A WETLAND DELINEATION REPORT FOR THE PROPOSED RENEWABLE ENERGY GENERATION PROJECT ON PORTION 2 AND THE REMAINDER OF THE FARM EAST 270, NORTHERN CAPE PROVINCE

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WETLAND DELINEATION REPORT

April 2016

Conducted on behalf of:

Palus Energy (Pty) Ltd

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1 ASSIGNMENT

Exigo Sustainability was appointed by Palus Energy to conduct a wetland and riparian delineation study for the proposed establishment of two solar energy generation facilities to be known as the East Solar Park 2 (East 2) and East Solar Park 3 (East3) with associated and structures on a footprint area of approximately 250 hectares for each of the two solar parks. East 2 is located on the remainder portion of the farm East 270, while East 3 will be located on portion 2 of the farm East 270, located in the Joe Morolong Local Municipality, John Taolo Gaetsewe District Municipality, Northern Cape Province.

This report will include detailed impact assessment of the proposed development on the watercourses or wetlands of the site. This assessment is essential as it will contribute to meeting the requirements of the National Environmental Management Act (NEMA), 1998 (Act No. 107 of 1998) in conjunction with Regulation 543 of 18 June 2010, promulgated in terms of Section 24 (5) of NEMA and Chapter 4 of the National Water Act, Act 36 of 1998.

The assignment is interpreted as follows: Compile a study on the wetlands of the site according to guidelines and criteria set by the Department of Water Affairs and the Northern Cape Department of Environmental Affairs and Nature Conservation (DENC).

The study includes a wetland / riparian delineation and functionality assessment, with descriptions of the anticipated impacts (risks) associated with the proposed development activities and mitigation to reduce impacts. In order to compile this, the following had to be done:

1.1 Information Sources

The following information sources were obtained for the study:

1. All relevant topographical maps, aerial photographs and information (previous studies and environmental databases) related to wetlands in the study area;
2. Requirements regarding the wetland survey as stipulated in the following guidelines:
    a. A practical field procedure for identification and delineation of wetlands and riparian areas (DWAF, 2006);
    b. National Wetland Classification System for South Africa (SANBI, 2009);
3. Guidelines regarding development in and around wetlands as stipulated by DWA and LEDET;

1.2 Regulations governing this report

1.2.1 National Environmental Management Act Regulation 543 Section 32

This report has been prepared in terms of Regulation 32 of the National Environmental Management Act (No. 107 of 1998) Regulations GN 33306 GNR 543 for environmental impact assessment. Regulation 33 states that a specialist report must contain:

1. An application or the EAP managing an application may appoint a person to carry out a specialist study or specialized process.
2. The person referred to in sub-regulation 1 must comply with the requirements of regulation 17 (General requirements for EAPs or a person compiling a specialist report or undertaking a specialized process).
3. A specialist report or a report on a specialized process prepared in terms of these regulations must contain:
    a. Details of
        i. The person who prepared the report; and Letter of Appointment
        ii. The expertise of that person to carry out the specialist study or specialized process.
    b. A declaration that the person is independent in a form as may be specified by the competent authority;
    c. An indication of the scope of, and purpose for which, the report was prepared;
    d. A description of the methodology adopted in preparing the report or carrying out the specialized process;
    e. A description of any assumptions made and any uncertainties or gaps in knowledge;
    f. A description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives, on the environment;
    g. Recommendations in respect of any mitigation measures that should be considered by the applicant and competent authority;
    h. A description of any consultation process that was undertaken during the course of carrying out the study;
    i. A summary and copies of any comments that were received during any consultation process;
    j. Any other information requested by the competent authority.

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

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

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

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

a. Taking water from a water resource;
b. Storing water;
c. Impeding or diverting the flow of water in a watercourse;
d. Engaging in a stream flow reduction activity contemplated in section 36;
e. Engaging in a controlled activity identified as such in section 37(1) or declared under section 38(1);
f. Discharging waste or water containing waste into a water resource through a pipe, canal, sewer, sea outfall or other conduit;
g. Disposing of waste in a manner which may detrimentally impact on a water resource;
h. Disposing in any manner of water which contains waste from, or which has been heated in, any industrial or power generation process;
i. Altering the bed, banks, course or characteristics of a watercourse;
j. Removing, discharging or disposing of water found underground if it is necessary for the efficient continuation of an activity or for the safety of people; and
k. Using water for recreational purposes.

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

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

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

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

1.3 Terms of reference

1.3.1 Rationale of solar development

South Africa currently relies principally on fossil fuels (coal and oil) for the generation of electricity. At the present date, Eskom generates approximately 95% of the electricity used in South Africa. On the other hand, South Africa has a largely unexploited potential in renewable energy resources such as solar, wind, biomass and hydro-electricity to produce electricity as opposed to other energy types (fuel or coal).

South Africa's electricity supply still heavily relies upon coal power plants, whereas the current number of renewable energy power plants is very limited. In the last few years, the demand for electricity in South Africa has been growing at a rate of approximately 3% per annum. These factors, if coupled with the rapid advancement in community development, have determined the growing consciousness of the significance of environmental impacts, climate change and the need for sustainable development. The use of renewable energy technologies is a sustainable way in which to meet future energy requirements.

The development of clean, green and renewable energy has been qualified as a priority by the Government of South Africa with a target goal for 2013 of 10,000 GWh, as planned in the Integrated Resource Plan 1 (IRP1) and with the Kyoto Protocol. Subsequently the Department of Energy of South Africa (DoE) decided to undertake a detailed process to determine South Africa's 20-year electricity plan, called Integrated Resources Plan 2010-2030 (IRP 2010).

The IRP1 (2009) and the IRP 2010 (2011) outline the Government's vision, policy and strategy in matter of the use of energy resources and the current status of energy policies in South Africa.

In particular, the IRP 2010 highlights the necessity of commissioning 1200 MW with solar PV technology by the end of 2015. In order to achieve this goal, in 2011 the DoE announced a Renewable Energy IPP (Independent Power Producers) Procurement Programme. The IPP Procurement Programme, issued on 3rd August 2011, envisages the commissioning of 3725 MW of renewable projects (1450 MW with solar photovoltaic technology) capable of beginning commercial operation before the end of 2017.

The development of PV power plants will represent a key feature in the fulfilment of the proposed target goal and the reduction of CO_2 emissions. The purpose of the East 2 and 3 Solar Parks is to add new capacity for the generation of renewable electrical energy to the national electricity supply in compliance with the IPP Procurement Programme and in order to meet the "sustainable growth" of the Northern Cape Province. The use of solar radiation for power generation is considered as a non-consumptive use and a renewable natural resource which does not produce greenhouse gas emissions. With specific reference to photovoltaic energy and the proposed project, it is important to consider that South Africa has one of the highest levels of solar radiation in the world.

1.3.2 Objectives

The project was done according to the following objectives:

- Conduct a desktop and field investigation to confirm the presence or absence of wetlands and riparian areas within the study area;
- Delineate and map the identified wetland areas on site;
- Classify wetlands according to their hydro-geomorphic characteristics;
- Determine the Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS) of all wetlands and riparian areas on site;
- Determine the impacts associated with the proposed development on the wetlands;
- Specify mitigation measures and management plan for the wetlands on site;
- Compile a report with the findings and maps.

1.4 Limitations and assumptions

The large study area did not allow for the finer level of assessment that can be obtained in smaller study areas. Therefore, data collection in this study relied heavily on data from representative sections, as well as general observations and a desktop analysis.

2 INTRODUCTION

Wetlands can be classified under a family name given to a variety of ecosystems, ranging from rivers, springs, seeps and mires in the upper catchments, to midland marshes, pans and floodplains, to coastal lakes, mangrove swamps and estuaries at the bottom of the catchment. These ecosystems all share a common driving force: water. Wetlands protect and regulate the water source. In a dry land like South Africa wetland play a crucial role not only by regulating water flows during floods or being natural filters, but also as sources of biological diversity.

Wetlands have many distinguishing features, the most notable being the presence of water at or near the surface, distinctive hydromorphic soils, and the vegetation adapted to or tolerant of saturated soils. Similarly, riparian areas can be distinguished from adjacent terrestrial areas by observing the presence or absence of a few key indicators. Soils associated with wetlands can be distinguished into permanent, seasonal and temporary wetness zones.

At present, wetlands are some of the most threatened habitats in the world. In fact, in some catchments in South Africa, studies have revealed that over 50% of the wetlands have already been destroyed. The main culprits have been the drainage of wetlands for crops and pastures, poorly managed burning and grazing that has resulted in head-cut and donga erosion, the planting of alien trees in wetlands, mining, pollution and urban development. Continued wetland destruction will result in less pure water, less reliable water supplies, increased severe flooding, a lower agricultural productivity, and more endangered species. Therefore, the wetland delineation plays an important role as part of the study.

3 STUDY AREA

3.1 Location and description of activity

The East 2 Solar Park and East 3 Solar Park will be established on the Remainder (964.2695 ha) and Portion 2 (856.5320 ha) of the Farm East 270, Kuruman RD, 4 km North of Hotazel, located in the Joe Morolong Local Municipality, John Taolo Gaetsewe District Municipality, Northern Cape Province. (Figure 1). The proposed project is situated directly north of the town of Hotazel and 62 kilometers to the North of the town of Kathu, with the footprint planned to the west (East 2) and east (East 3) of Eskom's "Hotazel - Heuningvlei" 132 kV power line.

The solar projects are called EAST 2 SOLAR PARK and EAST 3 SOLAR PARK, and it envisages the establishment of two Photovoltaic (PV) Power Plants having a maximum generating capacity up to 120 MW each. The PV power plant will each have a footprint (fenced area) up to 250 ha, within the total study area 1830 ha in extent.

Access to the East Solar Park will be from a new access road, 4km long, running along the southern boundary of Portion 2 of the Farm East 270. This new access road will start from a local upgraded farm road diverted of the regional road R31, which runs parallel to the eastern boundary of Portion 2 of the Farm East 270.

The chosen site is suitable for the installation of a photovoltaic (PV) power plant. It is appropriate morphologically (flat terrain) and regarding the favourable radiation conditions. The available radiation allows a high rate of electric energy production, as a combination of latitude-longitude and climatic conditions.

The aerial image of the site is indicated in figure 2, while the layout plan of the proposed development is indicated in figure 3.

East 2 & 3 Solar Parks Wetland Delineation

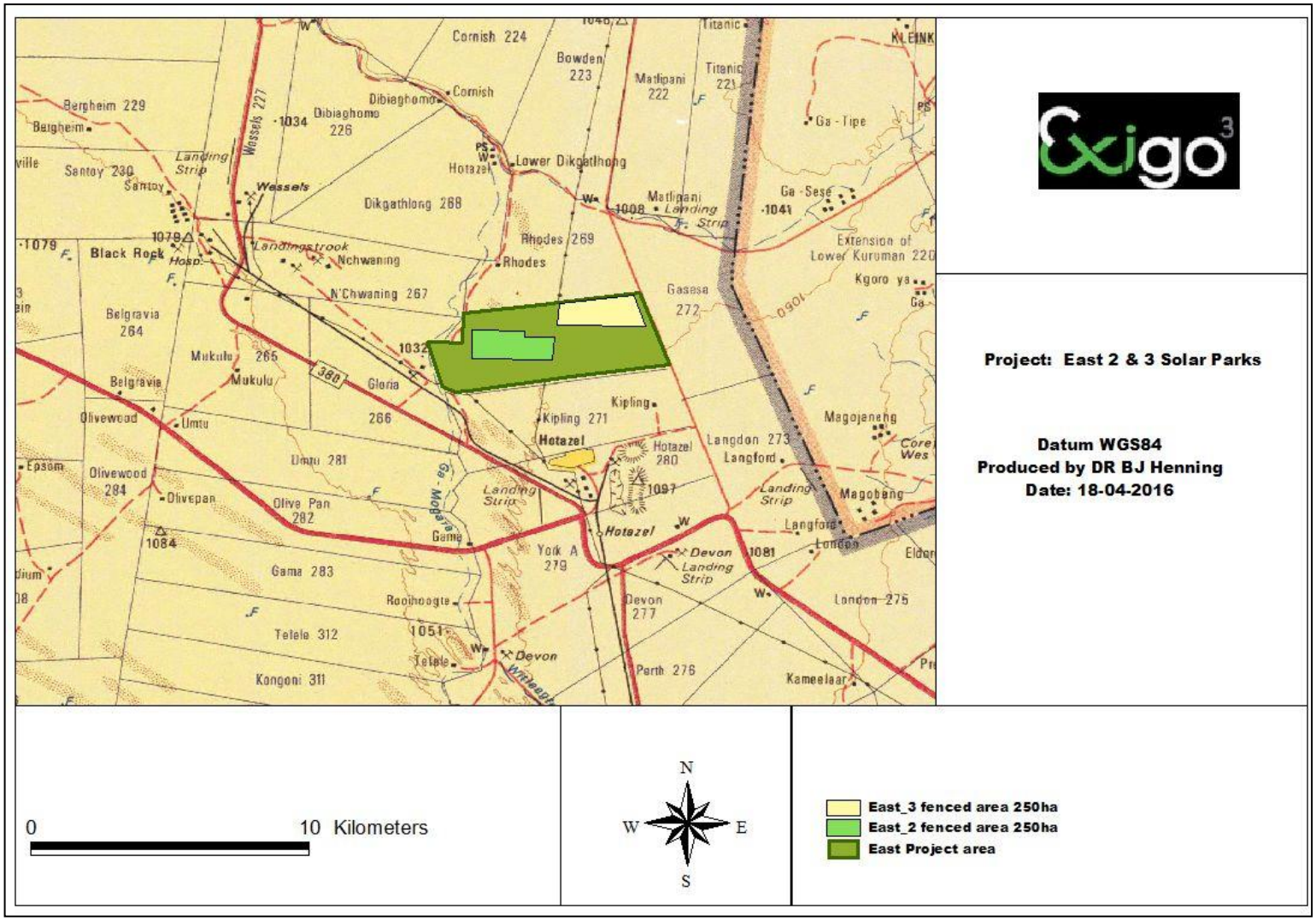


Figure 1. Regional Location Map

East 2 & 3 Solar Parks Wetland Delineation

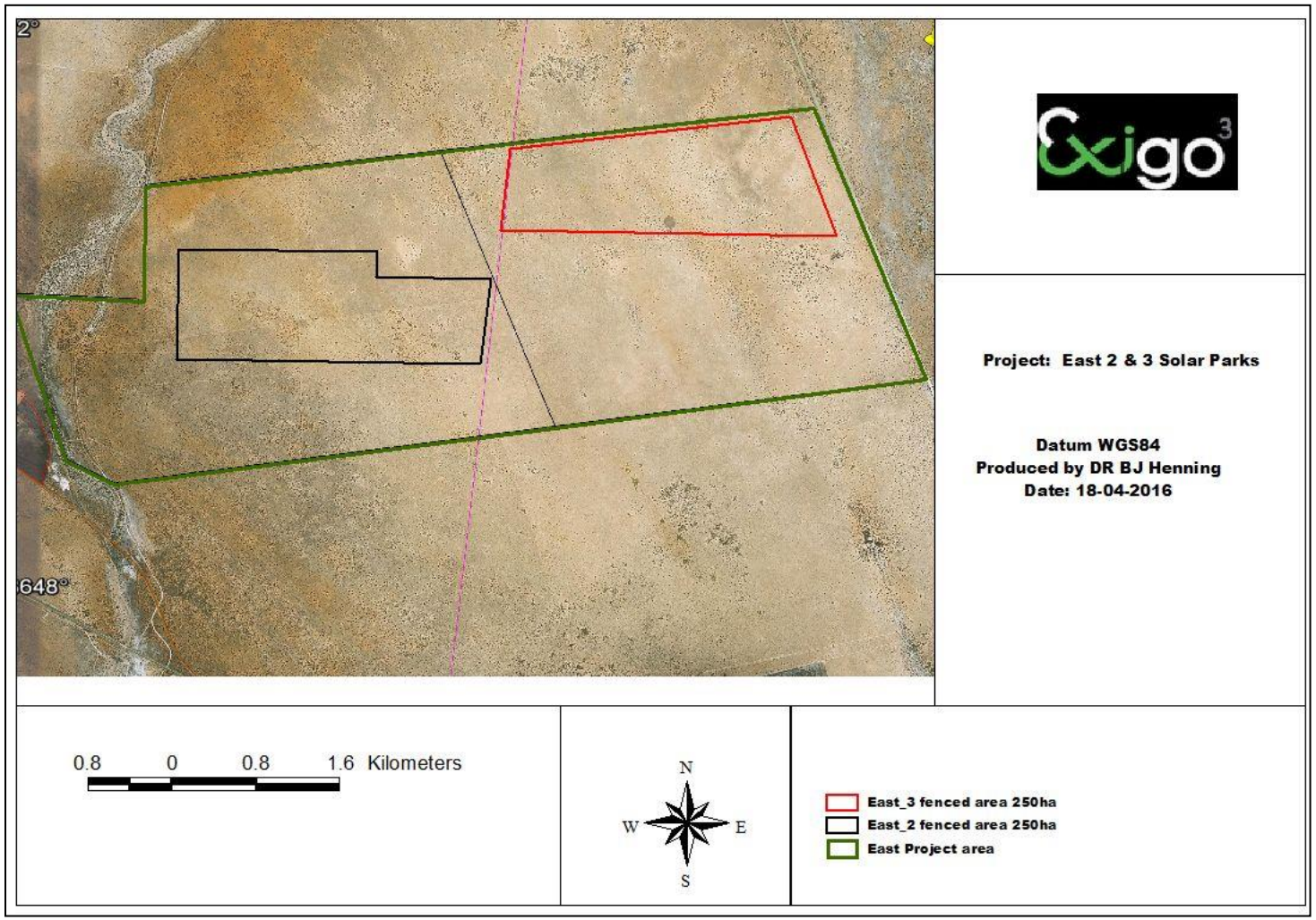


Figure 2. Satelite image showing the project area and proposed access road and focus area (Google Pro, 2010)

East 2 & 3 Solar Parks Wetland Delineation

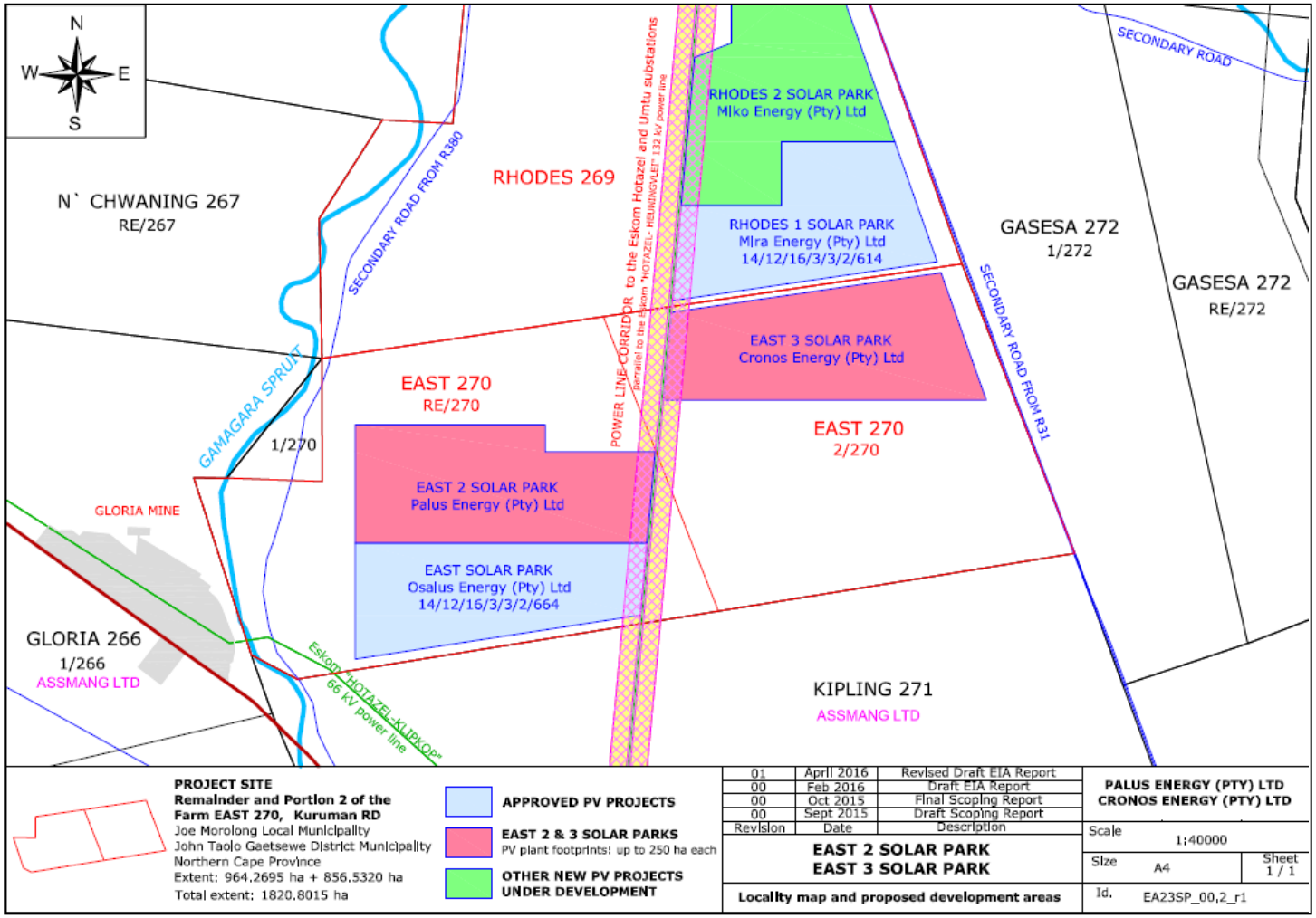


Figure 3. Layout plan for the proposed Solar Parks

3.2 CLIMATE

Climate in the broad sense is a major determinant of the geographical distribution of species and vegetation types. However, on a smaller scale, the microclimate, which is greatly influenced by local topography, is also important. Within areas, the local conditions of temperature, light, humidity and moisture vary greatly and it is these factors which play an important role in the production and survival of plants (Tainton, 1981). The climate for the region can be described as warm-temperate. In terrestrial environments, limitations related to water availability are always important to plants and plant communities.

The spatial and temporal distribution of rainfall is very complex and has great effects on the productivity, distribution and life forms of the major terrestrial biomes (Barbour et al. 1987). The study area is situated within the summer and autumn rainfall region with very dry winters and frequent frost that occurs during the colder winter months. The spatial and temporal distribution of rainfall is very complex and has great effects on the productivity, distribution and life forms of the major terrestrial biomes (Barbour et al. 1987). The mean annual precipitation varies between 120 and 260mm. The mean monthly maximum and minimum temperatures for the area are 41.5°C and -4°C, for December and July, respectively.

3.3 VEGETATION TYPES

3.3.1 REGIONAL CONTEXT: THE GRIQUALAND WEST CENTRE OF ENDEMISM

The vegetation of the proposed development site falls within the south-eastern range of the Griqualand West Centre of Endemism (Van Wyk & Smith 2001). A centre of plant endemism is an area with high concentrations of plant species with very restricted distributions. Centres of endemism are important because it is these areas, which if conserved, would safeguard the greatest number of plant species. They are extremely vulnerable; relatively small disturbances in a centre of endemism may easily pose a serious threat to its many range-restricted species (Van Wyk & Smith 2001). The Griqualand West Centre (GWC) is one of the 84 African centres of endemism and one of 14 centres in southern Africa, and these centres are of global conservation significance.

The endemic and near-endemic species make up 2.2% of the total flora, and are mostly from the Asclepiadaceae, Euphorbiaceae and Mesembryanthemaceae families. Some of the endemics are edaphic specialists, adapted to lime-rich substrates.

Endemics and near-endemics include *Searsia tridactyla, Aloinopsis orpenii, Euphorbia planiceps, Euphorbia bergii, Lebeckia macrantha, Lithops aucampiae* subsp. *aucampiae* and *Tarchonanthus obovatus*.

The GWC of endemism is extremely poorly conserved, and is a national conservation priority. Figure 4 shows the extent of the GWC.

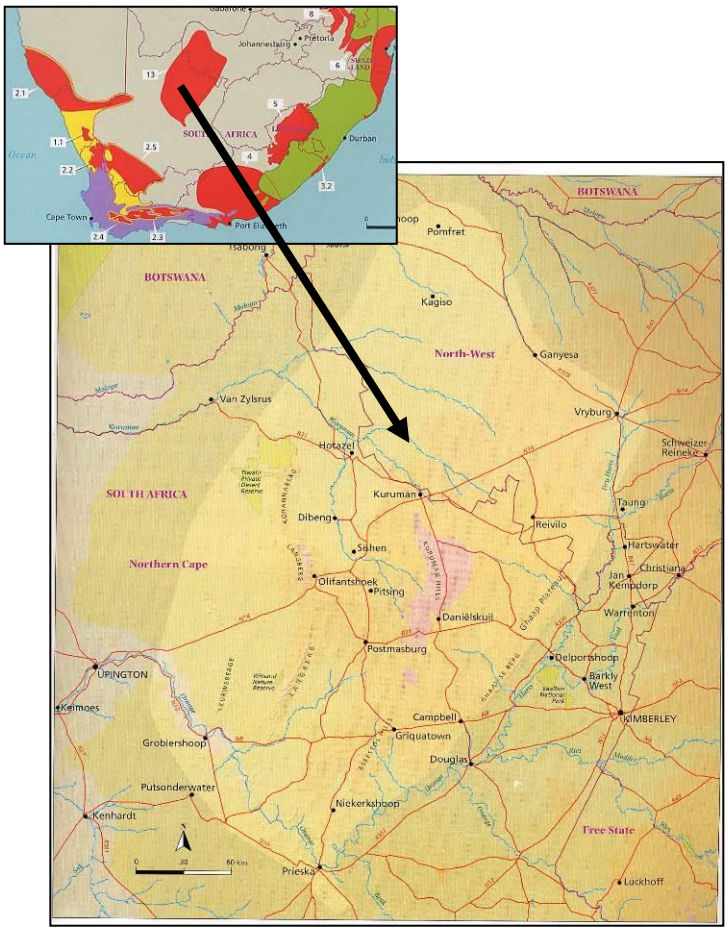


Figure 4. Map showing the extent of the Griqualand West Centre of Endemism (light centre). It is centred on the surface outcrops of the Ghaap Group (limestone and dolomite) and those of the Olifantshoek Supergroup (quartzite). From Van Wyk & Smith (2001)

3.3.2 LOCAL CONTEXT

The development site lies within the Savanna biome which is the largest biome in Southern Africa. It is characterized by a grassy ground layer and a distinct upper layer of woody plants (trees and shrubs). The environmental factors delimiting the biome are complex and include altitude, rainfall, geology and soil types, with rainfall being the major delimiting factor. Fire and grazing also keep the grassy layer dominant. The most recent classification of the area by Mucina & Rutherford (2006) shows that the sites forms part of the Kathu Bushveld and Gordonia Dunveld vegetation types.

The vegetation and landscape characteristics of the Kathu Bushveld include a medium-tall tree layer with dense stands of *Acacia erioloba* in places, but mostly an open woodland with *Boscia albitrunca* as the prominent tree species, while the shrub layer is dominated by *Acacia mellifera, Lycium hirsitum* and *Diospyros lycioides*. This vegetation type in its pristine state is characterized by plains with layer of scattered, low to medium high deciduous microphyllous trees and shrubs with a few broadleaved tree species, and an almost continuous herbaceous layer dominated by grass species. This vegetation type has a Least Threatened conservation status, with 1% transformed and none statutorily conserved.

The landscape features of the Gordonia Duneveld vegetation type are mostly parallel dunes (3-8m in height) with an open shrubland woody structure and ridges of grassland dominated by *Stipagrostis amabilis* on the dune crests and *Acacia haematoxylon* on the dunes slopes. The conservation status of the Gordonia Duneveld is Least Threatened with very little transformation and 14% statutorily conserved in the Kgalagadi Transfrontier Park (Mucina & Rutherford, 2006).

3.4 GEOLOGY AND SOIL TYPES

Geology is directly related to soil types and plant communities that may occur in a specific area (Van Rooyen & Theron, 1996). A Land type unit is a unique combination of soil pattern, terrain and macroclimate, the classification of which is used to determine the potential agricultural value of soils in an area. The land type unit represented within the proposed footprint area include the Ah9 and Af28 land types (Land Type Survey Staff, 1987) (ENPAT, 2000). The land types, geology and associated soil types is presented in Table 1 below as classified by the Environmental Potential Atlas, South Africa (ENPAT, 2000).

Table 1. Land types, geology and dominant soil types of the proposed development site

Land type	Soils	Geology
Ah9	Red-yellow apedal, freely drained soils; red and yellow, high base status, usually < 15% clay	Aeolian sand of Recent age with a few outcrops of Tertiary Kalahari beds (surface limestone, silcrete and sandstone) in the riverbeds.
Af28	Red-yellow apedal, freely drained soils; red, high base status, > 300 mm deep (with dunes)	Red to flesh-coloured wind-blown sand (sand dunes) of Tertiary to Recent age with some outcrops of coarse-grained brown quartzite and subgreywacke and conglomerate (Matsap Formation).

Soils associated with the site are mostly deep, Aeolian sands overlying calcrete

3.5 Topography & Drainage

The assessment of slope class in an area is an important determinant in land evaluation for crop production. Slope impacts the use of mechanical traction and together with soil textural classes, influences the rate of soil erosion. Field topography can also have a direct effect on crop growth and yield by redirecting pools of soil water. Indirectly, slope affects the distribution of certain chemical and physical properties such as organic matter content, base saturation, soil temperature, and particle size distribution (Franzmeier et al., 1969; Stone et al., 1985; Jiang, and Thelen, 2004).

Two land facets are present on the site. Dunes occur as high-gradient hills in the north-western section of the site, while the remainder of the site represents slightly plains. The topography across the site is slightly undulating with the average elevation of 1030 mamsl.

The site is located within two quaternary catchments namely D41K (Eastern section of site) and D41L (western section of site) and is situated in the Lower Vaal Water Management Area. Drainage occurs as sheet-wash towards the major rivers namely the Gamagara River east of the site and the Kuruman River to the north of the site.

3.6 Land use and existing infrastructure

The current land-use of the proposed development site is grazing by livestock and game. Neighbouring farms are being used for livestock grazing and game farming, with mining further away from the site.

The major land use of the study area as classified by the Environmental Potential Atlas of South Africa (2000) is vacant / unspecified land.

4 METHODS

4.1 WETLAND DELINEATION AND CLASSIFICATION

The National Water Act, Act 36 of 1998, defines wetlands as follows:

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

Wetlands were delineated according to the delineation procedure given in "A Practical Field Procedure for the Identification and Delineation of Wetlands and Riparian Areas" (DWAF, 2003).

Wetland indicators are divided into different unit indicators which need to be given consideration in the delineation of wetlands (Figure 4). The outer edge of the temporary zone requires the delineator to take the following specific indicators into account:

- The terrain unit indicator helps to identify those parts of the landscape where wetlands are more likely to occur.
- The Soil Form Indicator identifies the soil forms, as defined by Macvicar (1991), which are associated with prolonged and frequent saturation.
- The Soil Wetness Indicator identifies the morphological "signatures" developed in the soil profile as a result of prolonged and frequent saturation.
- The Vegetation Indicator identifies hydrophilic vegetation associated with frequently saturated soils.

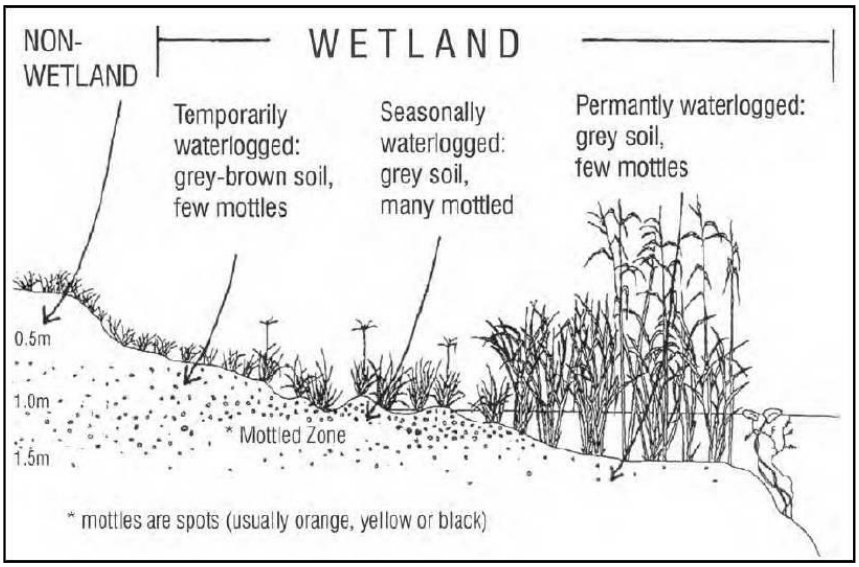


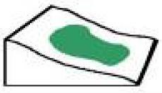
Figure 5. A cross section through a wetland showing how the soil form indicators and vegetation changes from the centre to the edge of the wetland (adapted from Kotze, 1996)

4.2 WETLAND CLASSIFICATION

The study area was sub-divided into transects and the soil profile was examined for signs of wetness within 50 cm of the surface using a hand auger along transects. The wetland boundaries were then determined by the positions of augered holes that showed signs of wetness as well as by the presence or absence of hydrophilic vegetation. The wetlands were subsequently classified according to their hydro-geomorphic setting based on the system proposed in the National Wetland Classification System (Table 2) (SANBI, 2009).

Furthermore, as a result of alluvial deposits being visible from the air, aerial photography was also used to assist in determining the extent of deposits, as well as the vegetation line indicating a difference in species composition or more vigorous growth. The aerial photographs were used to guide on-screen delineation of wetlands in ArcView GIS 3.3.

Table 2. Wetland Unit types based on hydrogeomorphic characteristics (Adapted from Kotze *et al.* 2005).

Hydro-geomorphic type	Code	Illustration	Description
Flood Plain	FP		Valley bottom areas with a well defined stream channel, gently sloped and characterized by floodplain features such as oxbow depressions and natural levees and the alluvial (by water) transport and deposition of sediment, usually leading to a net accumulation of sediment. Water inputs from main channel (when channel banks overspill) and from adjacent slopes.
Valley Bottom with a Channel	VBC		Valley bottom areas with a well defined stream channel but lacking characteristic floodplain features. May be gently sloped and characterized by the net accumulation of alluvial deposits or may have steeper slopes and be characterized by the net loss of sediment. Water inputs from main channel (when channel banks overspill) and from adjacent slopes.
Valley Bottom Without a channel	VB		Valley bottom areas with no clearly defined stream channel, usually gently sloped and characterized by alluvial sediment deposition, generally leading to a net accumulation of sediment. Water inputs mainly from channel entering the wetland and also from adjacent slopes.
Channelled Hillslope Seepage feeding a Water course	CHSW		Slopes on hillsides, which are characterized by the colluvial (transported by gravity) movement of materials. Water inputs are mainly from sub-surface flow and outflow is usually via a well defined stream channel connecting the area directly to a watercourse.
Hillslope Seepage feeding a Water course	HSW		Slopes on hillsides, which are characterized by the colluvial (transported by gravity) movement of materials. Water inputs are mainly from sub-surface flow connecting the area directly to a watercourse.
Hillslope Seepage not feeding a water course	HS		Slopes on hillsides, which are characterized by the colluvial (transported by gravity) movement of materials. Water inputs mainly from sub-surface flow and outflow either very limited or through diffuse sub-surface and/or surface flow but with no direct surface water connection to a watercourse.
Depression	D		A basin shaped area with a closed elevation contour that allows for the accumulation of surface water (i.e. it is inward draining). It may also receive sub-surface water. An outlet is usually absent.

4.3 WETLAND INTEGRITY ASSESSMENTS

4.3.1 Present Ecological Status (PES) of wetlands

The Present Ecological State (PES) assessment of the wetlands within the study area was undertaken to determine the extent of departure of the wetlands from a natural state or reference condition. This method is based on the modified Habitat Integrity approach (Table 3) developed by Kleynhans (1999). Anthropogenic modification of the criteria and its attributes can have an impact on the ecological integrity of a wetland.

Table 3. Habitat integrity assessment criteria for wetlands (Adapted from DWAF, 2003)

Criteria and Attributes	*Relevance*
Hydrologic	
Flow Modification	Consequence of abstraction, regulation by impoundments or increased runoff from human settlements or agricultural land. Changes in flow regime (timing, duration, frequency), volumes, velocity which affect inundation of wetland habitats resulting in floristic changes or incorrect cues to biota. Abstraction of groundwater flows to or from a wetland.
Permanent Inundation	Consequence of impoundment resulting in destruction of natural wetland habitat and cues for wetland biota.
Water Quality	
Water Quality Modification	From point or diffuse sources. Measure directly by laboratory analysis or assessed indirectly from upstream agricultural activities, human settlements and industrial activities. Aggravated by volumetric decrease in flow delivered to the wetland.
Sediment Load Modification	Consequence of reduction due to entrapment by impoundments or increase due to land use practices such as overgrazing. Cause of unnatural rates of erosion, accretion or infilling of wetlands and change in habitats.
Hydraulic/Geomorphic	
Canalization	Results in desiccation or changes to inundation patterns of wetland and thus changes in habitats. River diversions or drainage.
Topographic Alteration	Consequence of infilling, ploughing, dykes, trampling, bridges, roads, railway lines and other substrate disruptive activities which reduce or changes wetland habitat directly in inundation patterns.
Biota	
Terrestrial Encroachment	Consequence of desiccation of wetland and encroachment of terrestrial plant species due to changes in hydrology or geomorphology. Change from wetland to terrestrial habitat and loss of wetland functions.
Indigenous Vegetation Removal	Direct destruction of habitat through farming activities, grazing or firewood collection affecting wildlife habitat and flow attenuation functions, organic matter inputs and increases potential for erosion.
Invasive Plant Encroachment	Affects habitat characteristics through changes in community structure and water quality changes (oxygen reduction and shading).
Alien Fauna	Presence of alien fauna affecting faunal community structure.
Over utilization of Biota	Overgrazing, over fishing, etc.
Attributes above are rated and scored as one of the following: Natural/Unmodified 5; Largely Natural 4; Moderately Modified 3; Largely Modified 2; Seriously Modified 1; Critically Modified 0	

For the purpose of this study, the scoring system as described in the document "Resource Directed Measures for Protection of Water Resources, Volume 4. Wetland Ecosystems" (DWAF, 1999) was applied for the determination of the PES (Table 4).

Two tools have recently been developed to facilitate the derivation of scores to reflect the present ecological sate, namely the Index of Habitat Integrity (IHI) DWA, 2007, and Wet-Health, developed by Macfarlane et al., 2008. Both these tools have limitations in that they were developed primarily to assess conditions of floodplain and valley bottom wetlands and Hill slope seepage wetlands linked to drainage lines. The former tool was developed to provide a rapid assessment of the PES specifically for application in reserve studies, while the latter tool was developed to support the Working for Wetlands program. The objective of the latter tool was to provide a semi quantitative assessment of the state of wetland prior to rehabilitation, and one post rehabilitation to demonstrate "improvement". The intention in defining the health category (PES) of a wetland is to provide an indication of the current "condition" of a wetland in order to inform a management class. The latter provides the guidelines against that inform water quality and quantity required to maintain or improve the quality of the water resource.

The PES or health of wetlands has only been applied to the "natural" wetlands, i.e. those that have developed naturally as a consequence of the presence of water. Wetlands are rated on a scale of A to F, with A being a natural wetland and F being a completely modified and disturbed wetland (Table 4). The Wet-Health assesses the following four factors that influence the "health" or condition of wetlands and in this particular application floodplains and river channels associated with the site:

- Hydrology;
- Geomorphology
- Vegetation, and ideally
- Water quality.

The Present Ecological Status Class (PESC) of the wetlands was based on the available information for each of the criteria listed in Table 3 and the mean score determined for each wetland (Table 4). This approach is based on the assumption that extensive degradation of any of the wetland attributes may determine the PESC (DWAF, 2003).

Table 4. Present Ecological Status Class Descriptions

CLASS	CLASS BOUNDARY	CLASS DESCRIPTION
A	>4	**Unmodified, natural;** • The resource base reserve has not been decreased; • The resource capability has not been exploited
B	>3 and <=4	**Largely natural with few modification**; • The resource base reserve has been decreased to a small extent; • A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.
C	>2 and <=3	**Moderately modified**; • The resource base reserve has been decreased to a moderate extent. • A change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.
D	2	**Largely modified**; • The resource base reserve has been decreased to a large extent. • Large changes in natural habitat, biota and basic ecosystem functions have occurred.
E	>0 and <2	**Seriously modified**; • The resource base reserve has been seriously decreased and regularly exceeds the resource base; • The loss of natural habitat, biota and basic ecosystem functions is extensive.
F	0	**Critically modified**; • The resource base reserve has been critically decreased and permanently exceeds the resource base; • Modifications have reached a critical level and the resource has been modified completely with an almost total loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.

4.3.2 Ecological Importance and Sensitivity (EIS)

The Ecological Importance and Sensitivity (EIS) assessment was conducted according to the guidelines as discussed by DWAF (1999). Here DWAF defines “ecological importance” of a water resource as an expression of its importance to the maintenance of ecological diversity and function on local and wider scales. “Ecological sensitivity”, according to DWAF (1999), is the system’s ability to resist disturbance and its capability to recover from disturbance once it has occurred.

In the method outlined by DWAF a series of determinants for EIS are assessed for the wetlands on a scale of 0 to 4 (Table 5). The median of the determinants is used to determine the EIS of the wetland unit (Table 6).

Table 5. Criteria for assessing the Ecological Importance and Sensitivity of Wetlands

Determinant
PRIMARY DETERMINANTS
1. Rare & Endangered Species
2. Populations of Unique Species
3. Species/taxon Richness
4. Diversity of Habitat Types or Features
5. Migration route/breeding and feeding site for wetland species
6. Sensitivity to Changes in the Natural Hydrological Regime
7. Sensitivity to Water Quality Changes
8. Flood Storage, Energy Dissipation & Particulate/Element Removal
MODIFYING DETERMINANTS
9. Protected Status
10. Ecological Integrity

Score guideline Very high = 4; High = 3, Moderate = 2; Marginal/Low = 1; None = 0
Confidence rating Very high confidence = 4; High confidence = 3; Moderate confidence = 2; Marginal/low confidence = 1

Table 6. Ecological Importance and Sensitivity Classes

Ecological Importance and Sensitivity Category (EIS)	Range of Median
Very high Wetlands that are considered ecologically important and sensitive on a national or even international level. The biodiversity of these wetlands is usually very sensitive to flow and habitat modifications. They play a major role in moderating the quantity and quality of water of major rivers.	>3 and <=4
High Wetlands that are considered to be ecologically important and sensitive. The biodiversity of these wetlands may be sensitive to flow and habitat modifications. They play a role in moderating the quantity and quality of water of major rivers.	>2 and <=3
Moderate Wetlands that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these Wetlands is not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water of major rivers.	>1 and <=2
Low/marginal Wetlands that are not ecologically important and sensitive at any scale. The biodiversity of these Wetlands is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water of major rivers.	>0 and <=1

5 RESULTS

DWAF (2003) states that in order to classify an area as a wetland it must have one or more of the following attributes:

- Hydromorphic soils that exhibit features characteristic of prolonged saturation;
- The presence of hydrophytes (even if only infrequently);
- A shallow water table that results in saturation at or near the surface, leading to the development of anaerobic conditions in the top 50cm of the soil.

One wetland type was identified on site namely a pan that is classified as an endorheic depression.

A band of 30 meters was delineated around the periphery of the wetland zone as a buffer zone. A buffer zone is a collar of land that filters out edge effects, including the effects of invasive plant and animal species, physical damage and soil compaction caused through trampling and harvesting, abiotic habitat alterations and pollution. The author is confident that the proposed buffer zone would put the development outside the area of influence to the sensitive wetland area so that the edge effects are mitigated or prevented successfully. The wetland areas and buffer zone are presented in figure 8.

Wetland zone identification was done according to soil types, topography of the landscape and vegetation.

5.1 WETLAND CLASSIFICATION

5.1.1 Endorheic depression

A small pan occurs in the central section of the project area (Photograph 1). A depression is classified as a landform with closed elevation contours that increases in depth from the perimeter to a central area of greatest depth, and within which water typically accumulates. Dominant water sources are precipitation, ground water discharge, interflow and (diffuse or concentrated) overland flow. For ‘depressions with channelled inflow’, concentrated overland flow is typically a major source of water for the wetland, whereas this is not the case for ‘depressions without channelled inflow’. Dominant hydrodynamics are (primarily seasonal) vertical fluctuations. Depressions may be flat-bottomed (in which case they are often referred to as ‘pans’) or round-bottomed (in which case they are often referred to as ‘basins’), and may have any combination of inlets and outlets or lack them completely.

In the case of the project area the pan is classified as an endorheic depression. Water exits by means of evaporation and infiltration for endorheic depressions; and as concentrated surface flow in channels for exorheic depressions, although the primary means of water still exits as evaporation.

The depression in the project area is also known as a ‘salt pan’ and is classified as forming part of the

Kalahari Salt pans vegetation type (Mucina & Rutherford, 2006). These pans are also known as playas. They occur on plains of low relief, as a result of which drainage is poor. Their bases are impervious to downward (vertical) drainage. The base is often calcrete as observed in the study area. Some drainage occurs laterally, both into and out of the pan. Geomorphological processes, including wind-driven deflation, lead to the formation of depressions, which hold water for varying periods (Walsmley, 2003).

Anderson (2003) noted that the pans could be threatened by disturbances common to other land use practices in the area, such as trampling by livestock which transforms well-vegetated pan shorelines to open mud. The Mesquite (*Prosopis glandulosa*) and other alien plants could invade the pans if their spread is not controlled.

The current layout plan of the proposed PV plant development should not impede on the pan and a buffer zone should be implemented around this area. Walmsley (2003) concluded from a previous hydrological study on the Kalahari Pans that the degree of sensitivity of the pans is not considered particularly great due to the climatic conditions that cause a high evaporation rate and the pan bottoms that allow limited vertical movement of water due to the thick clay layer in the shallow aquifer.

Photograph 1. The endorheic depression in the central section of the project area

East 2 & 3 Solar Parks Wetland Delineation

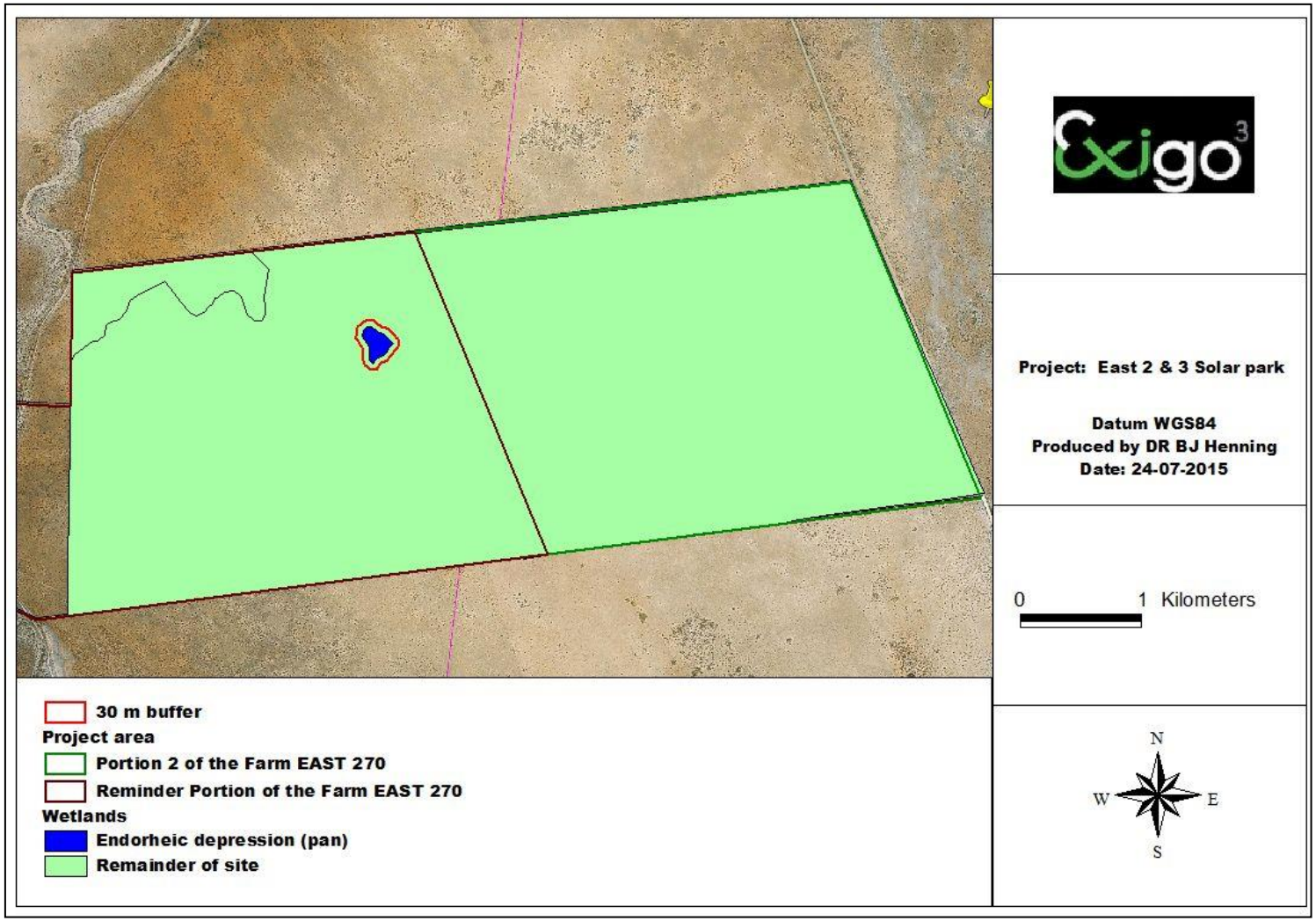


Figure 6. Wetland map for the proposed East 2 and 3 Solar Park project area

6 WETLAND INTEGRITY ASSESSMENTS

For the purpose of this study only the depression that occurs on the proposed development site was assessed. In determining the integrity of the wetland the condition of the site and the indirect and direct disturbances is taken into account. The roads, alien invasive vegetation species, etc. was taken into account in determining the PES and EIS of these hydrological features (Table 7). Appendix A and B indicate the scores for the PES and EIS respectively.

No evidence was observed on site of major transformation of the floristic characteristics of the site. Impacting activities which have altered the expected floristic composition include alien infestation, impoundment and road crossings.

Table 7. Present Ecological State, Ecological Importance & Sensitivity, Hydro-functional Importance and Direct Human Benefits of the wetland on the proposed development site

Wetland	PES	EIS
Depression	Class B: Largely natural with few modifications	High

The pan on the remainder section of the farm East can still be considered as having a 'Largely Natural' PES, with the only impacts being from livestock overgrazing, trampling and alien species encroachment. The pan has a 'HIGH' EIS and support ecosystem functioning, especially in terms of the connectivity towards the larger area.

7 POTENTIAL IMPACTS OF THE PROPOSED DEVELOPMENT ON THE WETLANDS

The proposed development will potentially have indirect or impacts on the water courses at the access road crossing or solar plant development areas. Indirect impacts could occur as a result of construction activities (dust, spillages etc.). The following section deals with the anticipated impacts of the proposed development on the water courses of the site. Considering the location of the pans in the northern section of the site, no major impacts are anticipated for these features.

7.1 Permanent loss of wetland and their associated functions

The construction activities of the project will potentially have an impact on the wetlands, whether it is through direct or indirect impacts. Some clearance of vegetation will occur. Any loss of the riparian or water course habitat will also result in permanent loss or displacement of the invertebrates, birds and small mammals dependant on the riparian zone vegetation for feeding, shelter and breeding purposes. All functions associated with the riparian zones and the surrounding landscape will be compromised.

7.1.1 Destruction or loss of water course floral diversity

The following major impacts of the development will potentially impact on the flora of the site:

- Loss of threatened, “near-threatened” and endemic taxa: The anticipated loss of some of the habitats that support endemic species will result in the local displacement of endemic listed flora;
- The construction activities and associated impacts might lead to the loss of individual plants around the water courses;
- The construction activities can impact on surrounding vegetation by dust and altered surface run-off patterns;
- The disturbance of the area could lead to an increase in the growth of alien vegetation in riparian zones;

7.1.2 Loss of water course and water dependant faunal diversity through migration and decline in animal numbers

The following major impacts of the development will potentially impact on the faunal habitats of the site:

- Habitat modification by construction activities will force water course dependant fauna out of the area and animal numbers will decrease. This impact could also take place because of hunting and snaring of animals in and around the riparian zones.

- Loss of threatened, “near-threatened” and conservation important taxa: The anticipated loss of the areas adjacent to the water courses will ultimately also result in the local displacement of some fauna species that occur in these areas.
- Changes in the community structure: It is expected that the faunal species composition will shift, due to an anticipated loss in habitat surface area. In addition, it is predicted that more generalist species (and a loss of functional guilds) will dominate the study area. Attempts to rehabilitate will attract taxa with unspecialised and generalist life-histories. It is predicted that such taxa will persist for many years before conditions become suitable for succession to progress.

7.2 Soil compaction and increased risk of sediment transport and erosion

The use of heavy machinery during the construction process will result in the compaction of soil, resulting in decreased infiltration of rain water and increased surface run-off volumes and velocities leading to a greater erosion risk in the area. Soil compaction is likely to occur over some parts of the proposed corridors.

The hardened surfaces and compacted soils of the development area will also lead to an increase in surface run-off during storm events which will likely be discharged via storm water outlet points, concentrating flows leaving the development area.

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

7.3 Soil and water pollution

Construction work will further carry a risk of soil and water pollution, with large construction vehicles contributing substantially due to oil and fuel spillages. If not promptly dealt with, spillages or accumulation of waste matter can contaminate the soil and surface or ground water, leading to potential medium/long-term impacts on fauna and flora. During the operational phase heavy machinery and vehicles as well as sewage and domestic waste would be the main contributors to potential pollution problems.

7.4 Spread and establishment of alien invasive species

The construction carries by far the greatest risk of alien invasive species being imported to the site, and the high levels of habitat disturbance also provide the greatest opportunities for such species to establish themselves, since most indigenous species are less tolerant of disturbance. The biggest risk is that seeds of noxious plants may be carried onto the site along with materials that have been stockpiled elsewhere at already invaded sites. Furthermore, the spread of the alien invasive species through the area will be accelerated when seeds are carried by stormwater into the water courses on the site that will cause environmental degradation and indigenous species to be displaced. Continued movement of personnel and vehicles on and off the site, as well as occasional delivery of materials required for maintenance, will result in a risk of importation of alien species throughout the life of the project.

7.5 Negative effect of human activities on riparian zones

An increase in human activity on the site and surrounding areas is anticipated during the construction phase of the development. The risk of snaring, killing and hunting of certain faunal species is increased. If staff compounds are erected for construction workers, the risk of pollution to riparian zones because of litter and inadequate sanitation and the introduction of invasive fauna and flora are increased. The presence of construction workers on site over a protracted period will result in a greatly increased risk of uncontrolled fires arising from cooking fires, improperly disposed cigarettes, etc.

8 MANAGEMENT RECOMMENDATIONS

The development will have a definite impact on some of the natural environment of the site. To limit the impact from being on the wetland areas identified and delineated in the previous section it is recommended that a 30-meter buffer zone be adapted from the periphery of the temporary zone of the pan. The buffer zone is essential to ensure healthy function and maintenance of wetland ecosystems. No development should be allowed in the wetland or its buffer zone.

The following general measures will have to be adhered to in order to mitigate impacts to wetlands:

- Coordinate erosion control measures with construction activities, including the staging of works;
- Minimize soil exposure during construction;
- Re-vegetate quickly and extensively;
- Manage water effectively on, to, within, and from this site;
- Provide suitable access tracks and loading, unloading, maintenance and wash-down areas;
- Incorporate effective litter management and “house-keeping” practices;
- Employ sediment capture techniques and storm-water attenuation techniques.

8.1 Disturbance to wetland / drainage channel habitats and soil

Stringent controls must be put in place to prevent any unnecessary disturbance or compaction of alluvial soils. Compaction of soils should be limited and / or avoided as far as possible. Compaction will reduce water infiltration and will result in increased runoff and erosion. Where any disturbance of the soil takes place (have taken place in the past), these areas must be stabilized and any alien plants which establish should be cleared and follow up undertaken for at least 2 years thereafter and preferably longer. Where compaction becomes apparent, remedial measures must be taken (e.g. “ripping” the affected area). Topsoil should preferably be separated from the subsoil, and topsoil sections should be kept intact as deep as possible.

Other specific mitigation measures needed for the riparian zone area during construction are as follows:

- All construction and maintenance activities should be conducted in such a way that minimal damage is caused to the water courses riparian zone. Only necessary damage must be caused and, unnecessary driving around in the veld or bulldozing natural habitat must not take place.
- Work in rivers, streams and riparian zones should preferably be done during the low flow season;

- The following mitigation measures and management actions should be taken to minimize potential impacts of the road crossing zones and the solar plant on the water courses:
    - Identify areas of historic or potential vulnerability, such as geologically unstable materials or areas subject to flooding.
    - Avoid problematic areas and avoid road locations in areas of high natural hazard risk, such as landslides, rock-fall areas, steep slopes (over 60-70%), wet areas, saturated soils, etc.
    - Minimize changes to natural drainage patterns and crossings to drainages. Drainage crossings are potentially problematic, so they must be well designed. Changes to natural drainage patterns or channels often result in either environmental damage or failures.
    - Perform scheduled maintenance to be prepared for storms. Insure that culverts have their maximum capacity, ditches are cleaned, and that channels are free of debris and brush than can plug structures.
    - Typically keep cut and fill slopes as flat as possible and well covered (stabilized) with vegetation to minimize slumping as well as minimize surface erosion. Well-cemented but highly erosive soils may best resist surface erosion with near-vertical slopes that minimize the surface area exposed to erosion.
    - Use deep-rooted vegetation for biotechnical stabilization on slopes. Use a mixture of good ground cover plus deep-rooted vegetative species, preferably native species, to minimize deep-seated mass instability as well as offer surface erosion control protection.
    - Ensure that structural designs for the road crossing the drainage channels include appropriate design criteria and have good foundations to prevent failures during floods.
    - Place retaining structures, foundations, and slope stabilization measures into bedrock or firm, in-place material with good bearing capacity to minimize undermining, rather than placing these structures on shallow colluvial soil or on loose fill material.
- Appropriate measures must be taken to manage storm water run-off and potential flooding.

8.2 Erosion prevention

During the construction phase the clearing of the site will leave the soil exposed and this can cause erosion. The following list provides a guide to preventing erosion on construction sites:

- Programming: Install erosion control measures before construction commences. Schedule construction activities to minimize land disturbance;
- Land clearing: minimize the extent and duration of land clearing;
- Storm water and run-off systems: install temporary drains and minimize concentrated water flows. Divert run-off around trench excavations or disturbed areas;
- Rehabilitation: revegetate or stabilise all disturbed areas as soon as possible. Indigenous trees can be planted in the buffer zone of the proposed development to enhance the aesthetic value of the site and stabilize soil conditions;
- Services: coordinate the provision of site services to minimize disturbance;
- Stockpiles: locate stockpiles away from concentrated flows and divert run-off around them.

8.3 Dust and Chemical Pollution prevention

The following measures need to be taken to prevent pollution to the riparian:

- Implement standard dust control measures, including periodic spraying (frequency will depend on many factors including weather conditions, soil composition and traffic intensity and must thus be adapted on an on-going basis);
- Soil dumps may be covered if necessary;
- A speed limit (preferably 40 km/hour) should be enforced on dirt roads;
- Water falling on areas polluted with oil/diesel or other hazardous substances must be contained. Any excess or waste material or chemicals should be removed from the site and discarded in an environmental friendly way. The Environmental Control Officer should enforce this rule rigorously;
- Chemicals to be stored on an impervious surface protected from rainfall and storm water run-off;
- Ensure that refuelling stations on site are constructed so as to prevent spillage of fuel or oil onto the soil, and put in place measures to ensure that any accidental spillages can be contained and cleaned up promptly;
- Spill kits should be on-hand to deal with spills immediately;
- Spillages or leakages must be treated according to an applicable procedure as determined by a plan of action for the specific type of disturbance;

- All construction vehicles should be inspected for oil and fuel leaks regularly and frequently. Vehicle maintenance will not be done on site except in emergency situations in which case mobile drip trays will be used to capture any spills. Drip trays should be emptied into a holding tank and returned to the supplier.

8.4 Littering prevention

Uncontrolled littering can be a source of pollution to the riparian zone. The following measures need to be taken in order to mitigate against littering in riparian zones:

- Litter storage and housekeeping: maintain a high standard of housekeeping. Store all litter carefully so it cannot be washed or blown into the storm-water drainage systems;
- Rubbish bins: provide bins for construction workers and staff at appropriate location, particularly where food is consumed;
- Daily site clean-up: clean-up site of all litter daily;
- Rubbish disposal: dispose of scrap materials (e.g. off-cuts and scrap machinery components) in a responsible manner.

8.5 Building activity associated impacts

Dust concrete, solvents, steel fillings, fuel and other wastes are all produced during building construction and can cause impacts to the riparian zones. Take the following mitigation measures:

- Materials storage: store building materials under cover or in contained areas;
- Site cleaning: clean the repair or construction site daily. Do not use water for cleaning the site;
- Temporary filters: fit temporary inlet pit filters near wash-down areas to prevent pollutant entry into the drainage system.

9 DISCUSSION & CONCLUSION

The wetland delineation for the project was done according to the criteria set by the Department of Water Affairs and Forestry (2003) and the National Wetland Classification System for South Africa (SANBI, 2009). The soils, vegetation associated with wetlands and landscape were all used as parameters in identifying the wetland zones. The wetland of the proposed development site can be classified as a depression. Baseline soil information, landscape profile and vegetation were used to confirm wetland / water courses and terrestrial properties within the study area. The soil in the pans (wetlands) showed signs of wetness within 50cm of the surface and displayed typical hydromorphic characteristics.

The impacts associated with the site are reflected in the results of the PES assessment which indicates that the pan are 'Largely Natural'. The impacts associated with the drainage features include encroachment, alien invasive species, sedimentation and road crossings.

The EIS of the water courses and pans are both considered as HIGH and are considered to be ecologically important and sensitive. The biodiversity of these wetlands may be sensitive to flow and habitat modifications. They play a role in moderating the quantity and quality of water of major rivers.

An impact assessment was conducted for the wetlands and water courses on site in addition to the buffer zones recommended to ensure the protection of the wetlands. Impacts relating to the proposed renewable energy development on the wetlands or water courses are as follows:

- Direct wetland destruction;
- Soil erosion and sedimentation;
- Water pollution from spillages, vehicle emissions and dust;
- Spread and establishment of alien invasive species in wetlands;

Specific mitigation measures need to be implemented in the areas surrounding the wetlands and water courses to prevent any impacts on these hydrological features during the construction phase of the development. The wetland / water courses should be strictly seen as ecologically sensitive zones and the development should aim to ensure the hydrological functioning of the water courses are kept intact (water flow regulation *etc*.). Provided that all the mitigation measures and recommendations surrounding the wetlands and water courses are strictly adhered to the development can be supported.

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11 APPENDIX A PES SCORES OF THE WETLANDS

Criteria and Attributes	Relevance	Depression
Flow Modification	Consequence of abstraction, regulation by impoundments or increased runoff from human settlements or agricultural land. Changes in flow regime (timing, duration, frequency), volumes, velocity which affect inundation of wetland habitats resulting in floristic changes or incorrect cues to biota. Abstraction of groundwater flows to the wetland.	3
Permanent Inundation	Consequence of impoundment resulting in destruction of natural wetland habitat and cues for wetland biota.	3
Water Quality Modification	From point or diffuse sources. Measure directly by laboratory analysis or assessed indirectly from upstream agricultural activities, human settlements and industrial activities. Aggravated by volumetric decrease in flow delivered to the wetland.	4
Sediment Load Modification	Consequence of reduction due to entrapment by impoundments or increase due to land use practices such as overgrazing. Cause of unnatural rates of erosion, accretion or infilling of wetlands and change in habitats.	3
Canalisation	Results in desiccation or changes to inundation patterns of wetland and thus changes in habitats. River diversions or drainage.	4
Topographic Alteration	Consequence of infilling, ploughing, dykes, trampling, bridges, roads, railway lines and other substrate disruptive activities which reduce or changes wetland habitat directly in inundation patterns.	3
Terrestrial Encroachment	Consequence of desiccation of wetland and encroachment of terrestrial plant species due to changes in hydrology or geomorphology. Change from wetland to terrestrial habitat and loss of wetland functions.	3
Indigenous Vegetation Removal	Transformation of habitat for farming, grazing or firewood collection affecting wildlife habitat and flow attenuation functions, organic matter inputs and in increases potential for erosion.	3
Invasive Plant Encroachment	Affects habitat characteristics through changes in community structure and water quality changes (oxygen reduction and shading).	3
Alien Fauna	Presence of alien fauna affecting faunal community structure	4
Over utilisation of Biota	Overgrazing, overfishing, etc.	4
Total		37
Mean		3.4
Category		**Largely natural with few modifications**
Ecological Management Class		B

12 APPENDIX B EIS SCORES OF THE WETLANDS IN THE STUDY AREA

Determinant	Depressions
PRIMARY DETERMINANTS	
1. Rare & Endangered Species	3
2. Populations of Unique Species	2
3. Species/taxon Richness	2
4. Diversity of Habitat Types or Features	1
5. Migration route/breeding and feeding site for wetland species	2
6. Sensitivity to Changes in the Natural Hydrological Regime	3
7. Sensitivity to Water Quality Changes	3
8. Flood Storage, Energy Dissipation & Particulate/Element Removal	3
MODIFYING DETERMINANTS	
9. Protected Status	0
10. Ecological Integrity	2
TOTAL*	21
MEDIAN	2.1
OVERALL ECOLOGICAL SENSITIVITY AND IMPORTANCE	**High**