Proposed Lethabo solar photovoltaic facility, Free State

Wetland Delineation and Functional Assessment
February 2015

Drafted by:
Limosella Consulting Pty Ltd
Reg No: 2014/023293/07
Email: antoinette@limosella.co.za
Cell: +27 83 4545 454
www.limosella.co.za

Prepared for:
Savannah Environmental (Pty) Ltd
1st Floor, Block 2, 5 Woodlands Drive Office Park
Woodmead
2191

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I, **Tracey Johnson**, in my capacity as a specialist consultant, hereby declare that I -

- Act as an independent consultant;
- 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);
- 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);
- As a registered member of the South African Council for Natural Scientific Professions, will undertake my profession in accordance with the Code of Conduct of the Council, as well as any other societies to which I am a member; and
- Based on information provided to me by the project proponent, and in addition to information obtained during the course of this study, have presented the results and conclusion within the associated document to the best of my professional judgement.

Tracey Johnson	28.02.2015
Hydric Soils Specialist	Date
SACNASP Reg. No. No: 100006/4	

I, **Robert Taylor**, in my capacity as a specialist consultant, hereby declare that I -

- Act as an independent consultant;
- 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);
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- Based on information provided to me by the project proponent, and in addition to information obtained during the course of this study, have presented the results and conclusion within the associated document to the best of my professional judgement.

Robert Taylor	28.02.2015
Ecologist/Botanist	Date

Indemnity

This report is based on survey and assessment techniques which are limited by time and budgetary constraints relevant to the type and level of investigation undertaken. The findings, results, observations, conclusions and recommendations given in this report are based on the author's best scientific and professional knowledge as well as information available at the time of study. Therefore the author reserves the right to modify aspects of the report, including the recommendations, if and when new information may become available from on-going research or further work in this field, or pertaining to this investigation.

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Qualification of Specialists

Field work, GIS and report writing	Robert Taylor Ecologist/Botanist SACNASP Registration pending
Field work, data analysis and report writing assistance	Tracey Johnson Hydric soils specialist SACNASP Reg. No: 100006/4
Report writing assistance and review	Antoinette Bootsma Ecologist/Botanist/Wetland specialist SACNASP Reg. No. 400222-09

EXECUTIVE SUMMARY

Limosella Consulting (Pty) Ltd was appointed by Savannah Environmental (Pty) Ltd to conduct wetland and riparian delineations and functional assessments to inform the Environmental Authorization process for the development of the Lethabo solar photovoltaic (PV) facility in the Free State. This facility is part of a series of proposed projects to harvest renewable energy to supplement the national power grid.

In accordance with EIA procedure all wetlands on or within 500m of the proposed site have been delineated and wetland functional assessments conducted. The sites are located within the Central Free State Grassland vegetation type near Sasolburg. Landscape setting suggested wetlands within the study area were likely to be seep wetlands.

Two wetlands were located within the study area, hillside seeps. The eastern wetland has been largely modified whilst the northern wetland is largely natural. Their PES scores ranged from D↓, a large change in ecosystem processes and loss of natural habitat and biota has occurred, to A→, near natural conditions. The EIS score of 1.6 falls into a category characterised by moderate ecological importance and sensitivity. Wetlands in this category are considered to be ecologically important and sensitive on a provincial or local scale. According to the generic description of this class the biodiversity of these wetlands are not usually sensitive to flow and habitat modifications.

Due to the higher level of impact, indicated by the PES score, the alternative site 1 would be the preferred site to develop followed by the alternative site 2.

Potential impacts of the solar PV facility were noted and included:

- Loss and disturbance of wetland habitat and fringe vegetation.
- Introduction and spread of alien invasive vegetation.
- Changes in the amount of sediment entering the system.
- Changes in water quality due to toxic contaminants and increased nutrient levels entering the system.
- Changes in water flow regime due to the alteration of surface characteristics.

It is important that appropriate mitigation measures are put into place and carefully monitored to ensure these potential impacts are contained and mitigated.

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1 INTRODUCTION

Limosella Consulting (Pty) Ltd was appointed by Savannah Environmental (Pty) Ltd to conduct wetland and riparian delineations and functional assessments to inform the Environmental Authorization process for the development of the Lethabo solar photovoltaic (PV) facility in accordance with the EIA Regulations (No. R. 385, Department of Environmental Affairs and Tourism, 21 April 2010) emanating from Part 5 of the National Environmental Management Act 1998 (Act No. 107 of 1998). The Lethabo solar PV facility is part of a series of proposed projects to harvest renewable energy to supplement the national power grid.

The proposed development of a 75MW Solar PV facility (or an alternative 35MW facility) includes the following infrastructure;

- Arrays of PV panels.
- Mounting structures to support the PV panels.
- Cabling between the project components.
- Inverters/transformer enclosures.
- An on-site substation or switching station.
- A power line to facilitate the connection of the solar energy facility to the existing substation/power line at the power station.
- Internal access roads.
- Buildings (which could include workshop area for maintenance and storage, and an on-site office).

Fieldwork was conducted on the 13th of February 2015.

1.1 Terms of Reference

The terms of reference for the study were as follows:

- Delineate the wetland areas;
- Classify the watercourse according to the system proposed in the national wetlands inventory if relevant,
- Undertake the functional assessment of wetlands areas within the area assessed;
- Discuss potential impacts and possible mitigation and management procedures relevant to the conservation of wetland areas on and near the site.

1.2 Assumptions and Limitations

- A detailed field study was conducted from a once off field trip and thus would not depict any seasonal variation in the wetland plant species composition and richness.

- » Extensive disturbance in the soil, from activities such as ploughing or earthworks, may confound the determination of the wet- and up-land interface.
- » Floodline calculation, groundwater and hydrological processes fall outside the scope of wetland and riparian delineation and functional assessments discussed in this report.
- » The GPS used for wetland and riparian delineations is accurate to within five meters. Therefore, the wetland delineation plotted digitally may be offset by up to five meters to either side. Additional inaccuracies may arise from during the course of converting spatial data to final drawings. The scale at which maps and drawings are presented in the current report may become distorted should they be reproduced by for example photocopying and printing.
- » All wetlands within 500m of construction activities should be identified as per the DWA Water Use Licence application regulations. In order to meet the timeframes and budget constraints for the project, wetlands within the study site will be delineated on a fine scale based on detailed soil and vegetation sampling. Wetlands that fall outside of these sites, but that fall within 500m of the proposed activities will be delineated based on desktop analysis of vegetation gradients visible from aerial imagery.

1.3 Definitions and Legal Framework

This section outlines the definitions, key legislative requirements and guiding principles of the wetland study and the Water Use Authorisation process.

The National Water Act, 1998 (Act No. 36 of 1998) [NWA] provides for constitutional water demands including pollution prevention, ecological and resource conservation and sustainable utilisation. In terms of this Act, all water resources are the property of the State and are regulated by the Department of Water Affairs (DWA). The NWA sets out a range of water use related principles that are to be applied by DWA when taking decisions that significantly affect a water resource. The NWA defines a water resource as including a watercourse, surface water, estuary or aquifer. A watercourse includes a river or spring; a natural channel in which water flows regularly or intermittently; a wetland, lake, pan or dam, into which or from which water flows; any collection of water that the Minister may declare to be a watercourse; and were relevant its beds and banks.

The NWA defines a wetland 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." In addition to water at or near the surface, other distinguishing indicators of wetlands include hydromorphic soils and vegetation adapted to or tolerant of saturated soils (DWA, 2005).

Riparian habitat often perform important ecological and hydrological functions, some similar to those performed by wetlands (DWA, 2005). Riparian habitat is also the accepted indicator used to delineate the extent of a river's footprint (DWAF, 2005). It is defined by the NWA as follows: "Riparian habitat includes the physical structure and associated vegetation of the areas associated with a watercourse, which are commonly characterised by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent land areas".

Water uses for which authorisation must be obtained from DWA are indicated in Section 21 of the NWA. Section 21 (c) and (i) is applicable to any activity related to a wetland:
Section 21(c): Impeding or diverting the flow of water in a watercourse; and
Section 21(i): Altering the bed, banks, course or characteristics of a watercourse.

Authorisations related to wetlands are regulated by Government Notices R.1198 and R.1199 of 18 December 2009. GN 1198 and 1199 of 2009 grants General Authorisation (GA) for the above water uses on certain conditions:
GN R.1198: Any activity in a wetland for the rehabilitation of a wetland for conservation purposes.
GN R.1199: Any activity more than 500 m from the boundary of a wetland.

These regulations also stipulate that these water uses must the registered with the responsible authority. Any activity that is not related to the rehabilitation of a wetland and which takes place within 500 m of a wetland are excluded from a GA under either of these regulations. Wetlands situated within 500 m of proposed activities should be regarded as sensitive features potentially affected by the proposed development (GN 1199). Such an activity requires a Water Use Licence (WUL) from the relevant authority.

In addition to the above, the proponent must also comply with the provisions of the following relevant national legislation, conventions and regulations applicable to wetlands and riparian zones:

- Convention on Wetlands of International Importance - the Ramsar Convention and the South African Wetlands Conservation Programme (SAWCP).
- National Environmental Management Act, 1998 (Act No. 107 of 1998) [NEMA].
- National Environmental Management: Biodiversity Act, 2004 (Act 10 of 2004).
- National Environment Management Protected Areas Act, 2003 (Act No. 57 of 2003).
- Regulations GN R.543, R.544 and R.545 of 2010, promulgated under NEMA.
- Conservation of Agriculture Resources Act, 1983 (Act 43 of 1983).
- Regulations and Guidelines on Water Use under the NWA.
- South African Water Quality Guidelines under the NWA.
- Mineral and Petroleum Resources Development Act, 2002 (Act No. 287 of 2002).

1.4 Locality of the study site

The study sites are located around the Lethabo Power Station (S26° 44.5' E27° 58.5') in the Metsimaholo municipality, Free State province, approximately 10 km southeast of Vereeniging and 14 km northeast of Sasolburg. The sites consist of an alternative site 1 of 130 ha, on the south-western boundary of the power station and an alternative site 3 of 52 ha, abuts the southern boundary of the power station. An additional alternative site 2 of 112 ha, lies adjacent to the western boundary of the power station (Fig. 1). The 2nd alternative site is the preferred site for the environmental department as it falls within the current fenced boundary of the power station and is largely disturbed, this site is also the least preferred site with managers as there is concern that the fly ash will be detrimental for the PV panels. All the sites are on Farm 1814.

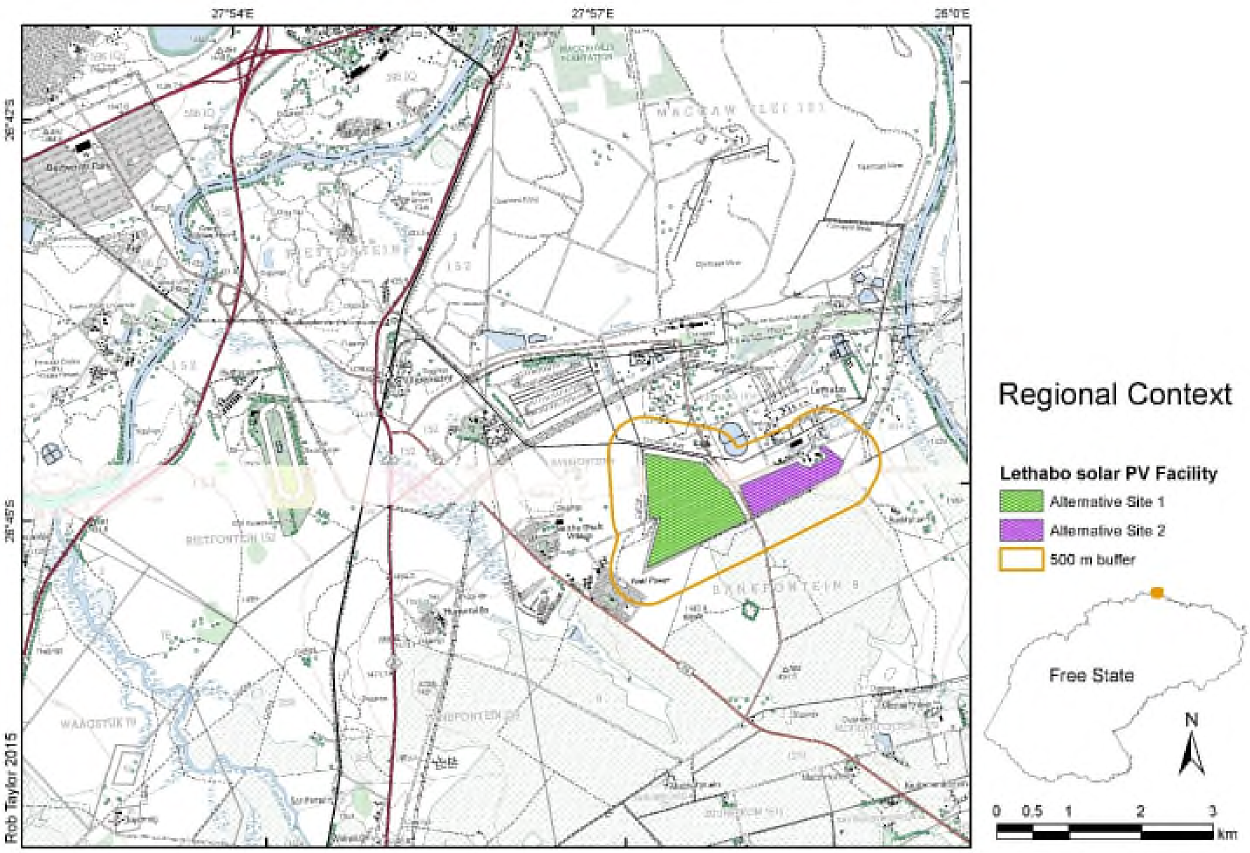


Figure 1: Regional context of the study sites (extracted from NGI 1:50 000 topo-cadastral maps)

1.5 Description of the Receiving Environment

A review of available literature and spatial data formed the basis of a characterisation of the biophysical environment in its theoretically undisturbed state and consequently an analysis of the degree of impact to the ecology of the study site in its current state.

1.5.1 Geology and Soils

The study site is on Ecca Group Arenite, Shale and Coal. Soils are Luvisols, showing increased clay content with depth, and may be high in Calcium and Sodium. They can be prone to erosion on slopes (Jones *et al.,* 2013).

1.5.2 Regional Vegetation

The study sites fall within Central Free State Grassland. Mucina and Rutherford (2006) suggest that under natural conditions this short grassland is dominated by *Themeda triandra* shifting towards *Erogrostis curvula, E. chloromelas* and dwarf karoo bushes in a degraded state. This vegetation type has been listed as vulnerable as only a small portion remains untransformed. The relevant National Freshwater Ecosystem Priority Area (NFEPA) WetVeg Group is the dry Highveld grassland group 4 (Nel *et al.,* 2011).

1.5.3 Regional Hydrology

The Vaal River bows to the east, north and west of the sites at a distance of 1.48km at its closest point (Fig. 1). Several open waterbodies are located within the arc of the river, the closest being 830 m north of the alternative site 3. Artificial furrows are installed around the power station draining water eastwards and away from the study sites (Fig. 2). One concrete reservoir is the only NFEPA wetland that has been demarcated with in the study site and its 500m buffer (Nel *et al.,* 2011). Inspection of aerial photos from 2012, provided by the office of the surveyor general, showed no obvious rivers or channelled waterways on or within 500m of the sites.

A 20 m interval contour map, provided by the client, allowed for estimations of the slope and altitude. The slope on the study sites varies from ~0.5% to ~1.8% in a north easterly direction, with the altitude ranging from ~1460-1450 m.a.s.l. Based on the landscape setting, any wetlands found in the study area are likely to be seeps.

1.5.4 Quaternary Catchments

The study site falls within the quaternary catchment C22F. In this catchment the mean annual precipitation is lower than the potential evapotranspiration and as such any wetlands in this catchment would rely largely on regional hydrology for their source of water (water supplied by rainfall is unlikely to be enough to support these wetlands). These wetlands are sensitive to any changes in the volume and duration of the water supplied by regional hydrology.

2 METHODOLOGY

The delineation methodology documented in the "Updated manual for identification and delineation of wetlands and riparian areas" (DWAF, 2008), the "Minimum Requirements for Biodiversity Assessments" (GDACE, 2009) and the "Classification System for Wetlands and other Aquatic Ecosystems in South Africa. User Manual: Inland Systems" (Ollis *et al,* 2013) was followed throughout the field survey.

A hand held GPS was used to capture GPS co-ordinates in the field. 1:50 000 cadastral maps and recent aerial imagery were used as reference material for the mapping of the preliminary wetland boundaries. These were converted to digital image backdrops and delineation boundaries were imposed accordingly after the field survey.

2.1 Wetland and Riparian Delineation

Wetlands were identified based on one or more of the following characteristic attributes (DWAF, 2005):

- The Terrain Unit Indicator;
- The presence of plants adapted to or tolerant of saturated soils (hydrophytes);
- Wetland (hydromorphic) soils that display characteristics resulting from prolonged saturation; and
- A high water table that results in saturation at or near the surface, leading to anaerobic conditions developing within 50cm of the soil surface.

Wetlands were delineated up to the interface of the temporary wetland zone and the upland zone (Fig. 2). A recommended buffer will be added to the perimeter of the wetland to reduce impacts of construction on the wetlands.

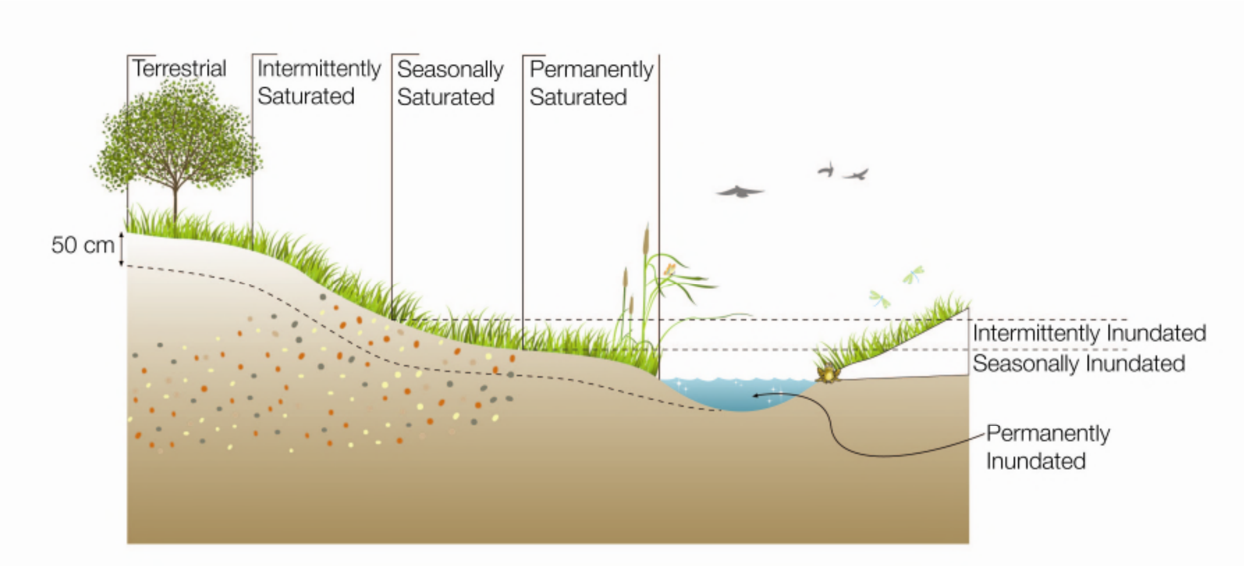


Figure 2. Typical Cross section of a wetland showing the temporary, seasonal, and permanent zones (Ollis, 2013)

Riparian habitat is classified as physical structure and the associated vegetation in areas adjacent to, or associated with a macro stream channel. This habitat can often be identified by its alluvial soils which are inundated or flooded with a frequency sufficient to support species composition and structure distinct from adjacent lands (National Water Act No 36 of 1998). Riparian habitat can be divided in to three distinct zones; marginal, lower, and upper zones (Fig. 3).

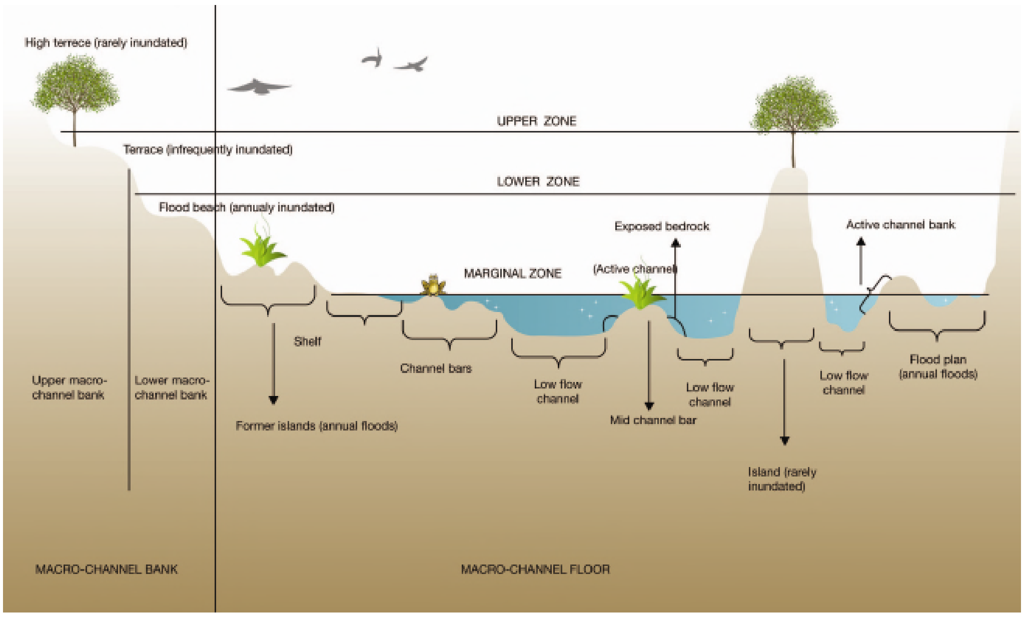


Figure 3. Schematic diagram illustrating the three riverine zones relative to geomorphic diversity (Kleynhans et al. 2007)

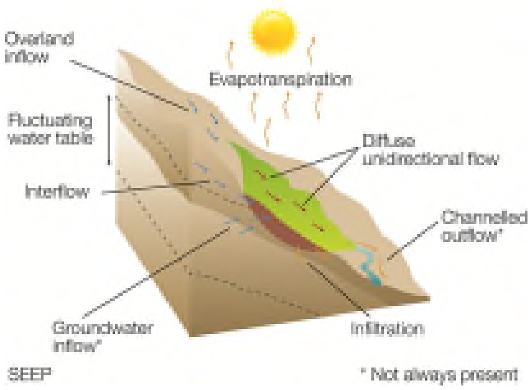
2.2 Wetland Classification and Delineation

The classification system developed for the National Wetlands Inventory is based on the principles of the hydro-geomorphic (HGM) approach to wetland classification (SANBI, 2009). The current wetland study follows the same approach by classifying wetlands in terms of a functional unit in line with a level three category recognised in the classification system proposed in SANBI (2009). HGM units take into consideration factors that determine the nature of water movement into, through and out of the wetland system. In general HGM units encompass three key elements (Kotze *et al,* 2005):

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

The wetland HGM types relevant to the study area are discussed below.

Table 1. Description of Hydrogeomorphic wetland type relevant to the study area

Hydro-geomorphic types (Ollis *et al,* 2013)	Description (Kotze *et al,* 2005)
Seepage Wetlands 	Seepage wetlands can be located on the mid- and footslopes of hillsides; either as isolated systems or connected to downslope valley bottom wetlands. Seepages occur where springs are decanting into the soil profile near the surface, causing hydric conditions to develop; or where through flow in the soil profile is forced close to the surface due to impervious layers.

2.3 Buffer Zones

A buffer zone is defined as a strip of land surrounding a wetland or riparian area in which activities are controlled or restricted (DWAF, 2005). A development has several impacts on the surrounding environment and on a wetland. The development changes habitats, the ecological environment, infiltration rate, amount of runoff and runoff intensity of the site, and therefore the water regime of the entire site. An increased volume of stormwater runoff, peak discharges, and frequency and severity of flooding is therefore often characteristic of transformed catchments. The buffer zone identified in this report serves to highlight an ecologically sensitive area in which activities should be conducted with this sensitivity in mind. Buffer zones have been shown to perform a wide range of functions and have therefore been widely proposed as a standard measure to protect water resources and their associated biodiversity. These include (i) maintaining basic hydrological processes; (ii) reducing impacts on water resources from upstream activities and adjoining land uses; (iii) providing habitat for various aspects of biodiversity. A brief description of each of the functions and associated services is outlined in Table 2 below.

Table 2. Generic functions of buffer zones relevant to the study site (adapted from Macfarlane et al, 2010)

Primary Role	Buffer Functions
Maintaining basic aquatic processes, services and values.	» Groundwater recharge: Seasonal flooding into wetland areas allows infiltration to the water table and replenishment of groundwater. This groundwater will often discharge during the dry season providing the base flow for streams, rivers, and wetlands.
Reducing impacts from upstream activities and adjoining land uses	» Sediment removal: Surface roughness provided by vegetation, or litter, reduces the velocity of overland flow, enhancing settling of particles. Buffer zones can therefore act as effective sediment traps, removing sediment from runoff water from adjoining lands thus reducing the sediment load of surface waters. » Removal of toxics: Buffer zones can remove toxic pollutants, such hydrocarbons that would otherwise affect the quality of water resources and thus their suitability for aquatic biota and for human use. » Nutrient removal: Wetland vegetation and vegetation in terrestrial buffer zones may significantly reduce the amount of nutrients (N & P), entering a water body reducing the potential for excessive outbreaks of microalgae that can have an adverse effect on both freshwater and estuarine environments. » Removal of pathogens: By slowing water contaminated with faecal material, buffer zones encourage deposition of pathogens, which soon die when exposed to the elements.

Despite limitations, buffer zones are well suited to perform functions such as sediment trapping, erosion control and nutrient retention which can significantly reduce the impact of activities taking place adjacent to water resources. Buffer zones are therefore proposed as a standard mitigation measure to reduce impacts of land uses / activities planned adjacent to water resources. These must however be considered in conjunction with other mitigation measures.

Local government policies require that protective buffer zones be calculated from the outer edge of the temporary zone of a wetland (KZN DAEA, 2002; CoCT, 2008; GDACE, 2009). This report suggests that a generic 30 m buffer zone be applied to the outer edge of the wetlands.

2.4 Wetland and Riparian Functionality and Integrity Assessments

In order to inform the water use licence application process, an analysis of wetland and riparian functionality and integrity must be undertaken. The hydrological, geomorphological and vegetation integrity was assessed for the wetlands in the study site to provide a Present Ecological Status (PES) score (Macfarlane *et al,* 2007)**,** and an Environmental Importance and Sensitivity category (EIS) (DWAF, 1999). The functional assessment methodologies presented below take into consideration recorded impacts in various ways to determine the scores attributed to each wetland.

2.4.1 Ecological Importance and Sensitivity

Ecological Importance and Sensitivity (EIS) relates to the importance of a wetland with regard to its ecological diversity and function, and its ability to resist or recover from disturbance. The Department of Water Affairs and Forestry (1999) provided a guideline for scoring a wetland's EIS using a series of determinants based on indigenous species and habitats found in the wetland. Each determinant is assessed on a scale of 0 to 4 (0 being not important and 4 having a very high importance. Each score needs to be substantiated and a confidence rating given. These scores are then used to determine the EIS status (Table 3). This classification allows or an appropriate ecological management class to be allocated to the wetland.

Table 3. EIS categories with an interpretation of median scores for biotic and habitat determinants. (DWAF, 1999)

Ecological Importance and Sensitivity Categories	Median score	EIS category
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 in major rivers	>3 and <=4	Very 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	High
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 in major rivers	>1 and <=2	Moderate
Wetlands that is 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 in major rivers	>0 and <=1	Low

2.4.2 Present Ecological Status

WET-Health is a tool to assess the health of a wetland, where health is a measure of the deviation of a wetlands structure and function from its natural reference condition (Macfarlane *et al*, 2007). WET-Health separates wetlands into Hydrogeomorphic (HGM) units based on their landform and hydrological characteristics. Each HGM unit is analysed separately for changes three primary modules namely; hydrology (activities affecting water supply and timing as well as water distribution and retention within the wetland), geomorphology (presence of indicators of excessive sediment inputs and/or outputs), and vegetation (changes in vegetation composition and structure due to site transformation or disturbance). The magnitude of each impact is calculated from both the extent and the intensity of the activity. The impacts of all the activities in the HGM unit are combined to calculate the Present Ecological Status (PES) score for each module. This score provides an understanding of the current condition of the wetland (Table 4). A trajectory class is allocated to indicate the predicted change in wetland health over the next 5 years (Table 5).

Table 4. Health categories used by WET-Health for describing the integrity of wetlands (Macfarlane et al, 2007)

Description	Impact Score Range	PES Score	Summary
Unmodified, natural.	0-0.9	A	Very High
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.	1-1.9	B	High
Moderately modified. A moderate change in ecosystem processes and loss of natural habitats has taken place but the natural habitat remains predominantly intact.	2-3.9	C	Moderate
Largely modified. A large change in ecosystem processes and loss of natural habitat and biota has occurred.	4-5.9	D	Moderate
The change in ecosystem processes and loss of natural habitat and biota is great but some remaining natural habitat features are still recognizable.	6-7.9	E	Low
Modifications have reached a critical level and the ecosystem processes have been modified completely with an almost complete loss of natural habitat and biota.	8-10	F	Very Low

Table 5. Trajectory class, change scores and symbols used to evaluate trajectory of change to wetland health (Macfarlane et al, 2007)

Change Class	Description	Symbol
Improve	Condition is likely to improve over the over the next 5 years	(↑)
Remain stable	Condition is likely to remain stable over the next 5 years	(→)
Slowly deteriorate	Condition is likely to deteriorate slightly over the next 5 years	(↓)
Rapidly deteriorate	Substantial deterioration of condition is expected over the next 5 years	(↓↓)

3 RESULTS

3.1 Land Use and Land Cover

The study sites are bordered by the Lethabo power station in the north-east and mines and coal dumps in the north and west (Fig. 4). Both alternative sites 1 and 2 are largely modified, covered in rubble and gravel, dense stands of alien plants, networks of old roads and drains (Fig. 5).

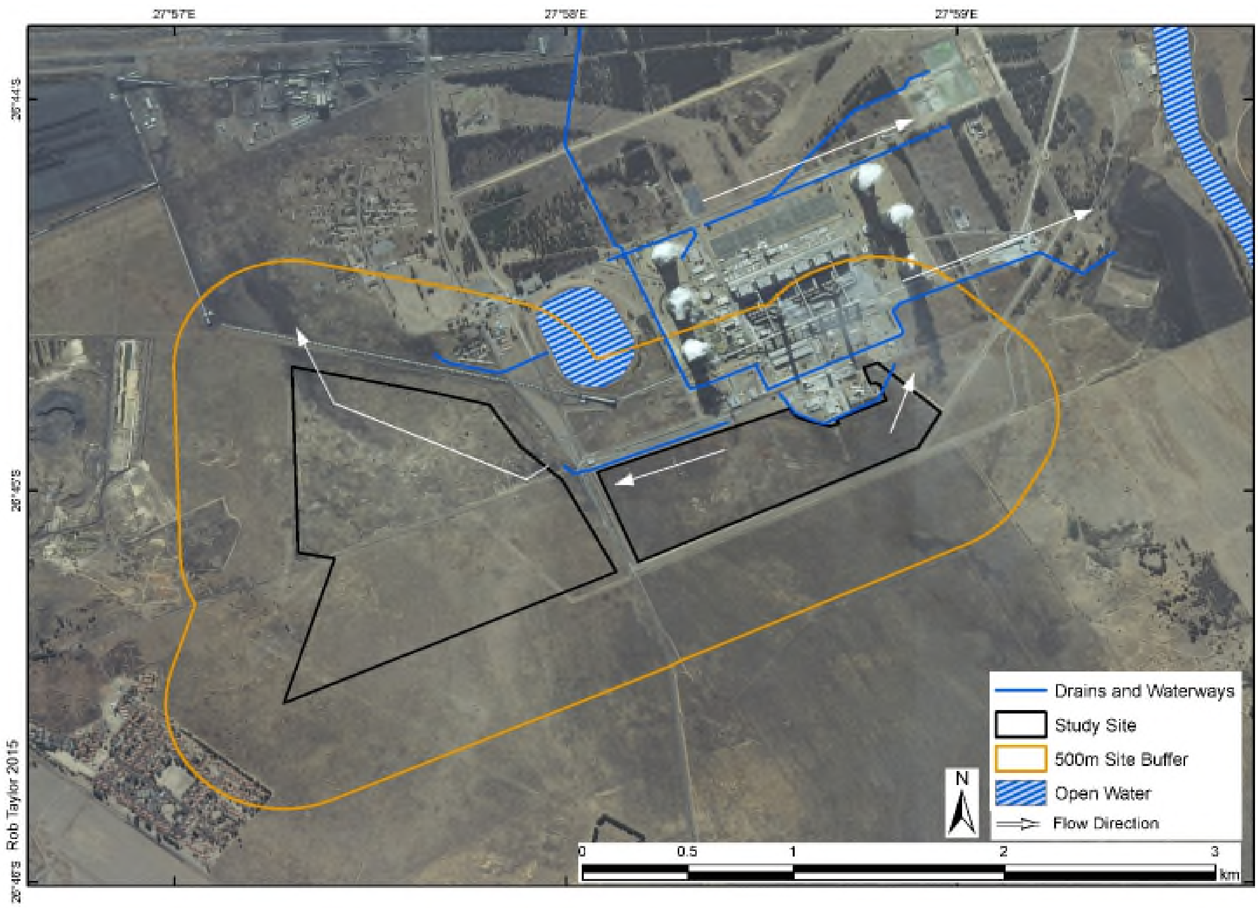


Figure 4. Local context of the study site relative to the Lethabo power station, with the waterways and drains, and direction of flow indicated.

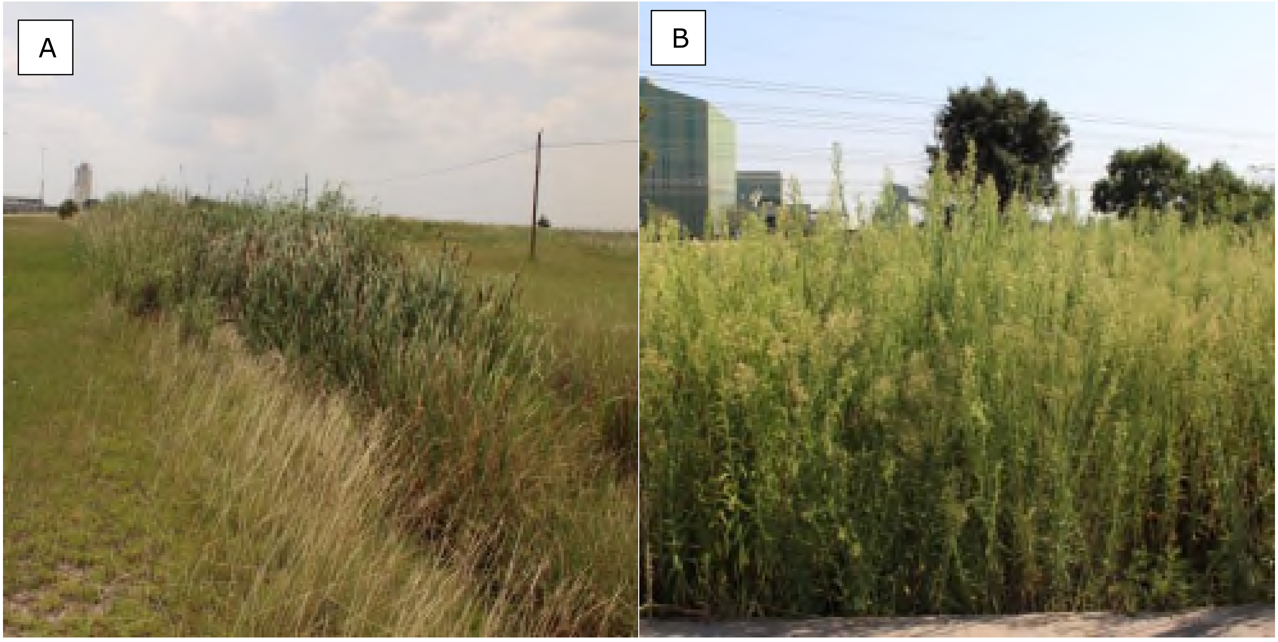


Figure 5. Some of the disturbances on the site included large drains (**A**) and alien vegetation growing amongst old building rubble (*Conyza albida* pictured in **B**).

3.1.1 Soil Indicators

Soils were used extensively for delineating the wetlands on site. Wetland soil types found on site included: Katspruit (Orthic A /G horizon), Westleigh (Orthic A / soft plinthic B), Witbank (Orthic A / Man-made soil deposit). Signs of wetness that were used to delineate the wetland boundary included red and yellow mottles, gleys, and soft plinthic nodules (Fig. 6).

Figure 6. Examples of some of the wetland indicators found in the soil. Red mottles, haematite, (**A**) form under fluctuating water table where the iron accumulates during redox. Various shades of grey (gleys) due to reduction (**B**) - formed with a fluctuating water table.

3.1.2 Vegetation Indicators

Wetland plants were an important indicator for the delineation process. *Typha capensis* (Bulrush) and *Phragmites australis* was found in ponding water, while a community of wetland species indicated the extent of the permanent, seasonal and temporary zones. Some common obligate and facultative wetland species used to delineate the wetlands were: *Paspalum urvilli*, *Imperata cylindrica, Kyllinga erecta*, *Cyperus longus, Persicaria limbata, Oenothera stricta* and *Verbena bonariensis.* Several of these species are shown in Figure 7. For the most part wetland plant community correlated with the soils except for where disturbance had altered the plant community.

Figure 7. Examples of some wetland indicator species found. **A:** *Paspalum urvilli* – facultative wetland species, **B:** *Imperata cylindrica* – obligate wetland species, **C:** *Kyllinga erecta* – obligate wetland species, **D:** *Oenothera stricta* – facultative wetland species, **E:** *Persicaria limbata* – obligate wetland species.

3.2 Wetland Classification and Delineation

Two wetlands were delineated on the study site, both being hillslope seeps. Figure 9 shows the delineated wetlands together with the 30m wetland buffers. 15.6ha of wetland was located on the alternative site 1 while 37ha and 56ha of wetland was located on the alternative sites 2 and 3 respectively. Several small depressions a few meters in diameter were located on the alternative site 1. These small depressions did show signs of wetness but due to their size they have been excluded as wetlands.

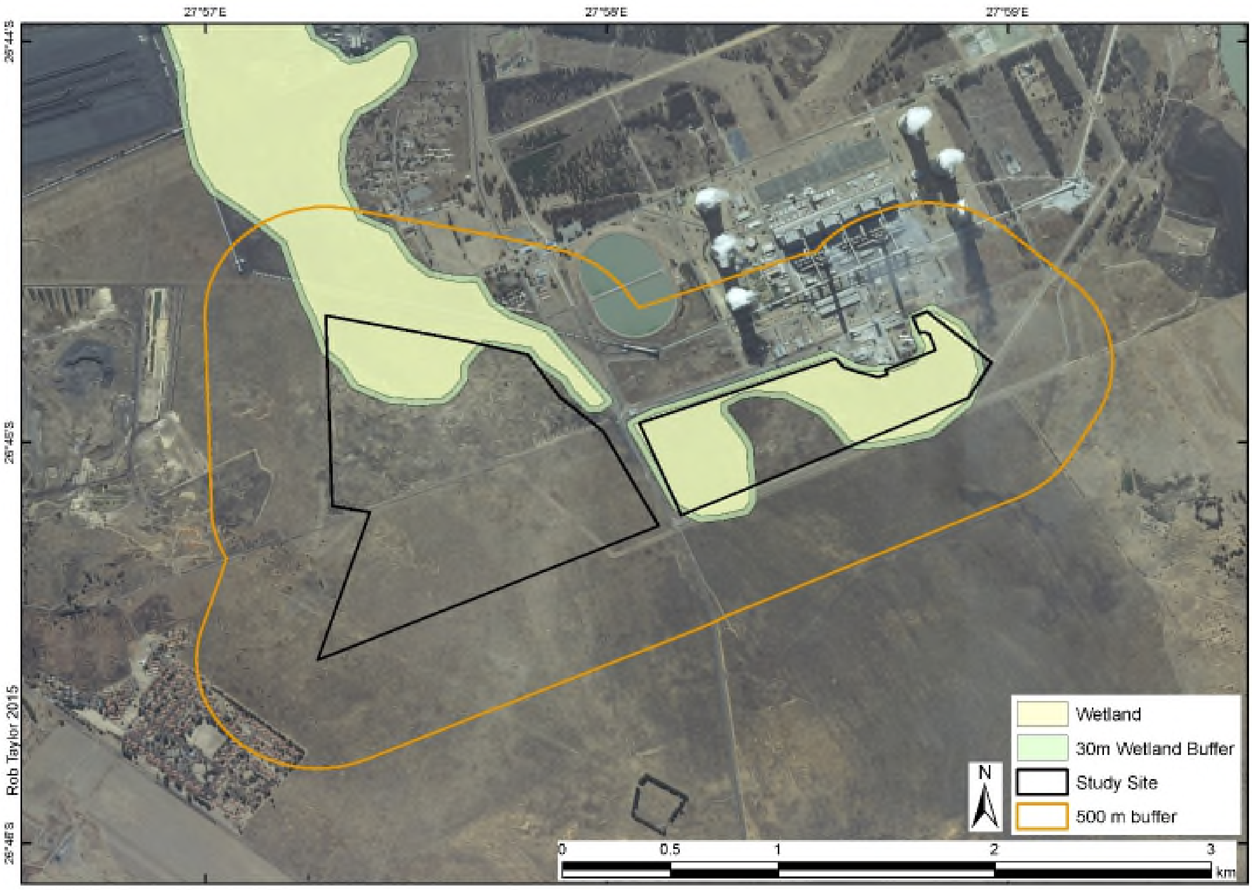


Figure 8. The wetlands and wetland buffers on the study site. All wetlands within a 500m buffer of the construction are prescribed by the DWA as relevant to the Water Use Licence application process.

3.3 Wetland Functional Assessment

The two wetlands in the study site are very similar in their function, type and ecology. They merge shortly downstream of the study area and as such they will be treated as one wetland for the purpose of these assessments.

3.3.1 Present Ecological Status (PES)

Large areas of the eastern wetland was covered in gravel and rubble. This wetland had also been drained with a herring-bone drain system. The dominant vegetation were invasive alien species. The PES score for this wetland is a D↓, a large change in ecosystem processes and loss of natural habitat and biota has occurred.

The northern wetland was largely natural with the upper (southern) parts of the seep being completely unmodified with the lower reaches being impacted on by old roads, a railway and demolished buildings. The PES score for this wetland is an A→, near natural conditions.

Table 6. Summary of hydrology, geomorphology and vegetation health assessment for the wetlands on the study site (Macfarlane *et al,* 2009).

Wetland Unit	Extent (%)	Hydrology		Geomorphology		Vegetation		Overall health score	PES Score
		Impact Score	Change Score	Impact Score	Change Score	Impact Score	Change Score		
Seep (East)	27	6.50	0.00	0.70	0.00	5.40	-1.00	**4.53**	**D↓**
Seep (North)	73	0.00	0.00	0.00	0.00	1.00	0.00	**0.29**	**A→**
Total	**100**	**1.76**	**0.00**	**0.19**	**0.00**	**2.19**	**-0.27**		

3.3.2 Ecological Importance and Sensitivity (EIS)

A combined EIS score of 1.6 was calculated for both the seep wetlands, placing them in the moderate importance and sensitivity category. Wetlands in this category are considered to be ecologically important and sensitive on a provincial or local scale (DWAF, 1999). No important or sensitive biota were found.

3.4 Impacts

This section discusses the impacts to the wetland expected to arise with the construction of a Solar PV facility.

The solar PV facility will have several impacts on the surrounding environment and wetland. The earth works, construction and operation of the facility will change habitats and the ecological environment, infiltration rates, amount of runoff and runoff intensity of storm-water, and therefore the hydrological regime of the site.

Potential impacts to be taken into account include:

- Loss and disturbance of wetland habitat and fringe vegetation.
- Introduction and spread of alien invasive vegetation.
- Changes in the amount of sediment entering the system.
- Changes in water quality due to toxic contaminants and increased nutrient levels entering the system.

» Changes in water flow regime due to the alteration of surface characteristics.

These impacts are assessed as recommended by the guidelines supplied by Savannah Environmental (Pty) Ltd. This impact evaluation will assess and rate the extent, magnitude, duration and significance of each potential impact together with possible mitigation measures.

3.4.1 *Loss and disturbance of wetlands and wetland fringe habitat*

Nature: Loss and disturbance of wetland habitat and fringe vegetation due to direct development on the wetland as well as changes in management, fire regime and habitat fragmentation.		
	Without mitigation	With mitigation
Extent	Moderate (3)	Low (1)
Duration	Permanent (5)	Permanent (5)
Magnitude	Very high (10)	Slight (4)
Probability	Highly probable (4)	Improbable (2)
Significance	72 (High)	20 (Low)
Status	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes	Yes
Can impacts be mitigated?	Yes	
Mitigation: » The development footprint should be designed around current wetland and wetland buffers. » Where wetlands will be lost to the development footprint, those wetlands that are least disturbed and show near natural conditions and functionality should be given priority for conservation. » Where wetlands are lost, compensation should be made to protect the remaining wetlands and their catchments, increase their buffers and rehabilitate their condition and functionality.		
Cumulative impacts: Any loss of wetlands will add to the overall loss of wetlands in the region.		
Residual impacts: Once lost it is unlikely that a wetland can be rehabilitated to its original state and functionality.		

3.4.2 *The introduction and spread of alien invasive species*

Nature:
Introduction and spread of alien invasive vegetation due to both opportunistic invasions after

disturbance and the introduction of seed in building materials and on vehicles. Invasions of alien plants can impact on hydrology, by reducing the quantity of water entering a wetland, and outcompete natural vegetation, decreasing the natural biodiversity. Once in a system alien invasive plants can spread through the catchment.		
	Without mitigation	**With mitigation**
Extent	Medium (3)	Low (1)
Duration	Permanent (5)	Medium-term (3)
Magnitude	Moderate (6)	Small (0)
Probability	Highly probable (4)	Improbable (2)
Significance	56 (Medium)	8 (Low)
Status	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes	No
Can impacts be mitigated?	Yes	

Mitigation:

» Weed control
» Retain vegetation and soil in position for as long as possible, removing it immediately ahead of construction / earthworks in that area and returning it where possible afterwards.
» Rehabilitate or revegetate disturbed areas
» Monitor the establishment of alien invasive species within the areas affected by the construction and maintenance and take immediate corrective action where invasive species are observed to establish.

Cumulative impacts:

If allowed to seed before control measures are implemented alien plans can easily colonise and impact on downstream users. Alien plants can form dense thickets which replace indigenous wetland habitats and their natural flow regime. This will result in a loss of wetland species and wetland functioning.

Residual impacts:

After clearing of invasive plants their seeds may remain dormant in the soil for many years and will require extensive follow-up control measures.

3.4.3 *Changes in the amount of sediment entering the system*

Nature: Changes in the amount of sediment entering the system due to earthworks and soil disturbance as well as the removal of natural vegetation. This could result in sedimentation of the wetland and increase the turbidity of the water.		
	Without mitigation	With mitigation
Extent	Moderate (3)	Low (1)

Duration	Permanent (5)	Medium-term (3)
Magnitude	Moderate (6)	Slight (4)
Probability	Very probable (4)	Improbable (2)
Significance	56 (Moderate)	16 (Low)
Status	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes	Yes
Can impacts be mitigated?	Yes	

Mitigation:

» Formalise access roads and make use of existing roads and tracks where feasible, rather than creating new routes through naturally vegetated areas.
» Retain vegetation and soil in position for as long as possible, removing it immediately ahead of construction / earthworks in that area.
» A vegetation rehabilitation plan should be implemented. Grassland can be removed as sods and stored within transformed vegetation. The sods must preferably be removed during the winter months and be replanted by latest springtime. The sods should not be stacked on top of each other or within sensitive environs. Once construction is completed, these sods should be used to rehabilitate the disturbed areas from where they have been removed. In the absence of timely rainfall, the sods should be watered well after planting and at least twice more over the next 2 weeks.
» Remove only the vegetation where essential for construction and do not allow any disturbance to the adjoining natural vegetation cover.
» Cordon off areas that are under rehabilitation as no-go areas using danger tape and steel droppers. If necessary, these areas should be fenced off to prevent vehicular, pedestrian and livestock access.
» Protect all areas susceptible to erosion and ensure that there is no undue soil erosion resultant from activities within and adjacent to the construction camp and work areas.
» Runoff from roads must be managed to avoid erosion and pollution problems.
» Source-directed controls
» Maintain buffer zones to trap sediments

Cumulative impacts:

Additional sediments would lead to increase turbidity downstream which will put additional stress on aquatic life and loss of sensitive biota. Downstream dams and weirs will face a reduction in capacity due to sedimentation.

Residual impacts:

Once sensitive biota are lost from a system it can take many years to recolonize.

3.4.4 *Changes in water quality*

Nature:

Changes in water quality due to toxic contaminants and changes in nutrients is largely caused by discharge of solvents and other industrial chemicals, leakage of fuel/oil from vehicles and the disposal of sewage. This could result in the loss of sensitive biota in the wetlands and a reduction in wetland function.		
	Without mitigation	With mitigation
Extent	Moderate (3)	Low (1)
Duration	Medium-term (3)	Medium-term (3)
Magnitude	Moderate (6)	Minor (2)
Probability	Highly probable (4)	Improbable (2)
Significance	48 (Moderate)	12 (Low)
Status	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes	Yes
Can impacts be mitigated?	Yes	

Mitigation:

- After construction, the land must be cleared of rubbish, surplus materials, and equipment, and all parts of the land shall be left in a condition as close as possible to that prior to use.
- Ensure that maintenance work does not take place haphazardly, but, according to a fixed plan, from one area to the other.
- Maintenance of construction vehicles
- Control of waste discharges
- Guidelines for implementing Clean Technologies
- Maintenance of buffer zones to trap sediments with associated toxins
- All potentially polluting and hazardous substances used and stored on site should be stored in clearly demarcated areas away from storm water.

Cumulative impacts:

The addition of toxic contaminants will impact on downstream ecosystems resulting in the loss of sensitive biota. Bioaccumulation of toxins in the food chain can be harmful especially to predators higher up in the food chain. Nitrification can lead to algal blooms that reduce the oxygen levels in the water causing anaerobic conditions.

Residual impacts:

Once sensitive biota are lost from a system it can take many years to recolonize. Once in the system it may take many years for some toxins to be eradicated.

3.4.5 *Changes in water flow regime due to the alteration of surface characteristics*

Nature:

Changes in water flow regime due to the alteration of surface characteristics (the compaction of soil, the removal of vegetation, surface water redirection and infrastructure) is likely to

increased peak flows and decrease flood attenuation. Increased storm water discharge could result soil erosion.		
	Without mitigation	With mitigation
Extent	Moderate (3)	Low (1)
Duration	Permanent (5)	Medium-term (3)
Magnitude	Moderate (6)	Slight (4)
Probability	Very probable (4)	Improbable (2)
Significance	56 (Moderate)	16 (Low)
Status	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes	Yes
Can impacts be mitigated?	Yes	
Mitigation: » Maintain buffer zones to retard storm water. » Stormwater should be managed and stormwater discharge points must be suitably protected against erosion		
Cumulative impacts: Increase stromwater will affect downstream users who are dependent on their topsoil and grass cover for agriculture. A reduced infiltration of water into the soil may reduce low flows that sustain wetlands during dry periods.		
Residual impacts: Once topsoil is lost it is hard to replace and revegetate. The disturbance caused by erosion will create a window of opportunity for alien invasive plants to colonise.		

4 CONCLUSION

Two wetlands, both hillside seeps, were found on the site. The wetlands were found to have a moderate importance and sensitivity to changes in flow regime and lacked sensitive biota. It was recommended that a 30m buffer is set to protect wetland functionality.

Due to the higher level of impact, indicated by the PES score, the alternative site 1 would be the preferred site to develop followed by the alternative site 2.

Potential impacts of the solar PV facility included:

» Loss and disturbance of wetland habitat and fringe vegetation.
» Introduction and spread of alien invasive vegetation.
» Changes in the amount of sediment entering the system.
» Changes in water quality due to toxic contaminants and increased nutrient levels entering the system.

- Changes in water flow regime due to the alteration of surface characteristics.

All impacts can be mitigated and appropriate mitigation measures should be put into place and carefully monitored to ensure potential impacts are mitigated. Wetlands with little modification should be prioritized for conservation, and remediation is needed to restore wetland function for those wetlands that have been highly modified.

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Appendix A: Points sampled on the study site.

Sample	Lat	Long	Terrain unit	Vegetation	Soil type	Soil wetness	Notes
1	-26.741470	27.955460	4	*Eragrostis curvula, Cyperus longus, *Conyza albida*	**Katspruit** (Orthic A / G horizon)	Dark sandy A, Fe mottles, very sandy yellow-brown apedal, grey colours at 40 cm, goethite mottles, some stones (may have been disturbed)	Wetland (highly disturbed)
2	-26.741980	27.953300	3	Themeda triandra, Eragrostis gummiflua, Eragrostis curvula		Orthic A/ Yellow-brown apedal. 1 goethite mottle at 50 cm.	Wetland interface
3	-26.741320	27.955550	3	*Eragrostis curvula, *Conyza albida, *Paspalum urvillei*		Orthic A/ Yellow-brown apedal. Haemathite and goethite mottles present at 30 cm. Signs of wetness present.	Wetland
4	-26.741180	27.955680		*Eragrostis curvula*	**Witbank** (Orthic A / Man-made soil deposit)	A / a very yellow apedal B. Mottles, brown, signs of wetness. Sharp transition- possibly artificial.	Wetland (Change in slope)
5	-26.740870	27.956000	3	*Eragrostis lehmanniana*		Same yellow material with signs of wetness at 20 cm.	Wetland
6	-26.735770	27.956830	4	**Verbena bonariensis, Kyllinga erecta, Cyperus longus, Hyperrhenia hirta, *Conyza albida, (influenced by runoff)*	**Witbank** (Orthic A / Man-made soil deposit)	No soil point	Wetland
7	-26.746480	27.959920	3	*Cyperus longus, Cynodon dactylon, Eragrostis curvula, Aristida congesta*	**Westleigh 2000** (Orthic A / Soft plinthic B)	Orthic A/ Soft plinthic B (luvic). Haemathite along root channels, Mn concretions.	Temporary wetland
8	-26.747080	27.960380	3	*Pogonarthria squarrosa, *Physalis angulata, Eragrostis curvula,*Conyza albida, Digiteria eriantha*		A / Yellow-brown apedal B. 1 Mn nodule at 40 cm and 1 haemathite mottle.	Interface
9	-26.747550	27.960820		*Cyperus longus, Kyllinga erecta, Setaria sphacelata, Eragrostis gummiflua, Digiteria eriantha*		No soil point	Depression
10	-26.748890	27.962860		*Helicrysum sp., Setaria sphacelata*		Veg pt.	Wetland
11	-26.747200	27.975040		*Setaria sphacelata, Digiteria eriantha, Oenothera stricta, Kyllinga erecta, Cyperus longus.*	**Westleigh 1000** (Orthic A / Soft plinthic B)	Fe (haemathite) and Mn mottles at 20 cm. Orthic / Soft plinthic. Goethite.	Wetland
			3	*Setaria sphacelata*		In herringbone drain	Construction, gravel and tar
12	-26.748960	27.977840		*Imperata cylindrica, *Verbena bonariensis,*Conyza albida, *Paspalum urvillei*		Dark A, mottles at 20 cm. Signs of wetness present.	Wetland (in herringbone drain)

13	-26.748540	27.971510		**Verbena bonariensis, *Conyza albida, Hyperrhenia hirta*			Dryland (highly disturbed)
14	-26.749930	27.971330	3	**Verbena bonariensis, Aristida diffusa, Cyperus longus*		Mottles at 10 cm	Wetland
15	-26.750930	27.971860		*Paspalum urvillei, *Verbena bonariensis, *Conyza albida, Senecio sp.		No soil point	Wetland
16	-26.751760	27.966950					Dryland
17	-26.743250	27.959050	3	*Eragrostis gummiflua, Cyperus longus, Kyllinga erecta, Digiteria eriantha*		Mottles at 10 cm	Seasonal/ Temporary wetland
18	-26.743160	27.959360		*Eragrostis gummiflua, Eragrostis curvula, Kyllinga erecta*		Mottles at 30 cm, haemathite	Temporary wetland

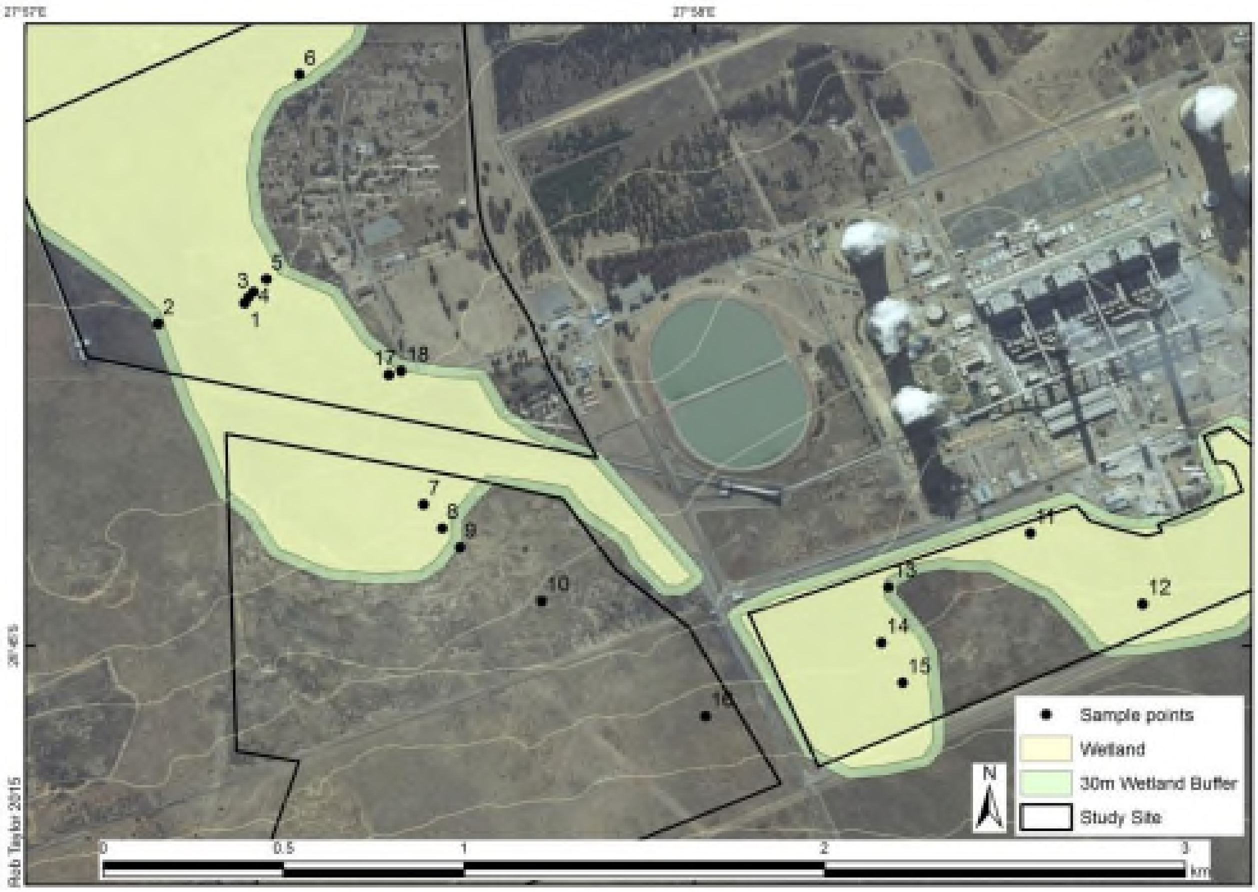

Figure 9. The location of sample points listed in Appendix A.

Appendix B: Summary of PES for the wetland in the study site

Lethabo - eastern wetland	Seep	Vulnerability factor: 1

Hydrological Assessment

			Dominant impacts	Extent (%)	Intensity	Magnitude of impact	Comments
Catchment Impacts	Change in quantity of inflows	Reduced flows	alien plants	40	-5	-2	stands of alien plants
		Increased flows	None	0	0	0	
		Overall change in quantity				-2	
	Alteration of floodpeaks	Reduced floodpeaks	None			0	
		Increased floodpeaks	Hardened surfaces			2	A some hardened surfaces draining into wetlands
		Overall change in floodpeaks				2	
	Overall score of catchment impacts					2.5	

		Dominant impacts	Extent (%)	Intensity	Magnitude of impact	Comments
Onsite Impacts	Impact of canalization on the distribution and retention of water	Drains	60	1.18	0.71	Large system of drains canalise the wetland
	Stream channel modification	None	0	0	0	
	Impact of impeding features (upstream)	Tar road	60	4	2.4	Road and assosiated drain through wetland impending flow
	Impact of impeding features (downstream)	Tar road	4	1.3	0.05	Low flows interrupted due to limited flows
	Impact of altered surface roughness	None	0	0	0	
	Impact of direct water loss	Alien plants	60	4	2.4	Dense stands of Oenothera stricta, Bidens pilosa, Datura stramonium, and Tagetes minuta
	Impact of recent deposition/excavation		0	0	0	
	Overall score of on-site activities				5.56	

Hydrology Impact Score	6.5	
Heath Category	E	Very largely modified some natural features still exist.
Anticipated trajectory of change	→	

Geomorphology Assessment

	Extent (%)	Intensity	Magnitude of impact	Comments
Impacts of changes in runoff characteristics	70	1	0.7	modification due to increased floodpeaks
Erosional features	0	0	0.00	
Depositional features	0	0	0	
Loss of organic sediment	0	0	0	

Geomorphology Impact Score	0.70	
Heath Category	A	Near natural
Anticipated trajectory of change	→	

Vegetation Assessment

Disturbance	Extent (%)	Intensity	Magnitude of impact	Comments
Dense Alien vegetation patches.	60	8	4.8	Dense stands of Oenothera stricta, Bidens pilosa, Datura stramonium, Paspalum urvillei, and Tagetes minuta
Minimal human disturbances	30	2	0.6	Gravel spread over the veld

Geomorphology Impact Score	5.40	
Heath Category	D	Largely Modified
Anticipated trajectory of change	↓	

Lethabo - northern wetland	Seep	Vulnerability factor: 1

Hydrological Assessment

			Dominant impacts	Extent (%)	Intensity	Magnitude of impact	Comments
Catchment Impacts	Change in quantity of inflows	Reduced flows	alien plants	10	-5	-0.5	some alien plants
		Increased flows	None	0	0	0	
		Overall change in quantity				**-0.5**	
	Alteration of floodpeaks	Reduced floodpeaks	None			0	
		Increased floodpeaks	Hardened surfaces			2	~5% of catchment hardened (roads)
		Overall change in floodpeaks				**2**	
	Overall score of catchment impacts					**0.5**	

		Dominant impacts	Extent (%)	Intensity	Magnitude of impact	Comments
Onsite Impacts	Impact of canalization on the distribution and retention of water	None	0	0	0.00	
	Stream channel modification	None	0	0	0	
	Impact of impeding features (upstream)	Conveyerbelt and railway	8	4	0.32	Conveyerbelt and railway through wetland impending flow
	Impact of impeding features (downstream)	Conveyerbelt and railway	8	2.4	0.19	Low flows interrupted due to limited flows through Conveyerbelt and railway
	Impact of altered surface roughness	None	0	0	0	
	Impact of direct water loss	Alien plants	5	4	0.2	Some Conyza albida stands
	Impact of recent deposition/excavation	None	0	0	0	
	Overall score of on-site activities				**0.71**	

Hydrology Impact Score	**0**	
Heath Category	**A**	Unmodified, natural
Anticipated trajectory of change	→	

Geomorphology Assessment

	Extent (%)	Intensity	Magnitude of impact	Comments
Impacts of changes in runoff characteristics	0	0	0	
Erosional features	0	0	0.00	
Depositional features	0	0	0	
Loss of organic sediment	0	0	0	

Geomorphology Impact Score	**0.00**	
Heath Category	**A**	Unmodified, natural
Anticipated trajectory of change	→	

Vegetation Assessment

Disturbance	Extent (%)	Intensity	Magnitude of impact	Comments
Infrastructure	5	10	0.5	Demolished houses, Conveyerbelts
Alien vegetation patches.	5	6	0.3	Some Conyza albida stands
Minimal human disturbances	10	2	0.2	small scale dumping of waste (rubble, wire/cables)

Geomorphology Impact Score	**1.00**	
Heath Category	**B**	Largely natural
Anticipated trajectory of change	→	

Appendix C: Summary of EIS

ECOLOGICAL IMPORTANCE AND SENSITIVITY	Score (0-4)	*Confidence (1-5)*	Motivation	Scoring Guideline
Biodiversity support	**1.33**	**3.33**		
Presence of Red Data species	1	*4*	No rare or endangered species found.	*Endangered or rare Red Data species presence*
Populations of unique species	1	*4*	None found	*Uncommonly large populations of wetland species*
Migration/breeding/feeding sites	2	2	Possible, none found	*Importance of the unit for migration, breeding site and/or a feeding.*
Landscape scale	**1.60**	**3.80**		
Protection status of the wetland	1	*4*	Protected under broad national legistlation (National Water Act)	*National (4), Provincial, private (3), municipal (1 or 2), public area (0-1)*
Protection status of the vegetation type	2	*4*	Central Free State grassland is listed as vulnerable.	*SANBI guidance on the protection sutatus of the surrounding vegetation*
Regional context of the ecological integrity	2	*3*	regionally important	*Assessment of the PES (habitat integrity), especially in light of regional utilisation*
Size and rareity of the wetland type/s present	2	*4*	Not rare, moderate size	*Identification and rareity assessment of the wetland types*
Diversity of habitat types	1	*4*	Low diversity	*Assessment of the variety of wetland types present within a site.*
Sensitivity of the wetland	**1.33**	**4.00**		
Sensitivity to changes in floods	1	*4*	seeps less sensitive to floods	*floodplains at 4; valley bottoms 2 or 3; pans and seeps 0 or 1.*
Sensitivity to changes in low flows/dry season	2	*4*	seeps are sensitive to low flows	*Unchannelled VB's probably most sensitive*
Sensitivity to changes in water quality	1	*4*	Low sensitivity - No sensive species	*Esp naturally low nutrient waters - lower nutients likely to be more sensitive*
ECOLOGICAL IMPORTANCE & SENSITIVITY	**1.60**	**4.00**	Moderate Importance and sensitivity to flow and habitat modifications.	