WETLAND AND DESKTOP AQUATIC IMPACT ASSESSMENT

FOR A BASIC ASSESSMENT APPLICATION FOR THE ERGO MINING SOLAR PV FACILITY (PHASE 1), INCLUDING A PLANT CAPACITY UP TO 19.9MW AND 11KM OF 22KV OVERHEAD POWER LINE, LOCATED WITHIN THE EKURHULENI LOCAL MUNICIPALITY, GAUTENG

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Draft Version 2

May 2021

Declaration of Independence by Specialists

We, **Rowena Harrison** and **Byron Grant**, hereby declare that we -

- Act as independent wetland and aquatic consultants.
- 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 and will not have vested interest in the proposed activity proceeding.
- 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).
- Will provide the competent authority with access to all information at our disposal regarding the application, whether such information is favourable to the applicant or not.
- Based on information provided to us 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 our professional ability.

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EXECUTIVE SUMMARY

Malachite Ecological Services and Ecology International were appointed by Environmental Management Assistance (Pty) Ltd to undertake a Wetland and Desktop Aquatic Impact Assessment for the proposed construction of a Solar Photovoltaic (PV) plant, with a capacity of up to 19.9MW to supply power (embedded generation) to the existing Ergo Mining (Pty) Ltd Brakpan Plant as well as the construction of 11km of an 22kV Overhead Power Line (OHL) to link the PV facility to substations.

Wetland Findings

Based on the current identification of the four wetland indicators, six Hydrogeomorphic (HGM) units were delineated within the assessment area (PV facility (both the preferred and alternative layouts), OHL route and 500m assessment area). These included an unchannelled valley bottom wetland, two seep systems, a channelled valley bottom wetland and two depression wetlands.

Apart from the natural wetland systems delineated within the assessment area, a number of artificial depressions, functional dams, discarded dams, and seepage from dams were also delineated. Of particular importance were the artificial depressions delineated within the PV facility site (both alternative layouts), as well as an artificial seep which was identified below an existing dam which is situated between the two zones associated with the preferred layout. The depressions were saturated at the time of the field investigation and supported a number of hydrophytic plant species. The same is true for the artificial seep. These wetland systems were however identified to be artificial in nature and have been created by the extensive anthropogenic modifications to the PV facility site and surrounding areas. The proposed PV facility site was converted into a tailings facility, this was remined in the 2000s and subsequently rehabilitated to its current form. As a result of these anthropogenic disturbances, the soils of the site have been completely modified and are now classified as the Hydric Technosol, Stilfontein form. These soils show signs of saturation but are not natural wetland soils. The depressions were delineated based on the presence of hydric characteristics of the soil, at the surface of the soil profile or within the first 10cm. The saturation of the depressions is further compounded by the deposition of sediment on top of the Stilfontein form and which causes stormwater ponding on the soil surface. During the drier seasons, these depressions will become desiccated over time and decrease in size. While these depressions do allow for the growth of hydrophytic plant species, they are artificial in nature and do not provide large scale ecosystem benefits to the broader landscape. The adjacent dam and artificial seep will not be directly impacted by the proposed preferred layout of the PV facility or the alternative layout. Stormwater control from the cleared site is recommended, particularly during the wetter seasons as the indigenous vegetation associated with the ‘depressions and site as a whole provides attenuation services.

The remaining natural HGM units were assessed with regards to their health according to the Wet-Health methodology. HGM 1, the unchannelled valley bottom wetland was classified as Seriously Modified (Present Ecological Status (PES) Category E), while the remaining HGM units were classified as Largely Modified (PES Category D). Impacts to the wetland systems stem from the use of the catchments associated with each wetland for historic and current mining activities as well as urban development. These developments have impacted the hydrological flow of the wetlands as well as the geomorphic setting. HGM 1 has been particularly disturbed as a result of mining within the catchment. Dams associated with HGM 2 and HGM 4, the seep wetlands, have also had an impact on the flow dynamics of these systems. This is particularly so for HGM 4 where two dams are located within the system. A dam is furthermore situated in HGM 3, the channelled valley bottom wetland, to the west of the proposed OHL route. The damming of wetland systems has long-term negative impacts on the hydrology, geomorphology and vegetation dynamics of these systems. The depression wetlands, HGM 5 and HGM 6, have smaller catchment areas and this has limited the impacts to these wetlands to a degree. However, the wetlands are still impacted through the development of residential areas to the west of these systems.

Ecosystem goods and services were calculated for the HGM units. All HGM units received generally low to moderate scores for the ecosystem services. Highest scores received were associated with flood attenuation (particularly for HGM 1 and HGM 3), streamflow regulation, erosion control, sediment trapping and filtration (in the form of nitrate, phosphate and toxicant trapping). The depression wetlands received generally lower scores compared to the other HGM units, due mainly to their endorheic nature, limiting the influence of the wetlands on the larger landscape. However, these wetlands do still provide functions related to sediment control and filtration.

An Ecological Importance and Sensitivity (EIS) assessment was undertaken to rank the water resources in terms of provision of goods and services or valuable ecosystem functions which benefit people; biodiversity support and ecological value as well as the reliance of subsistence users (especially basic human needs uses). The EIS scores received for all HGM units was Low. The location of the wetlands within an urban landscape that has been largely disturbed limits the ability of the wetlands to provide suitable habitat for faunal and floral species. The channelled valley bottom (HGM 3) received a higher score as a result of the presence of open water which provides habitat for semi-aquatic and aquatic species.

Desktop Aquatic Findings

In general, a low diversity of aquatic habitats is expected within the study area given the nature of the associated watercourses associated with the study site. Further, all sites assessed had relatively small, low-gradient catchments and thus a low accumulation of flow, resulting in slow-flowing hydraulic habitat. Consequently, it is expected that aquatic habitat within the channelled valley bottom system (HGM 3) would comprise primarily of emergent and aquatic vegetation with slow-flowing open water and a mud-based substrate where open substrate is found. In contrast, aquatic habitat within the unchannelled valley bottom is likely to be temporary and seasonal, with water likely present only during the wet season, with shallow water, emergent and aquatic vegetation present. Within the artificial depressions located at the proposed PV facility site, aquatic habitat is expected to present similar conditions as that within the unchannelled valley-bottom wetland feature (HGM 1), with emergent vegetation being the dominant habitat structure. However, the shallow depth and lack of flowing water as well as possible water quality impairment from leaching of underlying substrate is expected to be a significant limitation to the occurrence of aquatic diversity within these systems.

In general, the valley bottom wetlands and depressional systems, are unlikely to support a diverse array of aquatic biota during even unimpacted conditions given the lack of diverse hydraulic habitat. Accordingly, given the water quality of the generally reducing environment associated with wetlands and the possible impacts from historic gold mining activities within the area, as well as hydrological dynamics of such systems, the aquatic macroinvertebrate assemblage is expected to be dominated by species with a strong preference for instream and emergent vegetation within very slow-flowing habitats, as well as taxa with a very low to low preference for unmodified water quality. As such, the area is expected to be dominated by taxa from the families Hemiptera and Coleoptera for much of the year.

A total of seven indigenous fish species and a further three alien fish species are expected to be associated with the reach of HGM 3 specifically. To a large degree, no fish species are expected to be associated with the unchannelled valley-bottom wetlands or the depressional wetlands associated with the northern extent of the study area (i.e., PV facility and nothern portions of the 22kV OHL). A notable exception would be the presence of several dams within the area which are expected to support the presence of larger indigenous fish such as *Clarias gariepinus* (Sharptooth Catfish), *Tilapia sparrmanii* (Banded Tilapia), and the alien species *Cyprinus carpio* (Carp) and *Micropterus salmoides* (Largemouth Bass). According to the unified framework, both *Cyprinus carpio* and *Micropterus salmoides* can be classified as fully invasive species, with individuals dispersing, surviving and reproducing at multiple sites across a greater or lesser spectrum of habitats and extent of occurrence.

According to the desktop assessment of sub-quaternary reach C22C-01405, the reach of the channelled valley bottom wetland, HGM 3, is considered to be largely modified (PES Category D), from a riverine perspective. This is in line with the findings of the Present Ecological Status of the wetland assessment. According to the Department of Water and Sanitation (2014), both the ecological importance and the ecological sensitivity of sub-quaternary reach C22C-01405 associated with HGM 3 is considered to be moderate from an aquatic perspective. It is however likely that the re-evaluation of the reach reflected by HGM 3 based on in-field studies will result in a lowering of the ecological importance and/or the ecological sensitivity given the impacts present within the catchment, which is in line with the EIS Assessment conducted as part of the wetland assessment.

Buffer Requirements

The proposed project, including both the preferred and alternative layout involves the construction of a PV facility which will change the stormwater flow dynamics of the cleared site proposed for the development. The proposed PV facility site is situated approximately 150m from the boundary of HGM 1, the unchannelled valley bottom. Furthermore, a dam and artificial seep which emanates from the dam, are situated between the two zones associated with the preferred layout. These provide habitat for floral and faunal species and flow into HGM 1. A buffer was therefore calculated for the protection of these linked systems (natural and artificial) taking into account the proposed activity, climatic factors, topographical factors, the nature of the soils and the sensitivity of the water resource. A 21m buffer has been calculated. This buffer is not expected to impact the PV facility layout (either the preferred or alternative layout). It is however recommended that the buffer be planted with indigenous grasses and maintained as part of the construction and operational phases of the

Environmental Management Programme for the development. A high basal cover of indigenous grass species will aid in the buffering out of sediment and pollutants from the development before stormwater enters into HGM 1 or the artificial wetlands. Furthermore, stormwater control from the development is key in reducing impacts to the downstream and adjacent wetland systems. With regards to the proposed Overhead Powerline (OHL), only HGM 3, the channelled valley bottom system will be crossed. The proposed OHL route follows the disturbed footprint of the gravel road. The gravel road already crosses HGM 3 and thus there is an existing disturbance footprint within which the pylons for the OHL are proposed to be constructed. Buffers have therefore not been calculated for the crossing of this wetland system, as they would not add any benefit to the positioning of the pylons, provided these pylon positions remain within the existing disturbed footprint.

Impact Assessment

The activities for both the preferred and alternative layout identified within the study site include:

- The clearing of portions of the PV facility site for the establishment of the solar panels, BESS and substation.
- Construction of the 22kV Overhead Power Line.
- Maintenance of the PV facility and Overhead Power Line during the operational phase.

Negative impacts therefore associated with this project include:

- Soil erosion, sedimentation of the wetland systems.
- Pollution potential.
- Encroachment of invasive alien species into the wetlands as a result of the additional disturbances to the area caused by the construction and operational phases of the project.

Several general and specific measures are proposed to mitigate these impacts.

The Risk Assessment for the proposed project was undertaken in accordance with the General Authorisation in terms of Section 39 of the National Water Act, 1998 (Act No. 36 of 1998) for Water Uses as defined in Section 21 (c) and (i) (Notice 509 of 2016). From a wetland and aquatic perspective, impact scores received are Low. This is due to the PV facility site being completely disturbed from historic mining operations. Furthermore, the 22kV OHL will only cross HGM unit 3, the channelled valley bottom wetland. Impacts to the wetland systems are small and easily mitigable.

Conclusion and Recommendations

From a wetland perspective, the specialist is of the opinion that impacts arising from the proposed project can be mitigated to an acceptably low level. This is attributed to the historically and currently disturbed nature of the area coupled with the largely modified to seriously modified nature of the wetlands assessed within the study site. Artificial depressions were noted within the PV facility location, for both the preferred and alternative layouts, however these have been created through the historic mining of the area and are compounded by the ponding of stormwater on the compacted Stilfontein soils. While they do support hydrophytic vegetation, the 'depressions' will only be saturated temporarily during the wet season, and do not provide large scale ecosystem benefits to the larger landscape.

In consideration of the aquatic habitat availability within the study area, it is expected that the aquatic biota assemblages present will be dominated by taxa with a strong preference for instream and emergent vegetation within very slow-flowing habitats, as well as taxa with a very low to low preference for unmodified water quality. Further, given the likely seasonal availability of water within the unchannelled and depressional wetland systems present, it is expected that the period of inundation of the watercourse will result in temporal variations of aquatic assemblages within these systems. As such and given that the proposed overhead powerline is understood to be the only watercourse crossing proposed and is not expected to impact on the instream features, the risk of impact from the proposed activity on the associated aquatic ecosystem is expected to be low.

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1. INTRODUCTION

1.1 Project Description and Locality

Malachite Ecological Services and Ecology International were appointed by Environmental Management Assistance (Pty) Ltd to undertake a Wetland and Desktop Aquatic Impact Assessment for the proposed construction of a Solar Photovoltaic (PV) plant, with a capacity of up to 19.9MW to supply power (embedded generation) to the existing Ergo Mining (Pty) Ltd Brakpan Plant as well as the construction of 11km of an 22kV Overhead Power Line (OHL) to link the PV facility to substations.

The proposed project is situated on off the R23 (Heidelberg Road) on various portions of the Farm Withok 131IR, various Holdings of the Withok Estates Agricultural Holdings, various portions of the Farm Witpoortje 117IR, as well as various holdings of the Witpoort Estates Agricultural Holdings, within the Ekurhuleni Local Municipality, Gauteng. The project site is furthermore situated within the quarter degree square 2628AD (Figure 1).

Two alternative layouts are presented, with the preferred layout consisting of two zones for the location of the PV Facility, with the substation and Batter Energy Storage System (BESS) located within Zone 2. Zone 1 will have enough solar panels to generate a capacity of 7965.7kW of power while Zone 2 will have enough solar panels to create a capacity of 11602kW of power (Figure 2). The proposed 22kV OHL will follow the same route in both layout alternatives, with the OHL entering the existing Brakpan plant to the south, crossing the plant, and entering into the Ergo substation in the preferred layout.

The alternative layout proposes a smaller PV array facility for the generation of 10MW power capacity. This layout consists of two blocks in which the solar panels will be situated. This alternative layout is located in the same area as the preferred layout. The overhead powerline will enter into an Eskom substation located adjacent to the western boundary of the Brakpan plant (Figure 3).

This Wetland and Desktop Aquatic Impact Assessment forms part of the environmental requirements in the Basic Assessment and Water Use License applications. These are undertaken in compliance with the National Environmental Management Act (Act 107 of 1998) and the Environmental Impact Assessment (EIA) Regulations, 2017, GN R. 327, R.325 and R. 324; as well as the Water Use Licence Application (WULA) in terms of the National Water Act (Act 36 of 1998).

Surface water attributed to wetland systems, rivers and riparian habitats comprise an important component of natural landscapes. These systems are often characterised by high levels of biodiversity and fulfil various ecosystems functions. As a result, these systems are protected under various pieces of legislation including the National Water Act, 1998 (Act No. 36 of 1998) and the National Environmental Management Act, 1998 (Act No. 107 of 1998). The primary aim of the study is to provide a description of the current ecological integrity and impacts pertaining to any water resources occurring within the assessment area as well as providing appropriate management recommendations to reduce any identified impacts on the delineated systems.

1.2 Scope of the Assessment

The terms of reference for the current study were as follows:

- Identify and delineate any wetland/watercourse systems within the defined study site according to the Department of Water Affairs and Forestry[1] "Practical field procedure for the identification and delineation of wetlands and riparian areas".
- Classify the identified wetland habitats in accordance with the latest approach; 'Classification System for Wetlands and other Aquatic Ecosystems in South Africa' (Ollis et al., 2013).
- Determine the Present Ecological State score (PES) and Functional Integrity of any identified wetlands using the WET-Health and Wet-EcoServices approach.
- Determine the Ecological Importance and Sensitivity (EIS) of the identified wetlands.
- Conduct a desktop aquatic assessment on any watercourses within the assessment area.
- Identify current negative impacts on any identified wetlands. Recommend mitigation measures to lessen these impacts and the implementation of suitable rehabilitation measures.

1.3 Assumptions and Limitations

It is difficult to apply pure scientific methods within a natural environment without limitations or assumptions. The following apply to this study:

i. In order to obtain definitive data regarding the biodiversity, hydrology and functioning of wetlands, studies should ideally be conducted over a number of seasons and over a number of years. This study took place during a single site visit conducted between the 5th and 7th February 2021.
ii. Wetland boundaries are essentially based on GPS coordinate waypoints taken onsite of indicator features. The accuracy of the GPS device therefore affects the accuracy of the maps produced. A hand-held Garmin eTrex 30x was used to delineate the wetlands and this has an accuracy of 3-6m.
iii. The assessment of the wetlands' Present Ecological State (PES), Functional Integrity (Wet-Ecoservices) and Ecological Importance and Sensitivity (EIS) was based on a two-day field investigation. Once-off assessments such as this may potentially miss certain ecological information, thus limiting accuracy, detail and confidence.

1.4 Reporting Conditions

The findings and recommendations provided in this report are based on the authors' best scientific and professional knowledge as well as information available at the time of compilation. No form of this report may be amended without the prior written consent of the authors.

[1] Department of Water Affairs and Forestry (DWAF) is now named the Department of Water and Sanitation (DWS).

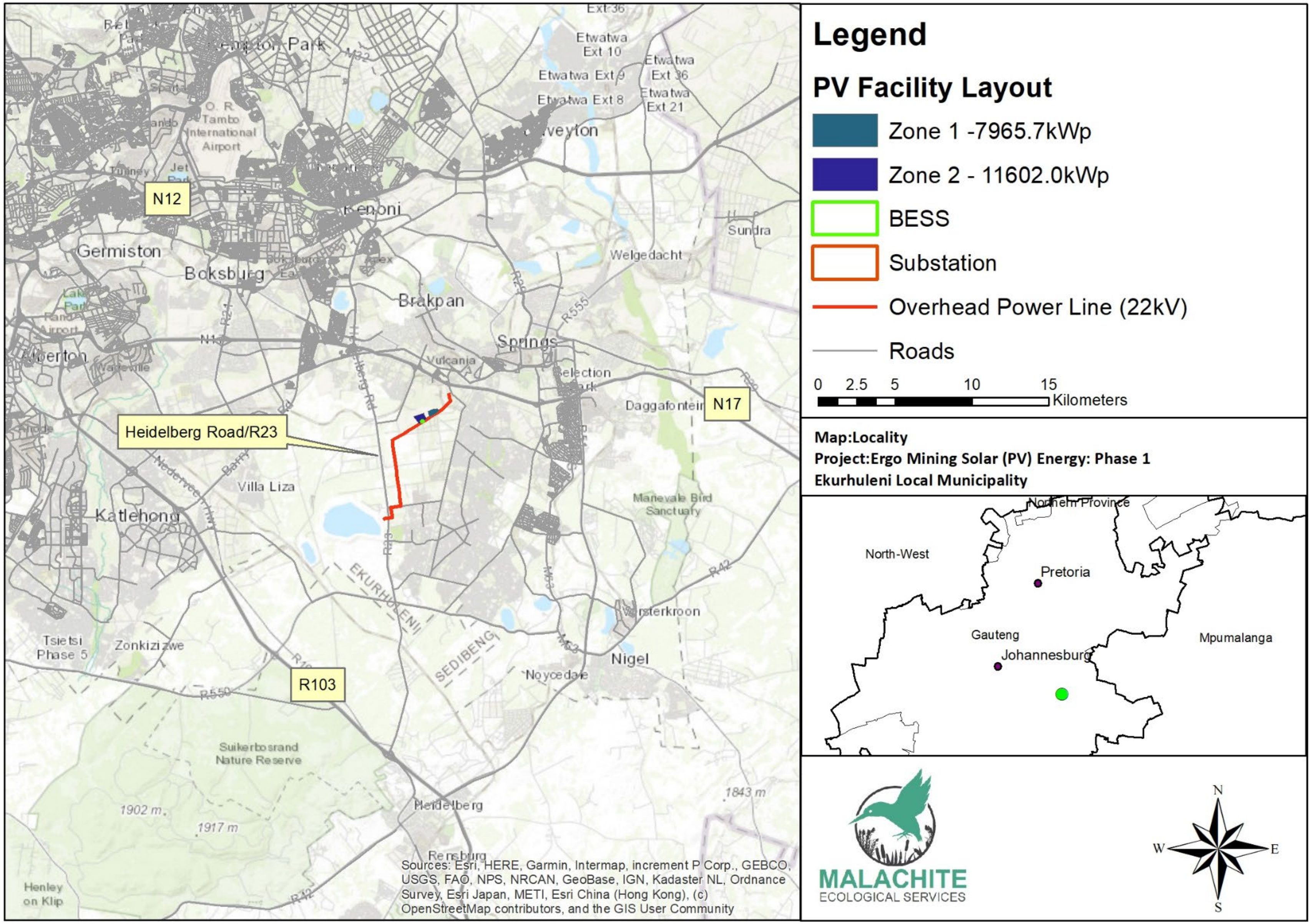


Figure 1: Locality of the study area

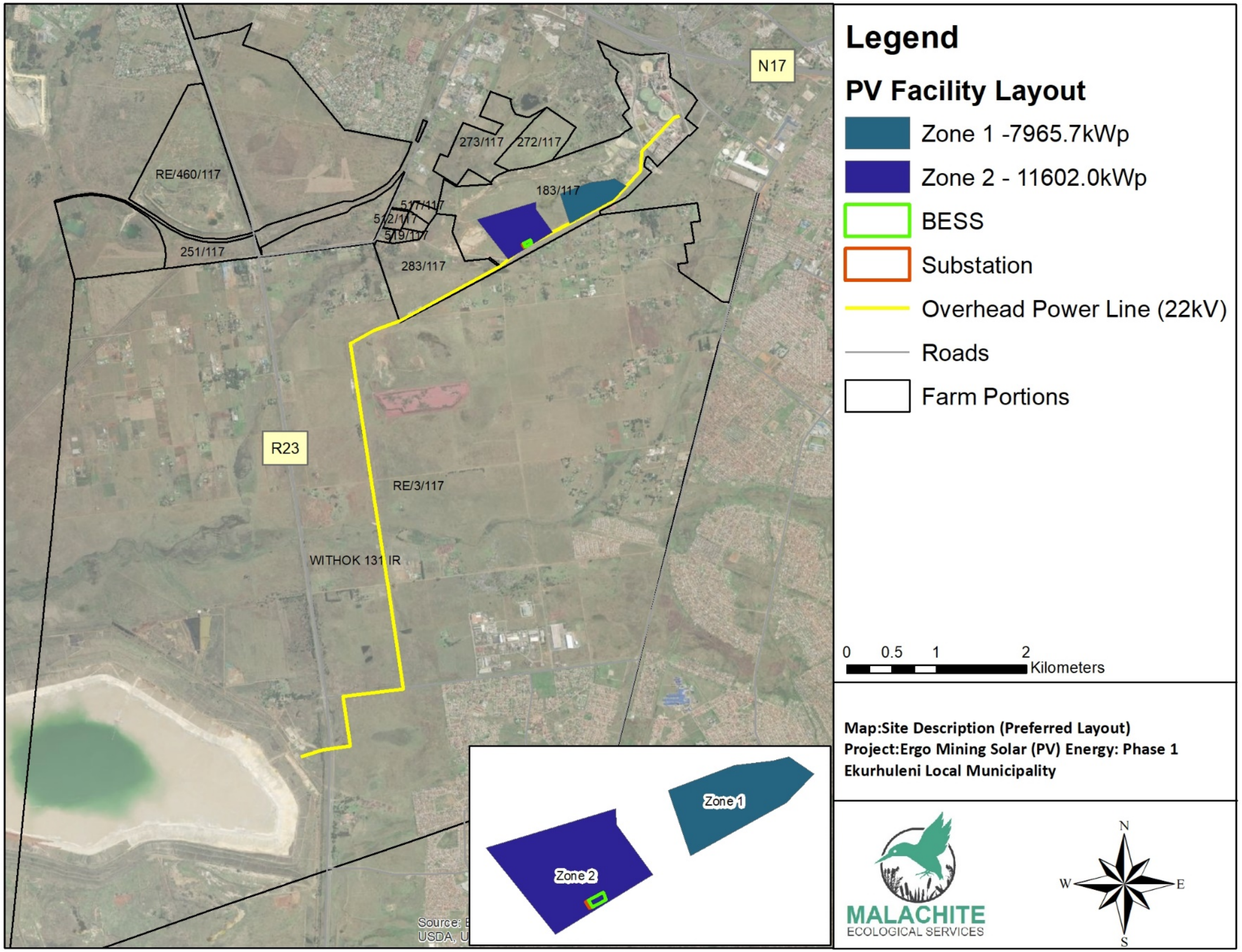


Figure 2: Aerial imagery of the study site showing the preferred layout

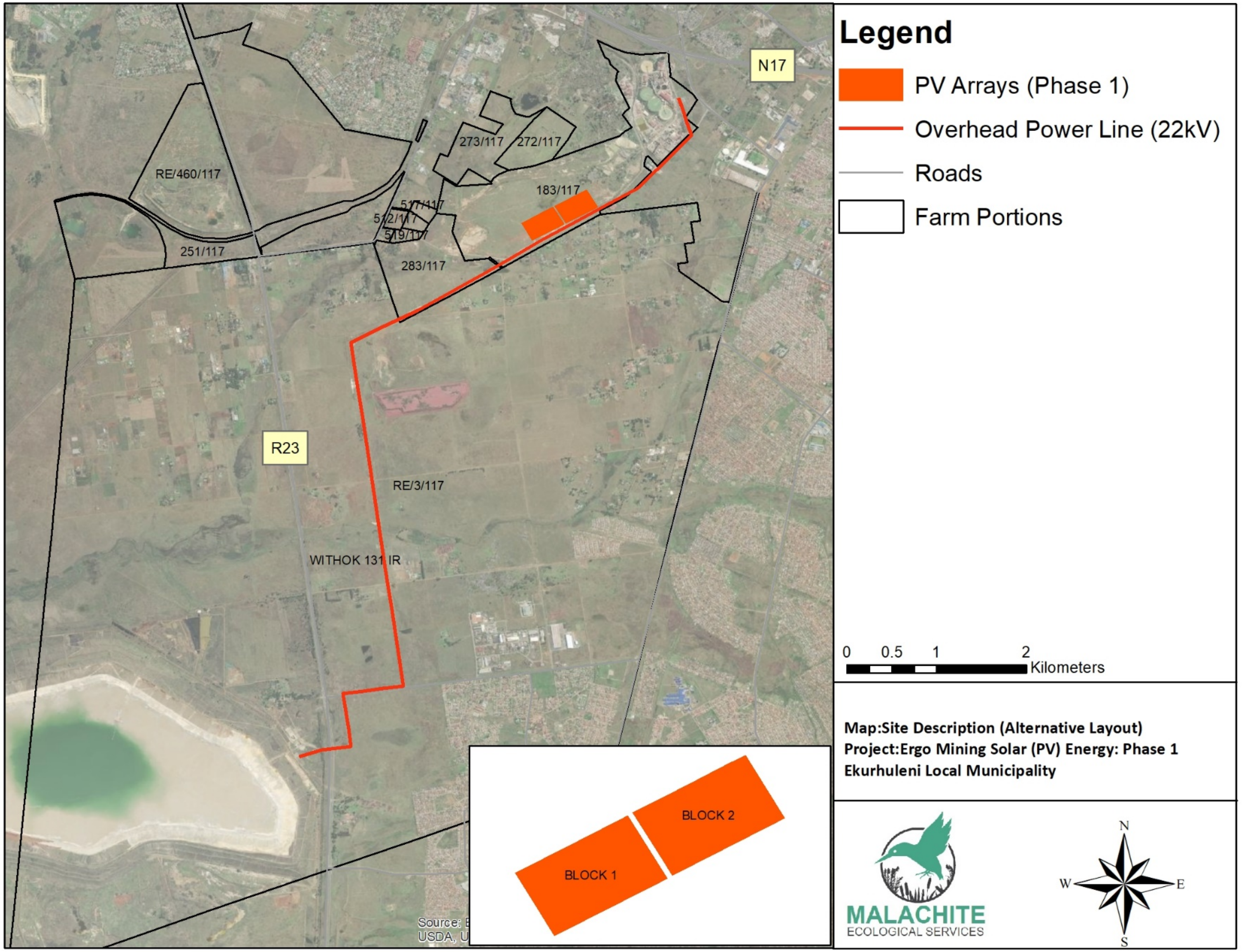


Figure 3: Aerial imagery of the study site showing the alternate layout

2. METHODOLOGY

2.1 Wetland Assessment

The techniques and tools utilised for this assessment can be divided into baseline data and field investigations. Baseline data was utilised during the desktop component to determine the biophysical context of the site as well as National and Provincial legislation that governs the proposed activity.

2.1.1. Baseline data

The study involved the examination of aerial photography and Geographical Information System (GIS) databases. The study made use of the following data sources:

- Google Earth™ satellite imagery was used at the desktop level.
- Relief dataset from the Surveyor General was used to calculate slope.
- Climatic data was obtained using a dataset on the climate-data.org website and was supplemented by information gathered in Mucina and Rutherford (2006).
- Historical imagery was obtained from the Department of Rural Development and Land Reform and the National Geospatial Information website (http://cdngiportal.co.za/cdngiportal/)
- Geology dataset was obtained from AGIS[2].
- Vegetation type dataset from Mucina & Rutherford (2006), with amendments by SANBI (NBA, 2018) were used in determining the vegetation type of the study area.
- The National Freshwater Ecosystem Priority Areas (NFEPA) were used in determining any priority wetlands.
- National Wetland Map 5 (NBA, 2018) was utilised at a desktop level to determine if there are any wetlands on the site and the classification of these wetland systems.

2.1.2. Site Investigation

In field data collection was taken from the 5th to the 7th of February 2021. This included the delineation exercise, topographical setting, soil sampling techniques, identification of current land use and the identification of existing impacts and dominant vegetation units present.

2.1.3. Wetland Definition & Delineation Technique

South Africa has a strong legislative framework enforcing the country's obligations to numerous international conservation agreements for the protection of freshwater/wetland resources. These frameworks include several Acts, Ordinances and treaties.

For the purpose of this assessment, wetlands are considered as those ecosystems defined by the National Water Act 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*

[2] Geological information was obtained from the Department of Agriculture's Global Information Service (AGIS) January 2014 – www.agis.agric.za

water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil."

Furthermore, the Ramsar Convention[3] defines wetlands as:

"areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed 6m"

These habitats are found where the topography and geological parameters impede the flow of water through the catchment, resulting in the soil profiles of these habitats becoming temporarily, seasonally or permanently wet. Further to this, wetlands occur in areas where groundwater or surface water discharges to the surface forming seeps and springs. Soil wetness and vegetation indicators change as the gradient of wetness changes (Figure 4).

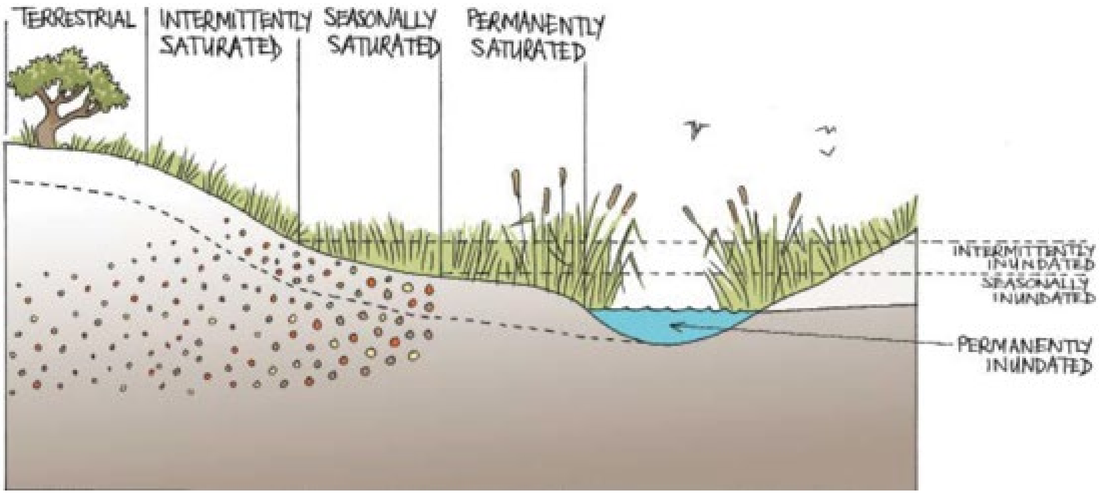


Figure 4: Increasing soil wetness zones identified within various wetland systems

Based on definition presented in the National Water Act, three vital concepts govern the presence of a wetland namely:

i. Hydrology- Land inundated by water or displays saturated soils when these soils are biologically active (the growth season).
ii. Hydric soils- Soils that have been depleted of oxygen through reduction resulting in the presence of redoximorphic features.
iii. Hydrophytic vegetation- Plant species that are adapted to growing in saturated soils and subsequent anaerobic conditions (hydrophytes).

[3] The Ramsar Convention is legally named the Convention on Wetlands of International Importance Especially as waterfowl Habitat and was adopted by the International Conference on the Wetlands and Waterfowl at Ramsar, Iran, 2 February 197 I in order to recognise amongst others that wetlands constitute a resource of great economic, cultural, scientific and recreational value, the loss of which would be irreparable.

The conservation of wetland systems is vital as these habitats provide numerous functions that benefit not only biodiversity but provide an array of ecosystem services. These services are further divided into direct and indirect and are detailed in Table 1. These transitional habitats also provide refugia for a variety of terrestrial and semi-aquatic fauna, plants and invertebrates.

Table 1: Direct and indirect benefits of wetland systems (Kotze et al. 2005)

Wetland Goods and Services	
Direct	**Indirect**
Hydrological Water purification Flood reduction Erosion control Groundwater discharge	*Socio-economic* Socio-cultural significance Tourism and recreation Education and Research
Biodiversity conservation	Water supply
Chemical cycling	Provision of harvestable resources

The study site was assessed with regards to the determination of the presence of wetland and watercourse areas according to the procedure described in 'A Practical Field Procedure for Identification and Delineation of Wetland and Riparian Areas –Edition 1' (DWAF, 2005). The WET-Health model was utilised to facilitate the rapid assessment of the integrity of wetland systems while WET-Ecosystems model measures the ecosystem goods and services provided by the wetland system/s in question.

2.1.4. Wetland Health and Functional Integrity Assessment Techniques

A Wet-Health Assessment to determine the Present Ecological State was undertaken. The draft 2018 version of Wet-Health (Ollis et al. 2018) was utilised for the Present Ecological State of each HGM unit. The 2018 version is currently at a draft stage and will be refined before being published. It takes into account impacts on the hydrology, geomorphology, vegetation and water quality of both the individual HGM unit as well as each HGM unit's catchment. A level 2 assessment (detailed) was undertaken on the units delineated.

A Level 2 Wet-EcoServices Assessment to determine the Functional Integrity of the identified wetland units, was carried out. Further to this, the Ecological Importance and Sensitivity of each delineated wetland unit was ascertained. Detailed methodology for the wetland delineation, health, provision of ecosystem goods and services (functional integrity), ecological importance and sensitivity is given in Appendix A.

2.2 Desktop Aquatic Assessment

The purpose of this element of the proposed study was for the determination of potential aquatic biodiversity characteristics and sensitivities of the proposed project area to be identified for the purposes of the relevant environmental process. Being a desktop-based exercise, extensive use was made of available literature and the latest spatial databases associated with the area of interest in order to identify threats and opportunities regarding aquatic biodiversity features relating to the proposed activities. Such databases included (but not limited to the National Freshwater Ecosystem Priority Areas (NFEPA), Global Biodiversity Information Facility database, Freshwater Biodiversity Information System, the Department of Water and Sanitation's PESEIS database, fish collection records of the South African Institute of Aquatic Biodiversity and the Albany Museum, as well as any other recent academic studies or national/provincial assessments associated with the area of interest. This information was then cross-referenced with the findings from the wetland component of the study in order to provide a spatial understanding of the likely aquatic features associated with the wetland units identified.

3. BIOPHYSICAL CHARACTERISTICS

3.1 Climate

The Ergo Gold Mine is situated within an area characterised by summer rainfall patterns with sporadic rainfall events during the winter months. The mean annual precipitation is 132mm, with the bulk of the rainfall occurring between September and March (summer months). These high intensity rainfall conditions are conducive to high levels of surface runoff and subsequent erosion where soils are shallow, occur on steep slopes or are overgrazed. The wettest time of the year is January with an average of 123mm and the driest is June and July with 7mm (Table 2). The seasonality of precipitation is a driving factor behind the hydrological cycles of water resources within the area. Typically, watercourses have a higher flow rate during the summer months.

Mean temperatures vary between 9.7^{O}C to 19.7^{O}C for the Brakpan region (Table 3). The area is coldest in July with average minimum temperatures of 2.8^{O}C and hottest in November and December with average maximum temperature of 25.2^{O}C on average (Climate-data.org; Mucina & Rutherford, 2006; updated 2018).

Table 2: Mean annual rainfall data for the Brakpan area

	January	February	March	April	May	June	July	August	September	October	November	December
Mean Rainfall (mm)	123	96	86	42	19	7	7	9	24	65	105	109

Table 3: Temperature data for the Brakpan area

	January	February	March	April	May	June	July	August	September	October	November	December
Mean Temperature (^{O}C)	19.7	19.6	18.4	15.7	12.8	10	9.7	13	16.8	18.5	18.9	19.7
Max Temperature (^{O}C)	25	24.9	23.9	21.5	19.6	17.3	17.4	20.9	24.6	25.7	25.2	25.2
Min Temp (^{O}C)	14.8	14.6	13.2	10.2	6.5	3.5	2.8	5.6	9.1	11.6	12.9	14.6

3.2 Geology

Water resources in South Africa are the products of erosional and depositional processes, as well as the presence of geological influences controlled by the variable environment across the country. South Africa is a semi-arid country with differences in rainfall patterns, topography, and geology. The geological characteristic of an area influences the topography, soil types and textures, vegetation communities and faunal assemblages present. These all determine the types and locations of wetland and watercourse systems within the landscape.

The study area is underlain predominantly by the Ecca Group of the Madzaringwe Formation of the Karoo Supergroup. The geology of this region is primarily known to be sedimentary strata and is a very thick sequence of carbonaceous siltstone, mudstone, shale, sandstone and coal.

3.3 Regional Vegetation Structure and Composition

The study area is located within the Grassland Biome. According to the latest regional vegetation classification for South Africa (Mucina & Rutherford, 2006; updated 2018), the study area falls within the Soweto Highveld Grassland and the Tsakane Clay Grassland vegetation types, with the majority of the site with the latter vegetation type (Figure 4).

The Tsakane Clay Grassland unit is distributed throughout Gauteng and Mpumalanga in areas characterised by flat to slightly undulating plains and low hills. The community structure is comprised of short, dense grassland dominated by a mixture of common highveld grasses such as *Themeda triandra, Heteropogon contortus*, *Elionurus muticus* and a number of *Eragrostis* species. The dominant forbs are of the families Asteraceae, Rubiaceae, Malvaceae, Lamiaceae and Fabaceae. Disturbances within these grasslands changes the vegetation dynamics, with an increase in the abundance of *Hyparrhenia hirta* and *Eragrostis chloromelas* noted. Erosion is generally very low.

This vegetation unit is classified as Endangered, with only 1.5% conserved in statutory reserves. The latter was confirmed in the NBA (2018) which indicates that the vegetation type is Poorly Protected, with an estimated over 60% transformed for cultivation, urbanisation, mining, dam-building and roads.

A small portion of the northern extent of the OHL is located within the Soweto Highveld Grassland vegetation type (Figure 5). This vegetation type is also present largely in Gauteng and Mpumalanga on gently to moderately undulating landscapes on the Highveld Plateau. It supports short to medium-high dense tufted grassland dominated almost entirely by *Themeda triandra*. Other grasses are also present including *Elionurus muticus, Eragrostis racemose, Heteropogon contortus* and *Tristachya leucothrix*. This vegetation type is classified as Vulnerable within the NBA (2018) database with only a handful of patches statutorily or privately conserved. Over 50% has been transformed by cultivation, urbanisation, mining, dam-building and roads. Erosion is generally very low.

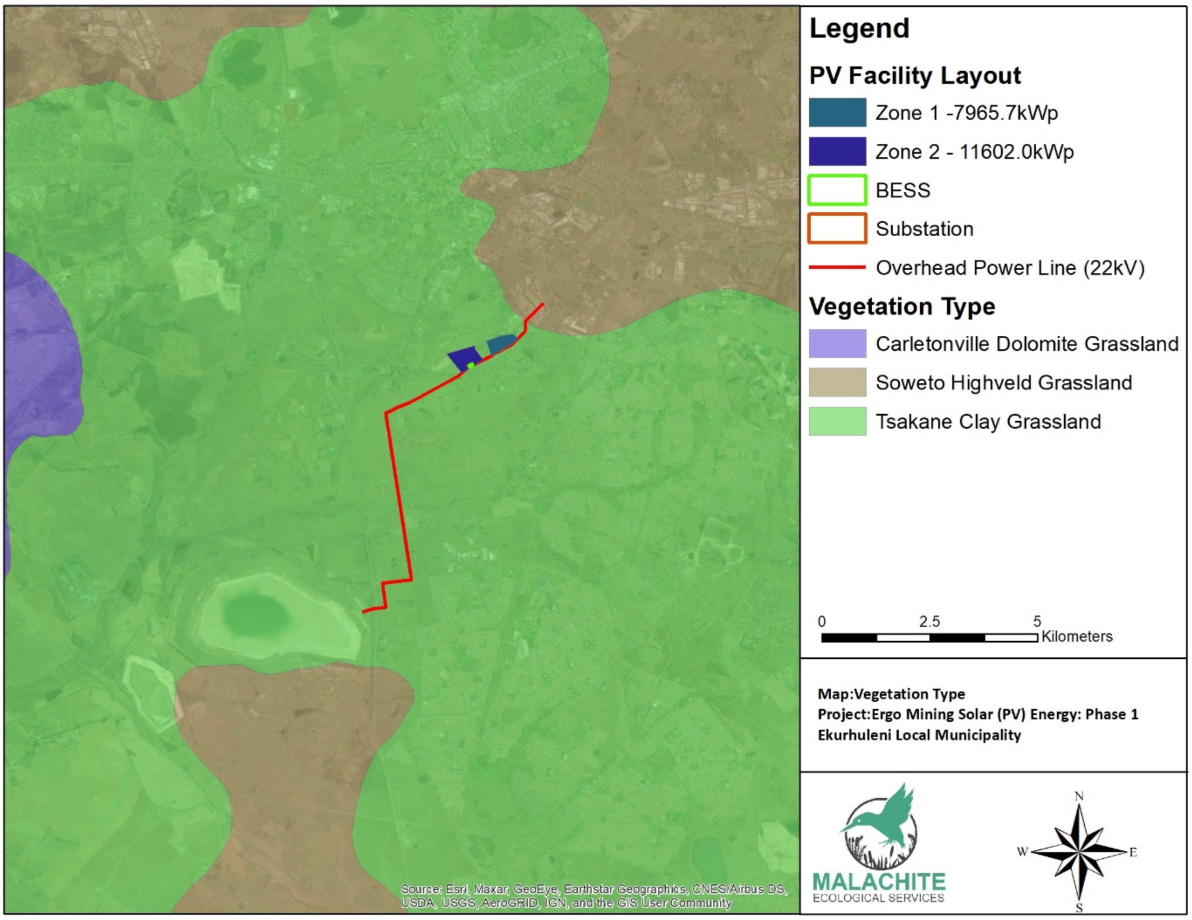


Figure 5: Regional Vegetation associated with the study site

3.4 Conservation Planning Frameworks

Systematic conservation planning is a globally recognised practice which identifies priorities for biodiversity conservation and informs legislation to facilitate the long-term conversion of identified biodiversity (Jewitt, 2018). The biodiversity sector is centred on a data-driven approach and is continually refining the outputs by improving input data (Dayaram et al., 2019).

3.5 National Biodiversity Assessment (NBA; 2018)

The National Environmental Management: Biodiversity Act (Act 10 of 2004) lists Threatened or Protected ecosystems, in one of four categories: Critically Endangered (CR), Endangered (EN), Vulnerable (VU) or Protected. The main purpose of listing Threatened Ecosystems is to reduce the rate of ecosystem and species extinction and includes the prevention of further degradation and loss of structure, function and composition of Threatened ecosystems.

There are four main types of implications of listed ecosystems on development:

- Planning related implications, linked to the requirement in NEMBA for listed ecosystems to be taken into account in municipal IDPs and SDFs.
- Environmental authorisation implications, especially in terms of NEMA and EIA regulations.
- Proactive management implications, in terms of NEMBA.

- Monitoring and reporting implications, in terms of NEMBA.

The most recent National Biodiversity Assessment (NBA), dated 2018, is a collaborative effort to synthesise the best available science on South Africa's biodiversity. The NBA is used to inform policy in the biodiversity sector and other sectors that rely on or impact on natural resources, such as water, agriculture, mining and human settlements. The NBA provides information to help prioritise resources for managing and conserving biodiversity and provides context and information that underpins biodiversity inputs to land use planning processes (Skowno et al., 2019).

The NBA has seven technical reports (of which only the terrestrial component is discussed within this assessment) and relies on two headline indicators:

- **Threat Status**: Degree to which ecosystems are still intact or alternatively losing vital aspects of their structure, function and composition, on which their ability to provide ecosystem services depends. Ecosystem types are categorised as Critically Endangered (CR), Endangered (EN), Vulnerable (VU) or Least Concern (LC), based on the proportion of each ecosystem type that remains in good ecological condition relative to a series of thresholds (Skowno et al., 2019).
- **Protection Level**: Addresses the extent to which ecosystems and species are protected. Ecosystem types are categorised as Not Protected, Poorly Protected, Moderately Protected or Well Protected, based on the proportion of each ecosystem type that occurs within a protected area recognised in the NEMPAA (Skowno et al., 2019).

These headline indicators provide important links for data comparison as well as providing a standardised framework that links with policy and legislation. Furthermore, comparing threat status and protection levels for terrestrial ecosystems is useful for identifying ecosystems in particular need of protection (Skowno et al., 2019).

According to the outputs of the NBA (2018) portions of both the PV facility and Overhead Power Line route are located in the remaining extent of the Tsakane Clay Grassland and Soweto Highveld Grassland vegetation types which implies that these have not been previously transformed and are regarded as natural habitat (Figure 6). The ecosystems associated with the vegetation type have a threat status of Endangered and Vulnerable respectively and a poor protection level. This would however need to be ground truthed as the study site is situated in an urban environment (refer to flora specialist report). It is important to note that the National List of Threatened Terrestrial Ecosystems published in terms of NEMBA remains in legal force, and that while the data contained in the National Biodiversity Assessment (2018) represents an update of the assessment of threat status for terrestrial ecosystems, the National List of Threatened Terrestrial Ecosystems has not yet been revised at the time of writing. Therefore, the majority of the extent of the study area is located within the Klipriver Highveld Grassland Ecosystem Type and this is listed as Critically Endangered (Figure 7).

Of further relevance is that this tributary associated with the proposed 22KV OHL as well as all the valley-bottom and seepage wetland systems are classified within the latest National Biodiversity Assessment as being Critically Endangered and not sufficiently protected (Van Deventer et al., 2019).

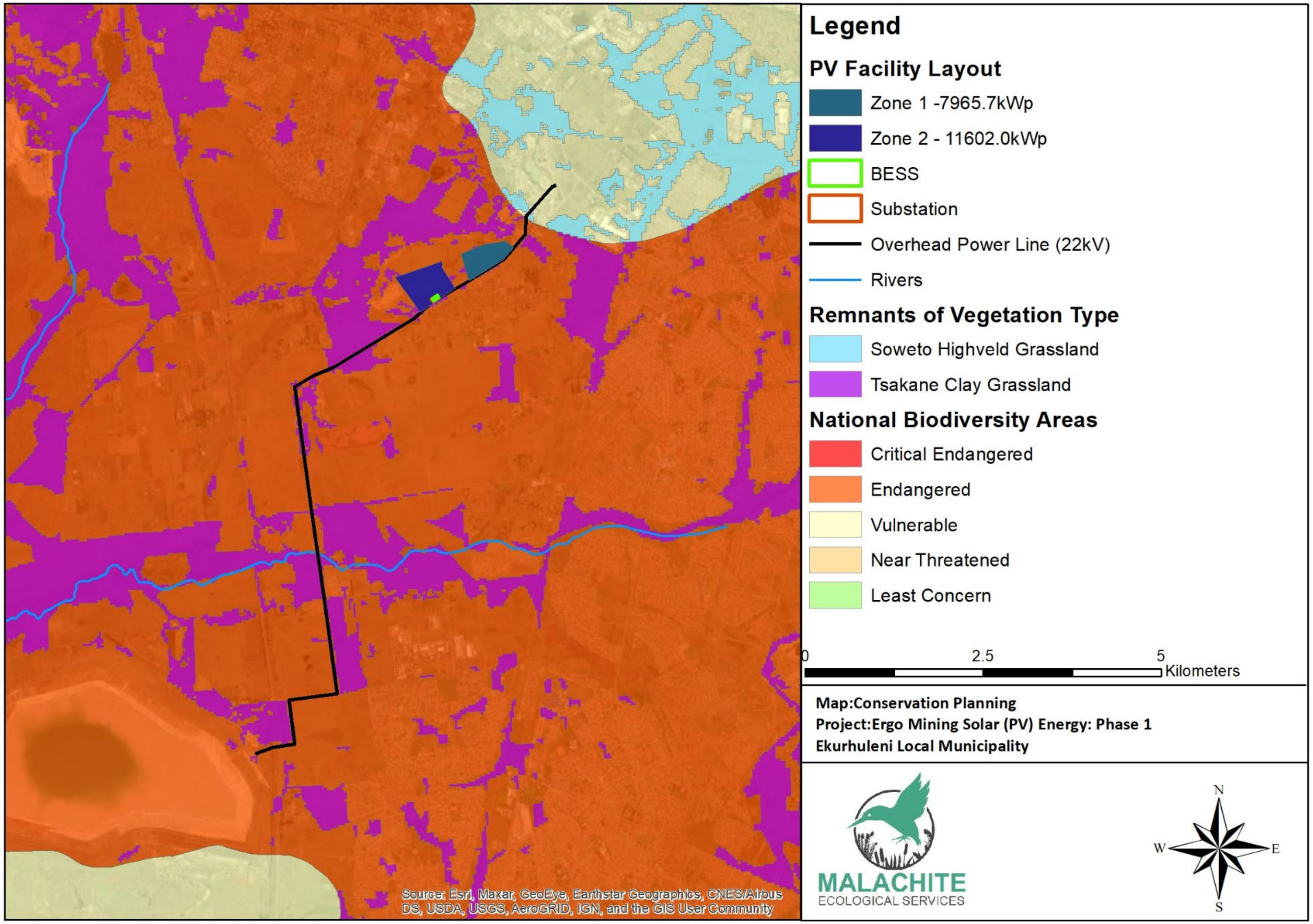


Figure 6: National Biodiversity Areas conservation planning in relation to the study site

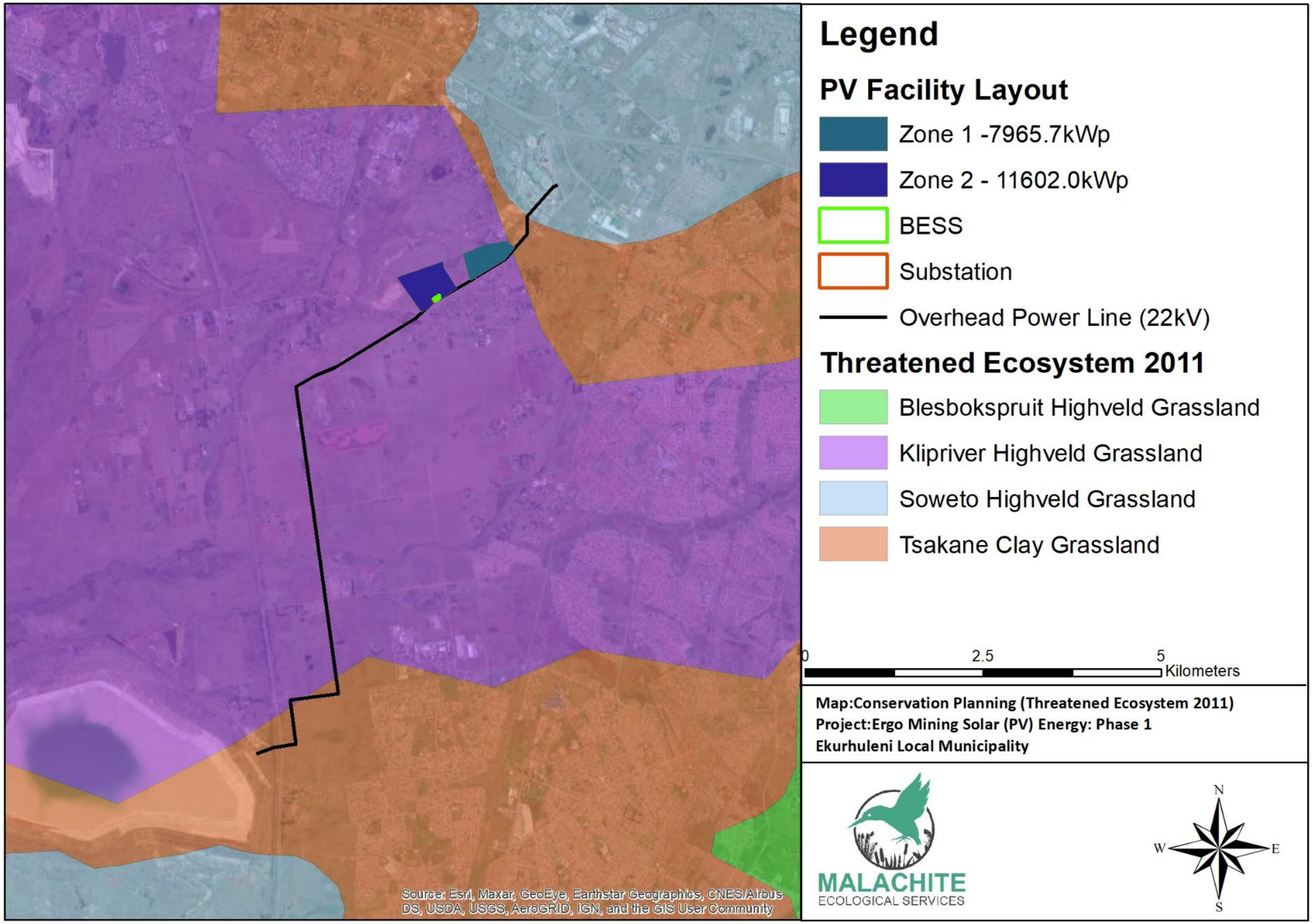


Figure 7: National List of Threatened Terrestrial Ecosystems in relation to the study site

3.6 Catchment characteristics and watercourses

The project area lies within the Vaal Water Management Area. Major rivers within this WMA include the Wilge, Liebenbergsvlei, Mooi, Renoster, Vals, Sand, Vet, Harts, Molopo and Vaal. These rivers experience significant levels of high-water demand related stress, particularly during drought seasons. Many of these surrounding communities rely on fresh water from these rivers throughout the year and supply adequate water for domestic, stock and irrigation.

More specifically, the project area is situated within the C22C Quaternary Catchment (Figure 8). The Rietspruit flows approximately 4.7km to the west of the study site with a tributary of the Rietspruit crossing the proposed route of the 22kV OHL and flowing in a westerly direction. Non-perennial drainage channels are also located along the OHL route.

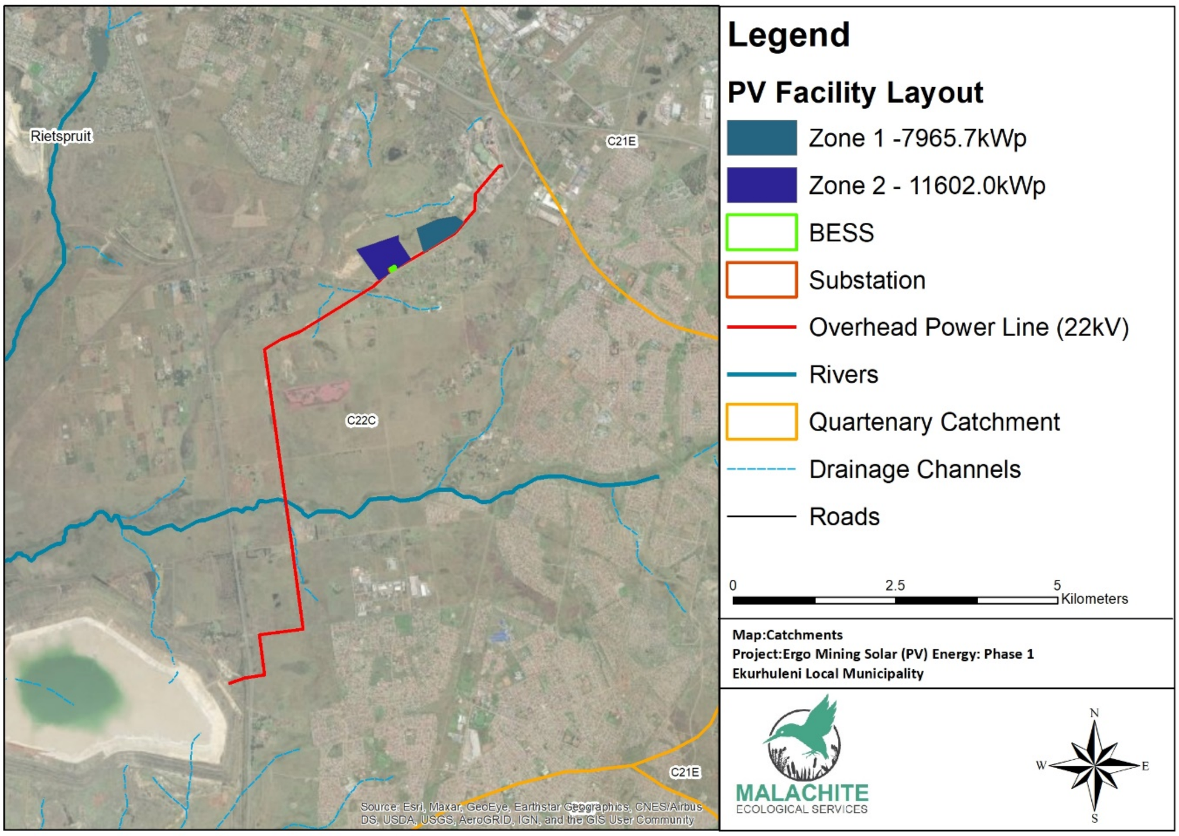


Figure 8: Quaternary catchments and river systems associated with the study area

3.7 National Freshwater Ecosystem Priority Areas (NFEPA) and the National Wetland Map 5

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.

According to the outputs of the NFEPA project (Figure 9) a number of wetland systems are located within the assessment area. These are classified as seeps, channelled valley bottom wetlands, an unchannelled valley bottom wetland and flats. These are furthermore classified as both natural and artificial, with the natural systems categorised as Moderately Modified.

As an additional database to the NFEPA database layer, the more recent National Wetland Map 5 (Van Deventer et al, 2019) database was furthermore utilised to assess the project area. The National Wetland Map 5 (NWM5) forms part of the National Biodiversity Assessment (2018), within the category of the Inland Aquatic (Freshwater) Realm. This project is a multi-partner project through the CSIR and SANBI. The NWM5 has significantly improved the representation of inland wetland ecosystem types. The representation of the extent of inland wetlands has improved by 123%, facilitating the reduction in the incorrect representation of terrestrial ecosystems as wetlands (Van Deventer et al, 2018).

The NWM5 was utilised to assess the project area. As shown in Figure 10, a number of unchannelled valley bottom wetlands, depressions/pans and seep wetlands are located along the proposed 22kV OHL route and within the larger study. These areas were assessed in more detail during the field investigation.

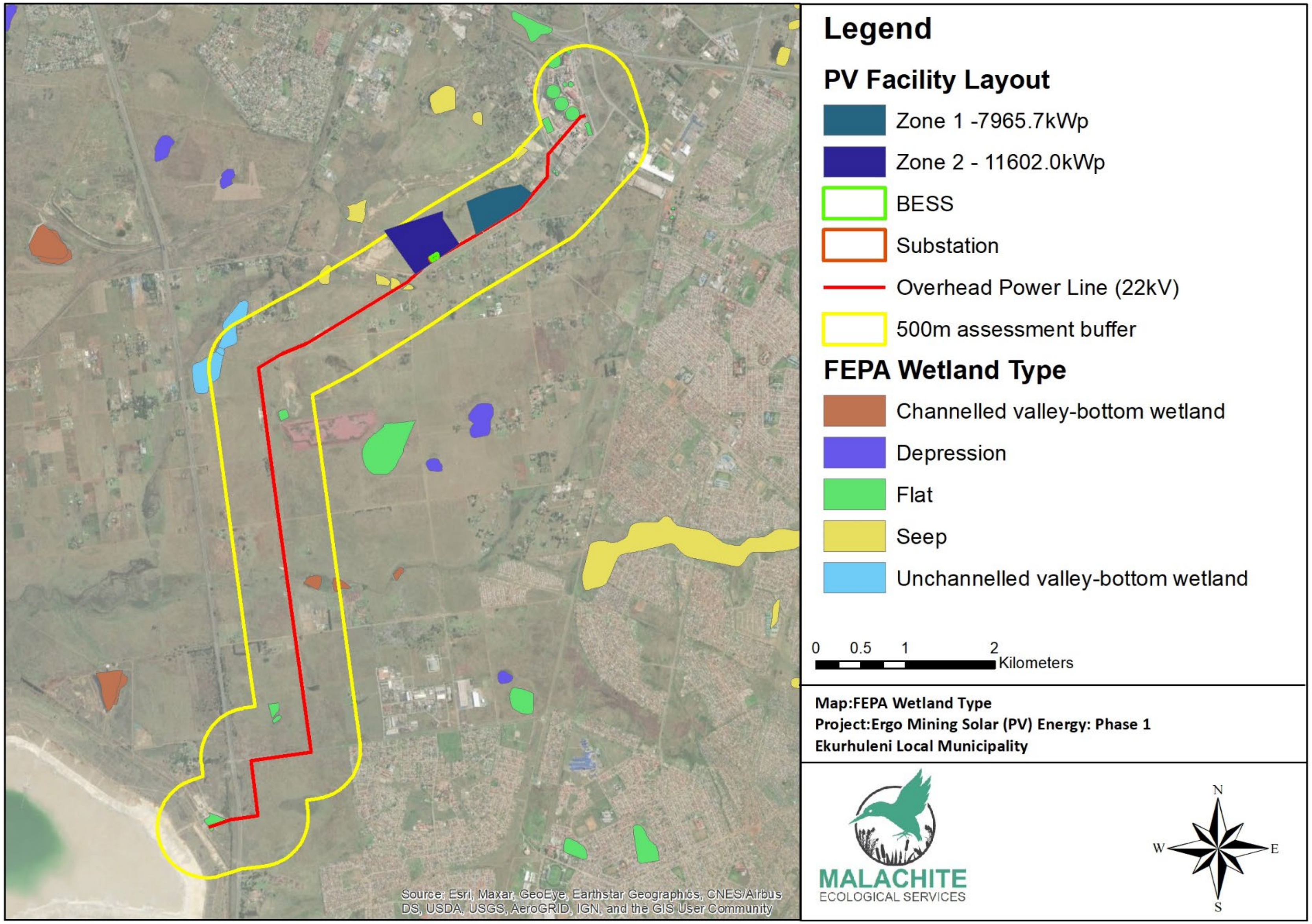


Figure 9: FEPA wetlands identified within the assessment area

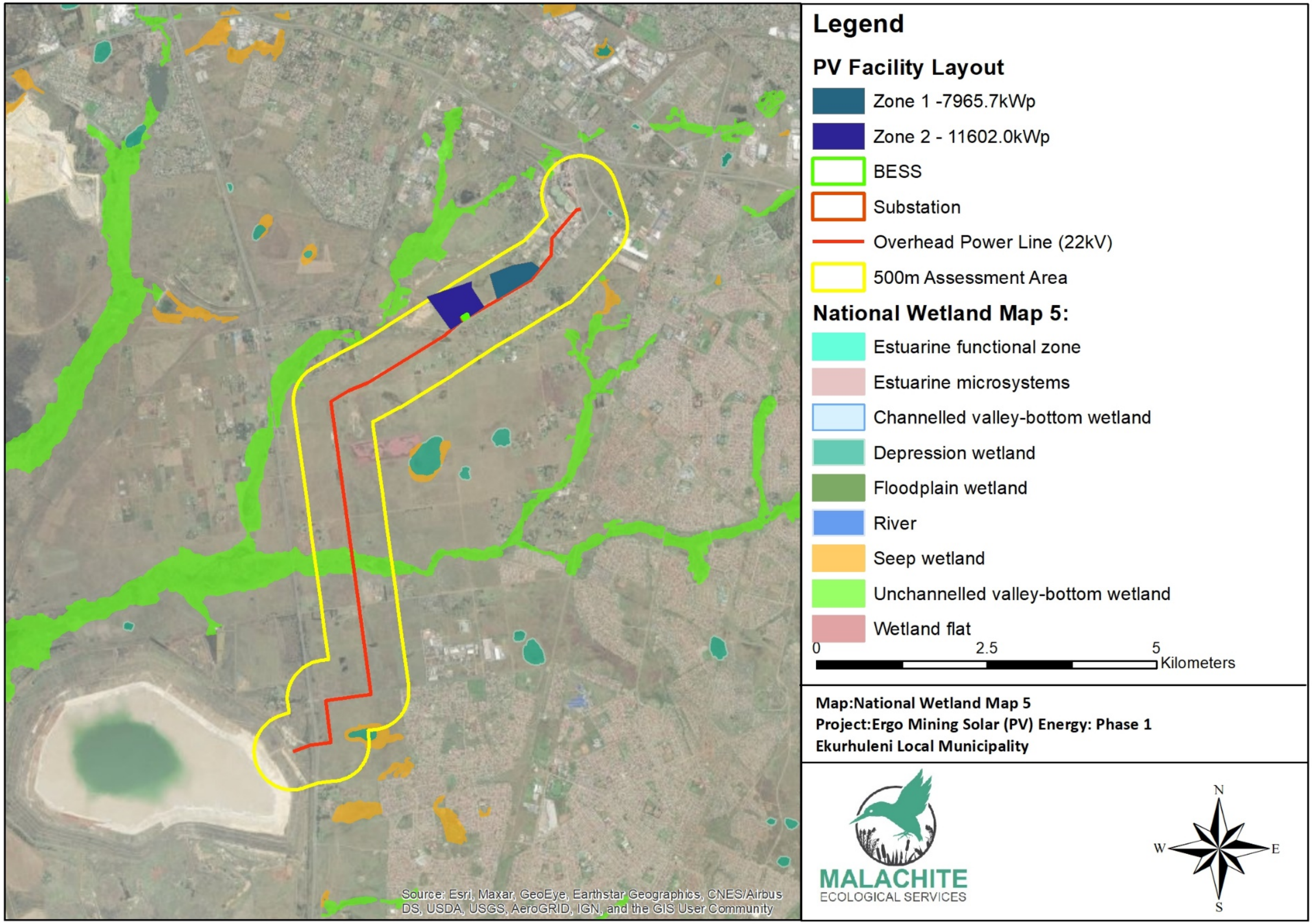


Figure 10: National Wetland Map 5 and Water Resource Probability for the assessment area

3.8 Historic and Current Land Use

An investiation into historic aerial imagery of the site was undertaken. Aerial imagery from 1938 (Figure 11) shows the proposed position of the preferred layout of the PV facility adjacent to and within a wetland system or watercourse. Disturbances to the wetlands/watercourses were already underway, with development and mining operations apparent within proposed Zone 1.

Figure 11: Historic aerial imagery from 1938 showing the proposed PV facility site

In imagery from 1985 the use of the proposed PV facility site as a tailings dam is clearly evident (Figure 12). A second dam is also apparent along the 22kV OHL to the south of the PV facility site. These dams are indications of the disturbed nature of the study site as a result of the use of this area for mining activities.

Figure 12: Historic aerial imagery from 1985

In the 2000s the proposed PV facility site was remined and this is evident in aerial imagery from 2002 (Figure 13). Haul roads, mining operations and the continued transformation of the site is apparent in the aerial imagery.

Figure 13: Aerial imagery from 2002 showing the remining of the area proposed for the PV facility as well as the general area around the 22kV OHL

From approximately 2004/2005, the rehabilitation of the area can be seen to be undertaken, with soil deposition and the re-grassing of the area. This is shown in aerial imagery from 2007/2008 (Figure 14).

Figure 14: Aerial imagery from 2007/2008 showing the rehabilitation of the proposed PV facility site as well as the general area along the 22kV OHL

The most current aerial imagery available on Google Earth[Tm] is from April 2020 (Figure 15). This shows the completed rehabilitation process with the PV facility site now a grassed area. The wetland/watercourse area to the north of the site as well as between the two Zones, is apparent as well, having been dammed as part of the mining activities.

Figure 15: Current imagery from April 2020 showing the rehabilitation of the proposed PV facility site as well as the general area along the 22kV OHL

4. WETLAND ASSESSMENT RESULTS

4.1 Wetland Delineation

The South African classification system categorises wetland systems based on the characteristics of different Hydrogeomorphic (HGM) Units. An HGM unit is a recognisable physiographic wetland-unit based on the geomorphic setting, water source of the wetland and the water flow patterns (Macfarlane et al., 2008). There are five broad recognised wetland systems based on the abovementioned system and these are depicted in Figure 16. The classification of these wetlands is then further refined as per the 'Classification System for Wetlands and other Aquatic Ecosystems in South Africa' (Ollis et al., 2013).

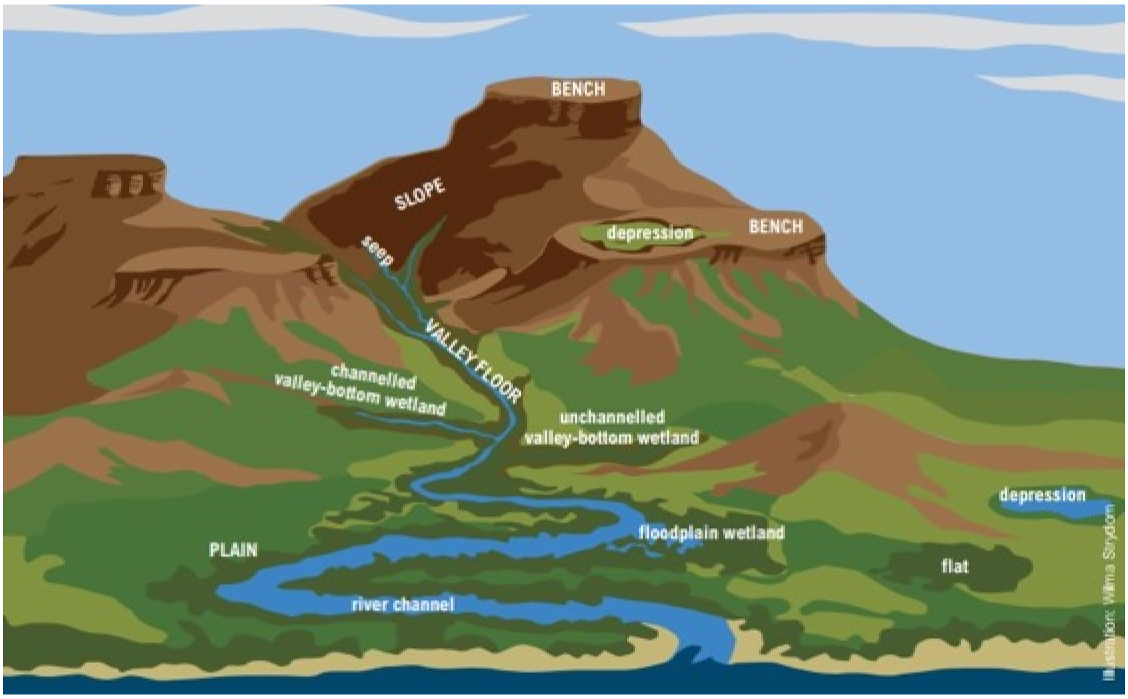


Figure 16: Diagrammatic representation of common wetland systems identified in Southern Africa

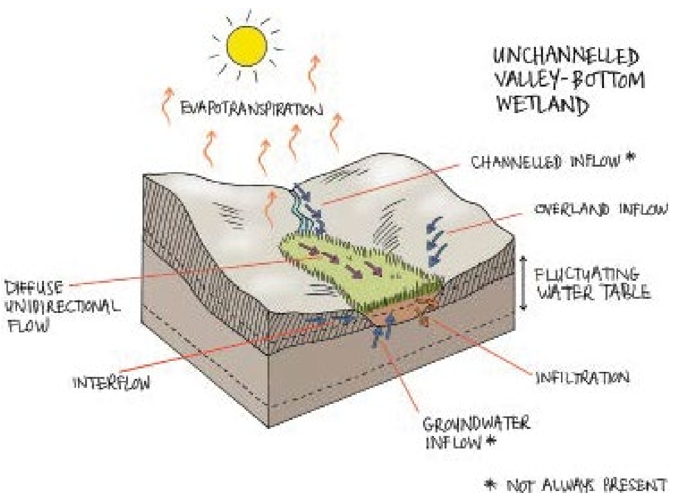
Based on the current identification of the four wetland indicators, six HGM units were delineated within the assessment area (PV facility preferred and alternative layout, OHL route and 500m assessment area). These included an unchannelled valley bottom wetland, two seep systems, a channelled valley bottom wetland and two depression wetlands (Table 4). These are displayed in Figures 17 to 19.

Table 4: Summary table of delineated wetlands

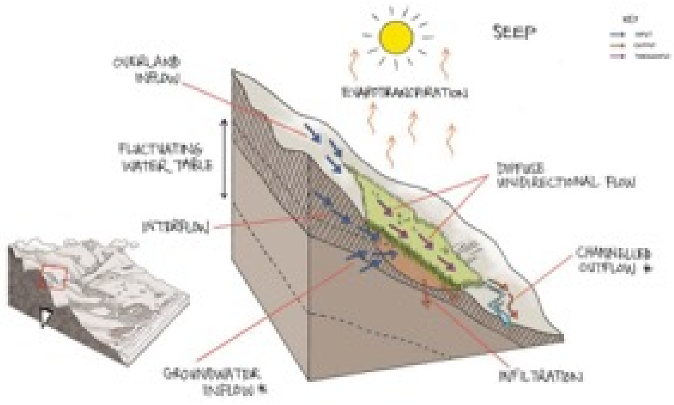
HGM unit number	Wetland Type
HGM 1	Unchannelled Valley Bottom
HGM 2	Seep
HGM 3	Channelled Valley Bottom
HGM 4	Seep
HGM 5	Depression
HGM 6	Depression

The various wetland classifications are explained in more detail below.

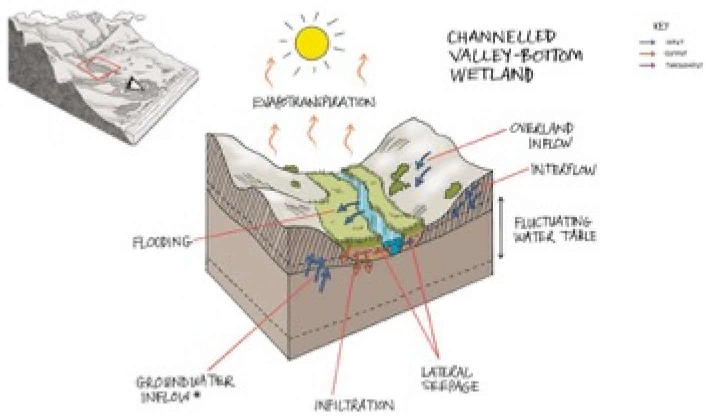
Unchanneled valley bottom wetlands are characterised by their location on valley floors and the absence of distinct channel banks and the prevalence of diffuse flows. These wetlands are generally formed when a river or stream channel loses confinement and spreads out over a wider area causing the concentrated flow associated with a river channel to change to diffuse flow (Ollis et al., 2013). Dominant water inputs to these wetlands are derived from the channels flowing through the wetland, either as surface flows resulting from flooding or as subsurface flow. Water generally moves through the wetland as diffuse surface flow although occasionally as short-lived concentrated flows during flood events (Ollis et al., 2013).



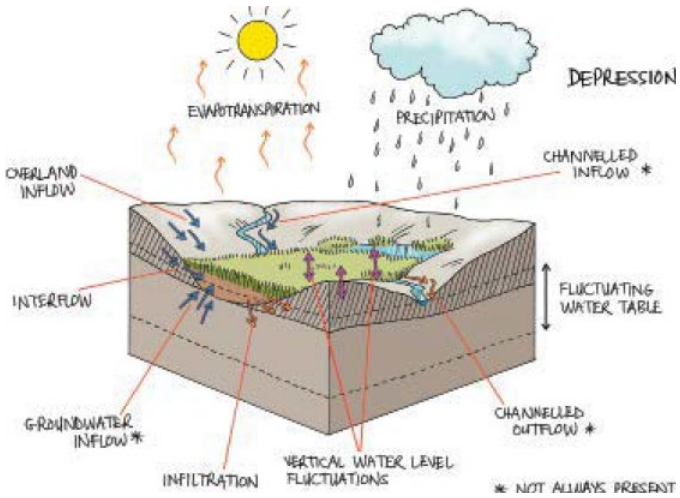
Seepage wetlands are characterised by their association with topographic positions that either cause groundwater to discharge to the land surface or rain-derived water to seep down-slope as subsurface interflow. Water movement through the seep is primarily attributed to interflow, with diffuse overland flow often being significant during and after rainfall events (Kotze et al., 2008; Ollis et al., 2013). Water inputs are mainly from sub-surface flow and outflow is usually via a well-defined stream channel connecting the area directly to a stream channel.



Channelled valley bottom wetlands are characterised by their location on valley floors and the presence of a river or stream channel flowing through the wetland (but lacking characteristic floodplain features). This may be gently sloped and characterised by the net accumulation of alluvial deposits or have steeper slopes and be characterised by the net loss of sediment. Dominant water inputs to these wetlands are derived from the channels flowing through the wetland, either as surface flows resulting from flooding or as subsurface flow. Water generally moves through the wetland as diffuse surface flow although occasionally as short-lived concentrated flows during flood events (Ollis et al., 2013).



Depression wetlands have closed (or near-closed) elevation contours, which increases in depth from the perimeter to a central area of greatest depth and within which water typically accumulates. They may be flat-bottomed, or round bottomed and have any combination of inlets and outlets or lack them Completely. Most depressions occur either where the water table intercepts the land surface, or in semi-arid settings where a lack of sufficient water inputs prevents areas where water accumulates from forming a connection with the open drainage network.



The delineation exercises were conducted based on the dominant indicators, including soil type (i.e., soil form and the presence of hydric characteristics); vegetation; and topographic position within a landscape. These are discussed in more detail in the following sections.

Apart from the natural wetland systems delineated within the assessment area, a number of artificial depressions, functional dams, discarded dams and seepage from dams was delineated. Of particular importance where the artificial depressions delineated within the PV facility site. These are detailed in Section 4.5.

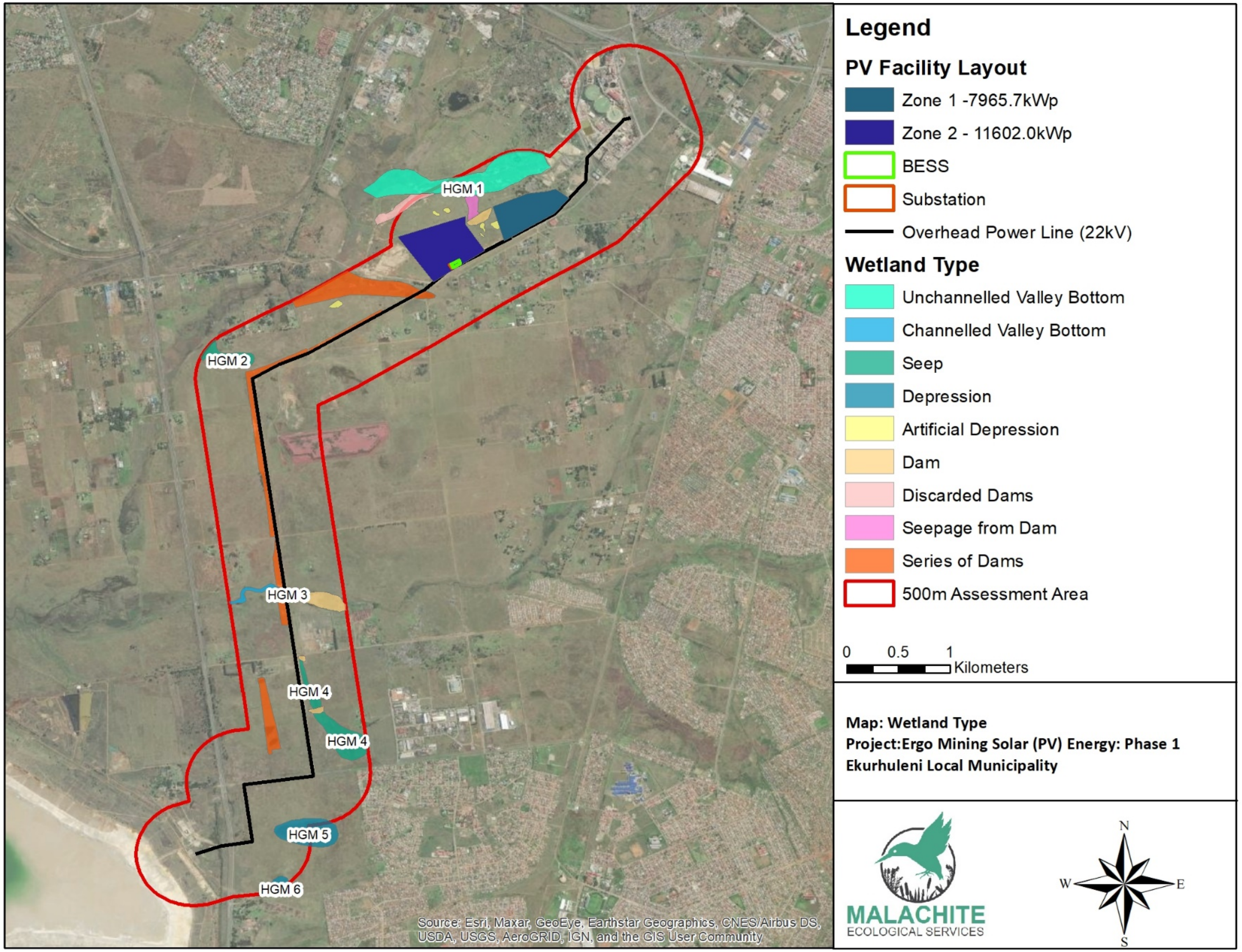


Figure 17: Wetland systems delineated within the assessment area

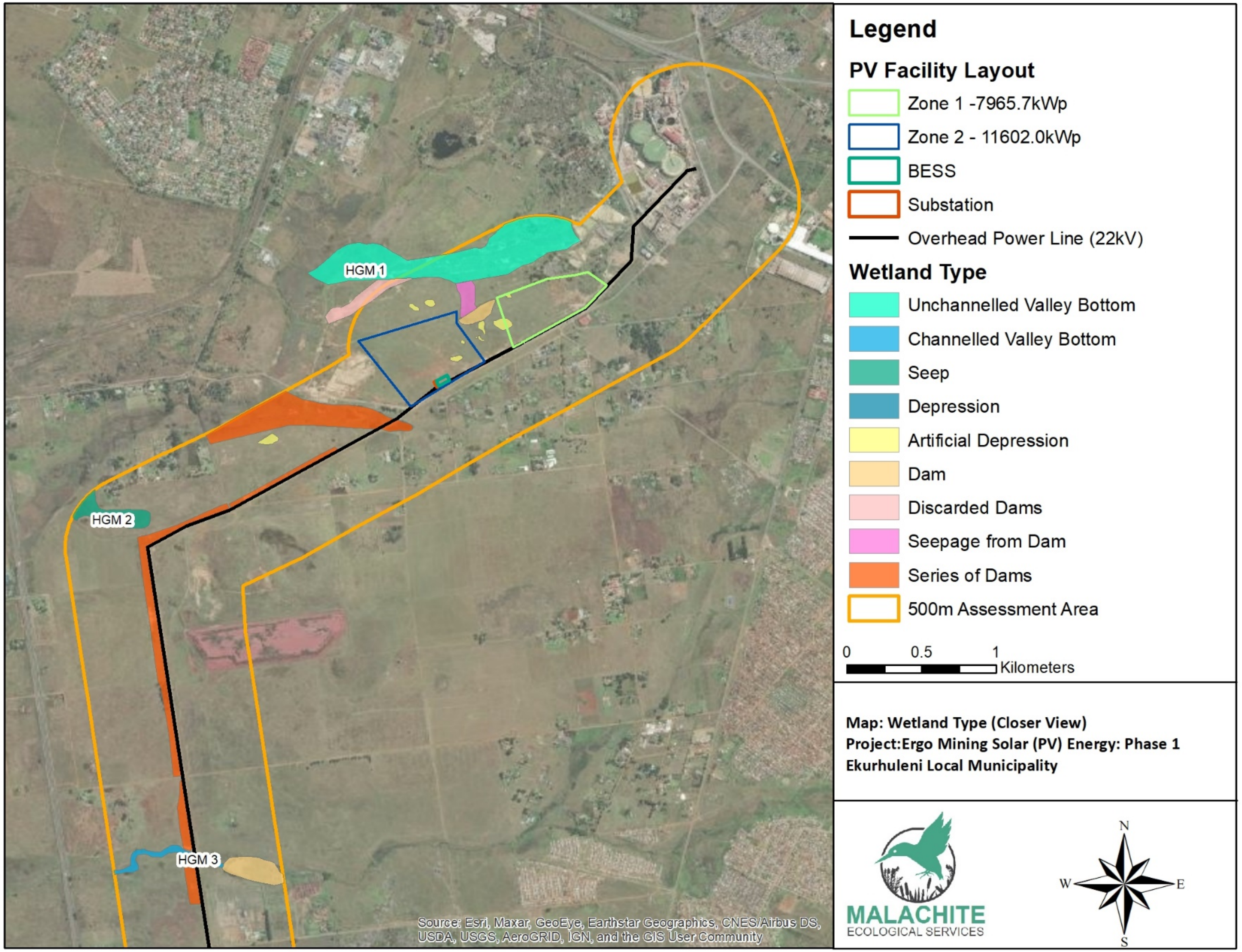


Figure 18: Closer view of the wetland systems delineated within the assessment area

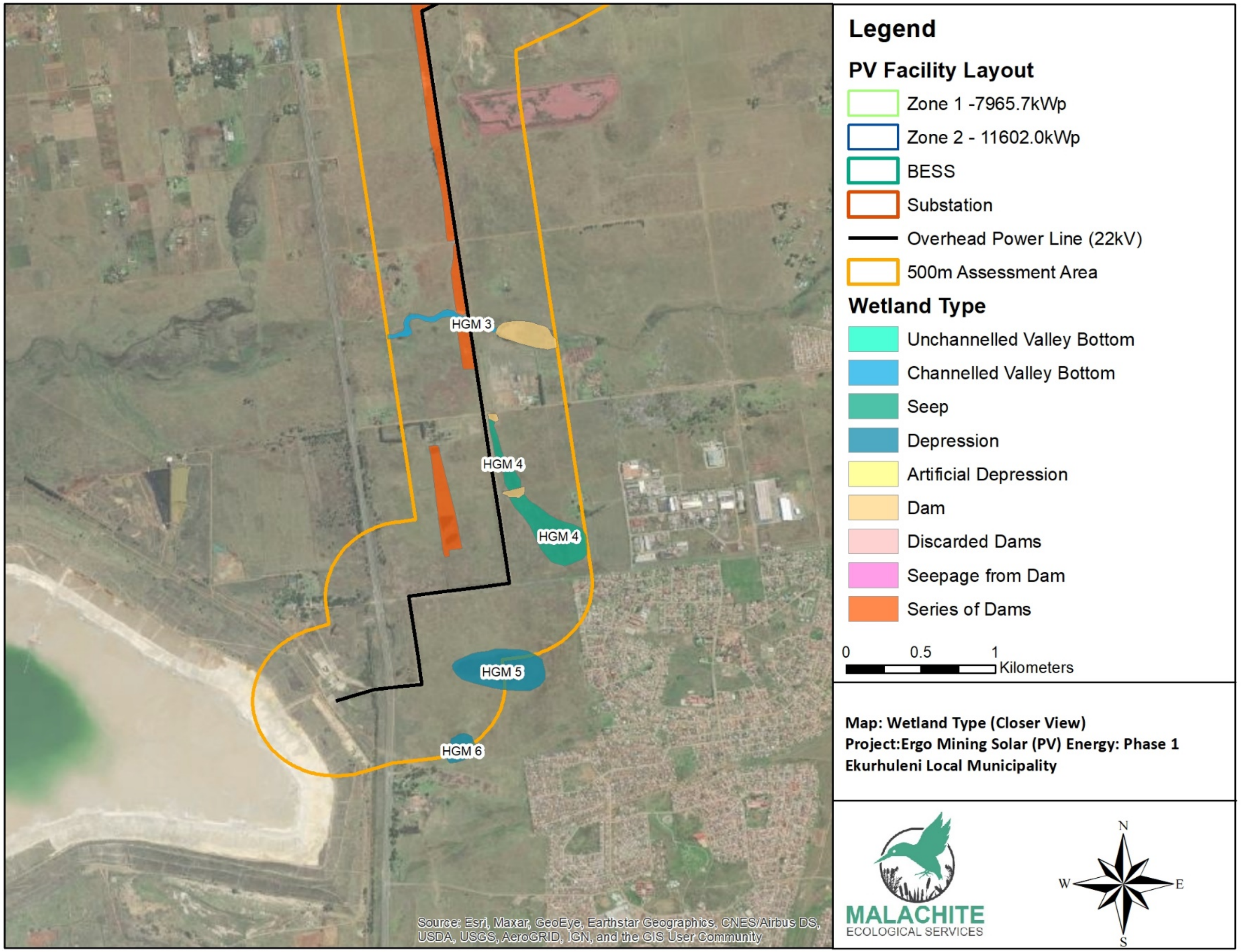


Figure 19: Closer view of the wetland systems delineated within the assessment area

4.2 Soil Wetness and Soil Form Indicator

Soil samples were taken throughout the study site and auger points were examined for the presence of hydric (wetland) properties. Hydric soils are defined as those that typically show characteristics resulting from prolonged and repeated saturation. These characteristics are called redoximorphic features and include the presence of mottling (i.e., bright insoluble iron compounds); a gleyed matrix; and/or Manganese (Mn)/Iron (Fe) concretions (Figure 20).

The presence of redoximorphic features is the most important indicator of wetland occurrence, as these soil wetness indicators remain in wetland soils, even if they are degraded or desiccated (DWAF, 2005). 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, or non-hydric and that a soil horizon does not have to be 100% saturated for this reduction reaction to begin and to show within the profile as either mottling, a gleyed matrix or a concretion. A hydric soil will therefore not necessarily contain all the diagnostic horizons associated with redoximorphic features; however, all hydric soils will contain at least one of these features within the upper 500mm of the soil profile (Collins, 2005).

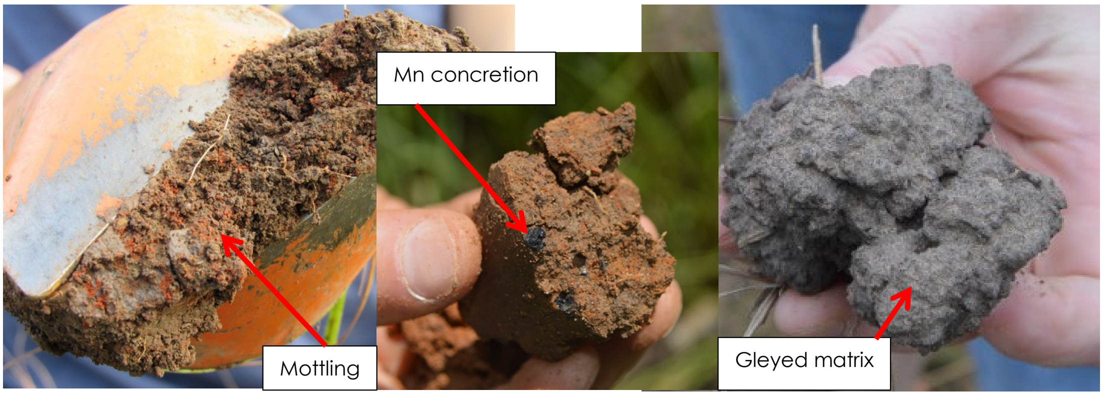


Figure 20: Generic examples of hydric characteristics used as indicators for wetland conditions

Further to the identification of hydric properties, it is important to consider the soil form. The type of soil (or the soil form) has a significant influence on the formation and functioning of a wetland system and its location within a catchment. This includes the way in which water enters and flows through a wetland (Ollis et al., 2013). Soil forms are not randomly distributed in a landscape and therefore hydrological soil types typically occupy specific positions in the hillslope. This means that certain soils play more of a releasing or receiving role related to water movement within a hillslope or topographic position. This has important implications in landscape hydrology (van Tol, et al., 2013).

Soil samples were taken throughout the proposed PV facility, along the OHL route, as well as within 500m of these areas. Terrestrial and hydric soils were identified. Hydric soils were dominated by the plinthic soil class and included the Avalon and Bainsvlei soil forms, with the Katspruit soil form identified in the valley bottom areas (Figure 21).

Due to significant anthropogenic modifications to the proposed PV Facility site, the majority of soil samples within this area were classified as the Hydric Technosol, Stilfontein. Hydric Technosols are soils which have undergone saturation for an extended period of time. The classification was applied to this area as hydric properties were identified both at the surface of the soil (i.e., where the artificial depressions are located) as well as within the lower reaches of all soil profiles examined within this area. Hydric properties included a gleying of the soil matrix as well as distinct and a high concentration of mottles and concretions. The presence of the Stilfontein soils in this area are a result of the transformation of this area to a tailings dam which was remined and then rehabilitated, leaving behind saturated soils as well as an alteration to the natural drainage of the area, causing current ponding of stormwater (Figure 22).

Stilfontein soils were furthermore identified along the OHL route and within the 500m assessment area and are associated with mining related dams (current and discarded) as well as stormwater control areas.

Terrestrial soils were also anthropogenically modified and included the Anthrosols and Technosols, Grabouw, Johannesburg and Witbank. Scattered natural soils were identified along the OHL route as well as within 500m of the site and included Nkonkoni, Mispah and Glenrosa. A full description of the soils identified is provided in the Soils, Land Capability and Agricultural Potential Assessment (Malachite Ecological Services, 2021).

Figure 21: Hydric soils identified within the assessment area including Bainsvlei, Avalon and Katspruit

Figure 22: Ponding of stormwater within the proposed PV facility site on the Stilfontein soils

4.3 Vegetation Indicator

According to DWAF (2005), vegetation is regarded as a key component to be used in the delineation procedure for wetlands as distinct changes in vegetation assemblages can be noted when moving through wetland systems, from the permanent zone to the temporary zone. Vegetation also forms a central part of the wetland definition in the National Water Act (Act 36 of 1998).

Hydrophytic vegetation are plant species that are adapted to growing in permanently or temporarily water-logged conditions (elevated water conditions in wetland soils). This is further subdivided into species that are obligate and facultative wetland species (Table 5). The composition of a plant community is determined by the complex interactions between climate, soil type, position in the landscape and competition between plant species.

Wetland plant species perform a variety of functions including:

- Maintaining water quality by filtering out nutrients and sediments.
- Providing food, shelter and breeding habitat for both aquatic and terrestrial fauna.
- Preventing erosion.

Table 5: The classification of plants according to occurrence in wetlands (DWAF, 2008)

VEGETATION COMPONENTS	DESCRIPTION
Obligate wetland species	Almost always grow in wetlands (> 99% of occurrences)
Facultative wetland species	Usually grow in wetlands (67-99% of occurrences) but occasionally are found in non-wetland areas
Facultative species	Are equally likely to grow in wetlands and non-wetland areas (34- 66% of occurrences)
Facultative dry-land species	Usually grow in non-wetland areas but sometimes grow in wetlands (1-34% of occurrences)

These wetland “indicator” species assist in the identification of wetland systems and associated boundaries. However, using vegetation as a primary wetland indicator requires undisturbed conditions (DWAF, 2005). The alteration of habitat and associated floral communities has a detrimental impact on the ability to confidently rely on vegetation as wetland indicators. In these instances, it makes scientific sense to utilise a combination of terrain and soil characteristics in determining wetland boundaries around transformed areas.

The study site has been largely transformed as a result of historic and present mining as well as urban activities and development. This made the reliance on indicator vegetation species to delineate wetland boundaries difficult. Hydrophytic species however were noted within areas where saturated soils were identified whether these soils were anthropogenically modified (Stilfontein soils) or natural (Bainsvlei, Avalon, Katspruit). Hydrophytic vegetation included *Juncus effuses*, *Cyperus congestus*, and *Pycreus macranthus*. Other species identified in both the wetlands and terrestrial portions of the study site included *Cynodon dactylon*, *Imperata cylindrica*, various *Helichrysum* species, *Paspalum* species, *Eragrostis* species, and *Digitaria eriantha* (Figure 23). A dam is located adjacent to the northern boundary of the proposed PV facility as well as a series of dams located further north (approximately 350-400m) and adjacent to HGM 1, the unchannelled valley bottom system. *Phragmites* species dominate these systems (Figure 24).

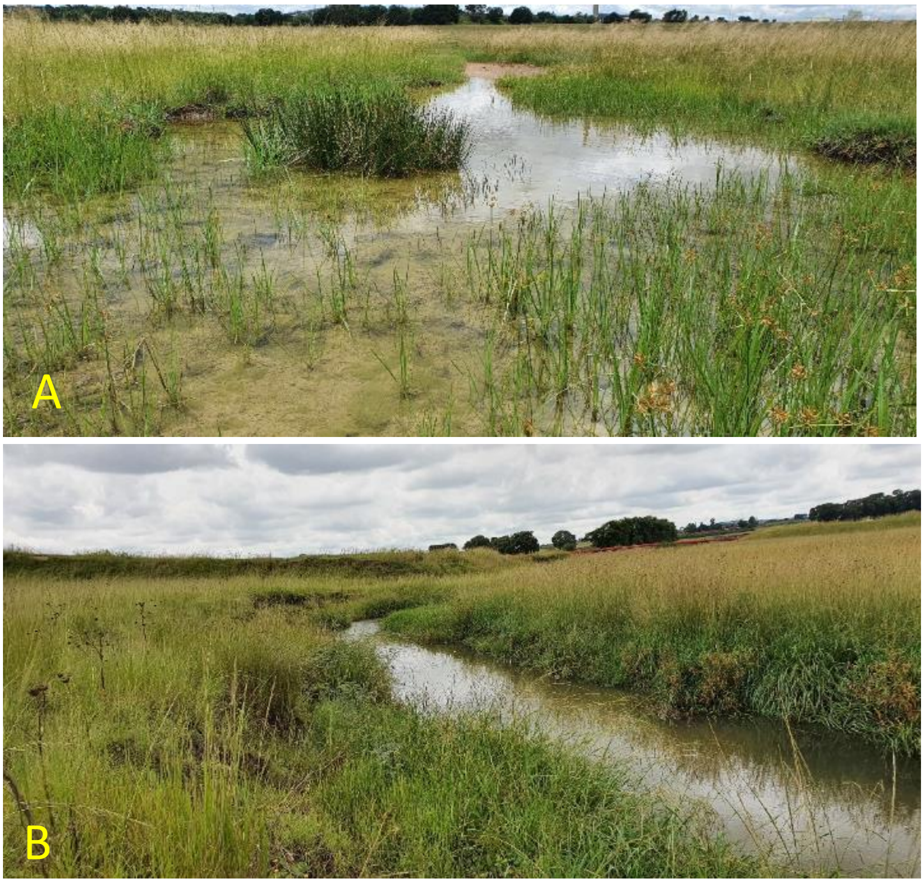


Figure 23: Hydrophytic vegetation including Juncus effusus and Cyperus congesta identified (A) in parts of the PV facility as a result of ponding stormwater in artificial depressions, and (B) in the Channelled Valley Bottom system (HGM 3)

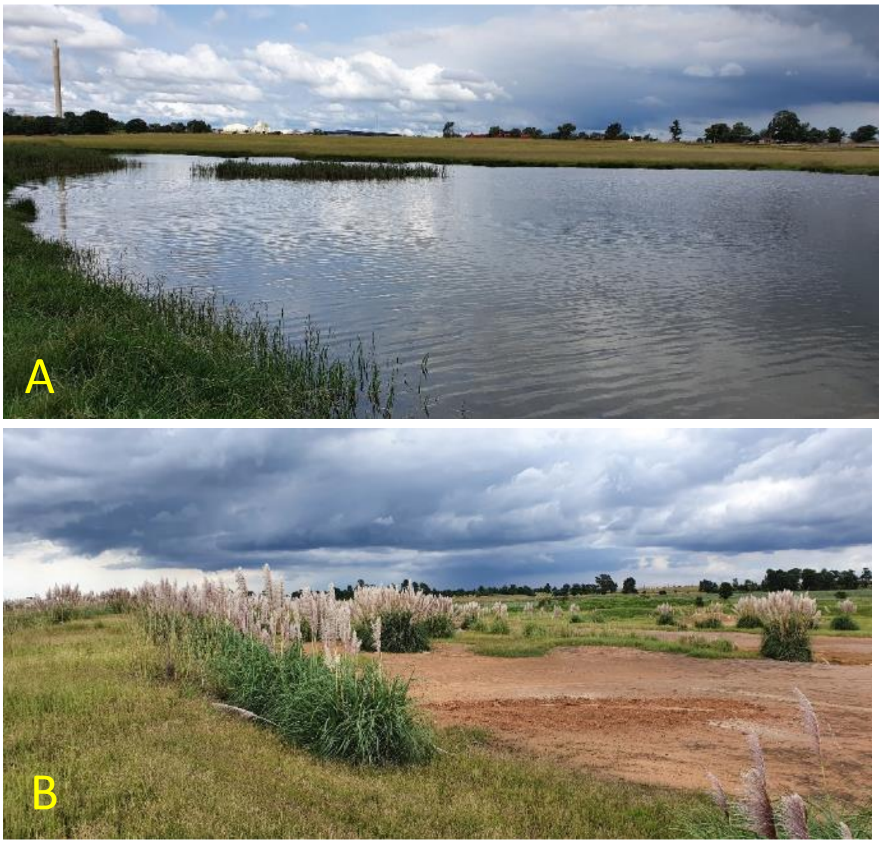


Figure 24: Hydrophytic vegetation identified around the dam situated on the (A) northern boundary of the PV facility site and the (B) discarded dams further north of the PV facility site

4.4 Terrain Indicator

The topography of an area is generally a good practical indicator for identifying those parts in the landscape where wetlands/watercourses are likely to occur. Generally, these occur as valley bottom units however, wetlands can also occur on steep to mid slopes where groundwater or surface water discharge is taking place through seeps (DWAF, 2005). In order to classify a wetland system and/or a watercourse the localised landscape setting must be taken into consideration through ground-truthing of the study site after initial desktop investigations (Ollis et al., 2014).

The project area is situated on a gently undulating landscape. Average slopes are between 1.5% - 2% with maximum slopes of 6% within the northern section of the OHL route, where the existing Ergo Gold Mine Brakpan Plant is located. The altitude ranges from 1658m above sea level (absl) on the northern extent of the OHL to 1573m absl in the more central region of the OHL and then rises again to 1613m absl in the southern portion adjacent to the existing Brakpan/Withok Tailings Dam facility (Figure 25).

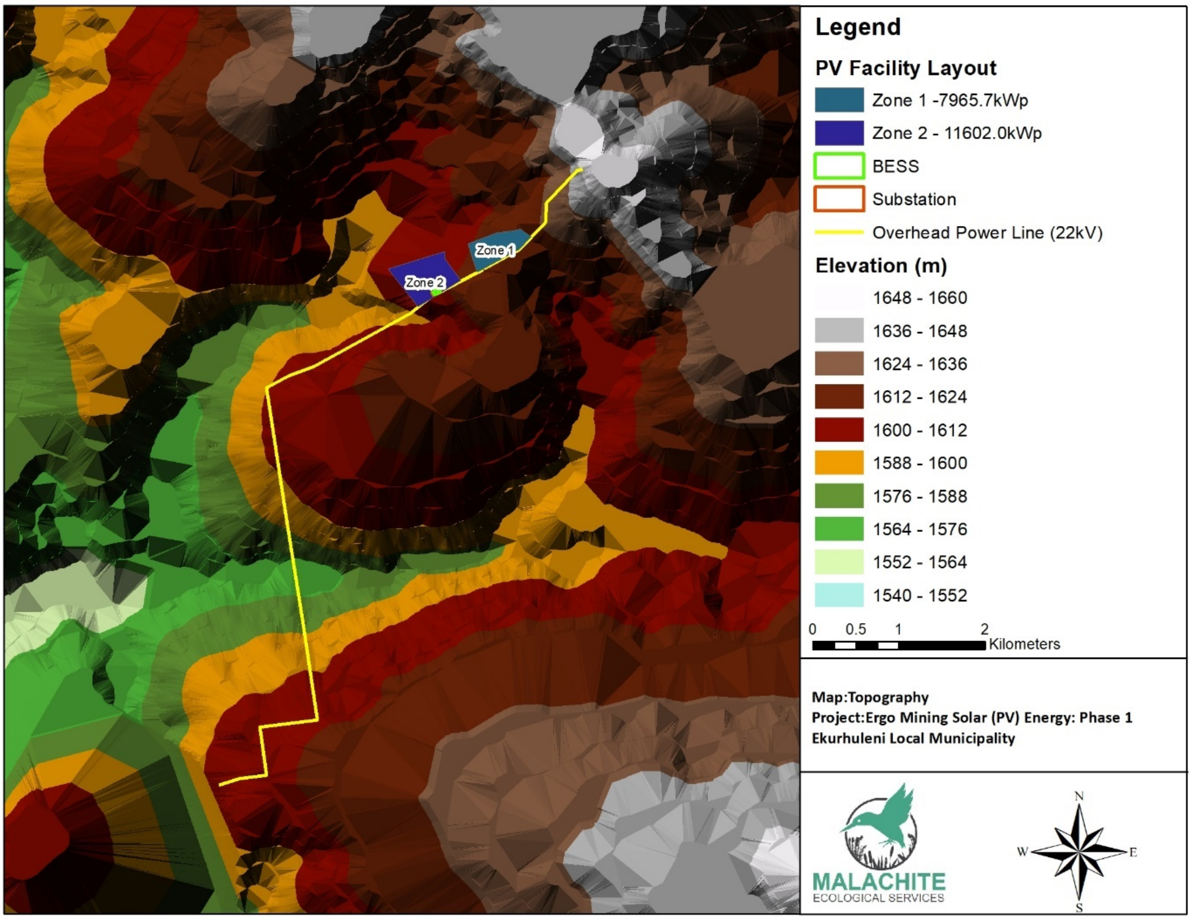


Figure 25: Topography of the site

4.5 Artificial Wetland systems and the PV facility site

A number of depressions were delineated within the proposed PV facility site, furthermore an artificial seep was identified below an existing dam which is situated between Zone 1 and Zone 2 of this site (Figure 26). The depressions were saturated at the time of the field investigation and supported a number of hydrophytic plant species. The same is true for the artificial seep.

These wetland systems were however identified to be artificial in nature and have been created by the extensive anthropogenic modifications to the PV facility site and surrounding area. As shown in historical aerial imagery of the site (Section 3.7) the area was converted into a tailings facility, this was remined in the 2000s and subsequently rehabilitated to its current form. As a result of these anthropogenic disturbances, the soils of the site have been completed modified and are now classified as the Hydric Technosol, Stilfontein form. These soils show signs of saturation but are not natural wetland soils. The depressions were delineated based on the presence of hydric characteristics of the soil, at the surface of the soil profile or within the first 10cm. Remaining Stilfontein profiles examined showed signs of saturation at approximately 60 to 70cm depths. The saturation of the depressions is further compounded by the deposition of sediment on top of the Stilfontein form and which causes stormwater ponding on the soil surface. During the drier seasons, these depressions will become desiccated over time and decrease in size.

While these 'depression' systems do allow for the growth of hydrophytic plant species, they are artificial in nature and do not provide large scale ecosystem benefits to the broader landscape. Furthermore, no species of conservation concern were noted within the PV facility site.

It is therefore the recommendation of this report that these artificial 'depressions' do not affect the proposed layout of the PV facility site. The dam and artificial seep will not be directly impacted by the proposed PV facility (preferred or alternative layouts). A recommended buffer for the dam and seep is proposed in Section 7. Stormwater control from the cleared site is furthermore recommended, particularly during the wetter seasons as the indigenous vegetation associated with the 'depressions' and site as a whole provides attenuation services.

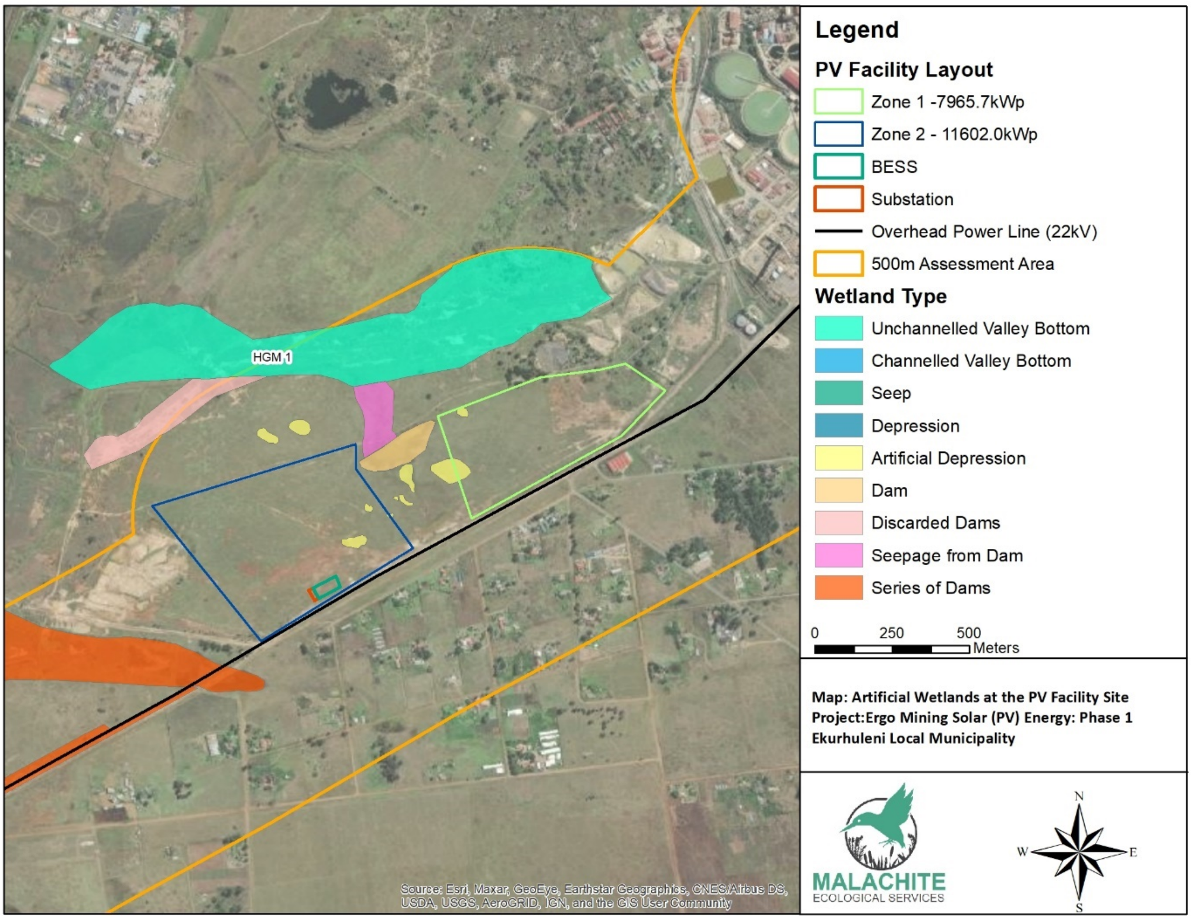


Figure 26: Location of the 'depressions' within the PV facility footprint as well as some images of these areas

5. WETLAND HEALTH AND FUNCTIONAL ASSESSMENT

5.1 Present Ecological State (PES)

The six natural HGM units were assessed with regards to their health according to the Wet-Health methodology[4]. HGM 1, the unchannelled valley bottom wetland, was classified as Seriously Modified (PES Category E), while the remaining HGM units were classified as Largely Modified (PES Category D).

Impacts to the wetland systems stem from the use of the catchments associated with each wetland for historic and current mining activities as well as urban development. These developments have impacted the hydrological flow of the wetlands as well as the geomorphic setting. HGM 1 has been particularly disturbed as a result of mining within the catchment. This wetland has been dammed

[4] The current size of the delineated wetlands was recorded. It must be noted that this is not the entire size of the wetland but rather the portion of the system delineated within the assessment area.

during historic mining within the area and while much has been rehabilitated through the decommissioning of the dams, the wetland remains seriously impacted. The existing Ergo Gold Mine Brakpan Plant is situated within the catchment of this HGM unit, with tailings facilities in the upper reaches of the valley bottom wetland. These have had a serious impact on the flow dynamics of the wetland, leading to erosion, desiccation and encroachment of alien invasive species.

Dams associated with HGM 2 and HGM 4, the seep wetlands, have also had an impact on the flow dynamics of these systems. This is particularly so for HGM 4 where two dams are located within the system. A dam is furthermore situated in HGM 3, the channelled valley bottom wetland, to the west of the proposed OHL route. The damming of wetland systems has long-term negative impacts on the hydrology, geomorphology and vegetation dynamics of these systems. Dams cause a decrease in the quantity of water reaching downstream wetland areas as well as the increase in flooding of the upstream wetland systems, leading to changes in the hydrological flow through the channels as surface flow and through the soil profile as subsurface flow. Further to this, impoundments act as sediment sinks, reducing the sediment load of water released downstream of the dam. This results in water that is regarded as 'sediment hungry', having an increased capacity for erosion.

The depression wetlands, HGM 5 and HGM 6, have smaller catchment areas and this has limited the impacts to these wetlands to a degree. However, the wetlands are still impacted through the development of residential areas to the west of these systems. A general desiccation of the wetlands is apparent in the series of aerial imagery from 1985 to 2020.

Anthropogenic disturbances within the area, both historic and current, have also allowed for the encroachment of alien invasive species within the wetland systems to differing degrees. Although this encroachment is not significant within the study site, it is predicted that without any control, coupled with increased disturbance within the site, the encroachment of alien invasive species will continue to exacerbate within the area. Alien species generally out-compete indigenous species for water, light, space, and nutrients as they are adaptable to changing conditions and are able to easily invade a wide range of ecological niches (Bromilow, 2010). Alien invader plant species pose an ecological threat as they alter habitat structure, lower biodiversity (both number and "quality" of species), change nutrient cycling and productivity, and modify food webs (Zedler, 2004).

A summary of the PES scores obtained for the field-based delineated systems following application of the Wet-Health approach is provided in Table 6.

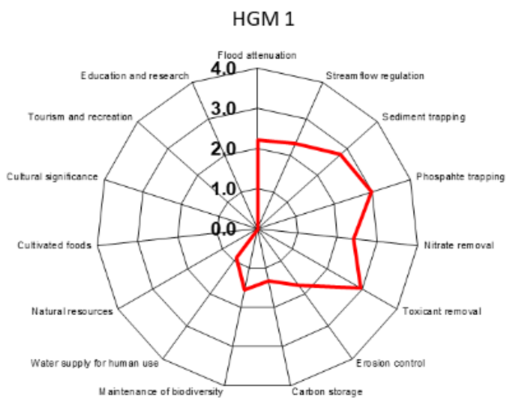
Table 6: Summary of PES score

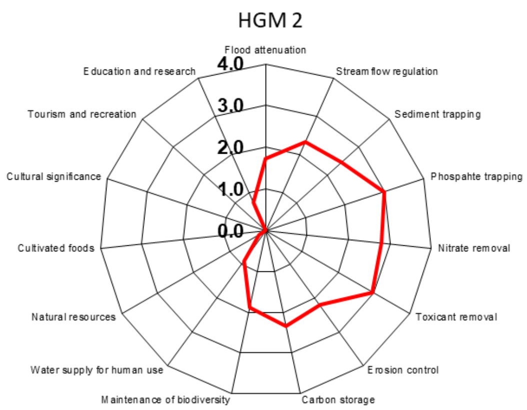
HGM Unit	Extent Delineated (Ha)	Hydrology	Geomorphology	Water Quality	Vegetation	PES Score (Category)
HGM 1	34.02	6.6	5.0	7.3	7.3	**E (6.50)**
HGM 2	5.15	5.2	4.0	3.4	6.0	**D (4.70)**

HGM Unit	Extent Delineated (Ha)	Hydrology	Geomorphology	Water Quality	Vegetation	PES Score (Category)
HGM 3	2.70	4.2	3.0	4.8	4.4	**D (4.10)**
HGM 4	12.67	6.4	4.3	4.5	6.3	**D (5.70)**
HGM 5	12.26	5.3	3.2	5.6	3.2	**D (4.4)**
HGM 6	2.60	5.5	3.3	5.9	3.8	**D (4.7)**

5.2 Functional Assessment (Ecosystem Goods and Services)

Ecosystem goods and services were calculated for the HGM units (Figure 27). All HGM units received generally low to moderate scores for the ecosystem services. Highest scores received were associated with flood attenuation (particularly for HGM 1 and HGM 3), streamflow regulation, erosion control, sediment trapping and filtration (in the form of nitrate, phosphate and toxicant trapping). The depression wetlands received generally lower scores compared to the other HGM units, due mainly to their endorheic nature, limiting the influence of the wetlands on the larger landscape. However, these wetlands do still provide functions related to sediment control and filtration.





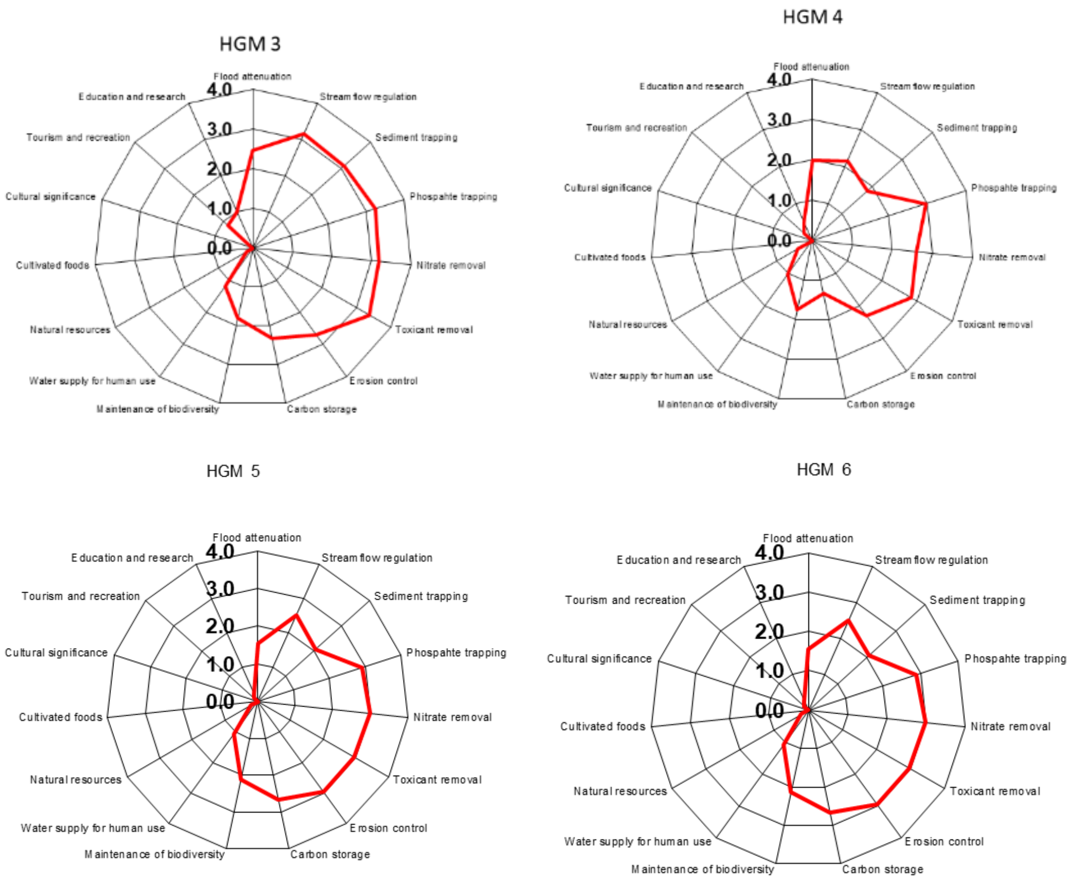


Figure 27: General WET-EcoServices results for all HGM units

5.3 Ecological Importance and Sensitivity (EIS)

The EIS scores received for all HGM units was Low[5] (Table 7). The location of the wetlands within an urban landscape that has been largely disturbed limits the ability of the wetlands to provide suitable habitat for faunal and floral species. The channelled valley bottom (HGM 3) received a higher score as a result of the presence of open water which provides habitat for semi-aquatic and aquatic species.

All systems received Moderate scores for the Hydrological Functional Importance, and this supports the scores received in the Present Ecological State scores as well as the Wet-Ecosystem services scores. The systems provide numerous ecological services to the surrounding community as well as their catchments. Socio-economic importance of the wetlands is low and is limited to grazing for livestock as well as the presence of dams in some of the systems.

[5] A low score indicates that features about the wetland are regarded as somewhat ecologically important and sensitive at a local scale. The functioning and/or biodiversity features have low-medium sensitivity to anthropogenic disturbances. They typically play a very small role in providing ecological services at the local scale.

Table 7: Summary of the Ecological Importance and Sensitivity

HGM UNIT	EIS	SCORE (0-4)	CONFIDENCE (0-5)	CATEGORY
HGM 1	Ecological Importance and Sensitivity	1.47	4	**Low**
	Hydrological Functional Importance	2.34	4	**Moderate**
	Direct Human Benefits	0.67	4	**Very Low**
HGM 2	Ecological Importance and Sensitivity	1.54	4	**Low**
	Hydrological Functional Importance	2.47	4	**Moderate**
	Direct Human Benefits	0.67	4	**Very Low**
HGM 3	Ecological Importance and Sensitivity	1.87	4	**Low**
	Hydrological Functional Importance	2.94	4	**Moderate**
	Direct Human Benefits	1.33	4	**Low**
HGM 4	Ecological Importance and Sensitivity	1.53	4	**Low**
	Hydrological Functional Importance	2.25	4	**Moderate**
	Direct Human Benefits	0.83	4	**Very Low**
HGM 5	Ecological Importance and Sensitivity	1.57	4	**Low**
	Hydrological Functional Importance	2.57	4	**Moderate**
	Direct Human Benefits	0.67	4	**Very Low**
HGM 6	Ecological Importance and Sensitivity	1.44	4	**Low**
	Hydrological Functional Importance	2.57	4	**Moderate**
	Direct Human Benefits	0.67	4	**Very Low**

6. DESKTOP AQUATIC ASSESSMENT

6.1 Aquatic Habitat

In general, a low diversity of aquatic habitats is expected within the study area given the nature of the associated watercourses associated with the 22kV OHL (being valley-bottom wetland systems) as well as the underlying geology which has resulted in a notable lack of stones habitat. Further, all sites assessed had relatively small, low-gradient catchments and thus a low accumulation of flow, resulting in slow-flowing hydraulic habitat. Consequently, it is expected that aquatic habitat within the channelled valley bottom system (HGM 3) would comprise primarily of emergent and aquatic vegetation with slow-flowing open water and a mud-based substrate where open substrate is found. In contrast, aquatic habitat within the unchannelled valley bottom is likely to be temporary and seasonal, with water likely present only during the wet season, with shallow water, emergent and aquatic vegetation present.

However, the urbanised upper reach of the channelled valley-bottom wetland (HGM 3) is likely to have contributed to increased periodicity and magnitude of flooding within this wetland system, which in turn is likely to have led to increased erosional potential, channel incision and bed armouring. The presence of a large dam immediately upstream of the proposed 22kV OHL crossing is further likely to impact on the seasonal hydraulic diversity of the system, reducing water flow downstream of the dam during low-flow periods.

Within the artificial depressions located at the PV facility site, aquatic habitat is expected to present similar conditions as that within the unchannelled valley-bottom wetland feature (HGM 1), with emergent vegetation being the dominant habitat structure. However, the shallow depth and lack of flowing water as well as possible water quality impairment from leaching of underlying substrate is expected to be a significant limitation to the occurrence of aquatic diversity within these systems.

6.2 Aquatic Macroinvertebrates

In general, the valley bottom wetlands and depressional systems, as was determined to be present within the study area, are unlikely to support a diverse array of aquatic biota during even unimpacted conditions given the lack of diverse hydraulic habitat. Accordingly, given the water quality of the generally reducing environment associated with wetlands and the possible impacts from historic gold mining activities within the area, as well as hydrological dynamics of such systems, the aquatic macroinvertebrate assemblage is expected to be dominated by species with a strong preference for instream and emergent vegetation within very slow-flowing habitats, as well as taxa with a very low to low preference for unmodified water quality. As such, while representatives from various aquatic macroinvertebrate families are expected, the assemblage associated with identified wetland features is expected to be dominated by taxa from the families Hemiptera and Coleoptera for much of the year.

With unchannelled valley-bottom wetlands and depressional systems generally only supporting surface water during the wetter parts of the year, the duration of the hydroperiod of the wetland has a further significant bearing on the aquatic assemblage present. Studies on the recolonisation of non-perennial watercourses by aquatic macroinvertebrates families are few, but it appears that Chironomidae (Midges), Oligochaeta (Earthworms) and Simulidae (Black Flies; only in true-running streams) are some of the early colonisers (Rossouw et al., 2005). This was supported by observation in a study by Harrison (1966), as other early-colonisers (i.e. within the first ten days) were also noted to be oligochaetes, small crustaceans and small insect larvae. However, it should be noted that species typical of permanent streams only returned within one month of re-inundation in lentic (or standing) pools and within 4-6 weeks in lotic (or flowing) streams (Rossouw et al., 2005). While such studies were specifically associated with non-perennial systems, a similar succession of aquatic macroinvertebrate is likely to be associated with re-inundation of unchannelled valley-bottom and depressional wetland systems. Such is of further relevance within the present study area, where the temporal extent of inundation of the unchannelled valley-bottom wetland (HGM 1) is unknown thus limiting the suitability for the application of aquatic biodiversity indices.

6.3 Ichthyofauna

A total of seven indigenous fish species and a further three alien fish species are expected to be associated with the reach of HGM 3 specifically (Table 8). To a large degree, no fish species are expected to be associated with the unchannelled valley-bottom wetlands or the depressional wetlands associated with the northern extent of the study area (i.e. PV facility and nothern portions of the 22kV OHL. A notable exception would be the presence of several dams within the area which are expected to support the presence of larger indigenous fish such as *Clarias gariepinus* (Sharptooth Catfish), *Tilapia sparrmanii* (Banded Tilapia), and the alien species *Cyprinus carpio* (Carp) and *Micropterus salmoides* (Largemouth Bass). According to the unified framework proposed by Blackburn et al. (2011), both *Cyprinus carpio* and *Micropterus salmoides* can be classified as fully invasive species, with individuals dispersing, surviving and reproducing at multiple sites across a greater or lesser spectrum of habitats and extent of occurrence (Ellender & Weyl, 2014).

Table 8: Fish species expected to be associated with the study area

Scientific Name	Common Name	Conservation Status
Indigenous species		
Clarias gariepinus	Sharptooth Catfish	Least Concern
Enteromius cf. anoplus	Chubbyhead Barb	Least Concern
Enteromius cf. pallidus	Goldie Barb	Least Concern
Enteromius paludinosus	Straightfin Barb	Least Concern
Labeo capensis	Orange Vaal Mudfish	Least Concern
Labeo umbratus	Moggel	Least Concern
Tilapia sparrmanii	Banded Tilapia	Least Concern
Non-native Species		
Cyprinus carpio	Carp	Alien
Gambusia affinus	Mosquitofish	Alien
Micropterus salmoides	Largemouth Bass	Alien

It should be noted that there are current taxonomic uncertainties with several species of fish expected to occur with the study area, which may have implications on assigned conservation status. These include:

- *Enteromius cf. anoplus* (Chubbyhead Barb complex). Genetic studies done on the Chubbyhead Barb complex by Da Costa (2012) suggested that this group have significant genetic variation and to represent multiple potential species. The study by Da Costa (2012) showed the separation of the complex into distinct lineages, with the species likely to occur within the present study area corresponding with Lineage A which represents the largest of the lineages identified. Four sub-groups were observed within Lineage A by Da Costa (2012), with those specimens present within the Upper Vaal catchments corresponding to sub-group 1, again the largest of the sub-groups identified. Nevertheless, if further taxonomic studies confirm that there are separate species, the assessment as Least Concern may need revision in some cases;

- *Enteromius cf. pallidus* (Goldie Barb). According to Chakona et al. (2015), genetic analyses of *Enteromius pallidus* collected from the currently known distribution range of the species within South Africa grouped into two distinct lineages, namely a southern lineage from where the original type specimen was collected, and a northern lineage. Further, the deep genetic divergence between the northern and southern lineages of *E. pallidus* suggests a long history of isolation, raising two taxonomic possibilities: The first possibility is that the northern lineage of *E. pallidus* may represent an undescribed species. A second possibility is that the 'true' *E. pallidus* is confined to coastal rivers of the Eastern Cape, and the northern lineage belongs to a different, but known species or species complex. However, further research is required to resolve this taxonomic uncertainty between the two genetically distinct lineages to determine implications on conservation priorities.

6.4 Present Ecological State

According to the desktop assessment of sub-quaternary reach C22C-01405 (Department of Water and Sanitation, 2014), the reach of the channelled valley bottom wetland, HGM 3, is considered to be largely modified (Ecological Category D; Table 9) from a riverine perspective based on the assessment of six metrics that represents a very broad qualitative assessment of both the instream and riparian components of a river. In general, the metrics assessed were all shown to represent large states of modification, with the exception of the presence of potential instream habitat and flow modifying activities which were considered to be serious. Given that the various other wetland features present within 500m of the proposed activities are artificial and/or primarily wetland in nature, the Present Ecological State thereof was not assessed from a riverine perspective by the Department of Water and Sanitation (2014), and as such the determination thereof from a wetland perspective is considered more relevant.

Table 9: Ecological State of sub-quaternary reach C22C-01405 (i.e. HGM 3) associated with the proposed 22kV OHL crossing (Department of Water and Sanitation, 2014)

Metric	Rating
Instream Habitat Continuity Modification	Large
Riparian/Wetland Zone Continuity Modification	Large
Potential Instream Habitat Modifying Activities	Serious
Riparian-Wetland Zone Modification	Large
Potential Flow Modifying Activities	Serious
Potential Physico-Chemical Modifying Activities	Large
Overall Ecological Category	**D (Largely Modified)**

6.5 Ecological Importance and Sensitivity

Ecological importance refers to biophysical aspects in the sub-quaternary reach that relates to its capacity to function sustainably. In contrast, ecological sensitivity considers the attributes of the sub-quaternary reach that relates to the sensitivity of biophysical components to general environmental changes such as flow, physico-chemical and geomorphic modifications. Essentially, the ecological importance and the ecological sensitivity of the relevant reaches are assessed to obtain an indication of its vulnerability to environmental modification within the context of the PES. This would relate to the ability of the sub-quaternary reach to endure, resist and recover from various forms of human use (Department of Water and Sanitation, 2014).

According to the Department of Water and Sanitation (2014), both the ecological importance and the ecological sensitivity of sub-quaternary reach C22C-01405 associated with HGM 3 considered to be moderate from an aquatic perspective. It is however likely that the re-evaluation of the reach reflected by HGM 3 based on in-field studies will result in a lowering of the ecological importance and/or the ecological sensitivity given the impacts present within the catchment. Given that the various other wetland features present within 500m of the proposed activities are artificial and/or primarily wetland in nature, the Ecological Importance and the Ecological Sensitivity were not assessed from a riverine perspective by the Department of Water and Sanitation (2014), and as such the determination thereof from a wetland perspective is considered more relevant.

Table 10: Ecological Importance and Ecological Sensitivity of sub-quaternary reach C22C-01405 (i.e. HGM 3) associated with the proposed 22kV OHL crossing (Department of Water and Sanitation, 2014)

Ecological Importance	**Rating**
Fish representivity	High
Fish rarity	High
Invertebrate representivity	High
Invertebrate rarity	High
Ecological Importance for riparian/wetland/instream (vertebrates excl. fish)	Low
Riparian/Wetland natural vegetation importance	Low
Habitat diversity class	Moderate
Instream migration link	Moderate
Riparian/Wetland zone migration link	Moderate
Riparian/Wetland zone habitat integrity class	Moderate
Instream habitat integrity class	Low
Mean Ecological Importance Value	***Moderate***
Ecological Sensitivity	
Fish physico-chem sensitivity	High
Fish no-flow sensitivity	High
Invertebrate physico-chem sensitivity	High
Invertebrate velocity preference	Very high
Riparian/Wetland/instream vertebrate sensitivity to water level/flow changes	High
Riparian/Wetland/instream vegetation intolerance to water level/flow changes	Low
Stream size sensitivity to modified flow/water level changes	Low
Mean Ecological Sensitivity Value	***Moderate***

7. BUFFER REQUIREMENTS

Wetland buffers are areas that surround a wetland and reduce adverse impacts to wetland functions and values from adjacent development. Buffer zones outside the boundary of wetlands are required to ensure that the ecotones between aquatic and terrestrial environments are effectively managed and conserved. These ecotones have a high ecological significance and have been shown to perform a wide range of functions, and on this basis, have been proposed as a standard measure to protect water resources and associated biodiversity (Macfarlane & Bredin, 2016). Literature indicates that buffers reduce wetland impacts by moderating the effects of stormwater runoff including stabilising soil to prevent erosion; filtering suspended solids, nutrients, and harmful or toxic substances; and moderating water level fluctuations (Castelie et al., 1992).

Buffers also provide essential foraging, roosting, refugia and breeding habitat for wetland-associated species. Finally, buffers reduce the adverse impacts of human disturbance on wetland habitats including blocking noise and glare; reducing sedimentation and nutrient input; reducing direct human disturbance from dumped debris, cut vegetation and providing visual separation.

The proposed project involves the construction of a PV facility (in both the preferred and alternative layouts) which will change the stormwater flow dynamics of the cleared site proposed for the development. The site is situated approximately 150m from the boundary of HGM 1, the unchannelled valley bottom. Furthermore, the site is located adjacent to a dam and artificial seep which emanates from the dam, but which provides habitat for floral and faunal species and which flows into HGM 1.

A buffer was therefore calculated for the protection of these linked systems (natural and artificial) taking into account the proposed activity, climatic factors, topographical factors, the nature of the soils and the sensitivity of the water resource. A 21m buffer has been calculated. This buffer is not expected to impact the PV facility layout (both the preferred and alternative layout). It is however recommended that the buffer be planted with indigenous grasses and maintained as part of the construction and operational phases of the Environmental Management Programme for the development. A high basal cover of indigenous grass species will aid in the buffering out of sediment and pollutants from the development before stormwater enters into HGM 1 or the artificial wetlands. Furthermore, stormwater control from the development is key in reducing impacts to the downstream and adjacent wetland systems.

With regards to the Overhead Powerline, only HGM 3, the channelled valley bottom system will be crossed. The proposed OHL route follows the disturbed footprint of the gravel road. The gravel road already crosses HGM 3 and thus there is an existing disturbance footprint within which the pylons for the OHL are proposed to be constructed. Buffers have therefore not been calculated for the crossing of this wetland system, as they would not add any benefit to the positioning of the pylons, provided these pylon positions remain within the existing disturbed footprint.

8. IMPACT ASSESSMENT

Anthropogenic activities and developments will negatively impact the receiving natural environment. As part of the current wetland and desktop aquatic impact assessment, potential impacts on the receiving natural environment have been identified. Such impacts are likely to include the following:

- Direct impacts: Impacts directly associated with the project. These impacts can be temporary or remain as residual impacts, i.e., the clearing of natural vegetation within PV facility site footprint.
- Indirect impacts: Impacts that are not a direct result of the project and often extend beyond the project boundary, i.e. encroachment of invasive alien vegetation outside of the project area.
- Residual impacts: Impacts that remain following the implementation of mitigation measures, and that may remain after the project has been completed.
- Cumulative impacts: Impacts occurring from the project combined with impacts from past, existing and future projects that will affect the same natural resources e.g. a number of impacts occurring in the same ecosystem.

The section below provides an initial indication and summary of potential impacts associated with the construction and operation of the proposed project.

The activities identified within the study site for both the preferred and alternative layouts include:

- The clearing of portions of the PV facility site for the establishment of the solar panels, BESS and substation.
- Construction of the Overhead Power Line.
- Maintenance of the PV facility and Overhead Power Line during the operational phase.

Negative impacts therefore associated with this project include:

- Soil erosion, sedimentation of the wetland systems.
- Pollution potential.
- Encroachment of invasive alien species into the wetlands as a result of the disturbance.

Several general and specific measures are proposed to mitigate these impacts.

8.1 Impact Assessment Criteria

Impacts of the project were assessed in terms of a formalised method, whereby a risk assessment process was undertaken in order to determine the significance of the impacts. The various inputs into the risk assessment process were as follows:

The **NATURE** of an impact refers to a description of the activity, inherent features, characteristics and/or qualities of the impact. Thus, each impact will be comprehensively detailed and contextualised prior to being assessed.

The **EXTENT** refers to the impact footprint. What that means is that if a species were to be lost then the extent would be global because that species would be lost to the world. If human health is threatened, then the impact is likely to be no more than local and possibly regional.

Table 11: Descriptors and scoring for the Extent of an impact

Descriptors	Definitions	Score
Site only	The impact remains within the footprint or cadastral boundary of the site.	1
Local	The impact extends beyond the footprint or cadastral boundary of the site, to include the immediately adjacent and surrounding areas.	2
Regional	The impact includes the greater surrounding area within which the site is located.	3
National	The scale/extent of the impact is applicable to the Republic of South Africa.	4
Global	The scale /extent of the impact is global (i.e. world-wide).	5

The **DURATION** is the period of time for which the impact would be manifest. Importantly, the concept of reversibility is taken into consideration in the scoring. In other words, the longer the impact endures, the less likely is the reversibility of the impact.

Table 12: Descriptors and scoring for the Duration of an impact

Descriptors	Definitions	Score
Temporary	The impact endures for only a short period of time (0-1 years).	1
Short term	The impact continues to manifest for a period of between 1-5 years.	2
Medium term	The impact continues to manifest for a period of 5-15 years.	3
Long term	The impact will cease after the operational life of the activity.	4
Permanent	The impact will continue indefinitely.	5

The **MAGNITUDE** is the measure of the potential severity of the impact on the associated environment. As with duration, the concept of reversibility should be taken into account when considering the magnitude of the potential impact.

Table 13: Descriptors and scoring for the Magnitude of an impact

Descriptors	Definitions	Score
Negligible	The ecosystem pattern, process and functioning are not affected, although there is a small negative impact on quality of the ecosystem.	1
Minor	Minor impact - a minor impact on the environment and processes will occur.	2
Low	Low impact - slight impact on ecosystem pattern, process and functioning.	4

Moderate	Valued, important, sensitive or vulnerable systems or communities are negatively affected, but ecosystem pattern, process and functions can continue albeit in a slightly modified way.	6
High	The environment is affected to the extent that the ecosystem pattern, process and functions are altered and may even temporarily cease. Valued, important, sensitive or vulnerable systems or communities are substantially affected.	8
Very High	The environment is affected to the extent that the ecosystem pattern, process and functions are completely destroyed and may permanently cease.	10

The **LIKELIHOOD** is the likelihood of the impact manifesting. Although likelihood and probability may be considered interchangeable, the term likelihood is preferred as probability has a very specific mathematical and/ or statistical connotation. As such the expectation created by the term probability is that there will be an accurate empirically or mathematically defined expression of risk, which is not necessarily required.

Table 14: Descriptors and scoring for the Likelihood of an impact

Descriptors	Definitions	Score
Very improbable / Rare	Where it is highly unlikely that the impact will occur, either because of design or because of historic experience	1
Unlikely	Improbable – where the impact is unlikely to occur (some possibility), either because of design or historic experience.	2
Probable	there is a distinct probability that the impact will occur (< 50% chance of occurring)	3
Highly Probable	Most likely that the impact will occur (50 – 90% chance of occurring)	4
Definite	The impact will occur regardless of any prevention or mitigating measures (>90% chance of occurring).	5

The **SIGNIFICANCE** of impacts will be derived through a synthesis of ratings of all criteria in the following calculation:

(Extent + Duration + Magnitude) x Likelihood = Significance

Table 15: Descriptors for the significance score of an impact

Descriptors	Definitions	Score
Low	The perceived impact will not have a noticeable negative influence on the environment and is unlikely to require management intervention that would incur significant cost.	**0 – 19**
Low to Moderate	The perceived impact is considered acceptable, and application of recommended mitigation measures recommended.	**20 – 39**
Moderate	The perceived impact is likely to have a negative effect on the receiving ecosystem, and is likely to influence the decision to approve the activity. Implementation of mitigation measures is required, as is routine monitoring to ensure effectiveness of recommended mitigation measures.	**40 – 59**
Moderate to High	The perceived impact will have a significant impact on the receiving ecosystem, and will likely have an influence on the decision-making process. Strict implementation of mitigation measures as provided is required, and strict monitoring and high levels of compliance and enforcement in respect of the impact in question are required.	**60 – 79**
High	The impact on the receiving ecosystem is considered of high significant and likely to be irreversible, and therefore highly likely to result in a fatal flaw for the project. Alternatives to the proposed activity are to be investigated as impact will have an influence on the decision-making process.	**80 - 100**

8.2 Summary of Impacts

2.1.5. Significance ratings tables for the Construction Phase

Activity:	**Soil erosion and sedimentation of wetland systems (Both layout alternatives are considered).**
Impact:	Construction activities expose soil to environmental factors including rainfall and wind. The exposure to these factors can result in the formation of erosion gullies and sheet erosion in disturbed areas. This is particularly so, in areas where soil will be compacted by heavy machinery. The eroded soil will quickly be washed downstream into wetland systems. This increased high-suspended particulate matter within the wetlands can accumulate particularly during the wetter months. Sedimentation poses a risk to the geomorphological/functional integrity of wetlands, reducing the ecological integrity of the water resource outside of the impacted area. Of particular concern is HGM 3, the channelled valley bottom as this will be crossed by the Overhead Power Line. From an aquatic perspective, various impacts have been attributed to sedimentation of aquatic ecosystems, including reduction of light penetration (resulting in reduction in photosynthesis and subsequently, productivity), alteration of foraging dynamics of both carnivores and herbivores, impacting on predator and prey relationships, clogging of gills, rendering the watercourse unfit for various aquatic organisms, truncating and shifting the trophic pyramid, absorption of nutrients onto suspended particles, rendering them unavailable and thereby reducing the productivity of the watercourse,

	and filling of interstitial spaces, thereby destroying habitat for macro invertebrates and vertebrates owing to sedimentation, etc. However, numerous variables (including sediment characteristics, sediment concentration, exposure time, temperature, natural ecosystem processes, etc.) dictate the vulnerability of aquatic assemblages and fish species specifically to elevated suspended sediment loads within a natural system. For example, warm water species differ in their response to elevated silt loads at different stages of their life histories (e.g. Smit et al., 1998) and at different water temperatures. In other studies, the response of species has also been shown to vary with duration of exposure, with short-term exposure reported to increase the frequency of gill flaring during periods of elevated turbidity in an attempt to facilitate clearing of suspended sediment on the gill surfaces (e.g. Berg & Northcote, 1985; Servizi & Martens, 1992), while long term exposure potentially causing thickening of the gill epithelium and loss of respiratory function (e.g. Bell, 1973). Still other research indicates the cardiovascular response of lacustrine fish is more extreme than that of riverine fish of the same species, suggesting that compensatory mechanisms that can minimise cardio-respiratory disruption caused by increased suspended silt concentrations are more prevalent in riverine species in relation to lacustrine species (Bunt et al., 2004).				
Significance rating:	**Duration**	**Extent**	**Magnitude**	**Probability**	**Significance**
Pre-Mitigation	2	2	6	5	**Moderate (50)**
Post-Mitigation	2	1	4	3	**Low - Moderate (21)**
Is the Impact Reversible?	• This is reversible should the mitigation measures recommended below be implemented. Rehabilitation of compacted areas, outside of the footprint of the PV Facility site as well as the powerline must occur once construction is complete.				
• Mitigation Measures:	• No stockpiling of any materials may take place adjacent to any of the natural wetland systems. Erosion control measures must be implemented in areas sensitive to erosion and where erosion has already occurred. These measures include but are not limited to - the use of sandbags, hessian sheets, silt fences, retention or replacement of vegetation and geotextiles such as soil cells which must be used in the protection of slopes. • Topsoil stockpiles must be appropriately protected using for example silt fences or sandbag barriers. • Do not allow surface water or storm water to be concentrated, or to flow down slopes without erosion protection measures being in place. • All disturbed areas along the Overhead Power Line alignment must be rehabilitated as soon as construction in an area is complete or near complete and not left until the end of the project to be rehabilitated. • Make use of existing access roads as much as possible and plan additional access routes if required to avoid wetland systems. • Minimise the extent of the work footprint. • Install sediment barriers across the entire construction right-of-way, to prevent sediment flow, particularly into HGM 3 as well as downstream of the PV facility.				

Cumulative impacts:	• Cumulative impacts are associated with continued development within the larger landscape. This ever-increasing development of the urban environment leads to a decrease in infiltration rates of stormwater and the increased likelihood of erosion gully formation. Given the limited footprint of the project the cumulative impact is expected to be low.
Residual impacts:	• Residual impacts from the construction phase are associated with the formation of erosion gullies from compacted soils that are not remediated. Over time this will increase in size and will impact areas downstream of the project site
Climate Change:	• Soil erosion leads to the disturbance and loss of predominantly the topsoil, this is the most productive horizon of a soil profile and the loss of the ecosystem which forms the topsoil has an impact on nutrient and carbon cycles, leading to an impact on climate change in the long-term.

Activity:	**Pollution of wetland systems (Both layout alternatives are considered).**				
Impact:	Sediment release into a watercourse is one of the most common forms of waterborne pollution. Furthermore, mismanagement of waste and pollutants including hydrocarbons, construction waste and other hazardous chemicals will result in these substances entering and polluting wetland systems either directly through surface runoff during rainfall events, or subsurface water movement				
Significance rating:	**Duration**	**Extent**	**Magnitude**	**Probability**	**Significance**
Pre-Mitigation	2	2	6	5	**Moderate (50)**
Post-Mitigation	2	1	4	3	**Low - Moderate (21)**
Is the Impact Reversible?	• Impacts regarding potential soil pollution as a result of leakage from chemicals can be reversed. Soils that have been contaminated would need to be remediated either on site or removed to a secure location. A spill team would need to be contacted to conduct the remediation exercise.				
Mitigation Measures:	• All waste generated during construction is to be disposed of as per an Environmental Management Programme (EMPr) and washing of containers, wheelbarrows, spades, picks or any other equipment that has been contaminated with cement or chemicals within any water resources, must be strictly prohibited. • Do not locate chemical storage areas associated with the construction camp or construction site on any of the hydric soils (whether natural or artificially saturated), without ensuring that these chemicals cannot leak or spill into these soil profiles. • Management and disposal of construction waste as per the Environmental Management Programme must occur during the construction of the development. • Waste disposal during the construction phase must ensure no litter or other contaminants particularly chemicals stored on site are deposited into the channelled valley bottom system crossed by the Overhead Power Line or any wetland systems to the north of the PV facility site.				

	• No release of any substance i.e. cements or oil that could be toxic to fauna or faunal habitats; Wet cement and/ or concrete must not be allowed to enter any of the wetland systems. • Portable toilets must be placed outside of a 100m buffer from any of the delineated wetlands
Cumulative impacts:	• Cumulative impacts relating to the pollution of wetland system are associated with the continued development of the larger area. As development occurs soils can and are contaminated with chemicals, hydrocarbons, and sediments from a variety of sources such as the existing mine, existing roads and leakage and spillage from construction activities. These soils are not remediated and are therefore changed from their natural state, making it difficult to utilise them in the future. Given the limited footprint of the project area, cumulative impacts of this project are low.
Residual impacts:	• Residual impacts occur if leakage or spillage of chemicals occur during the construction phase, and these soils are not remediated. These soils will continue to release these chemicals into the environment after construction has ended. Provided the recommendations of this report are adhered to this impact is expected to be low.
Climate Change:	• Soil pollution leads to a decrease in soil health and changes to the microbial populations of soil ecosystems. This can affect nutrient and carbon cycling leading to an effect on climate change in the long term.

Activity:	**Encroachment of alien invasive vegetation. (Both layout alternatives are considered).**				
Impact:	The clearing of vegetation within portions of the PV Facility site as well as along the OHL route, where pylons will be located will lead to the disturbance to the vegetation of these areas. This will lead to the encroachment of alien invasive vegetation species which do occur within the area, if not managed with the implementation of alien invasive management programme. Alien species generally out-compete indigenous species for water, light, space and nutrients as they are adaptable to changing conditions and are able to easily invade a wide range of ecological niches (Bromilow, 2010). Alien invader plant species pose an ecological threat as they alter habitat structure, lower biodiversity (both number and "quality" of species), change nutrient cycling and productivity, and modify food webs (Zedler, 2004).				
Significance rating:	**Duration**	**Extent**	**Magnitude**	**Probability**	**Significance**
Pre-Mitigation	3	2	6	3	**Low - Moderate (33)**
Post-Mitigation	2	1	4	2	**Low (14)**
Is the Impact Reversible?	• Impacts regarding the encroachment of alien invasive vegetation within the disturbed portions of the project site can be reversed provided ongoing alien vegetation clearing forms part of the environmental management programme for the construction phase.				

Mitigation Measures:	• Alien invasive species, that were identified within the study area must be removed, prior to construction. By removing these species, the spread of seeds will be prevented into disturbed soils which could have a positive impact on the surrounding natural vegetation. • An alien invasive management programme must be incorporated into an Environmental Management Programme. • Ongoing alien plant control must be undertaken after the construction phase and during the operational phase. Areas which have been disturbed will be quickly colonised by invasive alien species. An ongoing management plan must be implemented for the clearing/eradication of alien species. Recommendations of the botanical specialist assessment must also be adhered to.
Cumulative impacts:	• Cumulative impacts will only stem from a lack of alien invasive vegetative control. Should alien invasive plants be allowed to continue encroaching the disturbed areas as a result of the construction related activities these will quickly invade areas outside of the project footprint and lead to a decline in the vegetation conditions of the larger area.
Residual impacts:	• Residual impacts will occur should ongoing alien invasive vegetation monitoring not continue throughout the construction phase of the project and alien vegetation spread outside of the project footprint.
Climate Change:	• Large scale encroachment of alien invasive species leads to changes to the biomass and a loss of indigenous species as well as has negative knock-on effects to the broader soil nutrient cycles affecting gaseous emissions. This has long term impacts on climate change.

2.1.6. Significance ratings tables for the Operational Phase

Activity:	**Soil erosion and sedimentation of wetland systems. (Both layout alternatives are considered).**				
Impact:	In the longer term a lack of rehabilitation of any compacted soils within or adjacent to wetland systems will lead to the formation of erosion gullies and the long-term degradation of wetland systems.				
Significance rating:	**Duration**	**Extent**	**Magnitude**	**Probability**	**Significance**
Pre-Mitigation	5	2	4	3	**Low - Moderate (33)**
Post-Mitigation	5	1	2	2	**Low (16)**
Is the Impact Reversible?	• This is reversible should the mitigation measures recommended below be implemented. Rehabilitation of compacted areas, outside of the footprint of the PV Facility as well as the powerline must occur once construction is complete. Should compaction of soils occur during the operational phase these must be remediated as soon as possible.				

Mitigation Measures:	• All vehicles must stick to designated access roads. Driving within wetland systems during the operational phase must be prohibited. • Follow up and monitoring of rehabilitation measures. • Implementation of additional rehabilitation measures if certain rehabilitation techniques are not successful.
Cumulative impacts:	• Cumulative impacts are associated with continued development within the larger landscape. This ever-increasing development of the urban environment leads to an increase in soil compaction, a decrease in stormwater management, and therefore an increase in the likelihood for erosion gully formation. Mitigation measures recommended in this report will decrease the cumulative impacts of this project on the larger landscape.
Residual impacts:	• Residual impacts are associated with the formation of erosion gullies from compacted soils that are not remediated. Over time this will increase in size and will impact areas downstream of the project site.
Climate Change:	• Soil erosion leads to the disturbance and loss of predominantly the top soil, this is the most productive horizon of a soil profile and the loss of the ecosystem which forms the topsoil has an impact on nutrient and carbon cycles, leading to an impact on climate change in the long-term.

Activity:	**Pollution of wetland systems. (Both layout alternatives are considered).**				
Impact:	During the operational phase, any maintenance of the PV facility and/or powerline can lead to the release of substances into the soil profile, polluting the wetland systems.				
Significance rating:	**Duration**	**Extent**	**Magnitude**	**Probability**	**Significance**
Pre-Mitigation	5	2	6	3	**Low - Moderate (39)**
Post-Mitigation	5	1	4	2	**Low - Moderate (20)**
Is the Impact Reversible?	• Impacts regarding potential soil and wetland pollution as a result of leakage from chemicals can be reversed. Soils that have been contaminated would need to be remediated either on site or removed to a secure location. A spill team would need to be contacted to conduct the remediation exercise for both the soils and wetland systems impacted.				
Mitigation Measures:	• All waste generated during construction is to be disposed of as per the EMPr. • Waste disposal during the operational phase must ensure no litter or other chemicals used for maintenance activities are deposited into any of the natural wetland systems. Of particular concern is the channelled valley bottom system crossed by the Overhead Power Line or any wetland systems to the north of the PV facility site. • No release of any substance i.e., cements, oil, or any other substance that could be toxic into the soil profiles. Check vehicles and equipment entering the site for oil and fuel leaks and inspect site for possible spillages. • Spillages of fuels, oils and other potentially harmful chemicals must be contained and cleaned up immediately. Contaminants must be properly drained and disposed of using proper solid/hazardous waste facilities (never to be disposed of within the				

	natural environment). Any contaminated soil must be removed, and the affected area rehabilitated immediately.
Cumulative impacts:	• Cumulative impacts relating to wetland pollution are associated with the continued development of the larger area. As development occurs wetland systems can and are contaminated with chemicals, hydrocarbons, and sediments from a variety of sources such as the existing mine, existing roads and leakage and spillage from maintenance activities. These impacts cause a decline in the health, functional integrity and ecological importance and sensitivity of the affected wetland systems.
Residual impacts:	• Residual impacts occur if leakage or spillage of chemicals occur during maintenance activities and these chemicals make their way into adjacent or downstream wetlands. If affected soils are not remediated, they will continue to release these chemicals into the environment, and these could enter into the wetland systems. This leads to a decline in wetland health, functional integrity, and ecological sensitivity of these systems. Provided the recommendations of this report are adhered to this impact is expected to be low.
Climate Change:	• Soil pollution leads to a decrease in soil health and changes to the microbial populations of soil ecosystems. This can affect nutrient and carbon cycling leading to an effect on climate change in the long term.

Activity:	**Encroachment of alien invasive vegetation. (Both layout alternatives are considered).**				
Impact:	This will lead to the encroachment of alien invasive vegetation species which do occur within the area, if not managed with the implementation of alien invasive management programme.				
Significance rating:	**Duration**	**Extent**	**Magnitude**	**Probability**	**Significance**
Pre-Mitigation	5	2	6	4	**Moderate (52)**
Post-Mitigation	3	1	4	2	**Low (16)**
Is the Impact Reversible?	• Encroachment of alien invasive species is reversible provided ongoing alien plant control is undertaken as per the mitigation measure provided below.				
Mitigation Measures:	• An alien invasive management programme must be incorporated into an Environmental Management Programme. • Ongoing alien plant control must be undertaken after the construction phase and during the operational phase. Areas which have been disturbed will be quickly colonised by invasive alien species. An ongoing management plan must be implemented for the clearing/eradication of alien species. Recommendations of the botanical specialist assessment must also be adhered to.				

Cumulative impacts:	• Cumulative impacts will only stem from a lack of alien invasive vegetative control. Should alien invasive plants be allowed to continue encroaching the disturbed areas during the operational phase these will quickly invade areas outside of the project footprint and lead to a decline in the vegetation conditions of the larger area.
Residual impacts:	• Residual impacts will occur should ongoing alien invasive vegetation monitoring not continue throughout the operational phase of the project and alien vegetation spread outside of the project footprint.
Climate Change:	• Large scale encroachment of alien invasive species leads to changes to the biomass and a loss of indigenous species as well as has negative knock-on effects to the broader soil nutrient cycles affecting gaseous emissions. This has long term impacts on climate change.

9. RISK MATRIX

The Risk Assessment for the proposed project was undertaken in accordance with the General Authorisation in terms of Section 39 of the National Water Act, 1998 (Act No. 36 of 1998) for Water Uses as defined in Section 21 (c) and (i) (Notice 509 of 2016). The risk assessment involves the analysis of the risk matrix provided in appendix 1 of this notice and involves the evaluation of the severity of impacts to the flow regime, water quality, habitat, and biota of the water resource. Based on the outcome of the Risk Assessment Matrix, low risk activities will be generally authorised with conditions, while moderate to high-risk activities will be required to go through a Water Use Licence Application Process. Water use activities that are authorised in terms of the General authorisations will still need to be registered with the DWS.

It must 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 this report as well as within an Environmental Management Programme for the construction and operational phase of the project are feasible and will be implemented, and as such does not take into consideration significance before implementation of mitigation measures.

The risk assessment is provided in Appendix B. From a wetland and aquatic perspective, impact scores (for both the preferred and alternative layouts) received are Low. This is due to the PV facility site being located on a site completed disturbed from historic mining operations. Furthermore, the OHL will only cross HGM unit 3, the channelled valley bottom wetland. Impacts to the wetland systems are small and easily mitigable.

10. CONCLUSION

From a wetland perspective, the specialist is of the opinion that impacts arising from the proposed project can be mitigated to an acceptably low level. This is attributed to the historically and currently disturbed nature of the area coupled with the largely modified to seriously modified nature of the wetlands assessed within the study site. Artificial depressions were noted within the PV facility location; however, these have been created through the historic mining of the area and are compounded by the ponding of stormwater on the compacted Stilfontein soils. While they do support hydrophytic vegetation, the 'depressions' will only be saturated temporarily during the wet season.

In consideration of the aquatic habitat availability within the study area, it is expected that the aquatic biota assemblages present will be dominated by taxa with a strong preference for instream and emergent vegetation within very slow-flowing habitats, as well as taxa with a very low to low preference for unmodified water quality. Further, given the likely seasonal availability of water within the unchannelled and depressional wetland systems present, it is expected that the period of inundation of the watercourse will result in temporal variations of aquatic assemblages within these systems. As such and given that the proposed overhead powerline is understood to be the only watercourse crossing proposed and is not expected to impact on the instream features, the risk of impact from the proposed activity on the associated aquatic ecosystem is expected to be low.

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12. APPENDICES

Appendix A: Methodology

Wetland Definition & Delineation Technique

For the purpose of this assessment, wetlands are considered as those ecosystems defined by the National Water Act 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."*

The study site was assessed with regards to the determination of the presence of wetland areas according to the procedure described in 'A Practical Field Procedure for Identification and Delineation of Wetland and Riparian Areas – Edition 1' (DWAF, 2005). This methodology requires the delineator to give consideration to the following four indicators in order to identify wetland areas; to find the outer edge of the wetland zone; and identify the different zones of saturation within the wetland systems identified:

i. Terrain Unit Indicator: helps to identify those parts of the landscape where wetlands are more likely to occur.
ii. Soil Form Indicator: identifies the soil forms, as defined by the Soil Classification Working Group (1991), which are associated with prolonged and frequent saturation.
iii. Soil Wetness Indicator: identifies the morphological "signatures" developed in the soil profile as a result of prolonged and frequent saturation. Signs of wetness are characterised by a variety of aspects including marked variations in the colour of various soil components, known as mottling; a gleyed soil matrix; or the presence of Fe/Mn concretions. It should be noted that the presence of signs of wetness within a soil profile is sufficient to classify an area as a wetland area despite the lack of other indicators.
iv. Vegetation Indicator: identifies hydrophilic vegetation associated with frequently saturated soils.

In assessing whether an area is a wetland, the boundary of a wetland should be considered as the point where the above indicators are no longer present. 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, to delineate the boundary of that wetland and to assess its level of functionality and health.

Assessment of the Wetland's Functional Integrity

Wetlands within the study area serve to improve habitat within and potentially downstream of the study area through the provision of various ecosystem services. These ecosystem services relate to:

- Flood attenuation.

- Streamflow regulation.
- Water purification (including sediment trapping and the assimilation of phosphates, nitrates and toxicants).
- Carbon storage.
- Maintenance of biodiversity.
- Provision of water for human and agricultural use.
- Cultural benefits (including tourism, recreation and cultural heritage).

Wetlands therefore affect the quantity and quality of water within a catchment (Mitsch & Gosselink, 1993). The importance of wetland conservation and sustainable management is directly related to the value of the functions provided by a wetland. An indication of the functions and ecosystem services provided by wetlands is assessed through the WET-EcoServices manual (Kotze et al., 2008) and is based on a number of characteristics that are relevant to the particular benefit provided by the wetland. The tool uses biophysical characteristics of the wetland and the level of disturbance within the wetland and its catchment to estimate the level of supply of ecosystem goods and services. A Level 2 WET-EcoServices assessment was undertaken for the wetlands identified along the power line corridor. A Level 2 assessment is the highest WET-EcoServices assessment that can be undertaken and involves an on-site assessment as well as desktop work.

Assessment of the Wetland's Present Ecological State (PES)

The Present Ecological State (PES) for wetlands which is defined as '*a measure of the extent to which human impacts have caused the wetland to differ from the natural reference condition'* is also an indication of each wetland's ability to contribute to ecosystem services within the study area. This was assessed according to the methods contained in the Level 2 WET-Health: *A technique for rapidly assessing wetland health* (Macfarlane et al., 2009).

This document assesses the health status of a wetland through evaluation of three main factors -

- **Hydrology:** defined as the distribution and movement of water through a wetland and its soils.
- **Geomorphology:** defined as the distribution and retention patterns of sediment within the wetland.
- **Vegetation***: defined as the vegetation structural and compositional state.*

The WET-Health tool evaluates the extent to which anthropogenic changes have impacted upon the functional integrity or health of a wetland through assessment of the above-mentioned three factors. The deviation from the natural condition is given a rating based on a score of 0-10 with 0 indicating no impact and 10 indicating modifications have reached a critical level. Since hydrology, geomorphology and vegetation are interlinked their scores are then aggregated to obtain an overall PES health score These scores are then used to place the wetland into one of six health classes (A – F; with A representing completely unmodified/natural and F representing severe/complete deviation from natural as depicted in Table 16.

Table 16: Health categories used by WET-Health for describing the integrity of wetlands

DESCRIPTION	IMPACT SCORE	HEALTH CATEGORY
Unmodified, natural.	0 - 1.0	A
Largely natural with few modifications. A slight change in ecosystem processes is discernible and a small loss of natural habitats and biota may have taken place	1.1 - 2.0	B
Moderately modified. A moderate change in ecosystem processes and loss of natural habitats has taken place but the natural habitat remains predominantly intact	2.1 - 4.0	C
Largely modified. A large change in ecosystem processes and loss of natural habitat and biota and has occurred.	4.1 - 6.0	D
The change in ecosystem processes and loss of natural habitat and biota is great but some remaining natural habitat features are still recognizable	6.1 - 8.0	E
Modifications have reached a critical level and the ecosystem processes have been modified completely with an almost complete loss of natural habitat and biota	8.1 - 10.0	F

Due to differences in the pattern of water flow through various hydro-geomorphic (HGM) types, the tool requires that the wetland is divided into distinct HGM units at the outset. Ecosystem services for each HGM unit are then assessed separately.

Assessment of Ecological Importance and Sensitivity (EIS)

The Ecological Importance and Sensitivity (EIS) assessment was determined by utilising a rapid scoring system. The system has been developed to assess the 'Ecological Importance and Sensitivity' of the wetland within the larger landscape; the 'Hydrological Functional Importance' of the wetland; and the 'Direct Human Benefits' obtained from the wetland through either subsistence or cultural practices. The 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 (DWAF, 1999), and the work conducted by Kotze et al. (2008) on the assessment of wetland ecological goods and services from the WET-EcoServices tool. The scores obtained were placed into a category of very low; low; medium; high; and very high as shown:

- Very low: 0 – 1.0
- Low: 1.1 – 2.0
- Medium: 2.1 – 3.0
- High: 3.1 – 4.0
- Very High 4.1 – 5.0

Appendix B: Risk Matrix

RISK MATRIX (Based on DWS 2015 publication: Section 21 c and I water use Risk Assessment Protocol)

NAME and REGISTRATION No of SACNASP Professional member: Rowena Harrison Reg. no. 400715/15

Risk to be scored for construction and operational phases of the project. MUST BE COMPLETED BY SACNASP PROFESSIONAL MEMBER REGISTERED IN AN APPROPRIATE FIELD OF EXPERTISE.

					Severity																		
No.	Phases	Activity	Aspect	Impact	Flow Regime	Physico & Chemical (Water Quality)	Habitat (Geomorph + Vegetation)	Biota	Severity	Spatial scale	Duration	Consequence	Frequency of activity	Frequency of impact	Legal Issues	Detection	Likelihood	Significance	Risk Rating	Confidence level	Control Measures	Borderline LOW MODERATE Rating Classes	PES AND EIS OF WATER RESOURCE
1	Construction phase	Construction of the PV Facility and Overhead Power Line - Soil Erosion and Sedimentation	Exposure of soil from construction activities leading to it being washed away and deposited into wetland systems. Compaction of soils from heavy machinery	Disturbances to the hydrological flow of wetlands; formation of erosion gullies.	2	2	2	2	2	1	1	4	4	3	5	1	13	52	L	80	As per Section 8 of the report		6 HGM units within the 500m assessment area. HGM 1 occurs downstream of the PV facility and HGM 3 will be crossed by the OHL. HGM 1 – PES E, EIS Low; HGM 3 – PES D, EIS Low
2	Construction Phase	Construction of the PV Facility and Overhead Power Line - Pollution of watercourses and soil	Sediment deposition in downstream wetlands, release of hydrocarbons and other pollutants during construction	Deterioration in water quality affecting aquatic and terrestrial species that utilise these systems as well as downstream systems.	1	2	1	1	1.25	1	1	3.25	4	3	5	1	13	42.25	L	80	As per Section 8 of the report		6 HGM units within the 500m assessment area. HGM 1 occurs downstream of the PV facility and HGM 3 will be crossed by the OHL. HGM 1 – PES E, EIS Low; HGM

																							3 – PES D, EIS Low
3	Construction Phase	Construction of the PV Facility and Overhead Power Line - - Alien Invasive Species Encroachment	Removal of vegetation within construction footprint leads to disturbances and the encroachment of alien invasive species	Deterioration in vegetation communities associated with the wetland systems	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**3**	**4**	**3**	**5**	**1**	**13**	**39**	L	**80**	As per Section 8 of the report		6 HGM units within the 500m assessment area. HGM 1 occurs downstream of the PV facility and HGM 3 will be crossed by the OHL. HGM 1 – PES E, EIS Low; HGM 3 – PES D, EIS Low
4	Operational Phase	Existence, Use and Maintenance of PV facility and Overhead Power Line - Soil Erosion and Sedimentation	Long term deposition of sediment into wetlands from erosion gullies, altering their flow dynamics and impacting their health and functional integrity	Wetland degradation and erosion gully formation	**1**	**1**	**1**	**1**	**1**	**1**	**3**	**5**	**2**	**2**	**5**	**1**	**10**	**50**	L	60	As per Section 8 of the report		6 HGM units within the 500m assessment area. HGM 1 occurs downstream of the PV facility and HGM 3 will be crossed by the OHL. HGM 1 – PES E, EIS Low; HGM 3 – PES D, EIS Low
5	Operational Phase	Existence, Use and Maintenance of PV facility and Overhead Power Line - Pollution of watercourses and soil	Maintenance activities can lead to pollution of adjacent systems	Long-term deterioration in water quality of wetlands	**1**	**2**	**1**	**2**	**1.5**	**1**	**3**	**5.5**	**1**	**2**	**5**	**1**	**9**	**49.5**	L	60	As per Section 8 of the report		6 HGM units within the 500m assessment area. HGM 1 occurs downstream of the PV facility and HGM 3 will be crossed by the OHL.

																														HGM 1 – PES E, EIS Low; HGM 3 – PES D, EIS Low
6	Operational Phase	Existence, Use and Maintenance of PV facility and Overhead Power Line - Encroachment of Alien Invasive Species	Encroachment of alien invasive species within disturbed areas as a result of a lack of monitoring	Deterioration in the vegetation communities of the surrounding areas of the wetlands and possible further invasion of alien invasive species downstream	**1**		**1**		**1**		**1**		**1**	**1**	**3**		**5**		**1**	**2**	**5**	**1**		**9**	**45**	L	60	As per Section 8 of the report		6 HGM units within the 500m assessment area. HGM 1 occurs downstream of the PV facility and HGM 3 will be crossed by the OHL. HGM 1 – PES E, EIS Low; HGM 3 – PES D, EIS Low

Appendix C: CV of Authors

PERSONAL DETAILS

Name	Rowena Harrison
Date of Birth	21 April 1982
Identity Number	8204210320081
Nationality	South African
Current Position	Director (Wetland Specialist and Soil Scientist)
Office Location	Durban, KwaZulu-Natal
Website	www.malachitesa.co.za
Tel	+27 (0)78 023 0532
Email	rowena@malachitesa.co.za

ACADEMIC QUALIFICATIONS

2019 – present	PhD Soil Science (University of Free State and the University of Burgundy, France)
2015	Certificate in Wetland Rehabilitation – University of the Free State
2009	MSc (Soil Science) – University of KwaZulu-Natal
2008	Certificate course in Wetland Delineation, Legislation and Rehabilitation, University of Pretoria
2006	BSc (Environmental Science) – University of KwaZulu-Natal
2005	BSc (Applied Environmental Science) – University of KwaZulu-Natal

PROFESSIONAL AFFILIATIONS

- South African Council for Natural Scientific Professions – SACNASP (Pr. Sci.Nat 400715/15: Soil Science)
- International Association for Impact Assessments – IAIAsa
- South African Wetland Society

CONFERENCES ATTENDED AND PRESENTED

NAME	DATE
Biodiversity Symposium – Presenter on Hydropedology and Carbon Dynamics	November 2019
IAIAsa – KZN Branch – Presenter on wetland offsets from a soil's perspective	October 2019
Zoological Society of Southern Africa Conference	July 2019
Grass Identification Course hosted by African Land-Use Training	March 2019
Groundwater Modelling Course hosted by the Nelson Mandela Metropolitan University	February 2019
Hydropedology Course hosted by TerraSoil Science and the Water Business Academy	November 2018
Wetland National Indaba	October 2018
Wetland National Indaba	October 2017
Wetland Vegetation training course	February 2017
National Biodiversity and Business Network (NBBN). Biodiversity Indaba	March 2017
Certificate course in Wetland Rehabilitation and Management, University of the Free State	March 2015
Gauteng Wetland Forum: Basic Wetland Delineation course	February 2013
EIA Training Course: Real World EIA, Metamorphosis Environmental Consultants	November 2008
Certificate course in Wetland Delineation, Legislation and Rehabilitation, University of Pretoria	May 2008

EMPLOYEMENT RECORD

- April 2016 – Present Malachite Ecological Services – Director (Soil Scientist)
- March 2014 - Afzelia Environmental Consultants (Pty) Ltd (Soil Scientist March 2016 and Wetland Specialist)
- September 2012 - Strategic Environmental Focus (Pty) Ltd (Junior Wetland February 2014 Specialist)
- February 2008 - Afzelia Environmental Consultants cc (Soil Scientist/Junior December 2009 Wetlands Specialist and Environmental Assessment Practitioner)

PROJECT EXPERIENCE

Rowena has obtained a MSc. In Soil Science from the University of KwaZulu Natal, Pietermaritzburg. She is professionally affiliated to the South African Council for Natural Scientific Professions (Pr. Sci. Nat) and has 12 years consulting experience in the wetland and soil science field. She has conducted numerous wetland and soil assessments for a variety of development types across South Africa, Swaziland and into West Africa, and has recently added hydropedology assessments to her list of services offered.

She is a member of the International Association for Impact Assessment (IAIA) as well as a founding member of the South African Wetland Society. She is currently a joint PhD candidate at the University of the Free State and the University of Burgundy in France. Her research is focused on the interactions of dissolved organic carbon and hydropedology at a catchment scale.

Below is an abridged list of projects completed:

Soil and Agricultural Assessments

- Mutanda Mine, Kolwezi Province, Democratic Republic of Congo
- Soil and Agricultural Assessment for the cultivation of soil within pivot irrigation systems, Kokstad, KwaZulu-Natal.
- Pedological rehabilitation report for the implementation plan for the restoration of the conservation area within the Dube Tradeport Precint, Ethekwini Metropolitan Municipality.
- Macadamia Orchards, Paddock, KwaZulu-Natal
- Geluk Mine, Limpopo Province
- Madundube Housing Development, KwaZulu-Natal
- Vryheid Substations, Swellendam Local Municipality; Western Cape Province
- Gunther Muhl Agricultural Project; Vryheid; KwaZulu Natal Province
- Sokhulu Agricultural Development Project; KwaZulu Natal Province
- Portion 22 of the Farm Vaalkop Camperdown; KwaZulu-Natal Province
- Vlakfontein Mine, Ogies, Mpumalanga Province
- Silverhill Retreat; Kamberg KwaZulu Natal; KwaZulu Natal Province
- Cleopatra Extension Development; Kamberg; KwaZulu Natal Province
- Bartlett Estate, Hammarsdale KwaZulu Natal Province
- Valley View Estate Residential Development; Camperdown; KwaZulu Natal

Rehabilitation Plans

- De JagersKraal Compensation, wetland rehabilitation plan, KwaZulu-Natal
- Intaba Ridge Housing Estate, Pietermaritzburg, KwaZulu-Natal
- Greytown Bulk Water Supply, Greytown, KwaZulu-Natal
- Hluhluwe iMfolozi Park Bitumen Spill Rehabilitation Plan
- Hollingwood Housing Development, Pietermaritzburg, KwaZulu-Natal

- Samrand Estate; Centurion, Gauteng Province
- Paulpietersburg Shopping Centre; KwaZulu- Natal Province
- L1524 Road Upgrade; KwaZulu- Natal Province
- P187/1 Road Upgrade; KwaZulu- Natal Province
- P254/1 Road Upgrade; KwaZulu- Natal Province
- P483 Road Upgrade; KwaZulu- Natal Province
- N2/R56 Interchange
- Hluhluwe iMfolozi Park Bitumen Spill Rehabilitation Plan

Hydropedology Assessments

- Packo Industrial Site, KwaZulu- Natal Province
- St Joseph’s Housing Development. KwaZulu- Natal Province
- Lions River Housing Development, KwaZulu- Natal Province
- Cato Scrap Industrial Site, KwaZulu- Natal Province
- Somkhele Anthracite Mine, Hydropedological Buffers, KwaZulu- Natal Province

Wetland Impact Assessments

- Wetland and ecological sensitivity of Farm 1287, Mbabane Swaziland
- Ulundi Crossings Shopping Centre, KwaZulu-Natal
- Somkhele Mine, Mtubatuba, KwaZulu-Natal
- Lynton Hall housing development, Pennington KwaZulu-Natal
- Pennington PumpStation – Wetland Monitoring
- Enyathi Water Supply project, Vryheid, KwaZulu-Natal
- Agulhus Vryheid Eskom powerline and Substation, Swellendam, Western Cape
- D1095 road upgrade, KwaZulu-Natal
- Juno-Gromis 230km power line corridor, Northern and Western Cape Provinces
- Mt Albert Mixed Use Development, KwaZulu Natal
- Saldanha Strengthening Project, Saldanha, Western Cape Province
- Intaba Ridge Housing Development, Pietermaritzburg, KwaZulu-Natal
- Yoyo Mixed Use Development, Republic of Cameroon
- Elandspruit Colliery, Middleburg, Mpumalanga
- Bokoko Infrastructure Development, Douala, Republic of Cameroon
- P483 Road Upgrade; KwaZulu- Natal Province
- Paulpietersburg Shopping Centre; KwaZulu- Natal Province
- Tshipi e Borwa Strengthening Projects, Postmasburg, Northern Cape
- Portion 68 Hammarsdale, Wetland Assessment for a Section 24G application
- Esikhumbeni Stand Alone Water Supply System; KwaZulu- Natal Province
- AMI Colliery; Vryheid; KwaZulu- Natal Province
- Ephateni Bulk Water Supply System; KwaZulu- Natal Province
- Samrand Estate; Centurion, Gauteng Province

CURRICULUM VITAE

Name: **Byron Grant Pr.Sci.Nat.**
Company: Ecology International (Pty) Ltd
Years of Experience: 17 years

Nationality: South African
Languages: English (mother tongue), Afrikaans
SACNASP Status: Professional Natural Scientist (Reg. No. 400275/08)
Email address: byron@ecologyinternational.net
Contact Number: (+27) 82 863 0769

EDUCATIONAL QUALIFICATIONS

- B. Sc. (Botany & Zoology), Rand Afrikaans University (1997 - 1999);
- B. Sc. (Honours) Zoology, Rand Afrikaans University (2000);
- M. Sc. (Aquatic Health) *cum laude,* Rand Afrikaans University (2001 – 2004);
- Introduction to quantitative research using sample surveys, Rand Afrikaans University (2004);
- SASS5 Field Assessment Accreditation in terms of the River Health Programme, Department of Water Affairs (2005 – present);
- Monitoring Contaminant Levels: Freshwater Fish (*awarded Best Practice*), University of Johannesburg (2005);
- EcoStatus Determination training workshop, Department of Water Affairs and Forestry (2006);
- Multi-disciplinary roles in defining EcoStatus and setting flow requirements during an ecological reserve study, Department of Water Affairs (2008);
- Water Use Licence Applications: Section 21 (c) and (i) training workshop, Department of Water Affairs (2009);
- Advanced Wetland Course, University of Pretoria (2010) (*awarded with Distinction*);
- Determination of the Present Ecological State within the EcoClassification process, University of the Free State (2011);
- River Health Programme Training Workshop, Department of Water and Sanitation – Resource Quality Information Services (2014);
- Tools for Wetland Assessments, Rhodes University (2015);
- RHAM (Rapid Habitat Assessment Model) Training Workshop, Department of Water and Sanitation – Resource Quality Information Services (2015);
- Wetland, River and Estuary Buffer Determination Training Workshop, Institute for Natural Resources (2015);
- Fish Invertebrate Flow Habitat Assessment Model (FIFHA), Department of Water and Sanitation – Resource Quality Information Services (2015);
- Wetland Plant Taxonomy, Water Research Commission (2017);
- Vegetation Response Assessment Index (VEGRAI), Mr. James MacKenzie (co-developer of index) (2018);
- Wetland Soils, Agricultural Research Council in association with the University of the Free State (2018)
- Hydropedology and Wetland Functioning (Short course), Terrasoil Science in association with the Water Business Academy (2018).
- HCV (High Conservation Value) Assessor Training Course, Astra-Academy (2019)

KEY QUALIFICATIONS

- **Project Management:**
  Project management and co-ordination of specialist-related projects, including:
  - Aquatic assessments (see below);
  - Floral and Faunal assessments:
    - Design and implementation of monitoring programmes;
    - Baseline ecological assessments
    - Ecological impact and mitigation assessments;
    - Rescue and relocation assessments;
    - Alien and invasive vegetation management plans;
  - Wetland assessments:
    - Design and implementation of wetland monitoring programmes;
    - Wetland delineation studies;
    - Wetland Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS) determination assessments;
    - Wetland management plans;
    - Wetland impact and mitigation assessments;
    - Wetland offset strategies and assessments;
    - Wetland Reserve Determinations;
  - Water quality studies;
  - Dust monitoring studies;
  - Ecological Risk Assessments;
  - Biodiversity Action Plans (BAP);
  - Biodiversity Management Strategies;
  - Water Research Commission projects.

- **Specialist Assessments:**
  Extensive experience in conducting specialist aquatic assessments and providing specialist ecological input, including:
  - Baseline aquatic biodiversity assessments, including the determination of the Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS) according to latest methodology;
  - Aquatic impact and mitigation assessments;
  - Design, management and implementation of biological monitoring programmes for the aquatic environment;
  - Protocol development;
  - Fish kill investigations;
  - Ecological Flow Requirements;
  - Reserve Determinations;
  - Aquatic toxicity assessments;
  - Bioaccumulation studies;

  - Human health risk assessments for the consumption of freshwater fish;
  - Surface water quality studies;
  - Application of various monitoring indices, including the South African Scoring System version 5 (SASS5), the Macro-Invertebrate Response Assessment Index (MIRAI), the Invertebrate Habitat Assessment System (IHAS), the Index for Habitat Integrity (IHI), the Rapid Habitat Assessment Model (RHAM), the Fish Assemblage Integrity Index (FAII), the Fish Response Assessment Index (FRAI), the Physico-chemical Assessment Index (PAI), Riparian Vegetation Response Index (VEGRAI), Fish Invertebrate Flow Habitat Assessment Model (FIFHA), determination of EcoStatus, etc.;
  - Eco-Conditional Requirement (Eco-0) assessments for Green Star Accreditation;
  - Watercourse Protection Plans relating to Eco-Conditional Requirement (Eco-0) for Green Star Accreditation.

- **<u>Specialist Review:</u>**
  Specialist and independent review of impact assessment and management reports for all sectors of government, civil society and the scientific and legal fraternity:
  - Member of Technical Advisory Group for the Green Building Council of South Africa;
  - Member of Reference Groups for Water Research Commission;
  - Peer review of specialist biodiversity reports;
  - Peer reviewer for African Journal of Aquatic Science.

PROFESSIONAL REGISTRATIONS

- South African Council for Natural Scientific Professions (SACNASP) – Professional Natural Scientist (Aquatic Science, Ecological Science, Zoological Science), Reg. No. 400275/08

Other Society Memberships

- South African Society of Aquatic Scientists
- South African Wetland Society (Founding Member)
- Zoological Society of Southern Africa

Other Memberships

- Aquatox Forum
- Gauteng Wetland Forum
- Kliprivierberg Sustainability Association – Development Integration Team
- Yellowfish Working Group

COUNTRIES OF EXPERIENCE

- South Africa
- Lesotho
- Swaziland
- Mozambique

- Ghana
- Namibia
- Cameroon
- Namibia

SPECIALIST WORKSHOP PARTICIPATION

- Wetland and Watercourse Buffers Determination workshop. Project for the Department of Water Affairs, Sub-directorate: Water Abstraction and Instream Use;
- NEMBA category 2 alien fish species mapping for Gauteng, Limpopo and Northwest Provinces and a national review workshop, South African Institute for Aquatic Biodiversity (SAIAB);
- National Freshwater Ecosystem Priority Areas project – Specialist Input Workshop, South African National Biodiversity Institute (SANBI);
- Biodiversity Offsets Strategy workshop, Gauteng Department of Agriculture, Conservation and Environment (GDACE);
- Minimum Requirements for Biodiversity Assessments (Version 2) workshop, Gauteng Department of Agriculture, Conservation and Environment (GDACE);
- Gauteng Nature Conservation Bill, Gauteng Department of Agriculture and Rural Development (GDARD);
- Mainstreaming Biodiversity in Mining Training Workshop, SANBI's Grasslands Programme (in partnership with the South African Mining and Biodiversity Forum and the Departments of Environmental Affairs and Mineral Resources);
- National Biodiversity Offset Workshop, Department of Environmental Affairs (DEA), Endangered Wildlife Trust (EWT);
- Accreditation/certification of Wetland Practitioners Workshop, South African Wetland Society.

PRESENTATIONS AND PUBLICATIONS

Brink, K., Gough, P., Royte, J.J., Schollema, P.P. & Wanningen, H. (eds). (2018). From Sea to Source 2.0. Protection and restoration of fish migration in rivers worldwide. World Fish Migration Foundation. *Contributing author.*

Grant, B., Huchzermeyer, D. & Hohls, B. (2014). *A Manual for Fish Kill Investigations in South Africa.* WRC Report No. TT 589/14. Water Research Commission, Pretoria.

Grant, B., Hohls, B. & Huchzermeyer, D. (2013). Development of a Fish Kill Protocol for South Africa. South African Society for Aquatic Scientists - 2013 Conference, Arniston. Oral presentation.

Mlambo, S.S., van Vuren, J.H.J., Basson, R. & Grant, B. (2010). Accumulation of hepatic HSP70 and plasma cortisol in *Oreochromis mossambicus* following sub-lethal metal and DDT exposure. *African Journal of Aquatic Science* 35(1): 47-53.

Grant, B., van Vuren, J.H.J. & Cronjé, M.J. (2004). HSP 70 response of *Oreochromis mossambicus* to Cu^{2+} exposure in two different types of exposure media. South African Society for Aquatic Scientists – 2004 Conference, Cape Town. Poster presentation.

EMPLOYMENT EXPERIENCE

- **Ecology International:** Date: June 2017 - Present

  Role: Director & Principal Biodiversity Specialist
  - Management and co-ordination of staff members and specialists
  - Project management on various scales for environmental and biodiversity specialist-related services;
  - Co-ordinating, implementing and conducting specialist studies for various types of projects, including:
    - Protocol development;
    - Monitoring programmes;
    - Environmental Impact Assessments;
    - Strategic-level assessments (e.g. Strategic Environmental Assessments, Environmental Management Frameworks, State of the Environment Reports, etc.);
    - Biodiversity Management Plans, Biodiversity Action Plans, etc.;
  - Acting as an information source concerning environmental legislation;
  - Development of terms of reference and project proposals;
  - Quality control of specialist reports; and
  - Interfacing with clients in the consulting, mining, and government industries.

- **Independent Specialist:** Date: February 2017 – May 2017

  Role: Principal Biodiversity Specialist
  - Project management on various scales for biodiversity specialist-related services;
  - Co-ordinating, implementing and conducting specialist studies for various types of projects, including:
    - Protocol development;
    - Monitoring programmes;
    - Environmental Impact Assessments;
    - Strategic-level assessments (e.g. Strategic Environmental Assessments, Environmental Management Frameworks, State of the Environment Reports, etc.);
    - Biodiversity Management Plans, Biodiversity Action Plans, etc.;
  - Acting as an information source concerning environmental legislation;
  - Development of terms of reference and project proposals;
  - Quality control of specialist reports; and
  - Interfacing with clients in the consulting, mining, and government industries.

- <u>**GIBB** (June 2015 – January 2017)</u>
  Role: Principal Specialist
  - Project management on various scales for specialist-related services;
  - Co-ordinating, implementing and conducting studies for various types of projects, including:
    - Monitoring programmes;
    - Environmental Impact Assessments;
    - Strategic-level assessments (e.g. Strategic Environmental Assessments, Environmental Management Frameworks, State of the Environment Reports, etc.);
    - Biodiversity Management Plans, Biodiversity Action Plans, etc.;
  - Acting as an information source concerning environmental legislation;
  - Development of terms of reference and project proposals;
  - Quality control of specialist reports; and
  - Interfacing with clients in the consulting, mining, and government industries.

- <u>**Strategic Environmental Focus** (August 2009 – June 2015)</u>
  Role: Principal: Specialist Services
  - Management and co-ordination of staff members and specialists;
  - Project management on various scales for specialist-related services;
  - Co-ordinating, implementing and conducting studies for various types of projects, including:
    - Monitoring programmes;
    - Environmental Impact Assessments;
    - Strategic-level assessments (e.g. Strategic Environmental Assessments, Environmental Management Frameworks, State of the Environment Reports, etc.);
    - Biodiversity Management Plans, Biodiversity Action Plans, etc.;
  - Acting as an information source concerning environmental legislation;
  - Development of terms of reference and project proposals;
  - Quality control of specialist reports; and
  - Interfacing with clients in the consulting, mining, and government industries.

- <u>**Strategic Environmental Focus** (March 2009 – July 2009)</u>
  Role: Senior Natural Scientist
  - Project management for water, aquatic and monitoring-related projects;
  - Management and co-ordination of specialists;
  - Co-ordinating, implementing and conducting studies for various water and monitoring-related projects;
  - Acting as an information source concerning environmental legislation;
  - Development of terms of reference and project proposals;
  - Quality control of specialist reports; and
  - Interfacing with clients in the consulting, mining, and government industries.

- **Strategic Environmental Focus** (July 2006 – February 2009)

  Role: Aquatic Specialist
  - Conducting specialist assessments in the field of aquatic ecology and water science.
  - Acting as an information source concerning environmental legislation.

- **ECOSUN cc.** (January 2005 – June 2006)

  Role: Aquatic Scientist
  - Conducting specialist assessments in the field of aquatic ecology and water science.
  - Acting as an information source concerning environmental legislation.

- **Rand Afrikaans University** (January 2003 – December 2004).

  Role: Student Mentor / Post-Graduate Research Assistant
  - Validation of Antibodies for HSP70 Detection in the Freshwater Snail *Melanoides tuberculata* - B.Sc. (Honours) Student (January 2003 – December 2003);
  - The use of genotoxic and stress proteins in the active biomonitoring of the Rietvlei system, South Africa – M.Sc. Student (January 2003 – December 2003);
  - A comparison between Whole Effluent Toxicity (WET) testing and Active Biomonitoring (ABM) as indicators of in stream aquatic health – M.Sc. Student (January 2003 – December 2003);
  - The use of HSP70 and cortisol as biomarkers for heavy metal exposure - M.Sc. Student (January 2004 – December 2005).

- **Rand Afrikaans University** (January 2000 – December 2004)

  Role: Practical Demonstrator
  - Field supervisor for B.Sc. Honours (Zoology);
  - Aquatic Ecology (3rd year);
  - Human Physiology (2nd year); and
  - Ecology and Conservation (for Vista University)