Proposed Majuba solar photovoltaic facility, Mpumalanga

Wetland Delineation and Functional Assessment
February 2015

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Declaration of Independence

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
Hydric Soils Specialist
SACNASP Reg. No. No: 100006/4

28.02.2015
Date

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
Ecologist/Botanist

28.02.2015
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.

Although the author exercised due care and diligence in rendering services and preparing documents, she accepts no liability, and the client, by receiving this document, indemnifies the author against all actions, claims, demands, losses, liabilities, costs, damages and expenses arising from or in connection with services rendered, directly or indirectly by the author and by the use of this document.

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 Majuba solar photovoltaic (PV) facility in Mpumalanga. 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 Amersfoort Highveld Clay Grassland vegetation type near the town of Amersfoort. Landscape setting suggested wetlands within the study area were likely to be seeps and/or unchannelled valley bottom wetlands.

Four wetlands were located within the study area, one unchannelled valley bottom and three seeps. The ecological integrity of the wetlands range from a PES score of C↓ (moderately modified) to wetlands in a near natural condition with a PES score of A→. 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.

The level of impact to the wetland is likely to increase in the next 5 years as hardened/bare surfaces increase peak flows resulting in aggravated erosion and alien invasive plants spread further into the catchment.

Although the seepage wetlands on the southern section of the site are in the least impacted state, the most sensitive wetland is considered to be the valley bottom wetland (wetland unit A). This wetland unit is hydrologically directly connected to downstream watercourses. Any impact to this wetland or its associated buffer zone will negatively affect regional hydrology. This wetland should be considered as a no-go area.

Impacts to the seepage wetlands, although still not desirable, should be mitigated through the following:

- A stormwater management system that ensures that changes to the quality and quantity of water displaced from these wetlands will not have a negative effect to downstream watercourses
- Continuous monitoring of downstream water quality should be done to verify that the development does not negatively affect water quality

- Continuous monitoring should be done to identify any erosion, also downstream from the site. If erosion is observed, it should be rehabilitated effectively
- A suitably qualified vegetation specialist should visit these wetlands prior to construction activities to identify and potentially relocate conservation-worthy plants

Further general potential impacts of the construction as well as operational phase of the proposed solar PV facility include:

- **Clearing/removal of natural vegetation**. The plants that grow in wetlands are vital for preventing erosion, they play a role in the purification of water, reducing the severity of floods and regulating water, especially during droughts. The moment the vegetation is destroyed, these valuable functions disappear. In addition, vegetation around watercourses, especially upslope, holds soil in place and slows down water runoff during rainy events. The vegetation thus promotes groundwater recharge, while protecting soils from eroding, subsequently causing sedimentation in watercourses.
- **Mobilization of sediments**. Soil erosion could lead to increased sedimentation and turbidity downstream of the activity, which in turn reduces the water storage capacity thereof, smothers vegetation, and decreases oxygen concentration. If sedimentation is allowed to continue, wetlands will lose their function and likely become invaded by alien invasive plant species.
- **Compaction of wetland soils**. Construction activities may compact soils from heavy equipment access which could inhibit seed germination, reduce water infiltration, inhibit root establishment, and result in bare soil exposure. In particular, soil compaction can lead to an increase in runoff during rainy events. It is therefore necessary that the smallest possible footprint be identified, especially in terms of vehicle access and support crew. As far as possible work should occur in the dry season when soil compaction is less critical.
- **Changing or impeding the flow of water**. This impact can be avoided by limiting the activities to the area outside of the wetlands or their buffer zones. The dispersive quality of soils, slopes and volume and energy of water flows should form part of the design in order to prevent damage to downstream areas resulting from the activity.
- **Exposure to erosion**. Removal of wetland vegetation, vegetation against slopes and compaction of soils, expose the resulting bare soils to erosion during rainfall events. Erosion removes the top soil layer, thereby preventing the successful establishment of indigenous vegetation on eroded soils. Eroded areas are likely to be colonised by alien invasive and pioneer plants, or in severe cases, no vegetation will establish causing high velocity runoff during rainfall events and continuous erosion. The occurrence of erosion resulting from the proposed activities should be closely monitored and addressed effectively.
- **Mobilisation of pollutants**: Accidental pollution or illegal disposal and dumping of construction material such as cement or oil, as well as disposal or discharge of human (including partially treated and untreated sewage) into water resources will influence the water quality of watercourses, thereby influencing its functionality and the persistence of vegetation. Water is expected to seep into any area of digging that goes through a wetland area. It is likely that water could be contaminated within these trenches. During high

rainfall events, this polluted water could be washed into the wetlands – especially if vegetation cover is not sufficient to slow down water and filter pollutants.

It is important that these potential impacts be noted during the design phase of the project and that all care is taken to minimize these potential impacts. Mitigation measures should be carefully compiled and included into an Environmental Management Programme.

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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 Majuba 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 Majuba 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 65MW Solar PV 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 9th and 11th 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 site is located around the Majuba Power Station (S27° 06' E29° 46') in the Seme municipality, Mpumalanga, approximately 15 km southwest of Amersfoort. The site area is 96.9 ha on Portion 1, 2 and 6 of the farm Witkoppies 81 HS abutting the south-eastern boundary of the power station (Fig. 1).

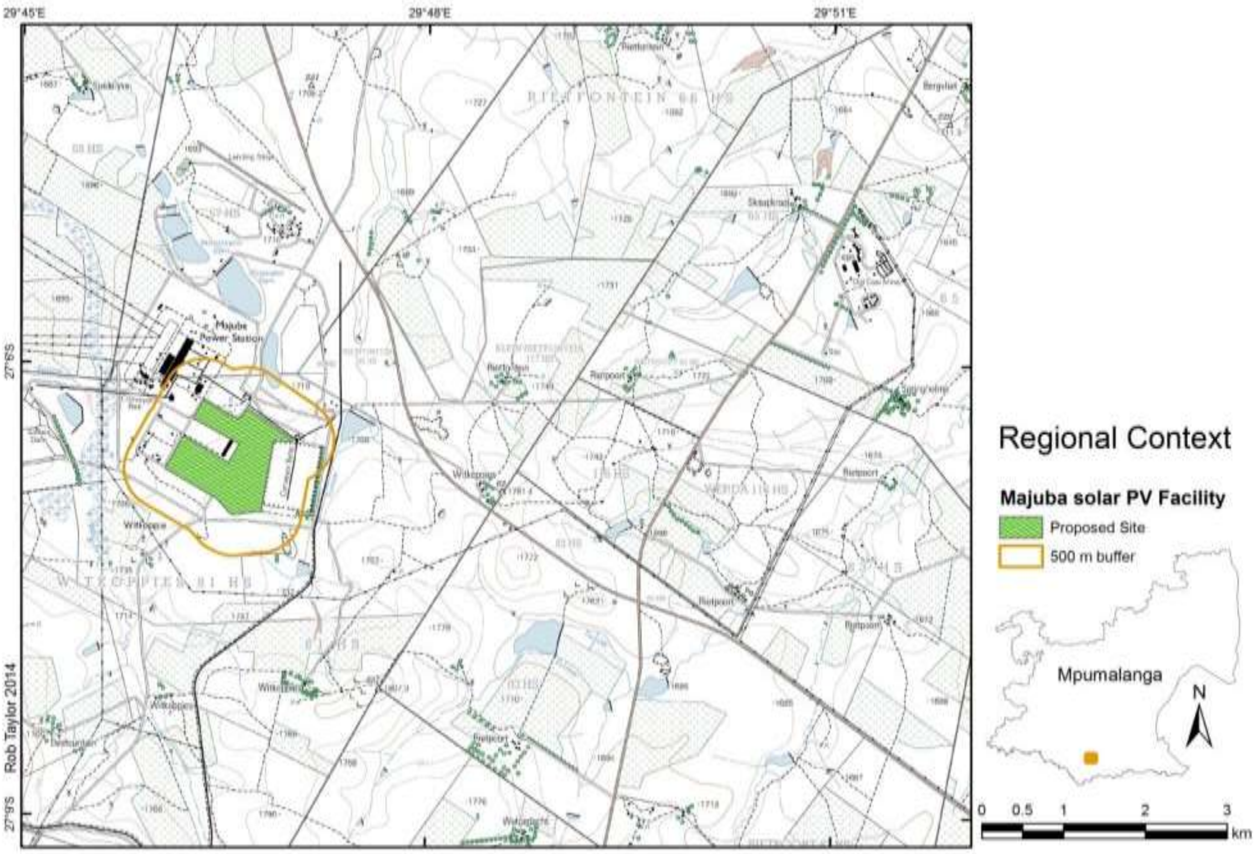


Figure 1: Regional context of the study sites (extracted from NGI 1:50 000 topo-cadastral maps)

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 Shale, Drakensberg formation. Soils are expected to be Vertisols and Planosols, clay-rich soils with or without a poorly structured surface layer. Clay rich soils form cracks when dry (Jones *et al.,* 2013) but have a very low erosion potential.

1.5.2 Regional Vegetation

The study sites fall within the Amersfoort Highveld Clay Grassland. The vegetation comprises of short closed grassland cover largely dominated by *Themeda triandra* (Mucina and Rutherford, 2006). This vegetation type has been listed as vulnerable with none being afforded formal protection. Some drainage lines have been invaded by exotic tree species. The relevant National Freshwater Ecosystem Priority Area (NFEPA) WetVeg Group is the mesic Highveld grasslands group 8 (Nel *et al.,* 2011).

1.5.3 Regional Hydrology

Several wetlands and open water bodies are located to the north east of the site and an unchannelled valley bottom wetland to the immediate east of the site. One earthen dam forms the only NFEPA wetland that has been demarcated with in the 500m buffer of the study site (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 within 500m of the sites. It was expected that hillside seeps and unchannelled valley bottom wetlands feed into the dam and surrounding wetlands.

A 20 m interval contour map, provided by the client, allowed for estimations of the slope and altitude. The proposed site has mostly north and north-west facing slopes of ~2%, with the altitude ranging from 1740-1720 mASL. One smaller slope faces south-east with a ~3% slope. Based on the landscape setting, any wetlands found in the study area are likely to be seeps, and unchannelled valley bottom wetlands.

1.5.4 Quaternary Catchments

The study site falls within the quaternary catchment C11J. 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 are 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.

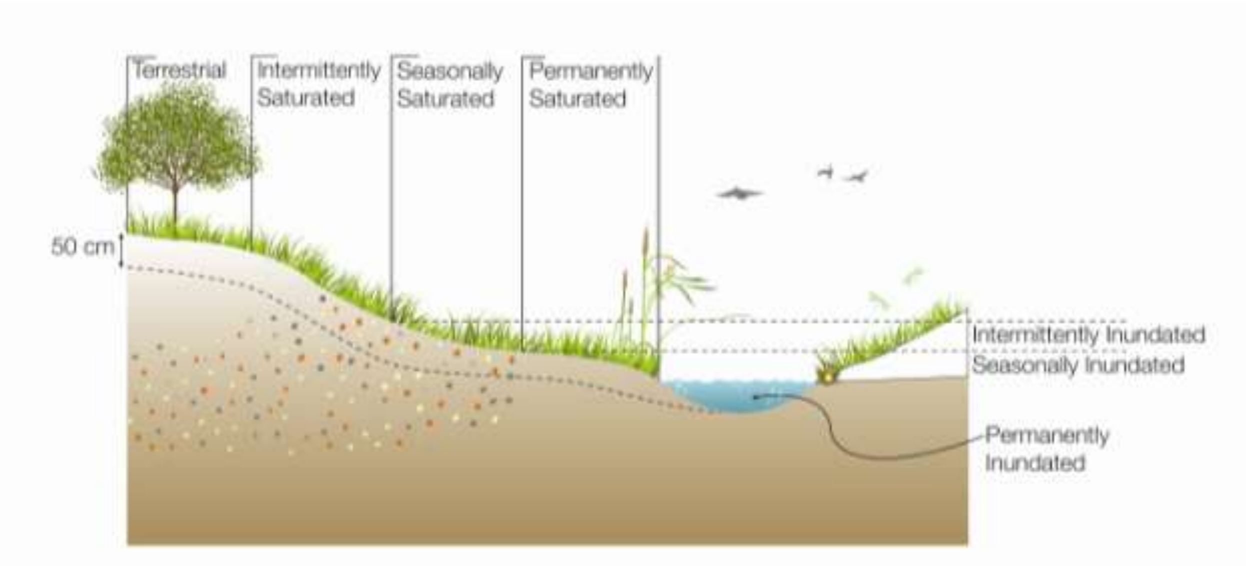


Figure 2. Typical Cross section of a wetland showing the temporary, seasonal, and permanent zones (Ollis, 2013)

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).

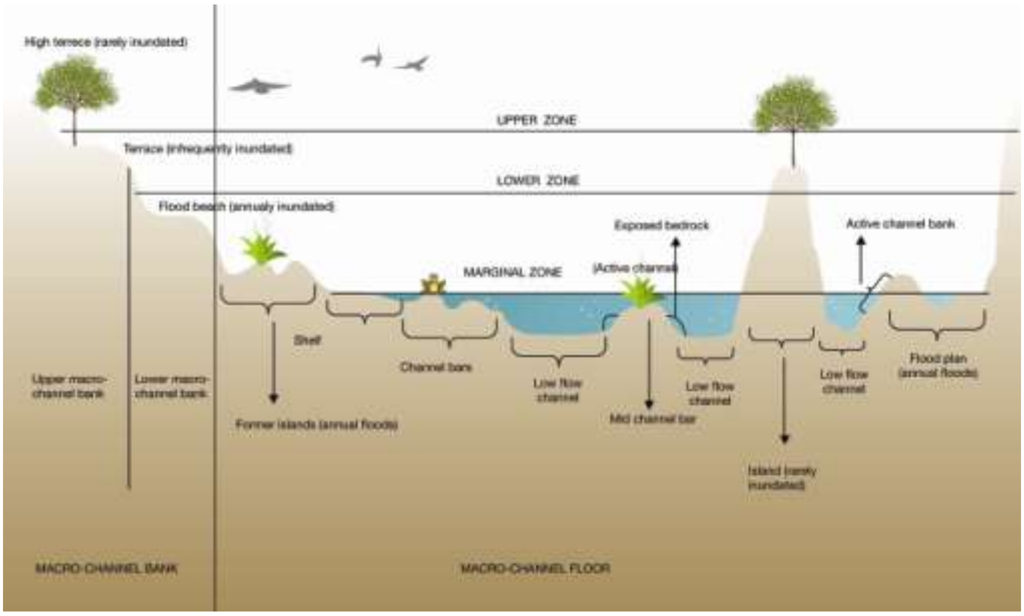


Figure 3. Schematic diagram illustrating the three riverine zones relative to geomorphic diversity (Kleynhans *et al*. 2007)

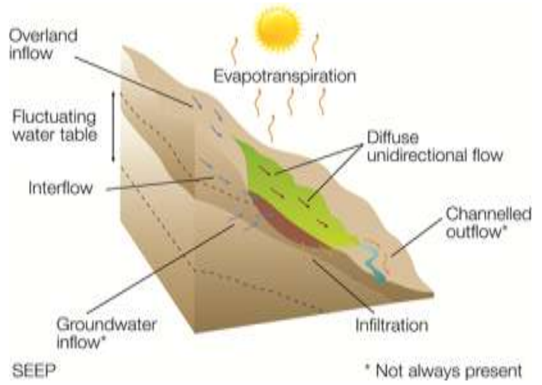
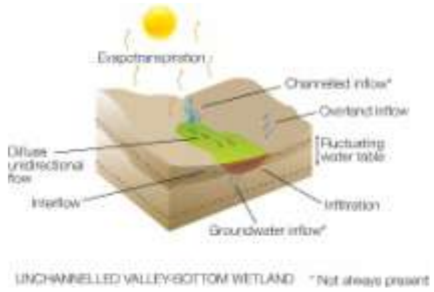
2.2 Wetland Classification and Delineation

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

<table>
<tr><th>Hydro-geomorphic types (Ollis et al, 2013)</th><th>Description (Kotze et al, 2005)</th></tr>
<tr><td>Seepage Wetlands

</td><td>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.</td></tr>
<tr><td>Unchannelled Valley-bottom Wetlands
</td><td>Unchannelled Valley-bottom Wetlands are characterised by their location on valley floors, their absence of distinct channeled banks and prevalence of diffuse flows. These wetlands occur where a river loses its confinment (often brought ablout by a change in gradient) or at the downstream end of a seep.</td></tr>
</table>

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 site is bordered by the Majuba power station in the north and north-west and a coal dump on the east (Fig. 4). The site has been largely modified by large concrete drains, scattered building rubble and alien plant infestations (Fig. 5). Gravel roads encompass the site on all sides and abandoned roads cut across the site. Despite the disturbance, a large part of the site still hosts natural grassland and a diverse range of forbs, notably: a colony of *Hypoxis rigidula,* two species of gladiolus (*G. crassifolius* and *G. sericeovillosus*) and *Aloe ecklonis.*

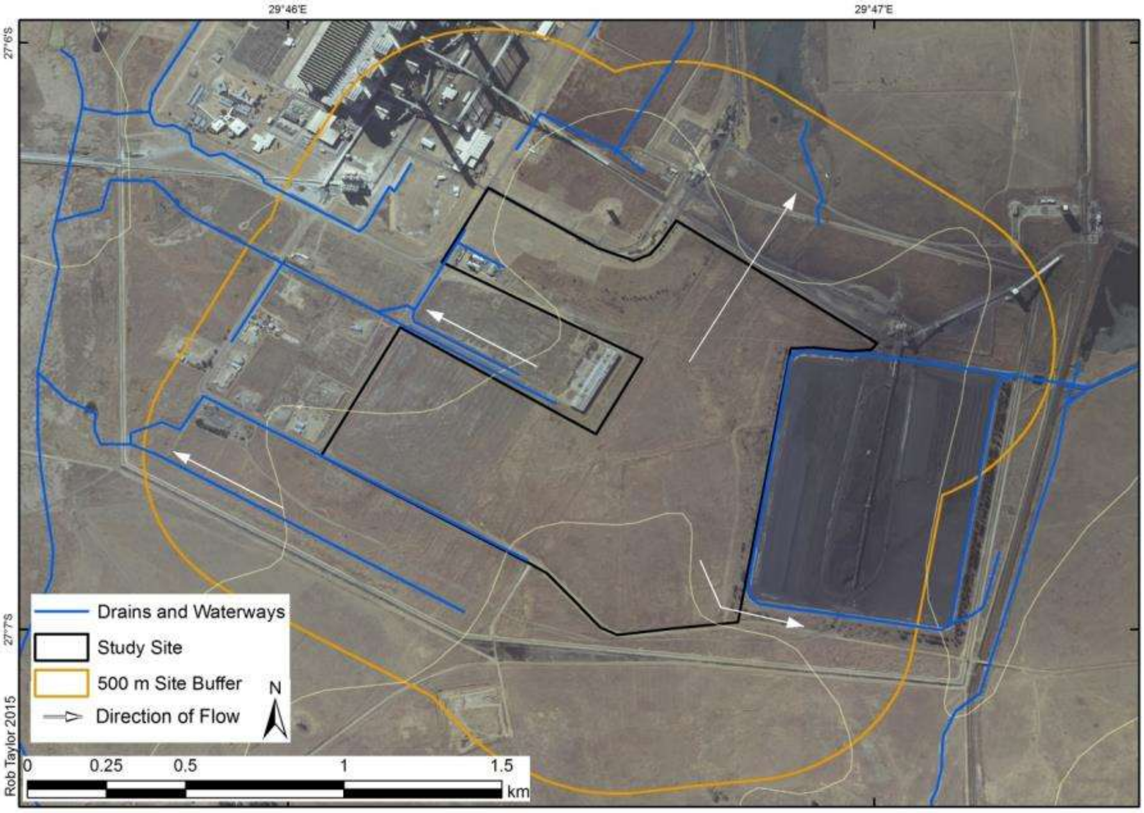


Figure 4. Local context of the study site relative to the Majuba power station and coal dump, with the drains and direction of flow indicated.

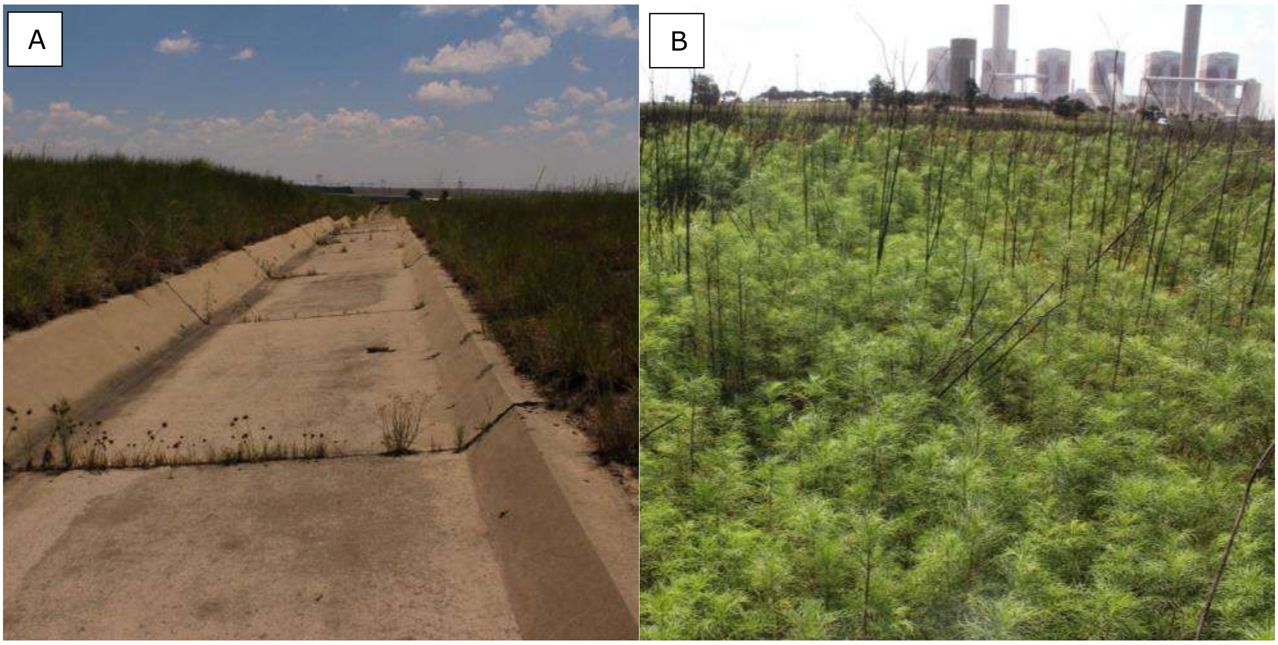


Figure 5. Some of the disturbances on the site included large concrete drains (**A**) and dense stands of alien vegetation (*Cosmos bipinnatus* pictured in **B**).

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), Longlands (Orthic A / E horizon / Soft plinthic B, Ehorizon "grey" when moist) and Kroonstad (Orthic / E horizon/ G horizon). Signs of wetness that were used to delineate the wetland boundary included red and yellow mottles, bleached E-horizons and soft and hard plinthic nodules (Fig. 6).

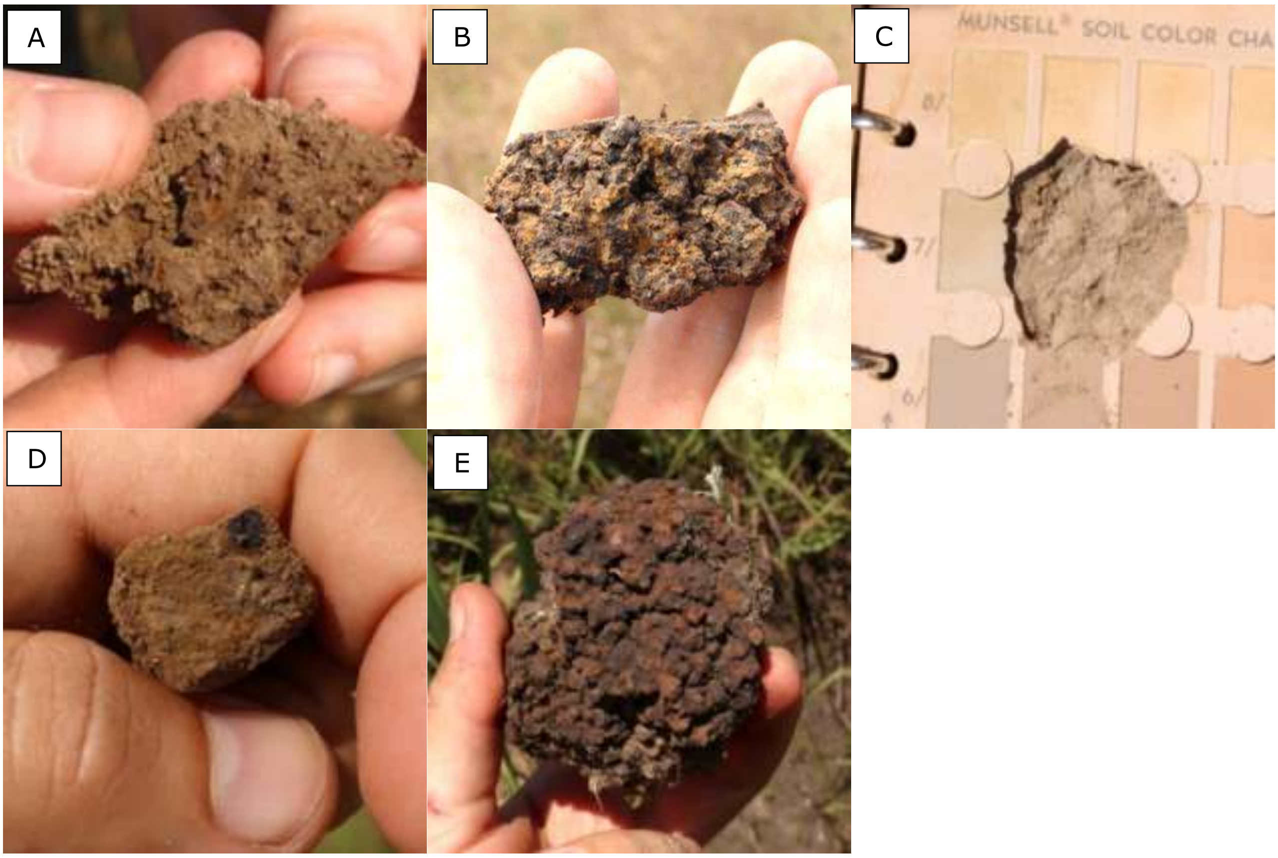


Figure 6. Examples of some of the wetland indicators found in the soil. Red mottles, haematite, (**A**) and yellow mottles, goethite, (**B**) form under fluctuating water table where the iron accumulates during redox. An E-horizon (**C**) bleached under saturated conditions, soft plinthic showing a manganese nodule (**D**), hard plinthic (**E**) - formed over many years of a fluctuating water table and an accumulation of iron and manganese mottles.

3.1.2 Vegetation Indicators

Wetland plants were an important indicator for the delineation process. *Typha capensis* (Bulrush) 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: *Agrostis lachnantha*, *Leersia hexandra* (Rice grass), *Andropogon eucomus* (Snowflake grass), *Kyllinga erecta*, *Cyperus longus*, *Cyperus denudatus* 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 dilatatum* – facultative wetland species, **B:** *Leersia hexandra* (Rice grass) – obligate wetland species, **C:** *Andropogon eucomus* (Snowflake grass) – obligate wetland species, **D:** *Typha capensis* (Bulrush) – obligate wetland species, **E:** *Kyllinga erecta* – obligate wetland species, **F:** *Cyperus longus* – obligate wetland species.

Figure 8. The wetland boundary between dryland on the right and a seep (indicated by the bulrush (*Typha capensis*) on the left.

3.2 Wetland Classification and Delineation

Four wetlands were delineated on the study site comprising of an unchannelled valley-bottom (7.3ha) wetland and three hillside seeps (the one hillside seep consisting of a series of small seeps lumped together for this assessment – 2.8ha, south-east seep – 6.3ha, north seep – 18.9ha,). Figure 9 shows the delineated wetlands together with the 30m wetland buffers. Figure 10 shows a regional perspective on how the wetlands drain from the site.

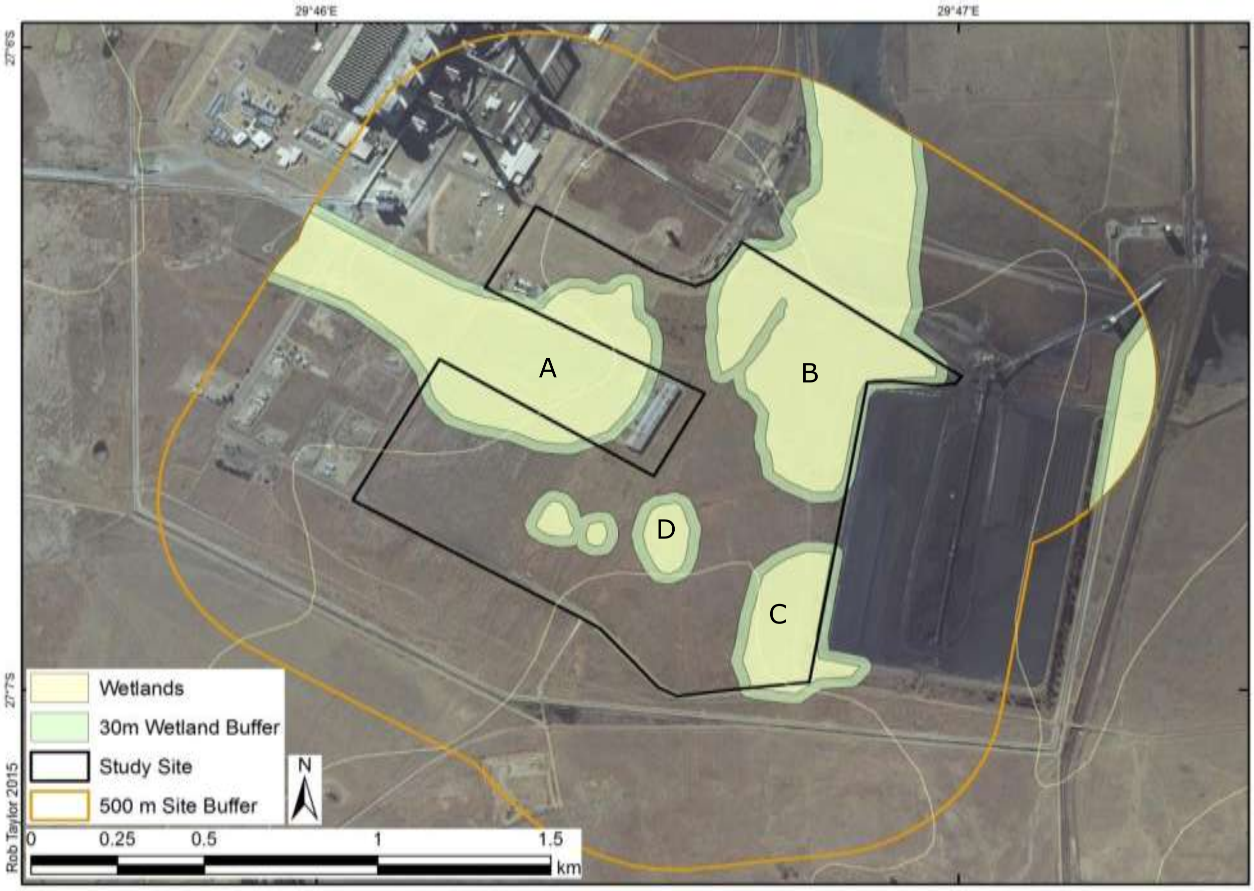


Figure 9. The wetlands and wetland buffers on the study site; **A**: the unchannelled valley-bottom wetland, **B**: a hillside seep draining northwards, **C**: a hillside seep draining south-eastwards, **D**: a cluster of hillside seeps draining north-westwards. All wetlands within a 500m buffer of the construction are prescribed by the DWA as relevant to the Water Use Licence application process.

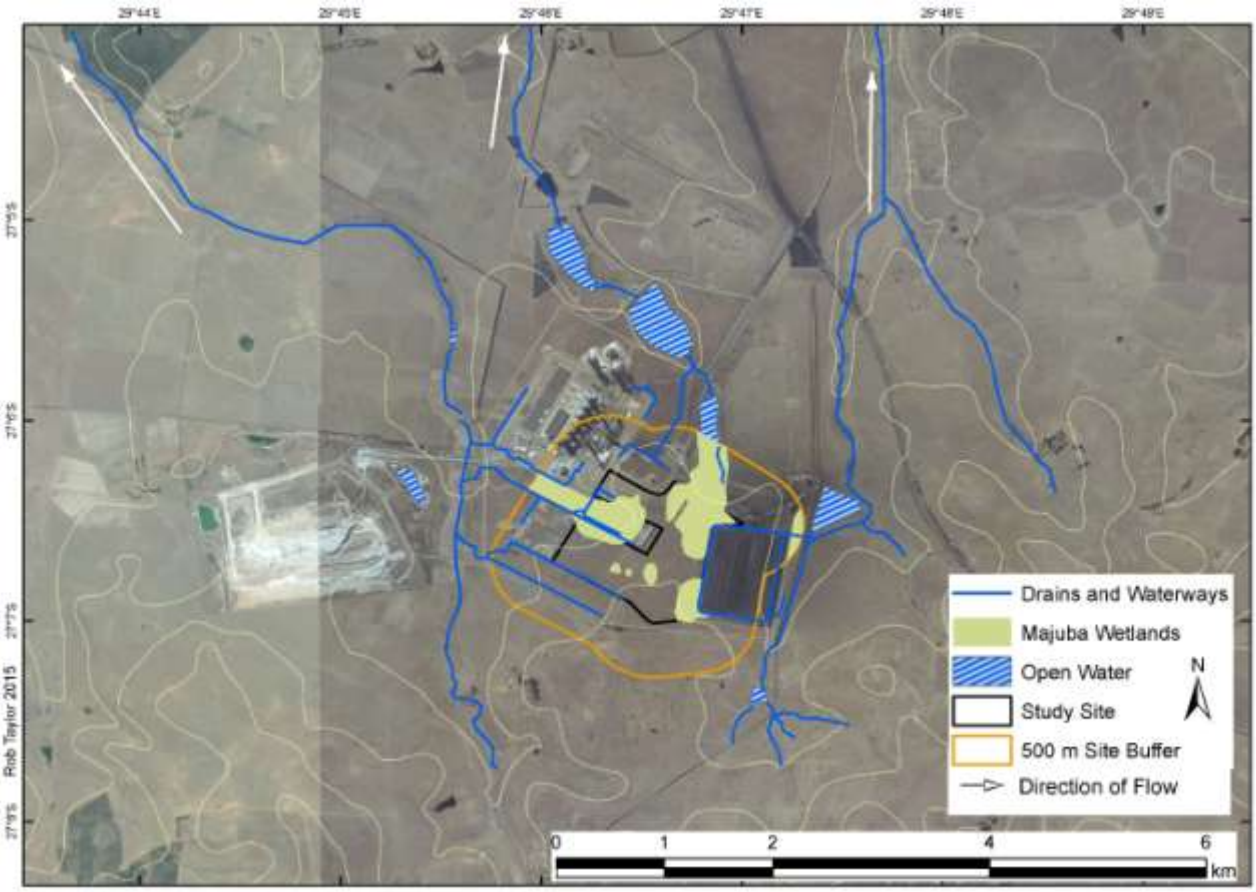


Figure 10: A regional perspective on the wetlands and how they drain from the site

3.3 Wetland Functional Assessment

3.3.1 Present Ecological Status (PES)

The wetlands in the study site vary in ecological status.

The unchannelled valley bottom wetland has been extensively drained and modified by dirt roads. Where infrastructure has been built in the wetland it has been drained and raised on a gravel bed. The disturbance has led to an invasion of alien plants. Unless actively controlled, the area and density of alien plants will increase in future years. The PES score for this wetland is a C↓, a moderate change in ecosystem processes and loss of natural habitats has taken place but the natural habitat remains predominantly intact.

Flows from the north draining seep are impeded by one active dirt road and several old roads. Large sections of this wetland have been colonised by alien invasive vegetation. The PES score for this wetland is also a C↓, a moderate change in ecosystem processes and loss of natural habitats has taken place but the natural habitat remains predominantly intact. Conditions are expected to deteriorate in a five year timeframe.

Both the south-east draining seep and the series of seeps draining north-westwards are relatively undisturbed. Although both these wetlands are cut by old roads that might impede flow, their ecological state and functioning appears natural. The PES score for both of these wetlands is an A→, near natural conditions.

The scores are summarised in the tables below (Table 6):

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		
B: Hillside seep - north draining	47	3.5	-1	1	0	5.4	-1	**3.33**	**C↓**
C: Hillside seep - south-east draining	10	0	0	0	0	0.8	0	**0.23**	**A→**
D: Hillside seep – north-west draining	4	0	0	0	0	1	0	**0.29**	**A→**
A: Unchannelled valley-bottom	39	6.5	-1	1.42	-1	2.6	-1	**3.93**	**C↓**
Total	**100**	**4.18**	**-0.86**	**1.0238**	**-0.39**	**3.672**	**-0.86**		

3.3.2 Ecological Importance and Sensitivity (EIS)

An EIS score of 1.6 was calculated for both the unchannelled valley bottom wetland and seeps, 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). The wetlands have been modified and as such 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 wetland loss is inevitable and authorized by the DWS, care should be taken to ensure no nett impact to regional hydrology. For example, impacts to wetlands connected to downstream watercourses should be effectively mitigated so as not to result in sedimentation, erosion, changes to water flow characteristics		
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 although measures can be put in place to protect downstream areas.		

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. Loss of wetland habitat may occur if depressions are silted up and vegetation smothered by sediments.

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

Four wetlands, one unchannelled valley-bottom and three seeps, were found on the site. The wetlands had been exposed to varying degrees of impact. The hillside seeps draining south-east and north-west (wetland units C and D) were the least impacted still showing a high level of natural ecological state. The unchannelled valley-bottom (wetland unit A) and the seep draining north (wetland unit B) were both largely modified with the valley-bottom wetland impacted on by large concrete drains and the seep was impeded by gravel roads. Overall the wetlands on site were moderately modified. The wetland was 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.

Although the seepage wetlands on the southern section of the site are in the least impacted state, the most sensitive wetland is considered to be the valley bottom wetland (wetland unit A). This wetland unit is hydrologically directly connected to downstream watercourses. Any impact to this wetland or its associated buffer zone can negatively affect regional hydrology. Impacts to the seepage wetlands, although still not desirable, should be mitigated through the following:

» A stormwater management system that ensures that changes to the quality and quantity of water displaced from these wetlands not have a negative effect to downstream watercourses
» Continuous monitoring of downstream water quality should be done to verify that the development does not negatively affect water quality
» Continuous monitoring should be done to identify any erosion, also downstream from the site. If erosion is observed, it should be rehabilitated effectively
» A suitably qualified vegetation specialist should visit these wetlands prior to construction activities to identify and potentially relocate conservation-worthy plants

Further general potential impacts of the construction as well as operational phase of the proposed solar PV facility include:

» Clearing/removal of natural vegetation. The plants that grow in wetlands are vital for preventing erosion, they play a role in the purification of water, reducing the severity of floods and regulating water, especially during droughts. The moment the vegetation is destroyed, these valuable functions disappear. In addition, vegetation around watercourses, especially upslope, holds soil in place and slows down water runoff during rainy events. The vegetation thus promotes groundwater recharge, while protecting soils from eroding, subsequently causing sedimentation in watercourses.
» Mobilization of sediments. Soil erosion could lead to increased sedimentation and turbidity downstream of the activity, which in turn reduces the water storage capacity thereof, smothers vegetation, and decreases oxygen concentration. If sedimentation is allowed to continue, wetlands will lose their function and likely become invaded by alien invasive plant species.
» Compaction of wetland soils. Construction activities may compact soils from heavy equipment access which could inhibit seed germination, reduce water infiltration, inhibit root establishment, and result in bare soil exposure. In particular, soil compaction can lead to an increase in runoff during rainy events. It is therefore necessary that the smallest possible footprint be identified, especially in terms of vehicle access and support crew. As far as possible work should occur in the dry season when soil compaction is less critical.
» Changing or impeding the flow of water. This impact can be avoided by limiting the activities to the area outside of the wetlands or their buffer zones. The dispersive quality of soils, slopes and volume and energy of water flows should form part of the design in order to prevent damage to downstream areas resulting from the activity.
» Exposure to erosion. Removal of wetland vegetation, vegetation against slopes and compaction of soils, expose the resulting bare soils to erosion during rainfall events. Erosion removes the top soil layer, thereby preventing the successful establishment of indigenous vegetation on eroded soils. Eroded areas are likely to be colonised by alien invasive and pioneer plants, or in severe cases, no vegetation will establish causing high velocity runoff during rainfall events and continuous erosion. The occurrence of erosion resulting from the proposed activities should be closely monitored and addressed effectively.
» Mobilisation of pollutants: Accidental pollution or illegal disposal and dumping of construction material such as cement or oil, as well as disposal or discharge of human (including partially treated and untreated sewage) into water resources will influence the water quality of watercourses, thereby influencing its functionality and the persistence of vegetation. Water is expected to seep into any area of digging that goes through a wetland area. It is likely that water could be contaminated within these trenches. During high rainfall events, this polluted water could be washed into the wetlands – especially if vegetation cover is not sufficient to slow down water and filter pollutants.

It is important that these potential impacts be noted during the design phase of the project and that all care is taken to minimize these potential impacts. Mitigation measures should be carefully compiled and included into an Environmental Management Plan.

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Appendix A: Points sampled on the study site.

Sample	Lat	Long	Terrain unit	Vegetation	Soil type	Soil wetness	Notes
1	-27.107800	29.779550	3 (4L)	*Cosmos bipinnatus, Themeda triandra, cf Cymbopogon plurinodis*Verbena bonariensis, Eragrostis curvula, cf Helichrysum pilosellum	**Westleigh 2000** (Orthic A / Soft plinthic B, Luvic B1)	Fe mottles at 30 cm, stones/concretions at 60 cm, soft plinthic (Mn concretions) at 90 cm. Luvic. Sandy orthic A/soft plinthic.	Seasonal wetland
2	-27.106710	29.779040	3	short cf Cymbopogon plurinodis dominant	**Longlands 1000** (Orhic A / E horizon /Soft plinthic B, E horizon "grey" when moist)	Fe mottles at 20 cm, Orthic/E/Soft plinthic. Stones and concretions at 60 cm. Geogenic mottles also present.	Temporary wetland
3	-27.106600	29.778770	3 (1)	short cf Cymbopogon plurinodis dominant	**Glenrosa** (Orthic A / Lithocutanic B)	Saprolite at 15 cm, hard rock at <20cm. Orthic/ Saprolite (Lithocutanic B).	Dryland
4	-27.106430	29.778680	3	Themeda triandra, Aristida junciformis, *Verbena bonariensis, Hibiscus microcarpus, Anthericum sp.	**Longlands 1000** (Orhic A / E horizon /Soft plinthic B, E horizon "grey" when moist)	Orthic/ E (5YR 7/1)/ Soft plinthic at 50 cm (Fe adnd Mn concretions). Sandy-loose structure.	Temporary wetland (near old road- acting as drainage ditch)
5	-27.106250	29.778300	3	Typha capensis (in the hole), Agrostis lachnantha, *Paspalum dilatatum, *Verbena bonariensis, Hyperrhenia tamba, *Cosmos bipinnatus, *Schkuhria pinnata, Kyllinga erecta	**Wasbank 1000** (Orthic A horizon /E horizon / Hard plinthic B, E horizon "grey" when moist)	A horizon at 5 cm / E horizon (10YR 4/2 mottles- dark greyish brown)/ Hard plinthic (Mn and Fe getting harder with depth)	Permanent/ Seasonal wetland (profile pit)
6	-27.106440	29.777500	3 (1)	*Verbena bonariensis, *Paspalum dilatatum, Themeda triandra, Sporobolus africanus, cf Pseudognaphalium luteo-album		Fe mottles at 20 cm, signs of wetness present.	Wetland
7	-27.106570	29.777070	3 (1)	Gladiolus crassifolius, Themeda triandra, *Verbena officinalis, Harpochloa falx, Kyllinga erecta. Dryland and wetland species	**Westleigh** (Orthic A/ Soft plinthic B)	Fe mottles and Mn concretions present at 20 cm (possibly geogenic). A/Plinthic.	Soils:wetland Plants:dryland
8	-27.106480	29.774340	3 (1)	*Verbena bonariensis, Hyperrhenia tamba, Eragrostis curvula, Andropogon eucomus	**Glenrosa** (Orthic A / Lithocutanic B)	A horizon (0-15 cm)/ Saprolite	Temporary wetland
9	-27.106270	29.774690	3 (1)	Mowed *Paspalum dilatatum growing in seep		Fe mottles within 20 cm. Exposed sheet of rock, causing water to be pushed out.	Hillslope seep- can see boundary
10	-27.106680	29.774200	3	Hyperrhenia tamba	**Katspruit** (Orthic A / G horizon)	Orthic A (Stoney coarse yellow material-possibly washed in, loose. Distinct boundary)/ G horizon (Grey matterial at 20 cm	Seasonal wetland
11	-27.106960	29.774230	3 (5)	*Paspalum dilatatum, Kyllinga erecta, Cyperus longus		No soil point	Permanent wetland
12	-27.109770	29.772660	3 (5)	algae crust, *Verbena bonariensis		No soil point	Wetland
13	-27.110500	29.772210		Hyperrhenia tamba		Orthic / rock (lithocutanic), shale	Dryland

14	-27.110230	29.772350	3 (5)	Andropogon eucomus, Gladiolus sericeovillosus		Gravelly/ Shale. Yellow apedal with mottles.	Temporary wetland-boundary
15	-27.110900	29.772430	3 (4)	Gladiolus sericeovillosus, Hyperrhenia tamba		Carbonate concretions, exposed rock- possibly sandstone	
16	-27.112140	29.772690	3	Typha capensis patch	**Katspruit** (Orthic A / G horizon)	Gleying, Mn and Fe mottles/ concretions at 10 cm	Peramnent wetland (Standing water due to seep or artificial pipe)
17	-27.112330	29.772970	3	*Verbena bonariensis, cf Cymbopogon plurinodis		Fe mottles at 20 cm, darker topsoil, loamy.	Seasonal wetland
18	-27.112520	29.773120	3	cf Cymbopogon plurinodis		There is a change at 15 cm from a light material (loose, coarse, yellow) to a darker material with a higher clay content. Perhaps a burried horizon. Fe mottles at 20, and redox depletions.	Temporary wetland
19	-27.112640	29.773350	3	Hypoxis rigidula, Hyperrhenia hirta		No soil point	Dryland
20	-27.112450	29.773860	3	*Verbena bonariensis	**Kroonstad** (Orthic / E horizon / G horizon)	Light layer at 20 cm E/ G horizon.	Seasonal wetland (depression)
21	-27.112210	29.775420		*Cosmos bipinnatus, Typha capensis, Eragrostis curvula, Setaria sphacelata		No soil point	Wetland
22	-27.110160	29.778330		cf Cymbopogon plurinodis		Orthic A/ G horizon. Grey matrix and goethite mottles.	Seasonal/ Temporary wetland
23	-27.109920	29.778590	3 (4)	Leersia hexandra , *Cosmos bipinnatus	**Katspruit 1000** (Orthic A / G horizon)	Fe mottles at 20 cm. Darker A/ G horizon (grey matrix with goethite and haematite.	Permanent wetland
24	-27.109650	29.778200		Dryland sp.		No soil point	Dryland interface
25	-27.108930	29.777890	3 (4)	Themeda triandra, Hypoxis rigidula		Orthic A/ E/ Soft plinthic at 45 cm.	Temporary wetland
26	-27.108540	29.777160		Typha capensis			Old road
27	-27.107820	29.777590					Crab
28	-27.106890	29.780450					Mudflat
29	-27.115910	29.778120	3	Agrostis lachnantha, *Paspalum dilatatum, *Verbena bonariensis, Setaria sphacelata, Cyperus	**Katspruit** (Orthic A / G horizon)	Fe mottles at 10 cm. Grey colours and heamathite mottles.	Permanent wetland
30	-27.115820	29.777770	3	Eragrostis curvula, cf Helichrysum inornatum	**Westleigh** (Orthic A / Soft plinthic B)	Orthic / soft plinthic (or lithocutanic/ unconsolidated withsigns ofwetness). Stones at 40 cm.	Temporary wetland
31	-27.113030	29.775970	3 (4)	Kyllinga erecta, Cyperus denudatus, *Verbena bonariensis, Setaria sphacelata		No soil point	Wetland

32	-27.113640	29.775730	3	Eragrostis curvula, hyperenia tamba, Andropogon sp.	**Glenrosa** (Orthic A / Lithocutanic B)	Dark A, sandy, orthic/ lithocutanic (weathering saprolite, yellow and orange colour, geogenic mottles, very faint colour variation)	Temporary wetland (seep boundary)
33	-27.111130	29.779530		*Cosmos bipinnatus, disturbed, Kyllinga erecta, *Paspalum dilatatum, *Pennisetum clandestinum, Hyperrhenia tamba		No soil point	Wetland
34	-27.110500	29.779760	3	Agrostis lachnantha, moss.		Mottles at 10 cm. Friable, dark and loose A.	Wetland
35	-27.108060	29.781600	3	*Agrostis lachnantha*		Mottles at 10 cm. Mn and Fe (haematite and goethite) mottles. Very sandy, loose, friable, yellow brown apedal.	Wetland
36	-27.109130	29.770280	3 (4)	Disturbed- Hyperrhenia hirta dominant, Eragrostis curvula - dryland species.		Grey colours, goethite mottles.	Wetland
37	-27.109580	29.770260	3	Themeda triandra, Eragrostis plana, Eragrostis curvula, Hyperrhenia tamba, Aristida congesta	**Glenrosa** (Orthic A / Lithocutanic B)	Dark sandy A/ saprolite, sharp boundary. Orthic A/ Lithocutanic. No signs of wetness. Parent material at 10 cm.	Dryland

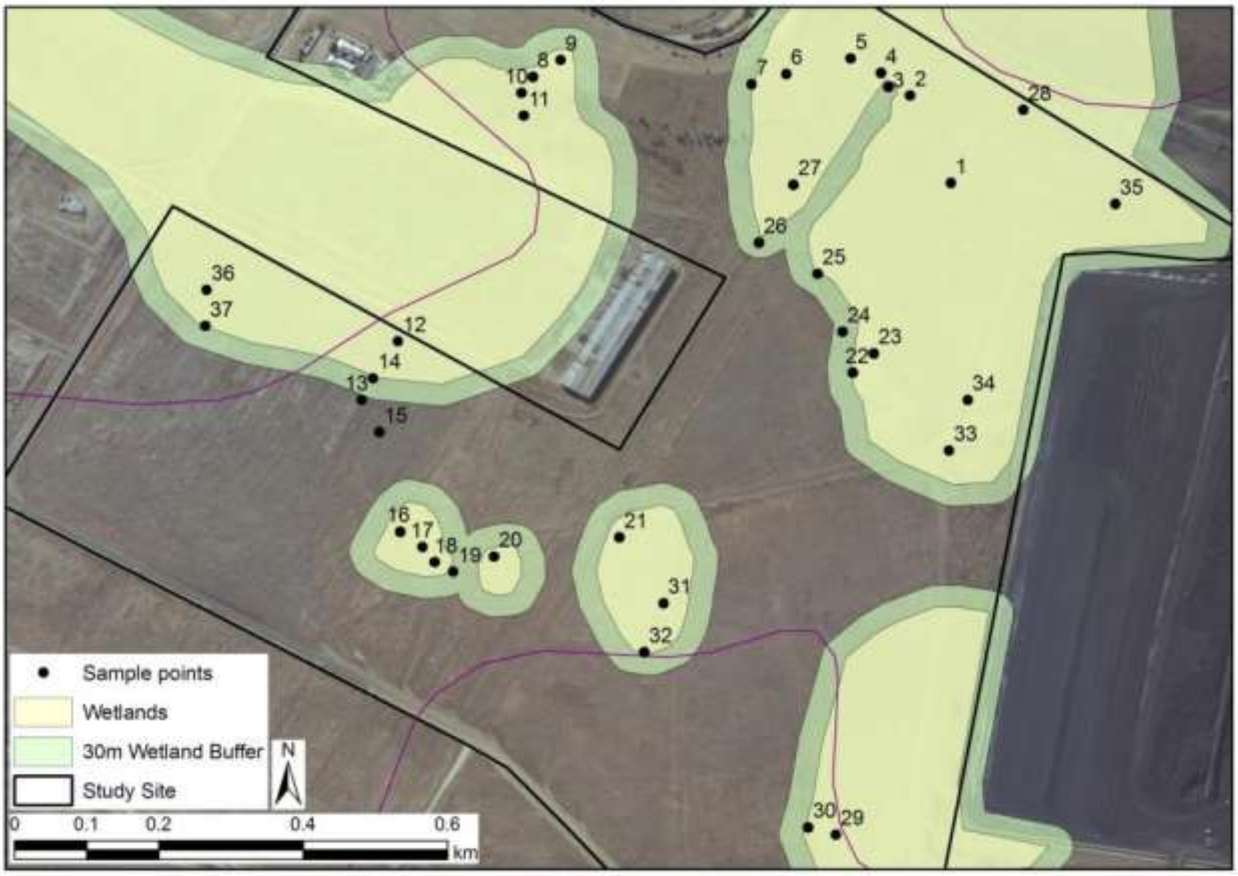

Figure 11. The location of sample points listed in Appendix A.

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

Majuba - north west draining **Unchanneled valley bottom** **Vulnerability factor: 1**

Hydrological Assessment							
			Dominant impacts	**Extent (%)**	**Intensity**	**Magnitude of impact**	**Comments**
Catchment Impacts	Change in quantity of inflows	Reduced flows	Drains and roads extracting water	20	-5	-1	Drains extract water away from catchment
		Increased flows	None	0	0	0	
		Overall change in quantity				**-1**	
	Alteration of floodpeaks	Reduced floodpeaks	None			0	
		Increased floodpeaks	Hardened surfaces			4	5-10% of catchment hardened (infrastructure, drains and roads). 15-20% of catchment bare soil.
		Overall change in floodpeaks				**4**	
	Overall score of catchment impacts					**2.5**	Moderate - The impact of the modifications on the hydrological integrity is clearly identifiable, but limited.
			Dominant impacts	**Extent (%)**	**Intensity**	**Magnitude of impact**	**Comments**
Onsite Impacts	Impact of canalization on the distribution and retention of water		Drains and erosion	50	4.08	2.04	Large concrete drains canalise the wetland
	Stream channel modification		None	0	0	0	
	Impact of impeding features (upstream)		Roads	8	6.4	0.512	Dirt road through wetland impending flow
	Impact of impeding features (downstream)		Roads	8	1.1	0.088	Low flows interrupted due to limited flows through dirt road
	Impact of altered surface roughness		Reduced grass cover	60	3	1.8	Disturbance has decreased grass cover resulting in some bare surfaces
	Impact of direct water loss		Alien plants	20	4.8	0.96	Several willow trees (*Salix babylonica*), and dense stands of *Verbeena bonariensis, Bidens pilosa* and *Cosmos bipinnatus*
	Impact of recent deposition/excavation			0	0	0	
	Overall score of on-site activities					**5.40**	
Hydrology Impact Score						**6.5**	
Heath Category						**E**	Seriously modified
Anticipated trajectory of change						**↓**	

Geomorphology Assessment				
	Extent (%)	**Intensity**	**Magnitude of impact**	**Comments**
Impacts of changes in runoff characteristics	50	2	1	Small modification due to increased floodpeaks
Erosional features	15	1.47	0.22	Slight erosion present
Depositional features	20	1	0.2	Slight deposition present
Loss of organic sediment	0	0	0	
Geomorphology Impact Score			**1.42**	
Heath Category			**B**	Largely natural
Anticipated trajectory of change			**↓**	

Vegetation Assessment				
Disturbance	**Extent (%)**	**Intensity**	**Magnitude of impact**	**Comments**
Infrastructure	5	10	0.5	Roads, substations and buildings
Dense Alien vegetation patches.	20	9	1.8	Dense stands of *Verbeena bonariensis, Bidens pilosa* and *Cosmos bipinnatus*
Minimal human disturbances	15	2	0.3	Disturbance from construction, small scale dumping of waste (rubble, wire/cables)
Geomorphology Impact Score			**2.60**	
Heath Category			**C**	Moderately Modified
Anticipated trajectory of change			**↓**	

Majuba - South facing	**Hillside seep**	**Vulnerability factor: 1**

Hydrological Assessment

			Dominant impacts	**Extent (%)**	**Intensity**	**Magnitude of impact**	**Comments**
Catchment Impacts	Change in quantity of inflows	Reduced flows	None	0	0	0	
		Increased flows	None	0	0	0	
		Overall change in quantity				**0**	
	Alteration of floodpeaks	Reduced floodpeaks	None			0	
		Increased floodpeaks	None			0	
		Overall change in floodpeaks				**0**	
	Overall score of catchment impacts					**0**	None - No discernible modifications, or the modifications are of such a nature that they have no impact on the hydrological integrity.

		Dominant impacts	**Extent (%)**	**Intensity**	**Magnitude of impact**	**Comments**
Onsite Impacts	Impact of canalization on the distribution and retention of water	Drain	10	1.9	0.19	Large concrete drain at the lower end of wetland
	Stream channel modification	None	0	0	0	
	Impact of impeding features (upstream)	Road	5	4	0.2	Dirt road through wetland impending flow
	Impact of impeding features (downstream)	Road	5	0.53	0.03	Low flows interrupted due to limited flows through dirt road
	Impact of altered surface roughness	None	0	0	0	
	Impact of direct water loss	Alien plants	5	6.4	0.32	Several pine (Pinus sp.) and gum trees(Eucalyptus cinerea), and Cosmos bipinnatus
	Impact of recent deposition/excavation		0	0	0	
	Overall score of on-site activities				**0.74**	

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	5	0	0	
Erosional features	0	0	0	
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	one old road, drain at lower end of wetland
Alien vegetation patches	5	6	0.3	Cosmos bipinnatus and pinus sp. along old road

Geomorphology Impact Score	**0.80**	
Heath Category	**A**	Vegetation composition appears natural.
Anticipated trajectory of change	**→**	

Majuba - north facing (group)	**Hillside seep**	**Vulnerability factor: 1**

Hydrological Assessment

			Dominant impacts	Extent (%)	Intensity	Magnitude of impact	Comments
Catchment Impacts	Change in quantity of inflows	Reduced flows	None	0	0	0	
		Increased flows	None	0	0	0	
		Overall change in quantity				**0**	
	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)	Roads	8	6.4	0.51	Dirt road through wetland impending flow
	Impact of impeding features (downstream)	Roads	5	2.4	0.12	Low flows interrupted due to limited flows through dirt road
	Impact of altered surface roughness	None	0	0	0	
	Impact of direct water loss	Alien plants	5	4	0.2	stands of Cosmos bipinnatus
	Impact of recent deposition/excavation	None	0	0	0	
	Overall score of on-site activities				**0.83**	

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	one old road, drain at lower end of wetland
Alien vegetation patches.	5	6	0.3	Cosmos bipinnatus patches
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	**→**	

Majuba - north draining	Hillside seep	Vulnerability factor: 1

Hydrological Assessment

			Dominant impacts	Extent (%)	Intensity	Magnitude of impact	Comments
Catchment Impacts	Change in quantity of inflows	Reduced flows	Drains and roads extracting water	30	-5	-1.5	Drains extract water away from catchment
		Increased flows	None	0	0	0	
		Overall change in quantity				-1.5	
	Alteration of floodpeaks	Reduced floodpeaks	None			0	
		Increased floodpeaks	Hardened surfaces			3	10-15% of catchment hardened (infrastructure and roads).
		Overall change in floodpeaks				3	
	Overall score of catchment impacts					1.5	Small - Although identifiable, the impact of the modifications on the hydrological integrity is small.

		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)	Roads	35	4	1.4	Several road through wetland impending flow
	Impact of impeding features (downstream)	Roads	10	3.2	0.32	Low flows interrupted due to limited flows through dirt road
	Impact of altered surface roughness	None	0	0	0	
	Impact of direct water loss	Alien plants	40	4.8	1.92	Several gum trees (Eucalyptus cinerea), and dense stands of Tagetes minuta, Datura stramonium, Schkuhria pinnata, Verbeena bonariensis, Bidens pilosa, and Cosmos bipinnatus
	Impact of recent deposition/excavation		0	0	0	
	Overall score of on-site activities				3.64	

Hydrology Impact Score	**3.5**	
Heath Category	**C**	Moderately modified.
Anticipated trajectory of change	↓	

Geomorphology Assessment

	Extent (%)	Intensity	Magnitude of impact	Comments
Impacts of changes in runoff characteristics	50	2	1	Small 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	**1.00**	
Heath Category	**B**	Largely natural
Anticipated trajectory of change	→	

Vegetation Assessment

Disturbance	Extent (%)	Intensity	Magnitude of impact	Comments
Infrastructure	15	10	1.5	Roads, substations and buildings
Dense Alien vegetation patches.	40	9	3.6	Dense stands of Tagetes minuta, Datura stramonium, Schkuhria pinnata, Verbeena bonariensis, Bidens pilosa, and Cosmos bipinnatus.
Minimal human disturbances	15	2	0.3	Disturbance from construction, small scale dumping of waste (rubble, wire/cables), coating of coal dust.

Geomorphology Impact Score	**5.40**	
Heath Category	**D**	Largely Modified
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	2	*4*	A population of Hypoxis rigidula and Gladiolus sericeovillosus and G. crassifolius in tempoary wetland and buffer.	*Uncommonly large populations of wetland species*
Migration/breeding/feeding sites	1	*2*	Possible but not obvious	*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*	Amersfoort highveld clay grassland is listed as vulnerable.	*SANBI guidance on the protection sutatus of the surrounding vegetation*
Regional context of the ecological integrity	2	*4*	the unmodified wetlands are regionally important	*Assessment of the PES (habitat integrity), especially in light of regional utilisation*
Size and rareity of the wetland type/s present	1	*4*	Not rare or large.	*Identification and rareity assessment of the wetland types*
Diversity of habitat types	2	*3*	Two types of wetland (unchanneled valley-bottom and seep) present. Artificial pooling and the creation of mudflats, due to impeeded flow, increase the diversity of wetland habitats.	*Assessment of the variety of wetland types present within a site.*
Sensitivity of the wetland	**1.00**	**3.67**		
Sensitivity to changes in floods	1	*4*	Seeps	*floodplains at 4; valley bottoms 2 or 3; pans and seeps 0 or 1.*
Sensitivity to changes in low flows/dry season	1	*3*	Wetlands are already fairly channelized or impeeded by roads	*Unchannelled VB's probably most sensitive*
Sensitivity to changes in water quality	1	*4*	Low sensitivity - No sensive species observed. Invertabrates observed (river crab, Potamonautes unispinus, and dragonflies Othetrum caffrum and Crocothemis erythraea) are tollerant of disturbance, nutrification and pollution.	*Esp naturally low nutrient waters - lower nutrients likely to be more sensitive*
ECOLOGICAL IMPORTANCE & SENSITIVITY	**1.60**	**3.80**	Moderate Importance and sensitivity to flow and habitat modifications.	

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	2	*4*	A population of Hypoxis rigidula and Gladiolus sericeovillosus and G. crassifolius in tempoary wetland and buffer.	*Uncommonly large populations of wetland species*
Migration/breeding/feeding sites	1	*2*	Possible but not obvious	*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*	Amersfoort highveld clay grassland is listed as vulnerable.	*SANBI guidance on the protection sutatus of the surrounding vegetation*
Regional context of the ecological integrity	2	*4*	the unmodified wetlands are regionally important	*Assessment of the PES (habitat integrity), especially in light of regional utilisation*
Size and rareity of the wetland type/s present	1	*4*	Not rare or large.	*Identification and rareity assessment of the wetland types*
Diversity of habitat types	2	*3*	Two types of wetland (unchanneled valley-bottom and seep) present. Artificial pooling and the creation of mudflats, due to impeeded flow, increase the diversity of wetland habitats.	*Assessment of the variety of wetland types present within a site.*
Sensitivity of the wetland	**1.33**	**3.67**		
Sensitivity to changes in floods	2	*4*	Unchanneled valley bottom	*floodplains at 4; valley bottoms 2 or 3; pans and seeps 0 or 1.*
Sensitivity to changes in low flows/dry season	1	*3*	Wetlands are already fairly channelized or impeeded by roads	*Unchannelled VB's probably most sensitive*
Sensitivity to changes in water quality	1	*4*	Low sensitivity - No sensive species observed. Invertabrates observed (river crab, Potamonautes unispinus, and dragonflies Othetrum caffrum and Crocothemis erythraea) are tollerant of disturbance, nutrification and pollution.	*Esp naturally low nutrient waters - lower nutients likely to be more sensitive*
ECOLOGICAL IMPORTANCE & SENSITIVITY	**1.60**	**3.80**	Moderate Importance and sensitivity to flow and habitat modifications.	