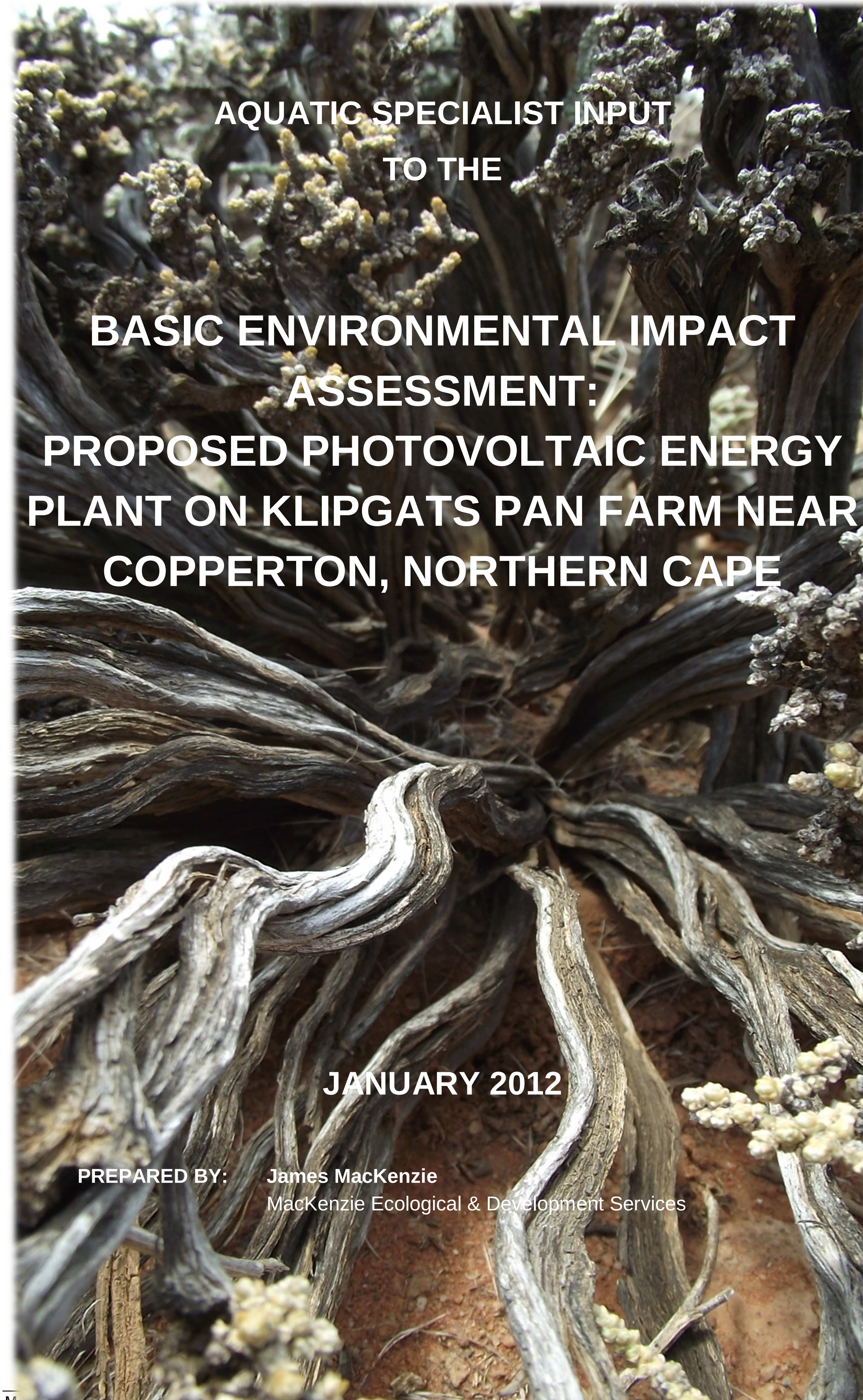

AQUATIC SPECIALIST INPUT

TO THE

BASIC ENVIRONMENTAL IMPACT ASSESSMENT: PROPOSED PHOTOVOLTAIC ENERGY PLANT ON KLIPGATS PAN FARM NEAR COPPERTON, NORTHERN CAPE

JANUARY 2012

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1 INTRODUCTION

1.1 BACKGROUND

Mulilo Renewable Energy (Pty) Ltd (Mulilo) proposes to construct a solar photovoltaic (PV) plant on the farm Klipgats Pan (Portion 4 of Farm No. 117), to generate approximately 100 MW,near Copperton in the Northern Cape. The proposed PV plant would cover an area of approximately 300 ha and would connect to the Kronos substation via a new 132 kV distribution line. Two potential sites were identified for further investigation. The current landuse of Klipgats Pan farm is predominantly sheep farming.

In terms of infrastructure required to service the proposed activity, the following would also be required (Aurecon, 2011):

- Upgrade existing internal farm roads as well as construction of new roads to accommodate construction vehicles and access to the site.
- Construction of a new 132 kV transmission line to connect the proposed PV plant to Eskom's grid via the Kronos substation.
- Erection of an electrical fence to prevent trespassing, and to exclude livestock.
- Construction of an office, connection centre and a guard cabin.

1.2 OBJECTIVES OF THE STUDY

The main objective of the study was to undertake an aquatic ecological assessment in order to

1) Assess the potential impacts that may affect site hydrology (water quantity) and water chemistry (quality) of streams, drainage channels, dams or wetlands during the construction and operational phases. To this end it was necessary to conduct riparian and wetland delineation procedures in order to define no-go and higher risk areas.
2) Evaluate impact criteria in order to ascertain their severity, and
3) Recommend mitigating measures aimed at minimising the predicted negative impacts and conflicts while retaining reasonable operational efficiencies.

The following specific tasks were carried out:

- Undertake an initial desktop study of reputable sources to provide background information for the aquatic ecological assessment.
- Collect primary data from rivers and/or wetlands on the site to provide information regarding wetland/riparian and instream (if any) sensitivity and importance.
- Undertake the requisite field work and compile a report that considers the following aspects:
    - Broad description of the aquatic ecology of the proposed sites
    - Delineation of any riparian zones or wetlands.
    - Conduct a comparative analysis for proposed PV positions and the alternatives in terms of environmental impact
    - Assessment of the ecological state, importance and sensitivity of aquatic ecosystems on the site,
    - General comment on whether ecosystem processes would be affected (including comment on how these would be affected)
    - Identification of potential impacts and recommendations to prevent or mitigate these
    - Outline any guidelines which may be relevant.
    - Outline any monitoring requirements, should this be needed.

1.3 SPECIALIST DETAILS

Specialist	Affiliation	Relevant expertise
James MacKenzie	M.E.D.S.	Riparian Vegetation: Environmental Flow Requirements (EFR); EcoClassification (VEGRAI); Riparian and wetland delineation; Ecological Importance and Sensitivity

1.4 DATA AVAILABILITY

Data availability for the aquatic assessment is shown in Table 1.1:

Table 1.1 Data availability for sites on the Klipgats Pan Farm.

Klipgats Pan	
Hydrology	No gauging weir of relevance
Diatoms	No data available for the farm, but diatom data exist for other typical endorheic pans in the region (Koekemoer, pers com).
Water Quality	No data available for the farm, but given the soils forms at the site, when pans hold water it is likely to of higher salinity
Fish	No data available for the farm, but given the degree of ephemerality no fish species are likely.
Macroinvertebrates	No SASS surveys available,
Vegetation, including wetland and riparian vegetation	Satellite images (Google earth) of the area (August 2005). Biomes and vegetation types of South Africa: (Rutherford, 1997; van Wyk & van Wyk, 1997; Mucina & Rutherford, 2006) SANBI Plant of Southern Africa online database (based on several herbaria collections). Data collected during field visit (November 2011).
Avifauna, especially associated with wet environments	Data collected during field visit (November 2011). Scoping report (Aurecon, 2011) Faunal distribution maps where relevant.

2 STUDY AREA

2.1 STUDY AREA DESCRIPTION

The study area occurs in the Northern Cape near the town of Copperton within the D54D quaternary catchment and the Lower Orange DWA water management area (part of the Hartbees River system). The area is well known for endorheic pans (which are a class of wetland, DWA 2005) and depressions (Nel *et al.*, 2011, Allan *et al,* 1995). The study area lies within the Nama Karoo Level 2 Ecoregion (26.04) described by Kleynhans et al. (2005, 2007), the Namib-Karoo-Kaokoveld Deserts and Shrublands WWF Terrestrial Ecosystems (Olson et al., 2004), and lies within the Arid Karoo and Desert False Grassveld Acocks veld types (Acocks 1988). Mean annual precipitation is approximately 137mm with peaks in late summer, usually March (DIVA GIS data, Fig 2.1, Mucina & Rutherford, 2006). Soils are generally base-rich, weakly structured and shallow, mostly Glenrosa and Mispah forms, with lime a feature of the landscape. Soils drain freely, usually with <15% clay and have characteristic high levels of salt (Mucina & Rutherford, 2006).

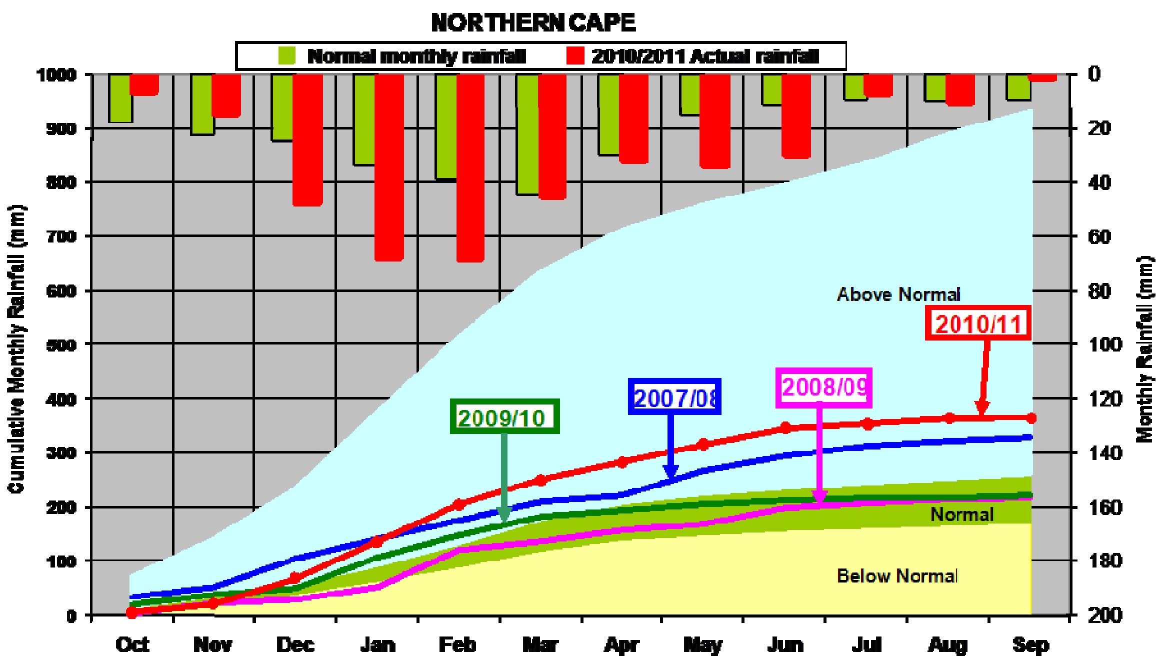

Figure 2.1 Rainfall summary and characteristics of the Northern Cape in general (Department of Water Affairs data)

2.2 SITE DESCRIPTION

The assessed area at Klipgats Pan occurs in the Bushmanland Basin Shrubland vegetation type, within the Nama-Karoo Biome and the Bushmanland Bioregion (Mucina & Rutherford, 2006). The area covered by the farm is generally flat to gently sloping, with drainage areas and pans being variously ephemeral. Some pans are not well defined although typical endorheic pans exist (Fig 2.2) (see note on pans below for more detailed information).

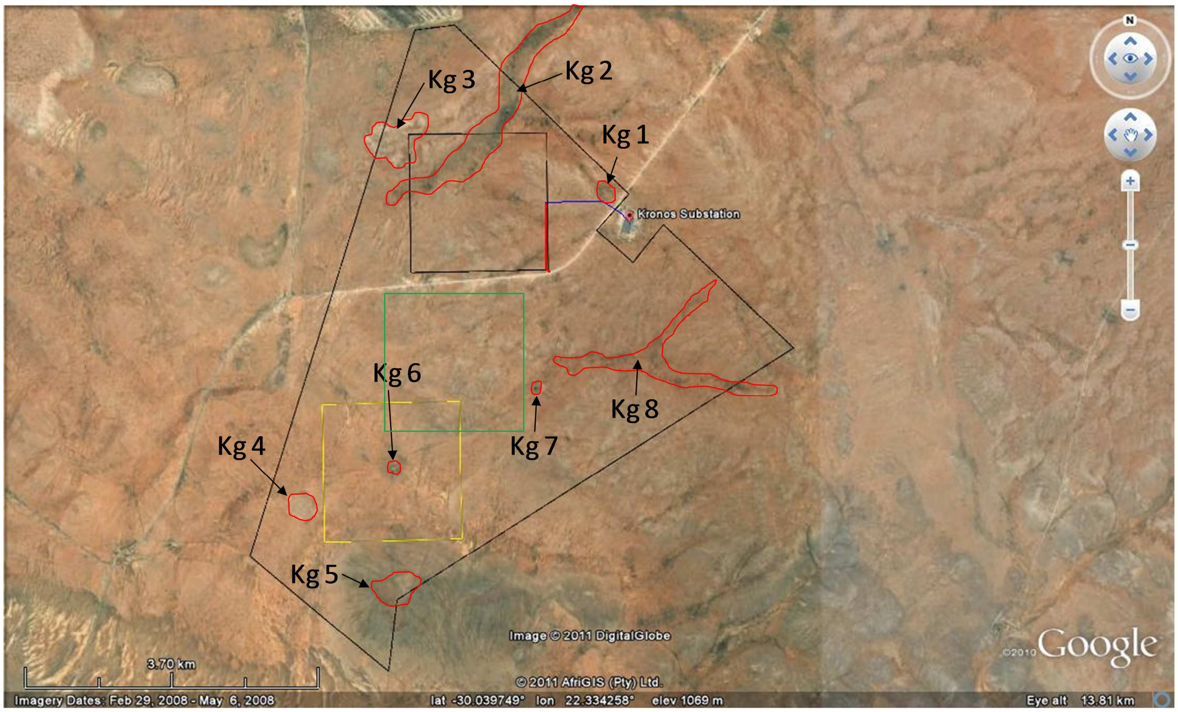

Figure 2.2 Satellite imagery (Google Earth ©, 2005) with boundaries of the farm Klipgats Pan superimposed and showing the Kronos substation. Also indicated are the preferred PV site (black square), alternate PV site (yellow square) and suggested PV site (green square) as well as drainage lines and relevant surface water features. Kg 1 and 4 are endorheic pans and Kg 2 and 8 form part of an ephemeral water course. For more details of features see section 3.2.

3 DELINEATION OF NO-GO AREAS

3.1 METHODS

Satellite imagery (Google Earth ©) was used to do a desktop assessment of all possible wetland (including pans) or riparian (including ephemeral drainage lines) features. These were noted and each possible feature visited for field verification. While in the field, all wetland and riparian features were delineated using topography, evidence of water movement through the landscape, evidence of water pooling in the landscape and changes in vegetation species composition and structure associated with such features. Features were then highlighted on satellite images as no-go areas i.e. ecologically sensitive areas where development should not occur.

3.2 SURFACE WATER FEATURES AND NO-GO AREAS

All features associated with surface water movement and pooling on the farm Klipgats Pan are shown in Fig. 2.2 and described in Table 3.1 below. Photographs of each feature are shown in Table 3.2. Pans are all rainfall dependant with little to no longitudinal connectivity in terms of water movement.

Table 3.1 Description of features investigated on the farm Klipgats Pan. Feature code refers to features shown in Fig. 2.2.

Feature code	Feature Description	No-go Area
Kg1	Small endorheic pan, extremely ephemeral, grass covered centre with shrub (mostly *Lycium cinereum*) boundary. Some *Prosopis glandulosa* present.	Yes
Kg2	This is a continuation of Hp1 on the farm Hoekplaas, essentially and rainfall drainage area that is not well defined or incised. Vegetation is slightly different with *Lycium cinereum* and *Rhigozum trichotomum* occurring along the drainage line and an elevated prevalence of *P. glandulosa*.	Yes
Kg3	This area was investigated due to its pattern on satellite imagery, but features are not endorheic pans and appear to be higher lying areas that are calcareous and support higher concentration of grasses, or are bare. Slight, localised inundation is likely following rain events but duration of inundation will be short.	No
Kg4	This is likely Klipgats Pan. It is a typical endorheic pan with an unvegetated centre characterised by open sediments and boulders. Inundation clearly takes place although it was dry at the time of the assessment. The unvegetated centre is surrounded by a zone of grass and small shrub, 100 – 150m wide and this is followed by an approximately 10m band of taller shrubs (typically *Lycium cinereum* and *Rhigozum trichotomum*).	Yes
Kg5	This area is high ground with drainage evident down the slope, but	No

	not a pan or surface water feature.	
Kg6 & 7	These are circular areas of grazing and trampling impact around watering points associated with wind pumps. They are most likely to be artificially wet features and not pans or depressions. The presence of sedges at these features indicates permanent inundation, but this is from underground water being regularly pumped and spilled.	No
Kg8	Drainage area that clearly channels flowing water during rain events. Vegetation composition and structure is different from upland area with a higher grass abundance and individual *P. glandulosa* along its route. Slight erosion and sediment movement is evident from past flows.	Yes

Table 3.2 Photographs (taken in Nov 2011) of all features investigates on the farm Klipgats Pan. Feature codes and descriptions correspond to those in a Table 3.1.

 Kg1	 Kg2
 Kg3	 Kg4
 Kg5	 Kg6

 Kg8	

3.3 SUGGESTED SITE FOR PV PLANT

After consideration of no-go areas a site has been suggested for a 100MW PV Plant where none of the no-go areas will be affected. The suggested site is indicated as a green square (approximately 300 ha) on satellite imagery in Fig. 2.2.

4 IMPACT ASSESSMENT

4.1 METHODS

Potential impacts for the construction and operational phases were assessed for the study site and mitigation measures per potential impact provided. The criteria for assessing type, spatial extent, duration, intensity and probability of potential impacts are shown in **Error! Reference source not found.**. These and the relevant abbreviations apply to all impact assessment in this report.

Table 4.1 The criteria for spatial extent, duration and probability of an impact, and confidence in the assessment.

Criteria	Categories	Abbreviation used in Tables	Explanation
Type	Negative	*N*	*Overall will represent a negative impact*
	Positive	*P*	*Overall will represent a positive impact*
Spatial Extent	Site	*S*	*Immediate area of activity*
	Local	*L*	*Area within 10km of the river site*
	Regional	*R*	*Entire drainage basin, municipal area, landscape etc*
	National	*N*	*South Africa*
Duration	Short-term	*S*	*0-1 year (or construction period)*
	Medium -Term	*M*	*1-5 years (initial operation)*
	Long-term	*L*	*5-20 years*
	Permanent	*P*	*Permanent change*
Significance	High	*H*	*Likely to lead to irreversible loss in ecosystem integrity at the spatial extent identified*
	Medium	*M*	*Likely to lead to major loss of ecosystem*

			functionality
	Low	*L*	*Possible loss of ecosystem integrity, but no deterioration in PES*
	Very Low	*VL*	*Unlikely to have measurable effect*
	Neutral	*N*	*No predicted impact*
Probability	Unlikely	*U*	
	Possible	*Po*	
	Probable	*Pr*	
	Definite	*D*	

The significance rating provided is that significance WITH mitigation and WITHOUT mitigation. Mitigation potential describes the ability to manage or mitigate an impact given the necessary resources. Some impacts, by their very nature are extremely difficult to mitigate, while others may be managed to an acceptable level with the implementation of a sound environmental management plan. The mitigation potential as presented in the sections below, is described in **Error! Reference source not found.**. Mitigation measures were recommended. It should be noted that a LOW mitigation potential does not necessarily imply that the impact is highly significant. An impact with a low significance rating may be extremely difficult to mitigate, while a highly significant impact may be relatively simple to mitigate with the implementation of the correct management measures.

Table 4.2 Definitions used for mitigation potential.

Mitigation potential	**Description**	**Example**
HIGH:	• The impact is relatively easy and cheap to manage. Specialised expertise or equipment is generally not required. • The nature of the impact is understood and may be mitigated through the implementation of a management plan, with regular monitoring undertaken to ensure that any negative consequences remain within acceptable limits. • The significance of the impact after mitigation is likely to be LOW to Non-Significant. • These impacts are normally mitigated by "good housekeeping".	Litter Clearing and nursing of protected plant species Bank stabilisation with planting (Bioengineering approach) Substrate continuity beneath crossing
MEDIUM:	• Management of this impact requires a higher level of expertise and resources in order to maintain within acceptable	Visual Impacts Changes to instream habitat

	levels • The significance of the impact after mitigation is likely to be LOW to MEDIUM depending on the level of management applied. • May not be possible to mitigate the impact entirely – may result in a residual impact (e.g. topographical change) • Despite mitigation being entirely possible, if complex, the experience of the assessor/s suggests that this /these mitigation measures are seldom managed successfully, and they are thus assessed as MEDIUM or LOW. This is for a number of reasons, including a lack of understanding by the developer or contractor of the severity of the consequences of not mitigating adequately; a lack of disciplined auditing by the Environmental Control Officer; and inadequate planning for seasonal flow events (e.g. floods).	
LOW:	• Will not be possible to mitigate this impact entirely regardless of the expertise and resources applied. • The potential to manage the impact may be beyond the scope of the Project • Management of this impact is not likely to result in a measurable change in the level of significance.	Alteration in local flow velocity due to channel constraint (acceleration of flow in restricted areas, e.g. culverts)

4.2 POTENTIAL IMPACTS FOR CONSTRUCTION PHASE

a) Destruction (clearing and levelling) of no-go areas

This impact will occur should the PV Plant be placed in such a way that it covers one or more (or part of) of the no-go areas that have been delineated and will result in loss of wetland habitat (i.e. pans) or loss of surface water drainage functionality (should drainage zones be cleared or levelled). The same applies to the placement of offices or staff /

construction worker accommodations, even if these are temporary, as well as access roads and power lines.

IMPACT ASSESSMENT

TYPE:	Negative
SPATIAL SCALE:	Site
DURATION:	Permanent
PROBABILITY:	Possible
SIGNIFICANCE WITH MITIGATION:	Low
SIGNIFICANCE WITHOUT MITIGATION:	High

MITIGATION

Mitigation potential is high, especially for a 100 MW PV Plant, since the 300 ha is easily placed in such a way as to avoid all no-go areas. Similarly, access roads to the proposed development can easily be placed in such a way that no clearing within no-go areas should be necessary. Mitigation for the placement of a 300 MW PV Plant is somewhat more difficult in order to avoid no-go areas and will require a different arrangement (overall shape of the panel array) of the panels. Nevertheless, should a 300 MW PV Plant be required, this impact should be relatively easy to mitigate.

b) Formation of barriers to drainage areas

Ephemeral drainage areas (also no-go areas) exist in the farm Klipgats Pan (see Fig. 2.2) which should not be blocked such that the movement of water is impeded.

IMPACT ASSESSMENT

TYPE:	Negative
SPATIAL SCALE:	Site
DURATION:	Long term
PROBABILITY:	Unlikely
SIGNIFICANCE WITH MITIGATION:	Low
SIGNIFICANCE WITHOUT MITIGATION:	High

MITIGATION

Mitigation potential is high for 100 MW as placement of the plant need not require access roads across any defined drainage areas, but should additional access roads be required (in the case of 300 MW), these will also have to be built with culverts to prevent the impediment of water movement.

c) Erosion and / or sediment inputs to no-go areas

Denuded areas and stockpiles of aggregates or soil should be protected in such a way that erosion or sediment inputs to no-go areas during rainfall events is prevented.

IMPACT ASSESSMENT

TYPE:	Negative
SPATIAL SCALE:	Site
DURATION:	Short term

PROBABILITY:	Possible
SIGNIFICANCE WITH MITIGATION:	Low
SIGNIFICANCE WITHOUT MITIGATION:	Medium

MITIGATION

Use of erosion control measures to minimise erosion at excavation / clearing sites or aggregate storage sites. Earth moving construction activities to take place in dry season as far as possible.

d) Increased invasion by alien plant species, especially perennial aggressive species such as *Prosopis glandulosa*

P. glandulosa already exists on the farm and is associated with areas of elevated wetness and inundation i.e. is preferentially associated with wetland and riparian areas. Construction activities will promote the colonisation of *P. glandulosa*, which is a deep-rooted tree that utilises groundwater. However, the impacts for surface water are indirect in that *P. glandulosa* alters the species composition in its vicinity (by excluding indigenous flora) and promotes open more erodible sub-canopy areas. Due to its provision of shade, these areas also tend to get highly trampled which exacerbates potential erosion.

IMPACT ASSESSMENT

TYPE:	Negative
SPATIAL SCALE:	Site
DURATION:	Long term
PROBABILITY:	Probable
SIGNIFICANCE WITH MITIGATION:	Low
SIGNIFICANCE WITHOUT MITIGATION:	Medium

MITIGATION

Removal of perennial alien species such as *Prosopis glandulosa* at sites disturbed or cleared by construction activities. Care should be taken not to introduce additional seed or propagules of alien species that may be present in aggregates brought to site.

e) Waste reticulation and removal.

This impact pertains to the production of and handling of waste water.

IMPACT ASSESSMENT

TYPE:	Negative
SPATIAL SCALE:	Site
DURATION:	Short term
PROBABILITY:	Probable
SIGNIFICANCE WITH MITIGATION:	Very Low
SIGNIFICANCE WITHOUT MITIGATION:	Medium

MITIGATION

Employ recognised best practices, and prevent spillage, especially into no-go areas.

4.3 POTENTIAL IMPACTS FOR OPERATIONAL PHASE

a) Increased surface water runoff from panel washing activities

This impact has the potential to change the water balance in the vicinity of its application since average annual rainfall is so low and panel washing activities will introduce additional water (which supersedes rainfall) to the runoff surface. Additional water to a cleared surface has to potential to erode surface substrates (presumably bare soil in this case), but will also illicit a vegetative response in that vegetation (including alien species) will readily colonise the area due to elevated and regular soil moisture availability. Also, since the medium for washing will be water mixed with a mild detergent, the potential exists for altered water quality to nearby areas, depending on how runoff is dealt with and the exact dilution and chemical nature of the mix.

IMPACT ASSESSMENT

TYPE:	Negative
SPATIAL SCALE:	Site
DURATION:	Long term
PROBABILITY:	Probable
SIGNIFICANCE WITH MITIGATION:	Low
SIGNIFICANCE WITHOUT MITIGATION:	Medium

MITIGATION

This impact has both a quantity and quality component, and the severity of each depends on factors which are not exactly known i.e. the potential of falling water to erode soils will depend on the nature of the application and the erodibility of the substrate, and the alteration to soil chemistry will depend on the dilution and chemical nature of the washing medium. To best mitigate this impact it will be necessary to monitor both soil chemistry and erosion and only mitigate if required. Should it be required it should not be difficult to channel runoff in such a way as to minimise erosion, or to employ soil stabilising techniques in vulnerable areas. Should soil chemistry be affected (this is likely to be a increase in salinity), the nature of the washing mixture could be changed, or acceptable waste treatment employed. Monitoring, together with the development of an environmental management plan as operation proceeds will be the most effective strategy. It should be noted that waste water from the PV Plant should not be diverted to or decanted into any of the defined no-go areas.

b) Increased invasion by alien plant species, especially perennial aggressive species such as *Prosopis glandulosa*

P. glandulosa already exists on the farm and is associated with areas of elevated wetness and inundation i.e. is preferentially associated with wetland and riparian areas. Operational activities (especially maintenance of cleared areas and elevated moisture availability from panel washing) will promote the colonisation of *P. glandulosa*, which is a deep-rooted tree that utilises groundwater. However, the impacts for surface water are indirect in that *P. glandulosa* alters the species composition in its vicinity (by excluding indigenous flora) and promotes open more erodible sub-canopy areas. Due to its provision of shade, these areas also tend to get highly trampled which exacerbates potential erosion.

IMPACT ASSESSMENT

TYPE:	Negative
SPATIAL SCALE:	Site
DURATION:	Long term
PROBABILITY:	Probable
SIGNIFICANCE WITH MITIGATION:	Very Low
SIGNIFICANCE WITHOUT MITIGATION:	Medium

MITIGATION

Removal of perennial alien species such as *Prosopis glandulosa* at sites disturbed or cleared, or where panel washing occurs. This will likely be an ongoing maintenance activity since the shade cast by *P. glandulosa* will be undesirable near the PV Plant, but should runoff occur from panel washing activities, *P. glandulosa* would need to be cleared in these areas as well.

c) Domestic waste reticulation and removal.

This impact pertains to the production of and handling of domestic waste water i.e. ablution facilities at offices.

IMPACT ASSESSMENT

TYPE:	Negative
SPATIAL SCALE:	Site
DURATION:	Long term
PROBABILITY:	Probable
SIGNIFICANCE WITH MITIGATION:	Very Low
SIGNIFICANCE WITHOUT MITIGATION:	Medium

MITIGATION

Employ recognised best practices, and prevent drainage from septic tanks / soak aways to enter no-go areas.

5 MONITORING / REHABILITATION REQUIRED

The National Water Act (NWA, Act No. 36 of 1998) requires the establishment of a national monitoring system that must provide for the collection of appropriate data and information necessary to assess water resources (DWAF, 2009a). (It should be noted that ephemeral drainage lines are classified as streams and endorheic pans as a recognised type of wetland, and as such enjoy protection under the Act). Such a system should collect relevant information that contributes to the management of the resource in a desirable ecological condition.

The need for pragmatic and easy to apply methods to monitor instream habitat led to the development of the Rapid Habitat Assessment Method (RHAM) (DWA, 2009b). This method aims to provide a rapid approach to assess instream habitat conditions in wadeable and to a more limited degree, non-wadeable streams. The premise of the RHAM is that suitable habitat conditions will indicate the likely presence, abundance and frequency of occurrence of particular biota. Baseline conditions are used to assess the possible future change in habitat conditions and the derived impact on the indicator biota. Available data and expert knowledge is used to associate particular habitat conditions with different indicator biota and the relevant ECs.

However, since all features on the farm Klipgats Pan are rainfall dependant systems, one cannot speak of environmental flow requirements in that there are no upstream or downstream requirements or obligations. As long as waste water from PV Plant activities does not enter any of the defined no-go areas, and as long as surface water is not abstracted from pans or drainage channels when water occurs, there should not be a need for monitoring in the no-go areas. As mentioned above, monitoring of soil chemistry and erosion in areas directly associated with the PV Plant is required and the results will define any operational mitigation or post Plant closure rehabilitation that may be required. To this end it is recommended that development of the PV Plant go hand in hand with the development of an environmental management plan, to be executed during Plant operation.

6 CONCLUSIONS AND RECOMMENDATIONS

The area covered by the farm Klipgats Pan is generally flat to gently sloping, with drainage areas and a few endorheic pans which contribute to the biodiversity of the area (Noss, 1990). Such endorheic pans, generally defined as circular or oval, shallow, closed drainage systems, are recognised by the Department of Water Affairs as a legitimate type of wetland, and as such are protected in accordance with the National Water Act (Act No. 36 of 1998). As such, these areas have been delineated as no-go areas (see Fig. 2.2) and should be avoided by the proposed PV Plant development. In addition no abstraction of water from these no-go areas should occur, although due to their ephemeral nature it is unlikely that this will occur. Similarly, no waste waters from PV Plant activities should be decanted into these no-go areas.

Since the proposed development will either pipe or truck water in from outside sources, water use of the water resource at the site will be insignificant. However, the additional water spilled to the soil surface from washing of solar panels has the potential to elevate soil erosion and /or alter soil chemistry. This impact has both a quantity and quality component, and the severity of each depends on factors which are not exactly known i.e. the potential of falling water to erode soils will depend on the nature of the application and the erodability of the substrate, and the alteration to soil chemistry will depend on the dilution and chemical nature of the washing medium. To best mitigate this impact it will be necessary to monitor both soil chemistry and erosion and develop mitigation strategies if required. Should it be required it should not be difficult to channel runoff in such a way as to minimise erosion, or to employ soil stabilising techniques in vulnerable areas. Should soil chemistry be affected (this is likely to be an increase in salinity), the nature of the washing mixture could be changed, or acceptable waste treatment employed. Monitoring, together with the development of an environmental management plan as operation proceeds will be the most effective strategy.

7 REFERENCES

Acocks, J.P.H. (1988). Veld types of South Africa, 3rd edn. Memoirs of the Botanical Survey of South Africa No. 57.

Allan, D.G., Seaman, M.T. and Kaletja, B. (1995). The endorheic pans of South Africa. In Wetlands of South Africa (G.I. Cowan, ed.) pp. 75±102. Department of Environmental Affairs and Tourism. Pretoria.

AURECON. 2011. Proposed Photovoltaic Energy Plant on Struisbult Farm near Copperton, Northern Cape: Draft Scoping Report. *Report No. 5749/107516.*

Department of Water Affairs, South Africa. (2009a). Operationalise the Reserve: Main Report. Prepared by Water for Africa. Compiled by D Louw and S Louw. RDM Report no. RDM/NAT/05/CON/0907.

Department of Water Affairs, South Africa. (2009b). Operationalise the Reserve: Rapid Habitat Assessment Model Manual. Prepared by Water for Africa. Authored by D Louw and CJ Kleynhans. Report no RDM/ Nat/00/CON/0707.

Kleynhans, CJ, Thirion, C and Moolman, J. (2005). A Level I River Ecoregion Classification System for South Africa, Lesotho and Swaziland. Report No. N/0000/00/REQ0104.Resource Quality Services, Department of Water Affairs and Forestry, Pretoria.

Kleynhans, C.J., Thirion, C., Moolman, J. and Gaulana, L. (2007). A Level II River Ecoregion classification System for South Africa, Lesotho and Swaziland. Report No. N/0000/00/REQ0104. Resource Quality Services, Department of Water Affairs and Forestry, Pretoria, South Africa.

Mucina, L. and Rutherford, M.C. (*eds*) (2006). The Vegetation of South Africa, Lesotho and Swaziland. Strelizia 19. South African National Biodiversity Institute, Pretoria.

Nel J.L., Driver A., Strydom W.F., Maherry A., Petersen C., Hill L., Roux D.J., Nienaber S., van Deventer H., Swartz E. and Smith-Adao A.B. (2011). ATLAS of FRESHWATER ECOSYSTEM PRIORITY AREAS in South Africa: Maps to support sustainable development of water resources Report to the WRC. No. TT 500/11.

Noss, R.F. (1990). Indicators for monitoring biodiversity: A hierarchical approach. Conservation Biology 4:355-364.

Olson, D.M., E. Dinerstein, E.D. Wikramanayake, N.D. Burgess, G.V.N. Powell, E.C. Underwood, J.A. D'Amico, I. Itoua, H.E. Strand, J.C. Morrison, C.J. Loucks, T.F. Allnutt, T.H. Ricketts, Y. Kura, J.F. Lamoreux, W.W. Wettengel, P. Hedao, and K.R. Kassem. (2004). Terrestrial Ecoregions of the World: A New Map of Life on Earth (PDF, 1.1M) BioScience 51:933-938.

Rutherford, M.C. (1997). Categorization of biomes. In: (eds. Cowling, R.M., Richardson, D.M. and Pierce, S.M.). Vegetation of Southern Africa. Cambridge University Press, Cambridge.

SANBI (2009). Biodiversity data provided by: South African National Biodiversity Institute (Accessed through the SIBIS portal, sibis.sanbi.org, 2009-06-01) .

Van Wyk, B. and van Wyk, P. (1997). Field Guide to Trees of Southern Africa. Struik. Cape Town..