlebag' wetland which currently receive leaking piped water and is likely naturally mostly supported through surface run-off processes. Although most of the main watercourses were described as wetlands (e.g. valley bottom wetlands, large sections of these watercourses were dominated by riparian habitat ("non-traditional riparian", thus riparian habitat dominated by graminoids). However, signs of wetness and hillslope driver processes were intermittently observed within these watercourses, a likely result of varying geology and intrusions between the dolerites. Therefore, a conservative approach was taken and classification were sided towards wetland classification as separating the various riparian versus wetland sections were not deemed practically or economically feasible.

HGM units encompass three key elements (Kotze *et al.*, 2005):

(1) Geomorphic setting. This refers to the landform, its position in the landscape and how it evolved (e.g. through the deposition of river borne sediment);
(2) Water source. There are usually several sources, although their relative contributions will vary amongst wetlands, including precipitation, groundwater flow, stream flow, etc.; and
(3) Hydrodynamics, which refers to how water moves through the wetland.

Table 1 describes the characteristics that form the basis for the classification of the HGM units within the study area. The disturbance caused by anthropogenic impacts and resulting successional vegetation changes made the use of vegetation indicators complex in various circumstances, especially on the temporary boundaries of wetlands. Therefore, identifying wetland features on site was primarily done by identifying terrain unit, soil forms and soil wetness features such as the presence of mottling, a gleyed matrix and/or Fe and Mg concretions. However, vegetation indicators did confirm to delineated boundaries and wetness zonation in many instances. Further, the exact extent of hydrological features could not always be determined due to subtle landscape gradients combined with various disturbances. Also, it is possible that many of the delineated channelled valley bottom wetlands were unchanneled valley bottom wetlands historically, especially upper catchments and sections of the systems (historic aerial imagery only dates back to the 1960's).

Table 1: Wetland hydro-geomorphic types typically supporting inland wetlands in South Africa within the vicinity of the study area (adapted from Kotze et al., 2008)

Hydro-geomorphic types	**Description**	**Source of water maintaining the wetland**[1]	
		Surface	**Sub-surface**
Valley bottom with a channel 	Valley bottom areas with a well defined stream channel but lacking characteristic floodplain features. May be gently sloped and characterized by the net accumulation of alluvial deposits or may have steeper slopes and be characterized by the net loss of sediment. Water inputs from main channel (when channel banks overspill) and from adjacent slopes.	***	*/ ***
Hillslope seepage feeding a watercourse 	Slopes on hillsides, which are characterized by the colluvial (transported by gravity) movement of materials. Water inputs are mainly from sub-surface flow and outflow is usually via a well defined stream channel connecting the area directly to a watercourse.	*	***
Depression (includes Pans) 	A basin shaped area with a closed elevation contour that allows for the accumulation of surface water (i.e. it is inward draining). It may also receive sub-surface water. An outlet is usually absent.	*/ ***	*/ ***

[1] Precipitation is an important water source and evapotranspiration an important output in all of the above settings

Water source:	*	Contribution usually small
	***	Contribution usually large
	*/ ***	Contribution may be small or important depending on the local circumstances
	Wetland	

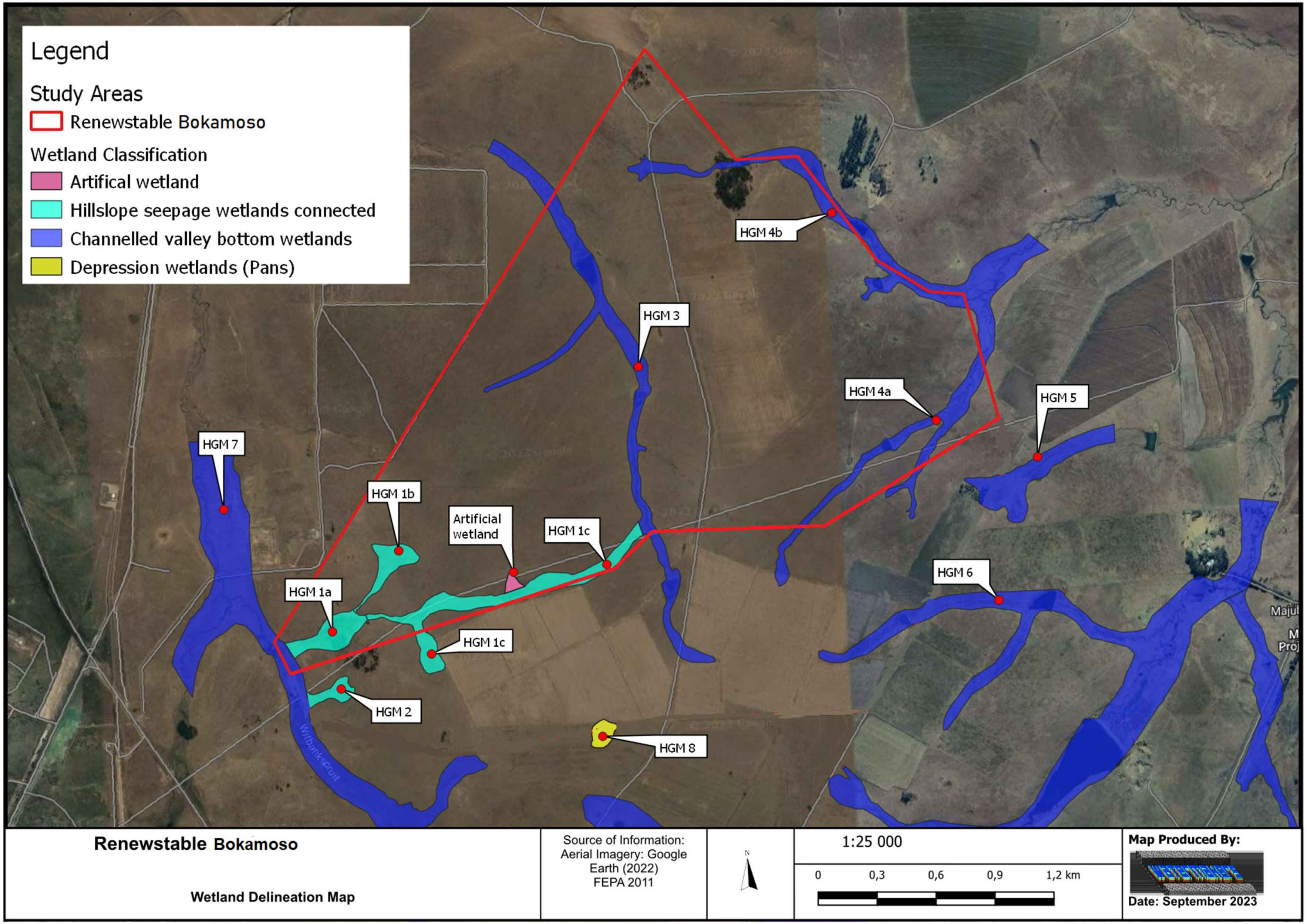


Figure 8: Delineated wetlands within the study area and within one kilometre

3.4 Functional and Present Ecological State Assessment

Wetlands within the study area serve to improve habitat within and potentially downstream of the study area through the provision of various ecosystem services. Many of these functional benefits therefore contribute directly or indirectly to increase biodiversity within the transformed study area as well as downstream of the study area through provision and maintenance of appropriate habitat and associated ecological processes (Table 2).

Hydro-geomorphic units are inherently associated with hydrological characteristics related to their form, structure and particularly their position in the landscape. This, together with the biotic and abiotic character (or biophysical environment) of wetlands, means that certain wetland types are able to contribute better to some ecosystem services than to others (Kotze et al., 2005) (Table 3).

Table 2: Potential wetland services and functions in study area

Function	Aspect
Water balance	Streamflow regulation
	Flood attenuation
	Groundwater recharge
Water purification	Nitrogen removal
	Phosphate removal
	Toxicant removal
	Water quality
Sediment trapping	Particle assimilation
Harvesting of natural resources	Reeds, Hunting, etc.
Foraging	Water for animals
	Grazing for animals

Table 3: Preliminary rating of the hydrological benefits potentially provided by a wetland given its particular hydro-geomorphic type (Kotze *et al*., 2005)

WETLAND HYDRO-GEOMORPHIC TYPE	HYDROLOGICAL BENEFITS POTENTIALLY PROVIDED BY THE WETLAND							
	Flood attenuation		Stream flow regulation	Erosion control	Enhancement of water quality			
	Early wet season	Late wet season			Sediment trapping	Phos-phates	Nitrates	Toxicants[2]
Valley bottom - channelled	+	0	0	++	+	+	+	+
Hillslope seepage feeding a stream channel	+	0	+	++	0	0	++	++
Pan/ Depression	+	+	0	0	0	0	+	+

[2]Toxicants are taken to include heavy metals and biocides

Rating: 0 Benefit unlikely to be provided to any significant extent
+ Benefit likely to be present at least to some degree
++ Benefit very likely to be present (and often supplied to a high level)

Each wetland's ability to contribute to ecosystem services within the study area is also dependant on the particular wetland's Present Ecological State (PES) in relation to a benchmark or reference condition. Present Ecological State scores were determined for wetlands within the study area using Wet-Health Level 2 assessment. Through the use of a scoring system, the perceived departure of elements of each particular system from the "natural-state" was determined (current state versus anticipated future rehabilitated state).

The following elements were considered in the assessment:

- Hydrologic: Flow modification (has the flow, rates, volume of run-off or the periodicity changed);
- Geomorphic (Canalisation, impounding, topographic alteration and modification of key drivers);
- Biota (Changes in species composition and richness, Invasive plant encroachment, over utilization of biota and land-use modification)

For the purpose of the present assessment, the determined Present Ecological State and wetland ecosystem services provided by wetlands within the study area are discussed in more detail below.

3.4.1 Hillslope Seepage Wetlands connected to a watercourse

The highest scoring eco-services attributes for hillslope seepage wetlands within the study area (HGM 1a, HGM 1b, HGM 1c) were nitrate removal, streamflow regulation, and provision of natural resources (Figure 9, Figure 10; Figure 11; Figure 12). The accumulation of organic matter and fine sediments in the wetland soils results in the wetland slowing down the sub-surface movement of water down the slope. This "plugging effect" increases the storage capacity of the slope above the wetland and prolongs the contribution of water to the stream system during low flow periods (Kotze, 2005). Seepage wetlands are commonly considered to supply a number of water quality enhancement benefits, for example, removing excess nutrients and inorganic pollutants produced by agriculture, industry and domestic waste (Rogers *et al*., 1985; Gren, 1995; Ewel, 1997; Postel, 1997). Hillslope seepage wetlands generally would be expected to have a relatively high nitrogen removal potential. Nitrogen, and specifically nitrate removal, could be expected as the groundwater emerges through low redox potential zones within the wetland soils, with the wetland plants contributing to the necessary supply of organic carbon. Particularly effective removal of nitrates has been recorded from diffuse sub-surface flow, as characterizes hillslope seepages (Muscutt *et al*., 1993). The extensive commercial maize production taking place within the catchment of the seepage wetlands and within some of the seepage wetlands themeselves would likely act as a considerable source of nitrates and phosphates through fertilizer application. The seepage wetlands are expected to contribute to biodiversity through serving as a movement corridor for several species as well as through the provision of habitat (for species of conservation concern e.g. *Crinum bulbispermum* and *Disa* sp.). Further, from a natural resource utilisation perspective, most seepage wetlands within the study area were highly utilised for grazing.

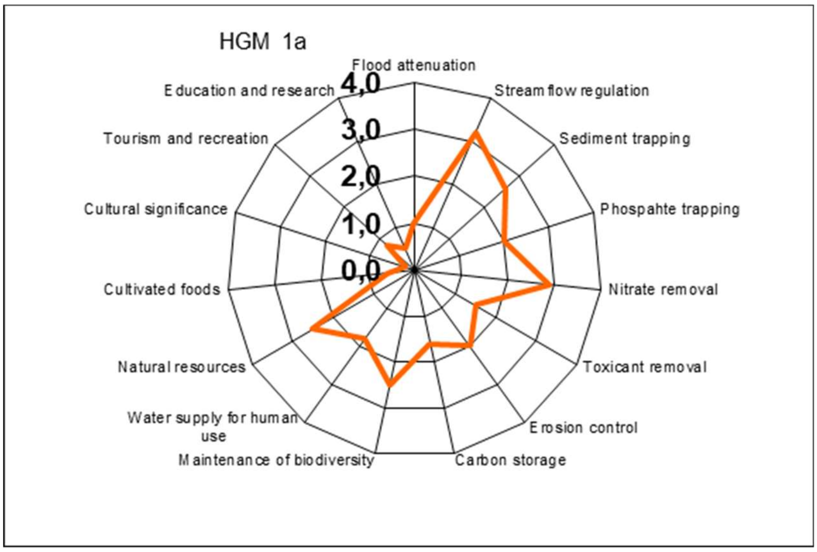


Figure 9: Radar diagrams depicting ecosystem services for HGM 1a within the study area

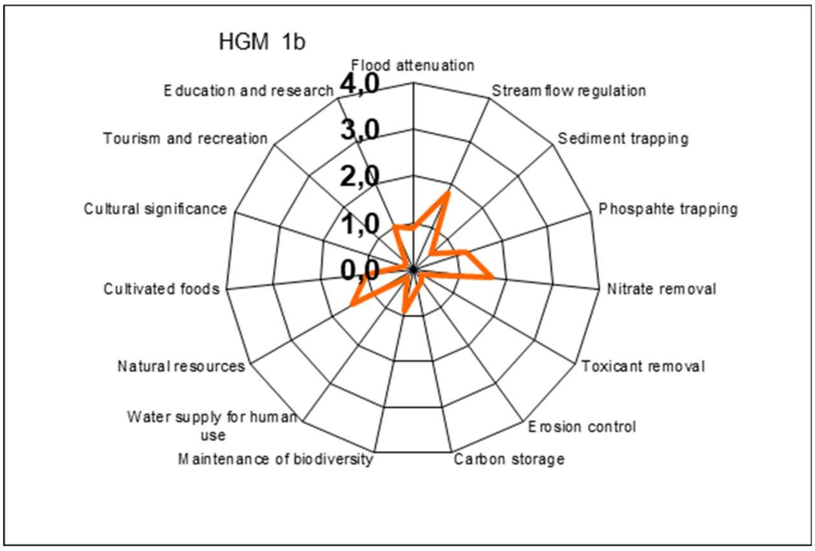


Figure 10: Radar diagrams depicting ecosystem services for HGM 1b within the study area

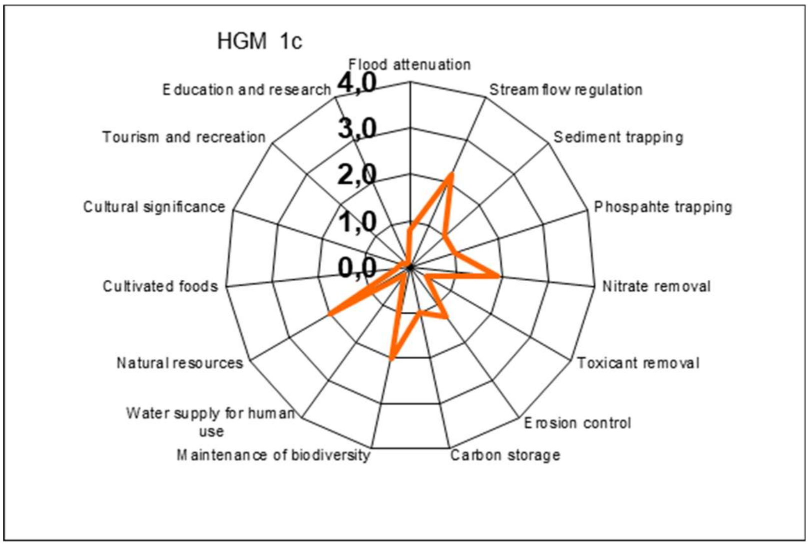


Figure 11: Radar diagrams depicting ecosystem services for HGM 1c

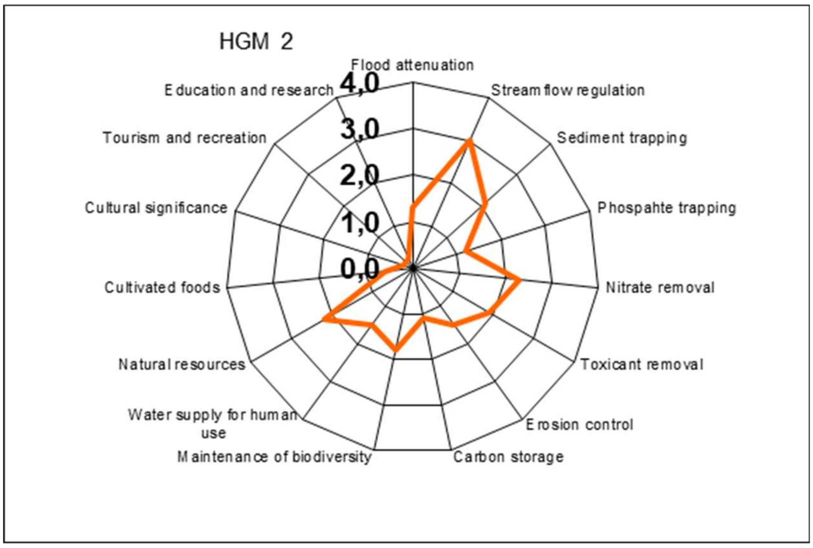


Figure 12: Radar diagrams depicting ecosystem services for HGM 2

PES scores obtained for the hydrology module indicated that water inputs (derived from the wetlands' respective catchments) and water retention and distribution patterns within most hillslope seepages within the study area have been moderately to largely modified. Some small scale historic contouring and draining were observed in HGM 1c, which is typically designed to reduce moisture regimes within the seepage wetlands. Such practices can have severe impacts on the geomorphology of affected wetlands, thereby greatly reducing the wetlands water retention capacity and ability to provide various other functions. Further, where preferential flow paths from fields enter seepages with a lower gradient, sediment deposition tends to occur, causing changes to the vegetation composition and geomorphology. However, the scale of impact was still considered to be moderate.

Vegetation composition changes of the hillslope seepage wetlands was one of the main drivers of the Present Ecological State category obtained for most of these wetlands. Due to the nature of historic and current land uses within the catchment, species composition within the wetlands is expected to have changed relative to the perceived natural condition of the wetlands. Surface roughness within the wetlands have also been reduced as a result of heavy grazing regimes. Further, invasive alien vegetation included *Verbena bonarienses*, especially in disturbed areas as well as clumps of *Populus* sp. located close to old homesteads.

PES scores obtained for HGM 1a , HGM 1b, HGM 1c and HGM 2 are indicated in Table 4.

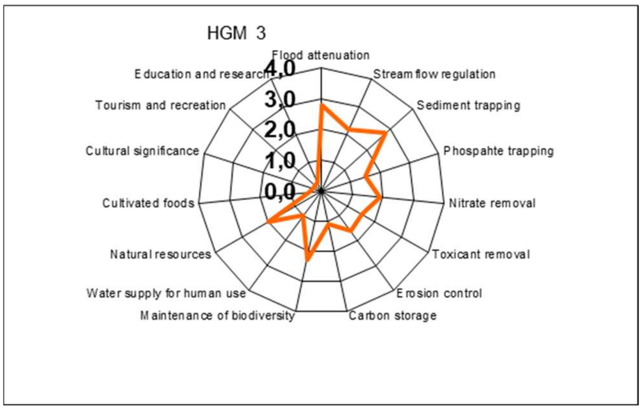
Table 4: Wet-Health scores for HGM 1a, HGM 1b, HGM 1c and HGM 2

HGM Unit	Hydrology	Geomorphology	Vegetation	PES category
HGM 1a	3.0	2.5	6.0	**C (3.7)**
HGM 1b	2.0	2.0	4.0	**C (2.6)**
HGM 1c	2.0	2.0	4.5	**C (2.7)**
HGM 2	2.5	2.0	5.0	**C (3.1)**

3.4.2 Valley-bottom Wetlands

The channelled valley bottom wetlands (HGM 3, HGM 4, HGM 5, HGM 6 and HGM 7) received its highest ecosystem services scores from the Wet-EcoServices assessment for flood attenuation, sediment trapping, erosion control, maintenance of biodiversity, carbon storage and the provision of natural resources (Figure 13; Figure 14; Figure 15). The relatively relaxed gradient associated within several sections of these valley bottom wetlands would allow for high levels of sediment deposition. Stream channel input will be spread diffusely across the wetlands even in low flows, resulting in extensive areas of the wetlands remaining saturated and tending to have high levels of soil organic matter. During flow events shallow water pools are present which would promote sunlight penetration, contributing to the photodegradation of certain toxicants. In addition there are also several farm dams with shallow water sections which would also further facilitate photodegradation processes.

The valley bottom wetlands occupied a relatively wide area with a relaxed gradient that would have played a significant role in flood attenuation. However, phosphate retention levels would of likely been lower than in floodplains because a certain amount of phosphate may be re-mobilized under prolonged anaerobic conditions (Cronk and Siobhan Fennessy, 2001; Keddy, 2002). The valley bottom wetlands are intermittently supported by subsurface water flows including a lateral seepage component from the adjacent hillslopes as well as small return flows via the vadose zone which would enhance the wetlands importance for stream flow regulation albeit much less than for example hillslopes with a plinthic catena. Some nitrate and toxicant removal potential would be expected, particularly from the water being delivered from the adjacent hillslopes as well as a few open water bodies present (The Federal Interagency Stream Restoration Working Group, 1998). From a biodiversity perspective, the potential exist that species of conservation concern may be present despite the majority of the wetlands being intensely utilised for grazing. Further, the valley bottom network serves as a movement corridor for fauna to connect terrestrial grassland and wetland habitat to each other.



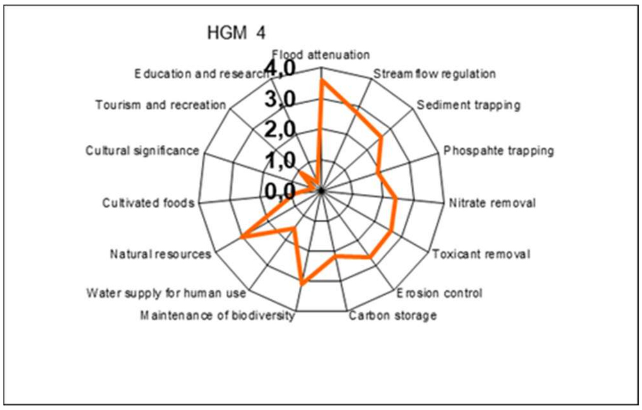
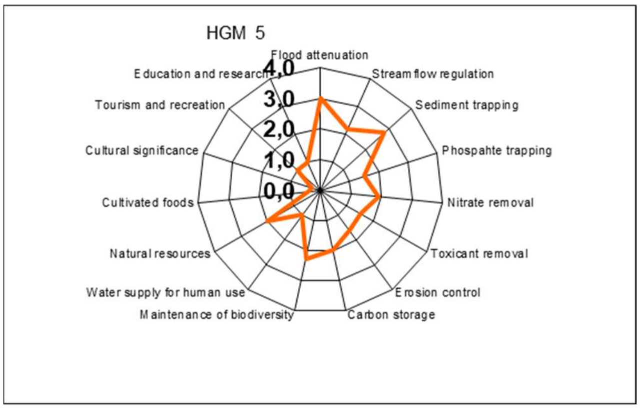


Figure 13a&b Radar diagrams depicting ecosystem services for HGM 3 and HGM 4 within the study area



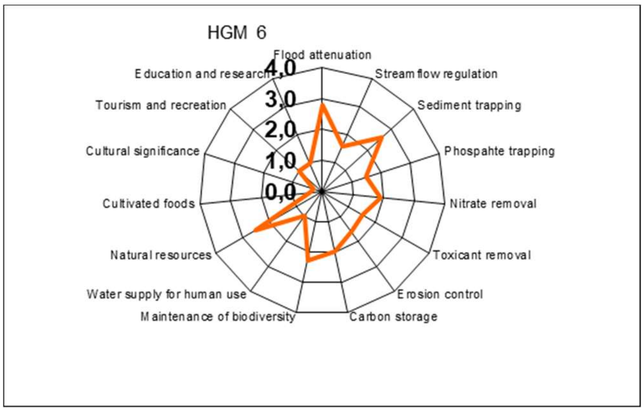


Figure 14 a&b: Radar diagrams depicting ecosystem services for HGM 5 and HGM 6 within the study area

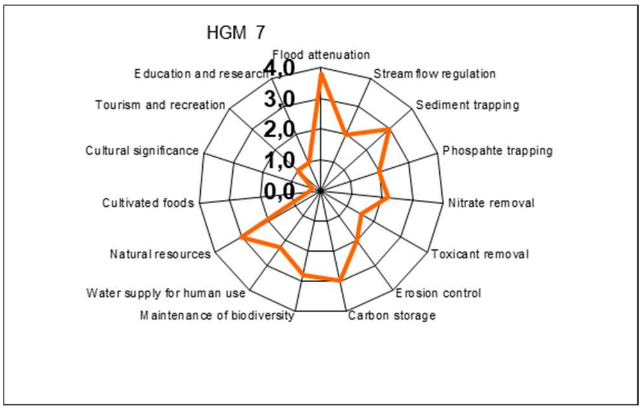


Figure 15: Radar diagrams depicting ecosystem services for HGM 7

Historic and current impacts on the wetland in combination with land use changes in the surrounding catchment resulted in geomorphological, hydrological and vegetation changes within the valley bottom wetlands. Impact on the hydrology of the valley bottom wetlands included evidence of channel formation within most reaches of the watercourses. Channel formation was attributed to concentrated dam outflow as well as concentrated preferential pathways formed from road crossings and especially cattle paths and disturbances. Further, within the valley bottom wetland's catchments, decreased surface roughness associated with extensive fields, dirt roads, negative successional vegetation changes as well as some of the supporting seepage wetlands with decreased basal cover were determined to contribute to a lower hydrological score obtained within the valley-bottom wetlands.

From a geomorphological perspective, the highest impact calculated within the valley bottom wetlands were related to altered runoff characteristics, which are likely to affect several sections of the wetland as a result of erodible soils. Further impacting features with regards to the geomorphology included the presence of dams (excavations), roads (excavations and infill), and some limited erosional features, although their magnitude of impact were determined to be limited in several instances due to the average gully width in relation to the width of the wetlands.

Due to the nature of historic and current land uses within the catchment, species composition within the wetlands is expected to have changed relative to the perceived natural condition of the wetlands, especially as a result of overgrazing practices.

Based on the assessment of the individual drivers of the wetlands, the Present Ecological State for HGM 1, HGM 2 and HGM 3 were determined to be representative of a Category C (moderately modified), with HGM 4 representing a Category D (largely modified) (Table 5).

Table 5: Wet-Health scores for HGM 1, HGM 2, HGM 3 and HGM 4

HGM Unit	**Hydrology**	**Geomorphology**	**Vegetation**	**PES category**
HGM 3	2.0	2.5	3.0	**C (2.4)**
HGM 4	2.0	2.0	4.0	**C (2.6)**
HGM 5	2.0	2.0	3.5	**C (2.4)**
HGM 6	2.0	2.5	4.5	**C (2.9)**
HGM 7	2.5	2.0	3.6	**C (2.7)**

3.4.3 Depression Wetlands (Pans)

The depression wetland (pan), received its highest ecosystem services scores for sediment trapping, erosion control and maintenance of biodiversity, albeit limited in all circumstances as a result of anthropogenic impacts through repeatedly applied cultivation practices (Figure 16).

Depressions can receive both surface and subsurface flows (not likely due to structured soils), which accumulate in the depression owing to a generally impervious underlying layer which prevents the water draining away (Kotze *et al*., 2005). Some nitrate removal could be expected through diffuse subsurface flows, especially where pans are associated with lateral and hillslope seepages. Pans capture runoff because of their inward draining nature, and thus they reduce the volume of surface water which would otherwise reach the stream system during storm events (Kotze *et al*., 2005). This also adds to the erosion control benefits performed by these type of wetlands. In addition, several waterfowl species could potentially utilise the pans during the summer. The pan is likely utilised for grazing purposes within the study area while some sections of especially their temporary zonation have been converted to fodder production.

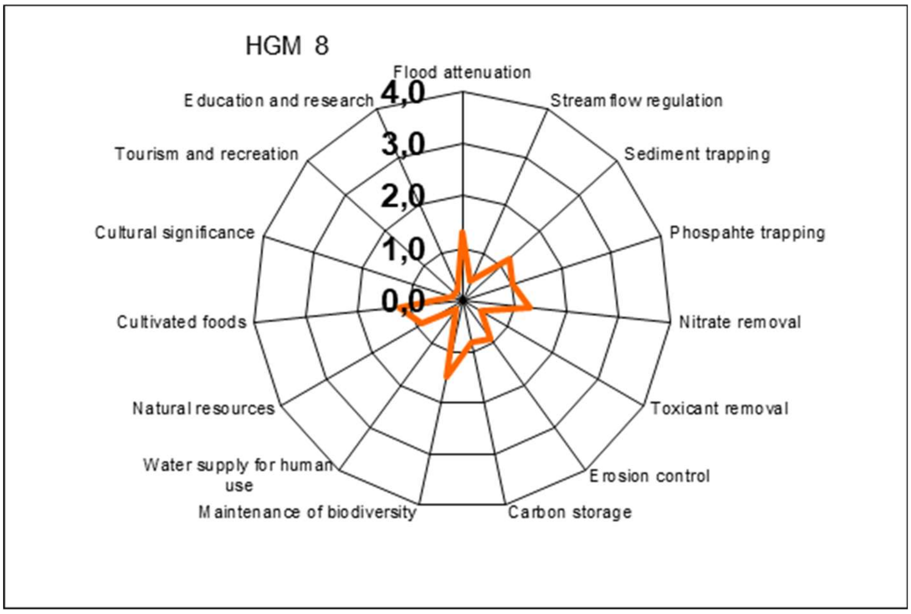


Figure 16: Radar diagrams depicting ecosystem services for HGM 8

From a hydrological perspective, the largest impact on the pan within the study area was changes in land use through agriculture. Cultivated production occupies a large portion of the pan's catchments and fodder production has also infringed on most of the pan. It would be anticipated that cultivated production resulted in changes to surface roughness and thereby impacted on water quality through changes in surface run-off characteristics and sediment transport.

It should however be noted that, according to the Macfarlane *et al.* (2009), the Wet-Health approach is applicable for the assessment of the Present Ecological State for all wetland types. However, for the assessment of wetlands not connected to a drainage network (such as endorheic pans), the geomorphology module could be excluded from the assessment, thus focussing on hydrology and vegetation for the determination of Present Ecological State (Macfarlane *et al.,* 2009). However, in the hydrology module, the scoring of "modification of existing channels" for evaluating changes to water distribution and retention patters within a wetland, and the scoring of "reduced floodpeaks" as a criterion in the evaluation of changes to water input characteristics from the catchment are not relevant for systems that do not form an intrinsic part of a drainage network (Ollis and Malan, 2014). In reality, this method is therefore most appropriate for the assessment of floodplain and valley-bottom wetlands (channelled and unchannelled), and (to a lesser degree) hillslope seeps connected to a drainage network, while it is not particularly well suited to the assessment of depressions (especially endorheic pans), wetland flats, or seeps that are not integrally connected to a watercourse (Ollis and Malan, 2014). As such, the application of the Wet-Health approach for the purpose of determining the PES of depression wetlands should be interpreted with caution.

Vegetation composition changes of the pan was one of the main drivers of the Present Ecological State category obtained due to the whole pan being incorporated into cultivation. Due to the nature of historic and current land uses within the catchment, species composition within the wetlands is expected to have changed significantly relative to the perceived natural condition of the wetland. PES and associated wetland functionality for wetlands were therefore reduced as a result of these anthropogenic impacts, with the wetlands scoring a PES Category C D, representing a largely modified systems (Table 6).

Table 6: PES scores obtained for HGM 28 to HGM 38

HGM Unit	Hydrology	Geomorphology	Vegetation	PES category
HGM 8	3.5	3	9.5	**C (5.1)**

3.5 Ecological Importance and Sensitivity

All wetlands, rivers, their flood zones and their riparian areas are protected by law and no development is allowed to negatively impact on rivers and river vegetation. The vegetation in and around rivers and drainage lines play an important role in water catchments, assimilation of phosphates, nitrates and toxins as well as flood attenuation. Quality, quantity and sustainability of water resources are fully dependent on good land management practices within the catchment. All flood lines, riparian zones and wetlands along with corresponding buffer zones must be designated as sensitive.

The Ecological Importance and Sensitivity (EIS) assessment was undertaken to rank water resources in terms of:

- Provision of goods and service or valuable ecosystem functions which benefit people;
- biodiversity support and ecological value; and
- Reliance of subsistence users (especially basic human needs uses).

Water resources which have high values for one or more of these criteria may thus be prioritised and managed with greater care due to their ecological importance (for instance, due to biodiversity support for endangered species), hydrological functional importance (where water resources provide critical functions upon which people may be dependent, such as water quality improvement) or their role in providing direct human benefits (Rountree et al., 2013). Ecological Importance and Sensitivity results for wetlands identified to be associated with the study area are listed in Table 7.

Table 7: Ecological Importance and Sensitivity scores for wetland complexes

Wetland	Parameter	Rating (0 -4)	Confidence (1 – 5)
HGM 1a	Ecological Importance & Sensitivity	Moderate (2.6)	Low (1.2)
	Hydrological / Functional Importance	High (3.0)	Moderate (2.1)
	Direct Human Benefits	Moderate (2.3)	Moderate (2.0)
HGM 1b	Ecological Importance & Sensitivity	Moderate (2.5)	Low (1.2)
	Hydrological / Functional Importance	Moderate (2.2)	Moderate (2.1)
	Direct Human Benefits	Moderate (2.2)	Moderate (2.0)

HGM 1c	Ecological Importance & Sensitivity	Moderate (2.1)	Low (1.2)
	Hydrological / Functional Importance	High (3.0)	Moderate (2.1)
	Direct Human Benefits	Moderate (2.3)	Moderate (2.0)
HGM 2	Ecological Importance & Sensitivity	Moderate (2.5)	Low (1.2)
	Hydrological / Functional Importance	High (3.0)	Moderate (2.1)
	Direct Human Benefits	Moderate (2.5)	Moderate (2.0)
HGM 3	Ecological Importance & Sensitivity	Moderate (2.6)	Low (1.2)
	Hydrological / Functional Importance	Moderate (2.1)	Moderate (2.0)
	Direct Human Benefits	Moderate (2.0)	Moderate (2.0)
HGM 4	Ecological Importance & Sensitivity	Moderate (2.0)	Low (1.2)
	Hydrological / Functional Importance	Moderate (2.9)	Moderate (2.0)
	Direct Human Benefits	Moderate (2.4)	Moderate (2.0)
HGM 5	Ecological Importance & Sensitivity	Moderate (2.6)	Low (1.2)
	Hydrological / Functional Importance	Moderate (2.1)	Moderate (2.0)
	Direct Human Benefits	Moderate (2.0)	Moderate (2.0)
HGM 6	Ecological Importance & Sensitivity	Moderate (2.1)	Low (1.2)
	Hydrological / Functional Importance	Moderate (2.0)	Moderate (2.0)
	Direct Human Benefits	Moderate (2.2)	Moderate (2.0)
HGM 7	Ecological Importance & Sensitivity	Moderate (2.0)	Low (1.2)
	Hydrological / Functional Importance	Moderate (2.4)	Moderate (2.0)
	Direct Human Benefits	Moderate (2.2)	Moderate (2.0)
HGM 8	Ecological Importance & Sensitivity	Low (1.4)	Low (1.2)
	Hydrological / Functional Importance	Low (1.1)	Moderate (2.0)
	Direct Human Benefits	Low (1.0)	Moderate (2.0)

The valley bottom wetlands, were regarded as having a moderate to high Hydrological and Functional Importance as a result of the relatively intact nature and various important ecosystem services they provide. Direct human benefits were associated with the provision of natural resources as well as grazing opportunities afforded by most wetlands within the study area. Collectively, the valley bottom systems along with their supporting hillslope seepages, play an important role in contributing to good water quality and quantity to the downstream environment.

The moderate to high Ecological Importance and Sensitivity assigned too the hillslope seepage wetland units can be attributed to the relatively intact hydrological and geomorphological nature associated with the wetlands and their associated catchments. Most seepages have been heavily utilised for especially grazing which reduced the perceived biodiversity observed. However, as usual, further multiple seasonal biodiversity studies focused within wetland habitat would be required in order to increase the confidence levels with regards to the identification of species of conservation concern.

The depression wetland (pan) received low scores for the Hydrological and Functional Importance as well as their Ecological Importance and Sensitivity as a result of several anthropogenically driven impacts and incorporation into a cultivated productions area.

4. FRESHWATER ECOSYSTEM BUFFERS

Buffer zones associated with water resources have been shown to perform a wide range of functions, and have been proposed as a standard measure to protect water resources and associated biodiversity on this basis. These functions can include (Macfarlane & Bredin, 2016):

- Maintaining basic aquatic processes;
- Reducing impacts on water resources from upstream activities and adjoining land uses;
- Providing habitat for aquatic and semi-aquatic species;
- Providing habitat for terrestrial species; and
- A range of ancillary societal benefits.

However, despite the range of functions potentially provided by buffer zones, buffer zones are unable to address all water resource-related problems. For example, buffers can do little to address impacts such as hydrological changes caused by for example stream flow reduction activities or changes in flow brought about by abstractions or upstream impoundments. Buffer zones are also not the appropriate tool for mitigating against point-source discharges (e.g. sewage outflows), which can be more effectively managed by targeting these areas through specific source-directed controls (Macfarlane & Bredin, 2016).

Nevertheless, buffer zones are well suited to perform functions such as sediment trapping and nutrient retention which can significantly reduce the impact of activities taking place adjacent to water resources. Buffer zones are therefore proposed as a standard mitigation measure to reduce impacts linked with diffuse storm water runoff from land-uses / activities planned adjacent to water resources. These must, however, be considered in conjunction with other mitigation measures which may be required to address specific impacts for which buffer zones are not well suited (Macfarlane & Bredin, 2016).

Determination of the preliminary buffer requirements for riparian features associated with the proposed study area followed the approach of Macfarlane & Bredin (2016), whereby the preliminary required buffers were developed based on various factors, including assumed agricultural impacts, slope, annual precipitation, rainfall intensity, channel width, catchment to wetland ratio, etc. Accordingly, conservative preliminary buffer requirements for the identified wetland habitat were determined to be between 29m to 35m from the edge of the watercourses for the majority of the site. The figure stems from the relatively good veld condition of the catchments of the wetland habitat. A general freshwater ecosystem buffer of a 35m was therefore decided in order to facilitate a more functional buffer logistically (Figure 17). Further, active rehabilitation to the graminoid layer within areas with low basal cover include reseeding, grazing exclusion, species diversification in order to be more resilient as well as increased monitoring for these sections. It is highly recommended that dense matts of *Pennisetum thunbergii* be planted within the buffer zones and any preferred drainage line or flow path, especially areas with low basal over and or areas exhibiting erosional processes, albeit even just slightly. The species seems to be very well adapted to the highly structured soils with inherently high swelling and shrinking properties typically leading to root pruning. The long rhizomes and high-density tufts that *Pennisetum thunbergii* forms increases the surface roughness and is ideal for erosion and run-off control. It is further recommended that these rehabilitation initiatives should take place well prior to construction to effect good establishment and afford the downstream freshwater resources the maximum protection.

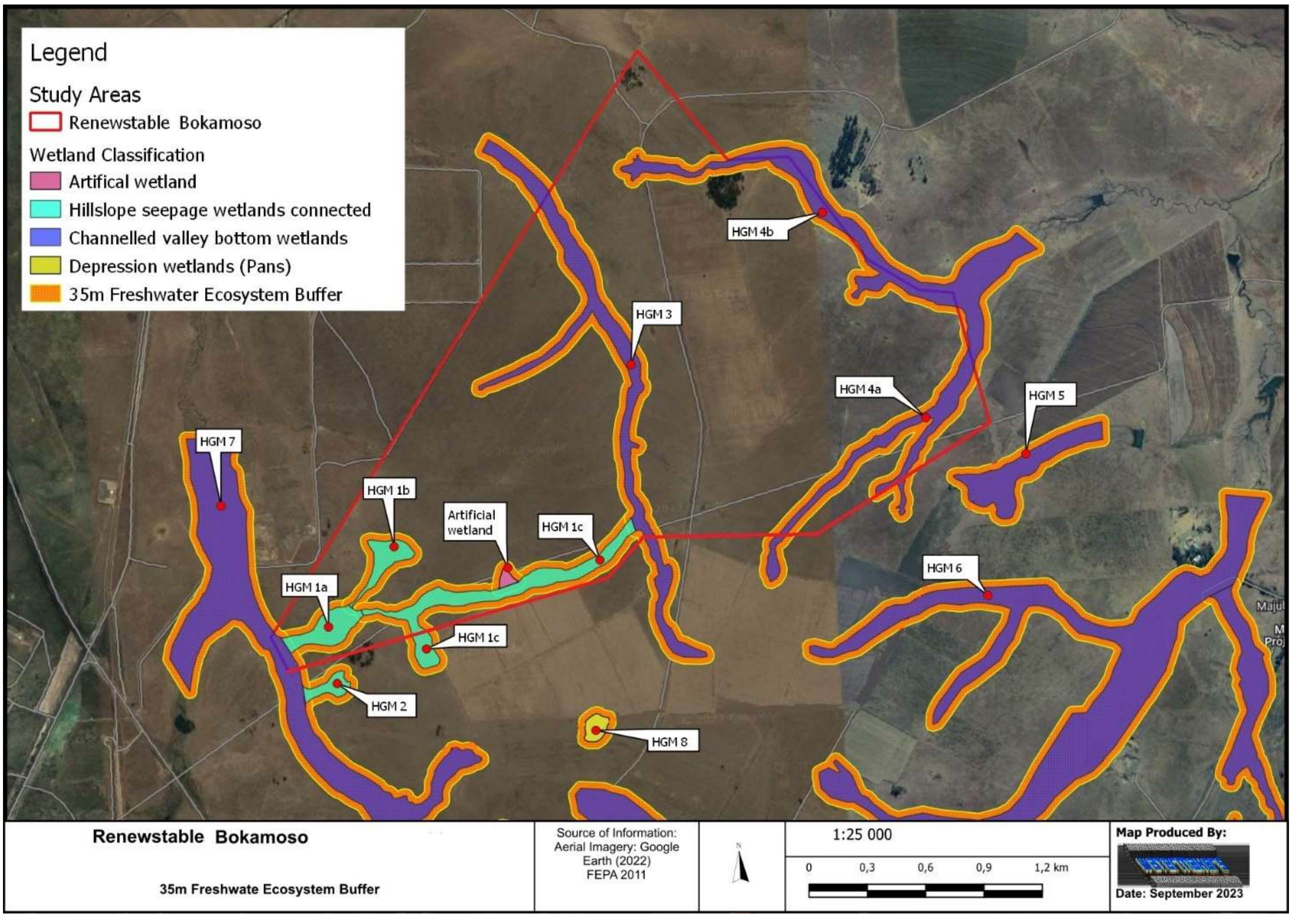


Figure 17: 35m Freshwater Ecosystem Buffer

5. PRELIMINARY ASSESSMENT OF IMPACTS

Any developmental activities in a natural system will have an impact on the surrounding environment, usually in a negative way. The purpose of this phase of the study was to identify and assess the significance of the potential impacts caused by the proposed activities and to provide a description of potential mitigation required so as to limit the perceived impacts on the natural environment. As the final baseline assessments are yet to still inform the final design and impact assessment, this pre-liminary impact assessment aim to guide the development to avoid unnecessary impacts and enhance potential positive outcomes from the proposed development. A final impact assessment should be produced once the final lay-out, construction methodologies and operational management regimes pertaining to landscape maintenance are established.

5.1 Impact Assessment Methodology

The environmental impacts are assessed with mitigation measures (WMM) and without mitigation measures (WOMM) and the results presented in impact tables which summarise the assessment. Mitigation and management actions are also recommended with the aim of enhancing positive impacts and minimising negative impacts.

In order to assess these impacts, the proposed development has been divided into two project phases, namely the construction and operational phase. The criteria against which these activities were assessed are discussed below.

Nature of the Impact
This is an appraisal of the type of effect the project would have on the environment. This description includes what would be affected and how and whether the impact is expected to be positive or negative.

Extent of the Impact
A description of whether the impact will be local, limited to the study area and its immediate surroundings, regional, or on a national scale.

Duration of the Impact
This provides an indication of whether the lifespan of the impact would be short term (0-5 years), medium term (6-10 years), long term (>10 years) or permanent.

Intensity
This indicates the degree to which the impact would change the conditions or quality of the environment. This was qualified as low, medium or high.

Probability of Occurrence
This describes the probability of the impact actually occurring. This is rated as improbable (low likelihood), probable (distinct possibility), highly probable (most likely) or definite (impact will occur regardless of any prevention measures).

Degree of Confidence
This describes the degree of confidence for the predicted impact based on the available information and level of knowledge and expertise. It has been divided into low, medium or high.

The following risk assessment was used to determine the significance of impacts:

Significance = (Magnitude + Duration + Scale) x Probability

The maximum potential value for significance of an impact is 100 points. Environmental impacts can thus be rated as high, medium or low significance on the following basis:

- High environmental significance 60 – 100 points
- Medium environmental significance 30 – 59 points
- Low environmental significance 0 – 29 points

Table 8 illustrates the scale used to determine the overall ranking.

Table 8: Scale used to determine significance ranking

Magnitude (M)		**Duration (D)**	
Description	**Numerical value**	**Description**	**Numerical value**
Very high	10	Permanent	5
High	8	Long-term (ceases at end of operation)	4
Moderate	6	Medium-term	5-15 years
Low	4	Short-term	0 – 5 years
Minor	2	Immediate	1
Scale (S)		**Probability (P)**	
Description	**Numerical value**	**Description**	**Numerical value**
International	5	Definite (or unknown)	5
National	4	High	4
Regional	3	Medium	3
Local	2	Low	2
Site	1	Improbable	1
None	0	None	0

5.2 Impact Assessment

Possible impacts and their sources associated with the proposed activities are provided in Table 9 (construction phase) and Table 10 (operational phase). Some of the impacts are relevant during more than one phase and has therefore only been described once under the initial phase. The mitigation hierarchy has been applied through the application of the recommended freshwater ecosystem buffer of 35m from the edge of all watercourses, thereby avoiding direct impacts such as destruction of wetland habitat.

Table 9: Possible impacts arising during the construction phase

Possible impact	Source of impact
Sedimentation of watercourse	Runoff from construction activities associated with clearing of natural vegetation
Increased erosion and increased run-off received by water courses	Heavy machines clearing vegetation for construction

Introduction and spread of invasive vegetation	Disturbance / destruction of indigenous vegetation making ecosystem vulnerable to invasions
Impacts on ground and surface water quality as well as soils	Activities of workforce, e.g., concrete mixing and sediment release including hydrocarbon spillages

Table 10: Possible additional impacts arising during the operational phase

Possible impact	Source of impact
Altered hydrological regime	The establishment of hardened surfaces and reduced basal cover leads to increased stormwater runoff volume and intensity and reduced subsurface flow supporting slow release mechanism, could potentially negatively affect watercourse systems downstream. In addition the possibility of water and sewage infrastructure leaks should also be considered.

5.2.1 Construction phase

Sedimentation of watercourse

	Scale	Duration	Magnitude	Probability of occurrence	Significance	Confidence
Without mitigation measures	Regional (3)	Medium-term (3)	High (8)	Definite (5)	High (70)	High
With mitigation measures	Local (2)	Short-term (2)	Low (4)	Low (2)	Low (16)	Moderate

<u>Description of Impact</u>

The clearing of natural vegetation and the stripping of topsoil will result in increased runoff of sediment from the site into watercourses downstream of the study area, particularly during times of high rainfall. Water flowing down trenches and access roads, as well as movement of construction vehicles and personnel, could cause additional sediment to accumulate within downstream wetland areas. The potential siltation of wetland systems downstream would alter geomorphologic functioning, the movement of water through the system (hydrological functioning) as well as having an impact on water quality within the resource. Considering the erosive nature of the smectic clays on terrain, sedimentation represents a high risk, however it is very mitigatable through maintaining appropriate basal cover. It is thus essential to maintain a healthy diverse basal cover throughout the terrain, especially considering changes in micro climate due to increased shading of solar panels. These likely micro climate changes could potentially be beneficially utilised to help establish a higher ratio of increaser species through appropriate graminoid/veld management including a seeding program. Therefore, the most important mitigation measure is considered to be maintaining and improving the graminoid sward on terrain, with no cleared areas beneath solar panels.

Mitigation Measures

- Management has a responsibility to inform staff of the need to be vigilant against any practice that will have a harmful effect on wetlands.
- An effective freshwater ecosystem buffer zone must be established prior to any construction activities taking place which include wetland and or riparian habitat.
- No person or vehicle will be allowed within the freshwater ecosystem buffer zone, management should be vigilant in preventing personnel taking short-cuts across the watercourses between construction sites.
- All cattle should be removed from the site prior to the initiation of rehabilitation areas and or veld with low basal cover for at least 3 years. This would increase veld condition and thereby afford the study area higher basal coverages with associated higher sediment and erosion control properties. The removal of cattle is also essential to realise successful rehabilitation initiatives which should be implemented prior to construction.
- It is recommended that a site-specific rehabilitation plan be designed in conjunction with the stormwater management plan, environmental management plan and wetland monitoring plan. The rehabilitation plan should also investigate possible sustainable land usages for the open space, wetland and riparian habitat for the medium and long term, including recommendations on possible grazing, fire and other required management regimes.
- Watercourse crossings should be minimised and be designed perpendicular to the flow of the watercourse. Low-water bridges with permeable bases should be designed and implemented in order to avoid concentrating flows. Flows exiting the bridge on the downstream side of the bridge should be diffused and span more than 80% of the width of the watercourse.
- Where topsoil stripping is to be done, it must be done in a phased approach, only strip what is needed immediately prior to construction.
- The construction of surface stormwater drainage systems during the construction phase must be done in a manner that would protect the quality and quantity of the downstream system. Where applicable, the use of swales, which should be seeded and grassed is recommended as the swales would attenuate run-off water and facilitate the settling of sediment within the swale rather than within wetlands or watercourses. For example, on the downslope edge of the infrastructure camp before vegetation clearing commences.
- It is highly recommended that dense matts of *Pennisetum thunbergii* be planted within the buffer zones and any preferred drainage line or flow path, especially areas with low basal over and or areas exhibiting erosional processes, albeit even just slightly. The species seems to be very well adapted to the highly structured soils with inherently high swelling and shrinking properties typically leading to root pruning. The long rhizomes and high-density tufts that *Pennisetum thunbergii* forms increases the surface roughness and is ideal for erosion and run-off control. It is further recommended that these rehabilitation initiatives should take place well prior to construction to effect good establishment and afford the downstream freshwater resources the maximum protection.

- All stockpiles must be protected from erosion, stored on flat areas where run-off will be minimized, and be surrounded by bunds. It should also only be stored for the minimum amount of time necessary.
- Erosion control of all banks must take place so as to reduce erosion and sedimentation processes.
- Topsoil, leaf and plant litter as well as subsoil must be stockpiled separately in low heaps.
- Do not strip topsoil when it is wet.
- In the absence of a recognizable topsoil layer, strip the upper most 500mm of soil.
- If possible, re-position the topsoil stockpile upslope of any infrastructure within the surface infrastructure footprint so as to prevent contaminated surface water coming into contact with topsoil.
- Ensure that all topsoil is stored in such a way and in such a place that it will not cause the damming up of water, erosion gullies, or wash away itself;
- Protect topsoil stockpiles from erosion.
- Develop soil management measures for the entire surface area of the proposed development area that will prevent runoff of sediment into the associated watercourses.
- Any additional topsoil stockpile areas required by the contractor must be approved by the Environmental Control Officer (ECO) in the form of an amended EMP indicating the position and extent of thereof.
- The ECO must be vigilant to detect any negative impacts on wetlands and consult with a wetland specialist if erosion or other negative impacts within wetlands are noticed.

Exposure to erosion

	Scale	**Duration**	**Magnitude**	**Probability of occurrence**	**Significance**	**Confidence**
Without mitigation measures	Local (2)	Long-term (4)	Moderate (6)	High (5)	High (60)	Medium
With mitigation measures	Site (1)	Short term (2)	Low (4)	Low (2)	Low (12)	Moderate

<u>Description of Impact</u>

The removal of surface vegetation will cause exposed soil conditions where rainfall and high winds can cause mechanical erosion. Rainfall and inadequate drainage systems would lead to sediments washing down into wetlands and rivers, causing sedimentation. In addition, hardened surfaces and bare areas are likely to increase surface run off velocities and peak flows received by wetlands. Considering the erosive nature of the smectic clays on terrain, sedimentation represents a high risk, however it is very mitigatable through maintaining appropriate basal cover. It is thus essential to maintain a healthy diverse basal cover throughout the terrain, especially considering changes in micro climate due to increased shading of solar panels. These likely micro climate changes could potentially be beneficially utilised to help establish a higher ratio of increaser species through appropriate graminoid/veld management including a seeding program. Therefore, the most important mitigation measure is considered to be maintaining and improving the graminoid sward on terrain, with no cleared areas beneath solar panels.

Mitigation Measures

- An ecologically-sound stormwater management plan must be implemented at the onset of the construction phase ;
- The stormwater plan must include adequate attenuation facilities to ensure that peak flows do not cause negative impacts on wetlands downstream.
- The above guidelines can be achieved through diffuse release of stromwater flows utilising the natural topography and associated contours;
- Erosion must not be allowed to develop on a large scale before effecting repairs;
- A wetland monitoring program should be initiated at the start of the construction phase. The ECO should also be briefed by a wetland specialist on specific monitoring issues during the construction and operational phases.
- Make use of existing roads and tracks where feasible, rather than creating new routes through vegetated areas;
- Vegetation and soil must be retained in position for as long as possible, and removed immediately ahead of construction / earthworks in that area (DWAF, 2005);
- Watercourse crossings should be minimised and be designed perpendicular to the flow of the watercourse. Low-water bridges with permeable bases should be designed and implemented in order to avoid concentrating flows. Flows exiting the bridge on the downstream side of the bridge should be diffused and span more than 80% of the width of the watercourse.
- Runoff from roads must be managed to avoid erosion and pollution problems;
- During the construction and operational phases, measures must be put in place to control the flow of surface water so that it does not impact on the vegetation, i.e., energy dissipaters and canal flow designs must be used to prevent scouring and erosion;
- All areas susceptible to erosion must be protected and ensure that there is no undue soil erosion resultant from activities within and adjacent to the construction camp and work areas;
- Natural trees, shrubbery and grass species must be retained wherever possible;
- Areas exposed to erosion due to construction should be vegetated with species naturally occurring in the area; and
- Surface water or storm water must not be allowed to concentrate, or flow down cut or fill slopes without erosion protection measures being in place.

Potential increase in invasive vegetation

	Scale	**Duration**	**Magnitude**	**Probability of occurrence**	**Significance**	**Confidence**
Without mitigation measures	Local (2)	Long-term (4)	Moderate (6)	High (5)	High (60)	Medium

With mitigation measures	Site (1)	Medium-term (3)	Low (2)	Medium (3)	Low (24)	Medium

Description of Impact

During construction, vegetation will be removed and soil disturbed. The seed of alien invasive species that occur on and in the vicinity of the construction area could spread into the disturbed and stockpiled soil. In addition, the construction vehicles and equipment were likely used on various other sites and could introduce alien invasive plant seeds or indigenous plants not belonging to this vegetation unit to the construction site. Alien vegetation could easily disperse into the watercourses through stormwater infrastructure located on site.

Mitigation Measures

- During construction, the construction area and immediate surroundings should be monitored regularly for emergent invasive vegetation;
- Surrounding natural vegetation should not be disturbed to minimize chances of invasion by alien vegetation;
- All alien seedlings and saplings must be removed as they become evident for the duration of construction and operational phase;
- Manual / mechanical removal is preferred to chemical control;
- All construction vehicles and equipment, as well as construction material should be free of plant material. Therefore, all equipment and vehicles should be thoroughly cleaned prior to access on to the construction site. This should be verified by the ECO;
- An alien invasive eradication and monitoring plan must be compiled and implemented whereby all emergent invasive species are removed during construction. The monitoring plan must also ensure that the re-emergence of invasive species is monitored continuously during the operational and decommissioning phases and that monitoring and eradication continues post decommissioning.

Pollution of water resources

	Scale	**Duration**	**Magnitude**	**Probability of occurrence**	**Significance**	**Confidence**
Without mitigation measures	National (5)	Long-term (2)	Moderate (6)	Medium (3)	Medium (39)	High
With mitigation measures	Local (2)	Short-term (2)	Low (4)	Low (2)	Low (16)	High

Description of Impact

Hydrocarbon-based fuels or lubricants spilled from construction vehicles, construction materials that are not properly stockpiled, and litter deposited by construction workers may be washed into the surface water bodies. Should appropriate toilet facilities not be provided for construction workers at the construction crew camps, the potential exists for surface water resources and surroundings to be contaminated by raw sewage. The utilisation of stormwater infrastructure for disposal of water used for washing could decrease the abundance and diversity of aquatic macro-invertebrates inhabiting the section of the wetland areas further downstream. Contaminated runoff from concrete mixing and sediment release including hydrocarbon spillages may lead to the infiltration of toxicants into the groundwater.

Mitigation Measures

- Construction vehicles are to be maintained in good working order so as to reduce the probability of leakage of fuels and lubricants;
- A walled concrete platform, dedicated store with adequate flooring or bermed area should be used to accommodate chemicals such as fuel, oil, paint, herbicide and insecticides, as appropriate, in well-ventilated areas;
- Storage of potentially hazardous materials should take place far away from preferential flow paths and or stormwater infrastructure. These materials include fuel, oil, cement, bitumen etc.;
- Surface water draining off contaminated areas containing oil and petrol would need to be channelled towards a sump which will separate these chemicals and oils;
- Concrete is to be mixed on mixing trays only, not on exposed soil;
- Concrete and tar shall be mixed only in areas which have been specially demarcated for this purpose;
- After all the concrete / tar mixing is complete all waste concrete / tar shall be removed from the batching area and disposed of at an approved dumpsite;
- Stormwater shall not be allowed to flow through the batching area. Cement sediment shall be removed from time to time and disposed of in a manner as instructed by the Consulting Engineer;
- All construction materials liable to spillage are to be stored in appropriate structures with impermeable flooring;
- Portable septic toilets are to be provided and maintained for construction crews. Maintenance must include their removal without sewage spillage;
- No uncontrolled discharges from the construction crew camps to any surface water resources shall be permitted. Any discharge points need to be approved by the relevant authority;
- In the case of pollution of any surface or groundwater, the Regional Representative of the Department of Water Affairs must be informed immediately;
- Store all litter carefully so it cannot be washed or blown into any of the water courses within the study area;
- Provide bins for construction workers and staff at appropriate locations, particularly where food is consumed;
- The construction site should be cleaned daily and litter removed;
- Conduct ongoing staff awareness programs so as to reinforce the need to avoid littering; and
- Backfill must be compacted to form a stabilised and durable blanket and the current load above the sewer lines must at no time be exceeded.

5.2.2 Operational phase

Impacts described in the construction phase are in most instances also applicable to the operational phase. The following are additional impacts during the operational phase.

Altered Hydrologic Regime

	Scale	Duration	Magnitude	Probability of occurrence	Significance	Confidence
Without mitigation measures	National (5)	Long-term (4)	Moderate (6)	High (4)	High (60)	Medium
With mitigation measures	Local (2)	Long-term (3)	Low (4)	Low (2)	Low (16)	Medium

Description of impact

The presence of hard impermeable surfaces such as roads, parking areas and roofs, will result in an increase in stormwater runoff volume and velocity. The cumulative impacts of developments within the catchments will cause an increase of surface water runoff and the decrease of infiltration which will potentially result in an increase in erosion potential and sedimentation to the wetlands downstream. Attenuation of surface water runoff and its subsequent diffused release are imperative to control on site and not accentuate the problem within the larger catchment. The development of a comprehensive surface runoff and sensitive stormwater management plan is therefore required, indicating how all surface runoff generated as a result of the development (during both the construction and operational phases) will be managed (e.g. artificial wetlands / stormwater and flood retention ponds/ attenuation and diffuse release mechanisms) prior to entering any local/regional drainage system. This plan should therefore indicate how surface runoff will be retained and subsequently released to simulate natural hydrological conditions. Further, special care must be taken with regards to the design, construction and maintenance of linear infrastructure e.g cabling, water and sewage infrastructure as the smectic clays on site can cause serious damage to especially linear infrastructure due to the swelling and shrinking properties.

Mitigation Measures

- Implement an ecologically-sensitive stormwater management plan that includes not allowing stormwater to be discharged directly into watercourses or associated buffers but rather be attenuated on site through attenuation facilities with diffuse release infrastructure (e.g. Attenuation swale facility with diffuse release swale on contour.
- Linear infrastructure such as cabling, water and sewage lines must be designed in such a way as to cope affectively with the swelling and shrinking properties associated with the vertic and melanic topsoil and well structured subsoil horisons dominating the site.

6. DWS RISK ASSESSMENT MATRIX

In addition to the approach presented above, a further assessment of potential risks associated with the various activities on the receiving aquatic ecosystem was done in accordance with Department of Water and Sanitation Notice(Gazette No. 49833, Notice 4167, 8 December 2023). The risk matrix for impacts associated with the proposed development, as required by DWS, is presented in Appendix B. It should be borne in mind that when assessing the impact significance following the DWS Risk Assessment Matrix, determination of the significance of the impact assumes that mitigation measures as listed within the present report are feasible and will be implemented, and as such does not take into consideration significance before implementation of mitigation measures. Accordingly, should proposed mitigation measures not be deemed feasible, a re-evaluation of the impact significance may be required.

Any developmental activities in a natural system will have an impact on the surrounding environment, usually in a negative way. The purpose of this phase of the study was to identify and assess the significance of the impacts potential caused by the proposed activities and to provide a description of potential mitigation required so as to limit the perceived impacts on the natural environment. The DWS Risk Assessment Matrix, in terms of GA 509, calculated the significance of perceived impacts on the key drivers and receptors (hydrology, water quality, geomorphology, habitat and biota) of the freshwater resources assessed that is situated within 500m from the proposed development. These results are summarised in the tables presented below (Appendix B). By assessing the severity, spatial scale, duration and frequency of the proposed infrastructure development, the risk to the potentially affected resource quality was determined to be low for all aspects during the construction and operational phases, assuming that all mitigation measures as proposed within the Impact assessment section (Section 5) of this report are adhered to.

7. CONCLUSION AND RECOMMENDATIONS

Eight separate hydro-geomorphic units (HGM), comprising three HGM types, namely channelled valley bottom wetlands, hillslope seepage wetlands connected to a watercourse and depressions (pans), were delineated and classified within the study area and within 500m surrounding the study area

Wetlands within the study area serve to improve habitat within and potentially downstream of the study area through the provision of various ecosystem services. Many of these functional benefits therefore contribute directly or indirectly to increased biodiversity within the study area as well as downstream of the study area through provision and maintenance of appropriate habitat and associated ecological processes

Combined area weighted Wet-Health results indicated that the wetlands from the study area have been moderately in most instances as a result of changes in water inputs (derived from its catchment) and water retention and distribution patterns within the wetlands units, as well as vegetation changes within the wetlands and surrounding catchments due to historic and current anthropogenic impacts, albeit relatively limited.

The valley bottom wetlands, were regarded as having a moderate to high Hydrological and Functional Importance as a result of the relatively intact nature and various important ecosystem services they provide. Direct human benefits were associated with the provision of natural resources as well as grazing opportunities afforded by most wetlands within the study area. Collectively, the valley bottom systems along with their supporting hillslope seepages, play an important role in contributing to good water quality and quantity to the downstream environment.

The moderate to high Ecological Importance and Sensitivity assigned to the hillslope seepage wetland units can be attributed to the relatively intact hydrological and geomorphological nature associated with the wetlands and their associated catchments. Most seepages have been heavily utilised for especially grazing which reduced the perceived biodiversity observed. However, as usual, further multiple seasonal biodiversity studies focused within wetland habitat would be required in order to increase the confidence levels with regards to the identification of species of conservation concern.

The depression wetland (pan) received low scores for the Hydrological and Functional Importance as well as their Ecological Importance and Sensitivity as a result of several anthropogenically driven impacts and incorporation into a cultivated productions area

The impact assessment identified the destruction of wetland habitat, surface water pollution including sedimentation as well as increased erosion, altered hydrological regimes, spread of invasive species and decreased downstream water quality as the major impacts during the construction and operational phase. Several general and specific mitigation measures were proposed in order to reduce negative impacts and incorporate some potentially positive impacts from the proposed development. Considering the erosive nature of the smectic clays on the terrain, erosion and sedimentation represents a very high risk on the study area, however, these aspects are very mitigatable through maintaining appropriate basal cover. It is thus essential to maintain a healthy diverse basal cover throughout the terrain, especially considering changes in micro climate due to increased shading of solar panels. These likely micro climate changes could potentially be beneficially utilised to help establish a higher ratio of increaser species through appropriate graminoid/veld management including seeding programs. Therefore, the most important mitigation measure was considered to be maintaining and improving the graminoid sward on terrain, leaving no cleared areas beneath or surrounding solar panels. Some other pertinent recommendations include:

- An appropriate wetland and terrestrial veld condition/basal cover monitoring and management program must be implemented prior to the start of the construction phase. It is recommended that local farmers familiar with local conditions and veld conservation techniques be incorporated in the management and utilisation of the grass sward on the terrain;
- Linear developments on terrain such as cabling must not concentrate surface and or subsurface flows, watercourses should receive surface and sub surface water diffusely as per the current hydrological regime. Keeping the graminoid layer intact and improving on veld condition and basal cover will assist a great deal towards achieving effective stormwater management. Where large areas of hardened surfaces are to be developed, SUDS based stormwater management plans must be developed for the specific terrain and approved by a suitably qualified wetland ecologist.
- The determined freshwater ecosystem buffer of a 35m must be implemented on all watercourses and be strictly enforced and appropriately managed.
- Active rehabilitation throughout the study area, but particularly in buffer zones and wetlands themselves should be initiated prior to the start of construction. Active rehabilitation to the graminoid layer within areas with low basal cover include reseeding, grazing exclusion, species diversification in order to be more resilient as well as increased monitoring for these sections. It is highly recommended that dense matts of *Pennisetum thunbergii* be planted within the buffer zones and any preferred drainage line or flow path, especially areas with low basal over and or areas exhibiting erosional processes, albeit even just slightly. The species seems to be very well adapted to the highly structured soils with inherently high swelling and shrinking properties typically leading to root pruning. The long rhizomes and high-density tufts that *Pennisetum thunbergii* forms increases the surface roughness and is ideal for erosion and run-off control. It is further recommended that these rehabilitation initiatives should take place well prior to construction to effect good establishment and afford the downstream freshwater resources the maximum protection.
- Watercourse crossings should be minimised and be designed perpendicular to the flow of the watercourse. Low-water bridges with permeable bases should be designed where appropriate and implemented in order to avoid concentrating flows. Flows exiting the bridge on the downstream side of the bridge should be diffused and span more than 80% of the width of the watercourse.
- Access roads must be designed in such a way to have a low impact on the veld condition/basal cover and hydrology of the terrain e.g. utilising grassed two tracks.

Considering all mitigation measures effectively and timeously implemented, flow regimes (including drivers), biota and water quality of the watercourses in the study area are unlikely to be observably affected or impacted, with no negative changes in watercourse PES, EIS or functionality of watercourses expected. However, a thorough wetland monitoring program must be designed and implemented prior to start of construction phase to ensure any negative impacts are detected and mitigated appropriately and timeously.

.

8. BIBLIOGRAPHY

Barnes, K.N. (ed.) (1998): *The Important Bird Areas of Southern Africa*, Johannesburg: BirdLife South Africa.

Collins, N.B. (2005). *Wetlands: The basics and some more*. Free State Department of Tourism, Environment and Economic Affairs

Department of Water Affairs and Forestry. (2005). *A practical field procedure for identification and delineation of wetlands and riparian areas*. Department of Water Affairs and Forestry, Pretoria, South Africa

Department of Water Affairs and Forestry. (2008). *Updated Manual for the identification and delineation of wetlands and riparian areas*. Department of Water Affairs and Forestry, Pretoria, South Africa

Ewel, C. (1997). Water quality improvement by wetlands. In: Daily G (ed), *Nature's Services: Societal Dependence on Natural Ecosystems*. Island Press, Washington, D. C.

GEM-science, (2011a). Aquatic Report. Ecology Report. Mining Right Application on the farm. BOSCHPOORT 211 IR. Ref. No. MP 30/5/1/2/2/504 MR. Prepared for: Hoyohoyo Mining (Pty) Ltd

GEM-science, (2011b). Environmental Management Program. Mining Right Application on the farm. Boschpoort 211 IR portion 1. Ref. No. MP 30/5/1/2/2/504 MR. Prepared for: Hoyohoyo Mining (Pty) Ltd

Gren, I. (1995). The value of investing in wetlands for nitrogen abatement. *European Review of Agricultural Economics* 22: 157–172

Kotze, D.C., Marneweck, G.C., Batchelor, A.L., Lindley, D.S. & Collins, N.B. (2008). *WET-EcoServices: A technique for rapidly assessing ecosystem services supplied by wetlands. WRC Report No TT 339/08*. WRC Report No. 339/08. Water Research Commission, Pretoria, South Africa

McCarthy, T.S. and Venter, J.S., (2006). *Increasing pollution levels on the Witwatersrand recorded in the peat deposits of the Klip River Wetland*. South African Journal of Science 102, January/February 2006, p 27 – 3

Macfarlane, D., Holness, S.D., von Hase, A., Brownlie, S., Dini, J.A. & Kilian, V. (2016). *Wetland Offsets: A Best Practice Guideline for South Africa*. WRC Report TT 660/16. Water Research Commission, Pretoria, South Africa

Macfarlane, D.M. & Bredin, I.P. (2016). *Buffer zone guidelines for rivers, wetlands and estuaries. Part 1: Technical Manual*. WRC Report No. TT 715/1/17. Water Research Commission, Pretoria, South Africa

Macfarlane, D.M., Kotze, D.C., Ellery, W.N., Walters, D., Koopman, V., Goodman, P. & Goge, C. (2008). *WET-Health: A technique for rapidly assessing wetland health*. WRC Report No. TT340/09. Water Research Commission

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

Muscutt, A.D., G.L., H., Bailey, S.W. & Davies, D.B. (1993). Buffer zones to improve water quality: a review of their potential use in UK agriculture. *Agriculture, Ecosystems and Environment* 45: 59–77

Nel, J.L., Driver, A., Strydom, N.A., Maherry, A.M., Peterson, C., Hill, L., Roux, D.J., Nienaber, S., van Deventer, H., Swartz, E.R. & Smith-Adao, L.B. (2011). *Atlas of Freshwater Ecosystem Priority Areas in South Africa: Maps to support sustainable development of water resources.* WRC Report No. TT 500/11. Water Research Commission, Pretoria, South Africa

Postel, S. & Carpenter, S. (1997). Freshwater ecosystem services. In: Daily G (ed), *Nature's Services: Societal Dependence on Natural Ecosystems*. Island Press, Washington, D. C.

Rogers, F.E., Rogers, K.H. & Buzer, J.S. (1985). *Wetlands for wastewater treatment: with special reference to municipal wastewaters*. WITS University Press, Johannesburg, South Africa

Rountree, M.W., Malan, H.L. & Weston, B.C. (2013). *Manual for the Rapid Ecological Reserve Determination of Inland Wetlands (Vers.2.0).* WRC Report No. 1788/1/12. Water Research Commission, Pretoria, South Africa

Soil Classification Working Group. (1991). *Soil classification. A taxonomic system for South Africa*. Department of Agricultural Development, Pretoria, South Africa

Soil Classification Working Group. (2018). *Soil classification. A natural and anthropogenic sytem for South Africa*. ARC- Institute for soil, Climat and Water, Pretoria.

APPENDIX A – Methodology

Wetland Delineation

The report incorporated a desktop study, as well as field surveys, with site visits conducted during August 2023. Additional data sources that were incorporated into the investigation for further reliability included:

- Google Earth images;
- 1:50 000 cadastral maps;
- ortho-rectified aerial photographs; and
- 5m contour data.
- Historic imagery (CDNGI-Geospatial Portal, 2023)

A pre-survey wetland delineation was performed in order to assist the field survey. Identified wetland areas during the field survey were marked digitally using GIS (changes in vegetation composition within wetlands as compared to surrounding non-wetland vegetation show up as a different hue on the orthophotos, thus allowing the identification of wetland areas). These potential wetland areas were confirmed or dismissed and delineation lines and boundaries were imposed accordingly after the field surveys.

The wetland delineation was based on the legislatively required methodology as described by Department of Water Affairs and Forestry (2005). The DWAF delineation guide uses four field indicators to confirm the presence of wetlands, namely:

- terrain unit indicator (i.e. an area in the landscape where water is likely to collect and a wetland to be present);
- soil form indicator (i.e. the soils of South Africa have been grouped into classes / forms according to characteristic diagnostic soil horizons and soil structure);
- soil wetness indicator (i.e. characteristics such as gleying or mottles resulting from prolonged saturation); and
- vegetation indicator (i.e. presence of plants adapted to or tolerant of saturated soils).

The wetland delineation guide makes use of indirect indicators of prolonged saturation by water, namely wetland plants (hydrophytes) and (hydromorphic) soils. The presence of these two indicators is indicative of an area that has sufficient saturation to classify the area as a wetland. Hydrophytes were recorded during the site visit and hydromorphic soils in the top 0.5 m of the profile were identified by taking cored soil samples with a bucket soil auger and Dutch clay auger (photographs of the soils were taken). Each auger point was marked with a handheld Global Positioning System (GPS) device (Figure 38).

Wetland Functionality

The methodology "Wet-EcoServices" (Kotze et al., 2008) was adapted and used to assess the different benefit values of the wetland units. A level one assessment, including a desktop study and a field assessment were performed to determine the wetland functional benefits between the different hydro-geomorphological types within the study area. Other documents and guidelines used are referenced accordingly. During the field survey, all possible wetlands and drainage lines identified from maps and aerial photos were visited on foot. Where feasible, cross sections were taken to determine the state and boundaries of the wetlands.

Following the field survey, the data was submitted to a GIS program for compilation of the map sets. Subsequently the field survey and desktop survey data were combined within a project report.

In order to gauge the Present Ecological State of various wetlands within the study area, a Level 2 Wet-Health assessment was applied in order to assign ecological categories to certain wetlands. Wet-Health (Macfarlane et al., 2008) is a tool which guides the rapid assessment of a wetland's environmental condition based on a site visit. This involves scoring a number of attributes connected to the geomorphology, hydrology and vegetation, and devising an overall score which gives a rating of environmental condition.

Wet-Health is useful when making decisions regarding wetland rehabilitation, as it identifies whether the wetland is beyond repair, whether rehabilitation would be beneficial, or whether intervention is unnecessary, as the wetland's functionality is still intact. Through this method, the cause of any wetland degradation is also identified, and this facilitates effective remediation of wetland damage. There is wide scope for the application of Wet-Health as it can also be used in assessing the Present Ecological State of wetlands and thereby assist in determining the Ecological Reserve as laid out under the National Water Act. Wet-Health offers two levels of assessment, one more rapid than the other.

For the assessments, an impact and indicator system were used. The wetland is first categorized into the different hydrogeomorphic (HGM) units and their associated catchments, and these are then assessed individually in terms of their hydrological, geomorphologic and vegetation health by examining the extent, intensity and magnitude of impacts, of activities such as grazing or draining. The extent of the impact is measured by estimating the proportion the wetland that is affected. The intensity of the impact is determined by looking at the amount of alteration that occurs in the wetland due to various activities. The magnitude is then calculated as the combination of the intensity and the extent of the impact and is translated into an impact score. This is rated on a scale of 1 to 10, which can be translated into six health classes (A to F – compatible with the EcoStatus categories used by DWAF, Table 12). Threats to the wetland and its overall vulnerability can also be assessed and expressed as a likely Trajectory of Change.

Determination of Ecological Importance and Sensitivity

The Ecological Importance and Sensitivity was determined by utilising a rapid scoring system. As wetlands outside of the study area were only partially visited, there could easily be oversight as detailed studies are required to increase the confidence of the assessment which relied heavily on the experience of the author. The system has been developed to provide a scoring approach for assessing the Ecological, Hydrological Functions; and Direct Human Benefits of importance and sensitivity of wetlands. These scoring assessments for these three aspects of wetland importance and sensitivity have been based on the requirements of the NWA, the original Ecological Importance and Sensitivity assessments developed for riverine assessments, and the work conducted by Kotze et al. (2008) on the assessment of wetland ecological goods and services from the WET-EcoServices tool (Rountree et al., 2013). An example of the scoring sheet is attached as Table 12. The scores are then placed into a category of very low, low, moderate, high and very high as shown in Table 13.

Table 12: Interpretation of scores for determining present ecological status (Kleynhans 1999)

Rating of Present Ecological State (Ecological Category)
CATEGORY A Score: 0-0.9; Unmodified, or approximates natural condition.
CATEGORY B Score: 1-1.9; Largely natural with few modifications, but with some loss of natural habitats.
CATEGORY C Score: 2 – 3.9; Moderately modified, but with some loss of natural habitats.
CATEGORY D Score: 4 – 5.9; Largely modified. A large loss of natural habitats and basic ecosystem functions has occurred.
OUTSIDE GENERAL ACCEPTABLE RANGE
CATEGORY E Score: 6 -7.9; Seriously modified. The losses of natural habitats and basic ecosystem functions are extensive.
CATEGORY F Score: 8 - 10; Critically modified. Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat.

* If any of the attributes are rated <2, then the lowest rating for the attribute should be taken as indicative of the PES category and not the mean

Table 13: Example of scoring sheet for Ecological Importance and sensitivity

Ecological Importance	Score (0-4)	*Confidence (1-5)*	Motivation
Biodiversity support			
Presence of Red Data species			
Populations of unique species			
Migration/breeding/feeding sites			
Landscape scale			
Protection status of the wetland			
Protection status of the vegetation type			
Regional context of the ecological integrity			
Size and rarity of the wetland type/s present			
Diversity of habitat types			
Sensitivity of the wetland			
Sensitivity to changes in floods			
Sensitivity to changes in low flows/dry season			
Sensitivity to changes in water quality			
ECOLOGICAL IMPORTANCE & SENSITIVITY			

Table 14: Category of score for the Ecological Importance and Sensitivity

Rating	Explanation
Very low (0-1)	Rarely sensitive to changes in water quality/hydrological regime.
Low (1-2)	One or a few elements sensitive to changes in water quality/hydrological regime.
Moderate (2-3)	Some elements sensitive to changes in water quality/hydrological regime.
High (3-3.5)	Many elements sensitive to changes in water quality/ hydrological regime.
Very high (+3.5)	Very many elements sensitive to changes in water quality/ hydrological regime.

APPENDIX B: DWS IMPACT RISK ASSESSMENT (for wetlands situated within 500m from the proposed development during the construction and operational phases)

PROJECT: **Renewstable**

RISK ASSESSMENT MATRIX for Section 21 (c) and (i) Water Use activities - Version 2.0

Name of Assessor: Willem Lubbe

SACNASP Registration Number: 4750

Signature:

Date: 10/07/2024

Risk to be scored for all relevant phases of the project (factoring in specified control measures). MUST BE COMPLETED BY SACNASP PROFESSIONAL MEMBER REGISTERED IN AN APPROPRIATE FIELD OF EXPERTISE.

Phase	Activity	Impact	Potentially affected watercourses: Name/s	PES	Ecological Importance	Intensity of Impact on Resource Quality – Abiotic Habitat (Drivers): Hydrology	Water Quality	Geomorph	Biota (Responses): Vegetation	Fauna	Overall Intensity (max = 10)	Spatial scale (max = 5)	Duration (max = 5)	Severity (max = 20)	Importance rating (max = 5)	Consequence (max = 100)	Likelihood (Probability) of impact	Significance (max = 100)	Risk Rating
CONSTRUCTION	<1>Site preparation and typical construction activities: Vegetation clearing, cutting/filling/shaping. stormwater infrastructure development, foundations, building and assocaited infrastructure development such as water, electricity,roads and sewage	Decreased Water Quality, especialy through increased sedimentaion loads, but other potential sources as well. E.g. hydrocarbons	HGM 1	C	Moderate	1	2	0	1	0	4	2	2	8	3	24	40%	9.6	L
		<1b>Increased peak flow dicharges received by HGM 1	HGM 1	C	Moderate	2	2	1	1	1	4	2	2	8	3	24	40%	9.6	L
		<1c>Increased alien invasive vegetation infestation	HGM 1	C	Moderate	0	0	1	2	1	4	2	2	8	3	24	40%	9.6	L
OPERATIONAL	<1>Developed area with mixed used activities, including more hardened surfaces and introduced pollution sources such as point and non point pollution (e.g. industy, vechiles	<1a> Altered hydrological regime	HGM 1	C	Moderate	2	2	0	1	1	4	2	2	8	3	24	40%	9.6	L
		<1b> Deteriorated water quality	HGM 1	C	Moderate	1	2	0	1	1	4	2	2	8	3	24	40%	9.6	L
		<1c> Spread of alien vegetation	HGM 1	C	Moderate	1	1	0	2	2	4	2	2	8	3	24	40%	9.6	L