Bloemsmond 5 PV
Near Upington, Northern Cape

Aquatic Specialist Study

for

Bloemsmond Solar 5 (Pty) Ltd

June 2019

by

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DECLARATION OF CONSULTANTS INDEPENDANCE

This report was compiled by Jacqueline (Jackie) Dabrowski, the Director of Confluent Environmental (Pty) Ltd. Jackie holds a Ph.D. in Veterinary Science and her post-graduate studies were in the field of freshwater ecology. She has conducted research and published scientific articles on a range of topics including aquatic food webs, fish health, and trends in water quality, branchiopod diversity, and land-use impacts on water quality. Her consulting work has focussed on a range of environmental assessments of dams, rivers, ephemeral watercourses and wetlands at various locations in South Africa.

At the time of conducting this study, I declare that:

- I am an independent specialist consulting in the field of Aquatic Science;
- I do not have any financial interest in the undertaking of the activity, apart from remuneration for work performed in terms of the Environmental Impact Assessment Regulations, 2014;
- I do not have any vested interest in the proposed activity proceeding;
- I will not engage in any conflicting interests in the undertakings of the activity;
- I undertake to disclose to the competent authority any relevant information with the potential to influence the decision of the competent authority or the objectivity of the report; and,
- I will provide the competent authority with access to all information at my disposal regarding the application, whether this information is favourable to the applicant or not.

Jackie Dabrowski (Ph.D., Pr.Sci.Nat. *Aquatic Science*)
SACNASP Registration Number 115166

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1 INTRODUCTION

1.1 BACKGROUND

AEP Bloemsmond Solar 5 (Pty) Ltd is proposing the development of the Bloemsmond Solar 5 PV Facility as well as all associated infrastructure on a site to be located within Portion 5 and Portion 14 (two adjacent farm portions) of the farm Bloemsmond 455. Confluent Environmental (Pty) Ltd were appointed by Bloemsmond Solar 5 (Pty) Ltd to provide aquatic specialist inputs to a Basic Assessment Report (BAR) for the development. Bloemsmond 5 is one of five PV Developments planned for the farm. The inputs of an aquatic specialist are required for the BAR and Water Use Authorisation (WUA) of the target areas where the establishment of the solar energy facility and associated infrastructure is proposed to be located. As well as to provide a professional opinion on surface hydrological issues pertaining to the target area and potential mitigation and measures to aid in future decisions regarding the proposed project and to minimise the significance of identified impacts for Bloemsmond 3. The site is located approximately 30 km south west of Upington and 16 km north east of Keimoes in the Kai !Garib Local Municipality (ZF Mgcawu District Municipality) in the Northern Cape.

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1.2 DEVELOPMENT DESCRIPTION

The technology proposed consists of arrays of photovoltaic (PV) solar panels with fixed-tilt, single-axis tracking or dual-axis tracking mounting structures. Fixed-tilt panels are north-facing at a defined angle of tilt, while single-axis panels have the ability to track the sun in an east-west trajectory. A typical tracker moves from -55° to +55° (Figure 1). Dual-axis trackers have the extra ability to adjust the tilt of the panels to capture more sunlight. The solar panels would be mounted at a maximum of ± 3.5m from the ground. The generation capacity of the array would be 100MW and the project would connect to the national grid via the Bloemsmond Collector Substation to the Upington Major Transmission Substation (MTS).

Within the solar array infrastructure in the ground is limited to steel H beams (150mm x 100mm) that are driven vertically into the ground and placed approximately 10m apart (Figure 1). A horizontal torque tube is mounted to the H beams approximately 1m above-ground, and the panels are attached to this. Tall vegetation that may impede movement of the panels (if trackers are installed) is slashed, but no earthworks or topsoil removal takes place for the mounting of the PV panels.

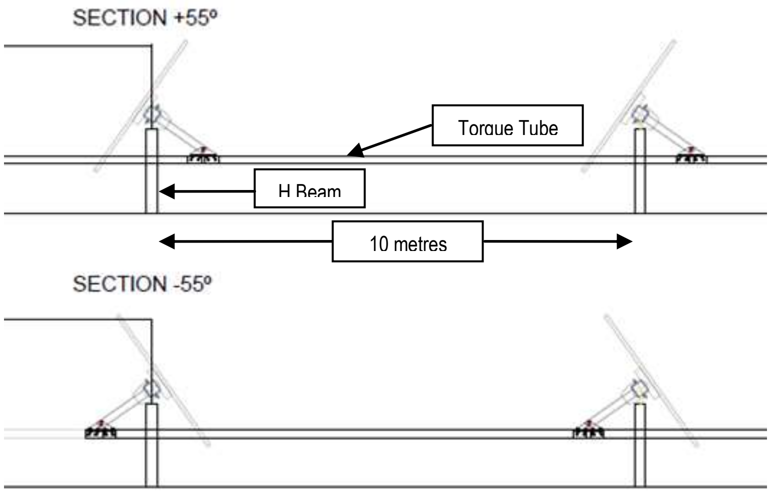

Figure 1. Typical layout of solar panels on a tracker system mounted on horizontal torque tubes attached to vertical H beams.

The entire development footprint includes PV panels, auxiliary buildings, an onsite sub-station, inverter stations and access roads. Auxiliary buildings consist of gate houses, ablutions, workshops, storage, a visitor centre and warehousing. These buildings will be situated at the laydown area at the access to the project site. Access roads will be up to 8m wide and 15km in length, the proposed access road largely follows the existing farm access.

1.3 SCOPE OF WORK

The scope of work covers the following aspects:

- Characterisation of the affected aquatic ecosystem in relation to its current and reference condition using methods recognised by the Department of Water and Sanitation (DWS) to determine the Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS);
- Classify and delineate all watercourses at the site;
- Consideration of the development of the solar array within the broader catchment context;
- Identification and assessment of the mitigated and unmitigated environmental impacts resulting from all phases of the development (design & layout, construction, operational etc.); and,
- Provision of recommendations for mitigating and monitoring impacts.

1.4 RELEVANT LEGISLATION

Any reference to a watercourse in this report is based on the definition in the National Water Act (NWA; Act 36 of 1998) which defines a watercourse as:

a) a river or spring;
b) a natural channel in which water flows regularly or intermittently;
c) a wetland, lake or dam into which, or from which, water flows ; and

d) any collection of water which the Minister may, by notice or Gazette, declare to be a watercourse.

Additional legislation relevant to this report includes:

- General Authorizations (GAs): As promulgated under the National Water Act and published under GNR 398 of 26 March 2004;
- South African Constitution Act 108 of 1996;
- National Environmental Management Act 107 of 1998;
- Environment Conservation Act (ECA) (No 73 of 1989) and amendments; and,
- National Environmental Management Act: Biodiversity Act / NEMA:BA (Act No. 10 of 2004) and amendments.

1.5 ASSUMPTIONS AND LIMITATIONS

- This assessment is based on the findings of a visual assessment of the site combined with available desktop resources. This study was not informed by detailed geohydrological or hydrological assessments;
- The assessment was conducted once-off during the late wet season and therefore lacks detailed information on seasonal and inter-annual variation inherent in natural ecosystems.
- The study area is very large, and it was not possible to inspect every individual drainage line. As a result, site-specific variations in sensitivity may have been missed in this report.

2 ATTRIBUTES OF THE AFFECTED AQUATIC ECOSYSTEM

2.1 CATCHMENT CONTEXT

The Farm Bloemsmond 455 is located within Quaternary Catchment D73F which drains into the Orange (alias Gariep) River (Figure 2). The Orange River is the only perennial river in the catchment which is otherwise dominated by non-perennial drainage lines and ephemeral pans and washes. Land-use at the farm is currently livestock and game farming with the dominant impact being grazing.

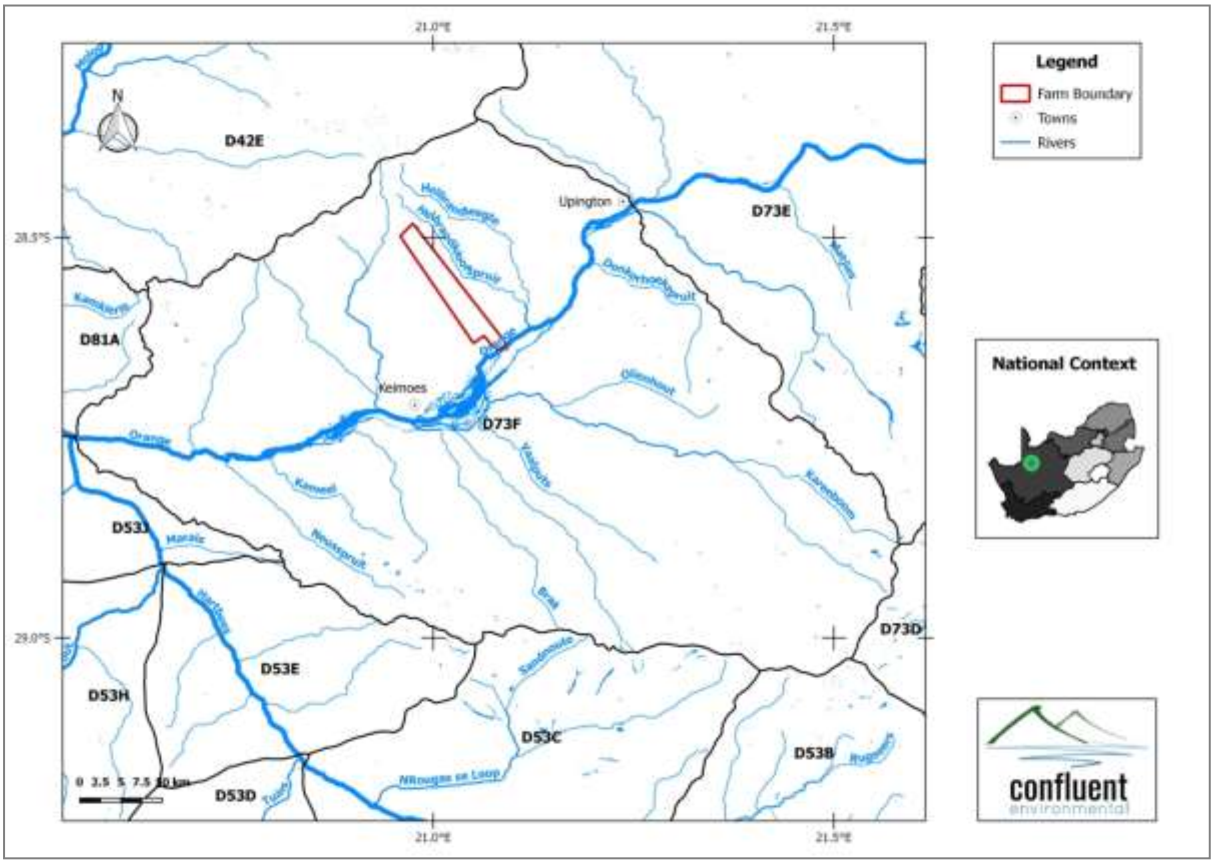

Figure 2. Location of Bloemsmond Farm in relation to quaternary catchments.

2.2 ECOREGION AND VEGETATION

The farm Bloemsmond is located in Ecoregion 26.05 of the Nama Karoo. Terrain is characterized by Irregular plains, dune hills with parallel crests and lowlands, and slightly irregular plains. The Mean Annual Precipitation is 0 – 300mm with most rainfall occurring in mid to late summer. Bloemsmond 5 is located near the boundary between Kalahari Karroid Shrubland and Bushmanland Arid Grassland (Mucina & Rutherford, 2006) and may therefore demonstrate characteristics of both vegetation types. The conservation status of both vegetation types is Least Threatened.

2.3 WATERCOURSE CLASSIFICATION

Aquatic ecosystem classification was determined according to a range of resources including Ollis *et al*. (2013). All the aquatic systems at Bloemsmond 5 are inland and are located in the Nama Karoo in Ecoregion 26.05. The drainage lines and alluvial washes occur on plains as well as slopes, while the pans occur on plains. The hydrological regime for all drainage lines is non-perennial with intermittent flows. The pans are ephemeral, and largely dependent on rainfall. A more detailed description of watercourses at the site is provided in the following sections and the location of watercourses at Bloemsmond 5 is shown in Figure 3.

2.3.1 Drainage Lines

Drainage lines follow flow paths through low points, connecting to form larger drainage lines, and ultimately, rivers. At Bloemsmond, there are no perennial streams or rivers, but during heavy rainfall events surface water runs off, creating channels which support distinctive bands of riparian vegetation. Riparian vegetation provides cover for terrestrial fauna for feeding, breeding and dispersal in the landscape. Drainage lines act as conduits for flood waters, delivering them to main stem rivers. As such, they should be retained in good condition to ensure water quality is not negatively affected downstream.

2.3.2 Pans

The pans at Bloemsmond are shallow depressions, usually oval in shape and measuring 20-50 m in diameter, but this may not be the case when they are associated with washes (see Section 2.3.3). The hydrology of pans at the site is not well understood, but they probably receive water from a combination of rainfall, river (drainage line) flow, and ground water. Some drainage lines are interspersed by pans. Pans that retain water and do not drain to other watercourses are termed endorheic (inward draining). They lose their water through evaporation or infiltration. Exorheic (outward draining) pans may drain a portion of their water into a drainage line or wash which can be via surface flow or interflow. The pans are not vegetated but have a distinct fringe of vegetation around their perimeter. Pans in this region typically host a range of branchiopod crustaceans which are specially adapted to survival in short-lived hydrological regimes. Their eggs survive extended dry periods and they emerge and mature rapidly when stimulated by wet conditions. Branchiopods are an important link in the terrestrial food web as they convert plant material (algae and detritus) into protein which is a valuable food resource, particularly for birds.

2.3.3 Alluvial Washes

Alluvial fans and washes do not fall into any of the HGM units defined by Ollis *et al*., (2013). Washes are characterized by unconsolidated alluvial sediments. Braided washes are common in low gradient arid systems with minimal valley confinement such as the site at Bloemsmond. They may have multiple channels and transient gravel bars. Washes may be cryptic and difficult to follow in the landscape as distinct channels can wash out into unconsolidated alluvium, also referred to as floodout zones. These areas play an important role in ground water recharge from floods as channelled flows are dispersed to shallow sheet flow which readily infiltrates the unconsolidated alluvium.

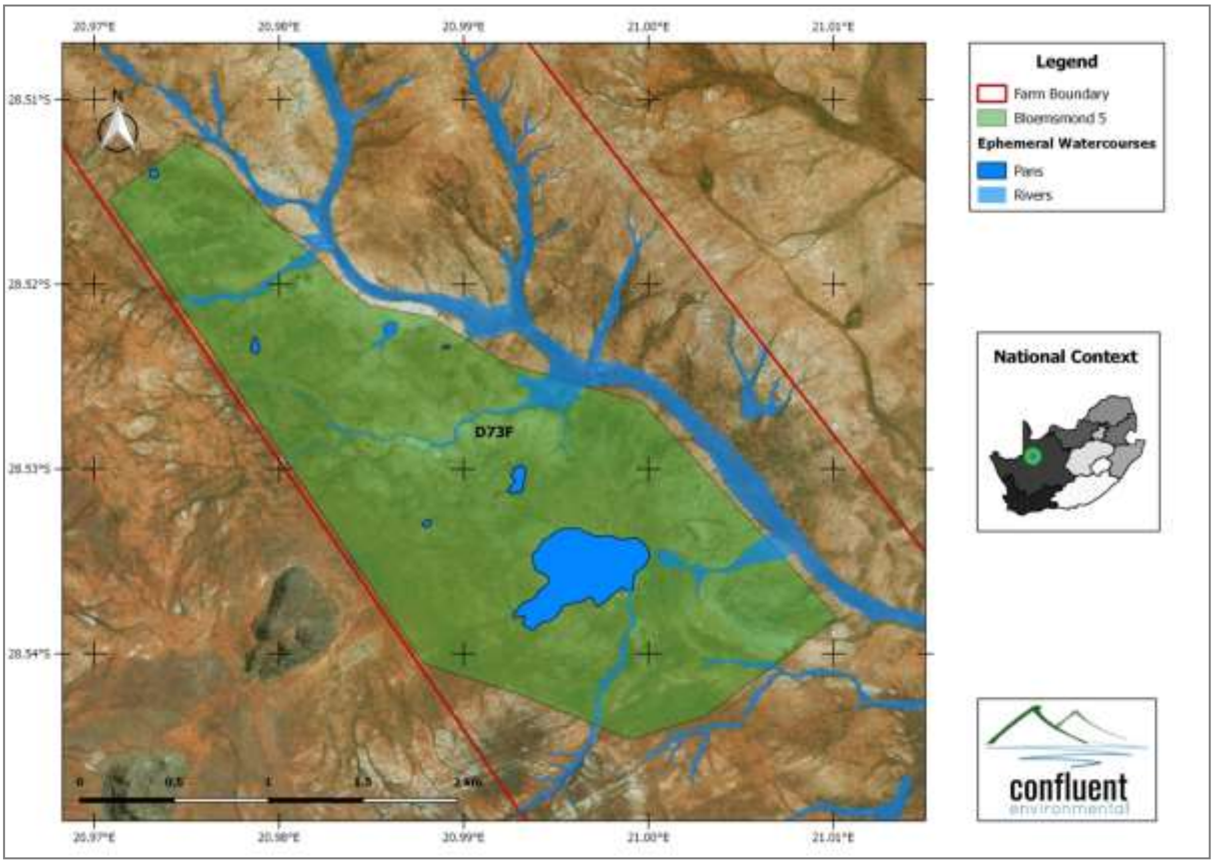

Figure 3. Ephemeral watercourses and pans associated with Bloemsmond 5

2.4 NATIONAL FRESHWATER ECOSYSTEM PRIORITY AREAS (NFEPA)

Bloemsmond Farm is located within two separate NFEPA sub-quaternary reaches (SQRs), 3051 in the northern portion, and 3193 in the southern portion (Figure 4; Nel *et al*., 2011). The full extent of Bloemsmond 5 is located in SQR 3051 which drains to Helbrandkloofspruit (a non-perennial tributary of the Orange River).

SQR 3051 is classified as an Upstream Management Area with the following management objectives:
These are sub-quaternary catchments in which human activities need to be managed to prevent the degradation of downstream Protected Areas and Fish Support Areas.

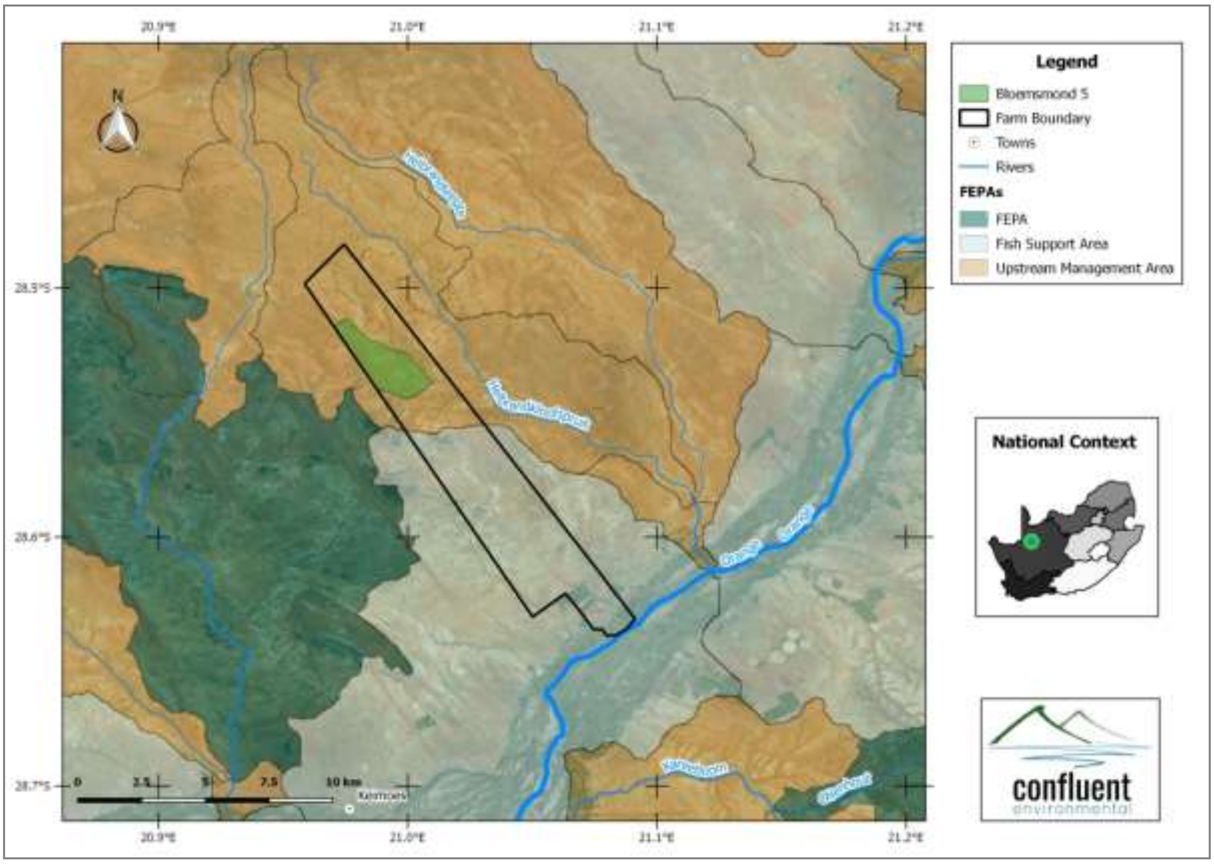

Figure 4. Map of Bloemsmond Farm showing Bloemsmond 5 in relation to NFEPA areas.

2.5 CONSERVATION STATUS

The Northern Cape Critical Biodiversity Areas (CBAs; 2016) does not identify any CBAs within Bloemsmond Farm, which is classified as Other Natural Area. The Helbrandkloofspruit is classified as an Ecological Support Area (ESA), but this is located beyond the footprint of Bloemsmond 5.

2.6 DESKTOP PRESENT ECOLOGICAL STATE & ECOLOGICAL IMPORTANCE AND SENSITIVITY (PESEIS)

Water resources can be defined by their degree of modification or impairment. Resource Quality and Information Services at DWS developed the desktop Present Ecological State (PES), Ecological Importance (EI) and Ecological Sensitivity (ES) assessment to achieve this for every sub-quaternary reach (SQR) in South Africa. The EI and ES class categories are rated as an indication of the vulnerability of the river reach to environmental modification. EI refers to biophysical aspects in the SQR that relate to its capacity to function sustainably. ES considers SQR attributes related to the sensitivity of biota to environmental changes such as flow, physico-chemical and geomorphology. The EIS is determined using a combination of expert knowledge and geospatial data to assess the estimated fish and macro-invertebrate species, along with riparian vegetation and vertebrates, and assessments of habitat (DWS, 2014). The PES categories used to describe the current condition of South African rivers are presented in Table 1.

Table 1: Present ecological state categories (DWS, 2014)

Ecological category	Description
A	Unmodified, natural
B	Largely natural
C	Moderately modified
D	Largely modified
E	Seriously modified
F	Critically / extremely modified.

The desktop Present Ecological State (PES; DWS, 2014) for SQR 3051 was not determined because the Helbrandkloofspruit system is ephemeral. The riparian zone associated with drainage lines in this SQR was assessed and their EI was classed as Very High. The methods used by DWS in desktop PESEIS assessments lean heavily toward impacts affecting communities of aquatic taxa including fish and macroinvertebrates, which are mostly absent from ephemeral systems.

2.7 HISTORICAL CONTEXT

The oldest historical aerial image that could be obtained was from 1964. This shows that the site within Bloemsmond Farm, and Bloemsmond 5 in particular is very similar in appearance to the present day (Figure 5). There has been little to no development at the site. The drainage lines and pans appear to be located in much the same position as their current location.

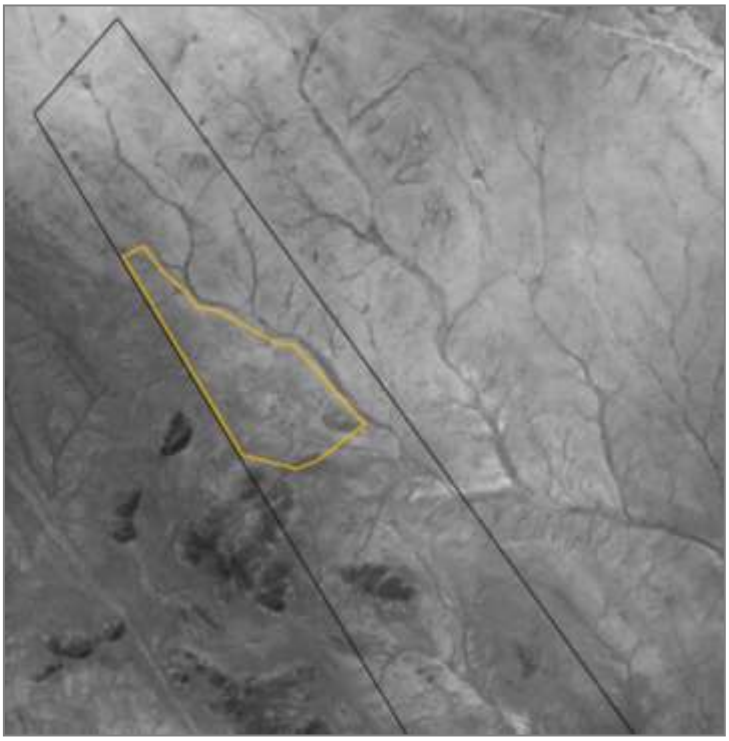

Figure 5. Historical aerial photo (1964) showing the approximate layout of Bloemsmond 5 (yellow line)

3 METHODS

3.1 SITE VISIT

The site was visited between 23 April and 26 April 2019 (4 days), which is considered to be representative of the late wet season. There was widespread light rainfall in the area on the day and evening before fieldwork commenced (22 April) resulting in small pools of water in rock pools. The rainfall was however insufficient to result in any surface flows or pooling in drainage lines or pans in the area.

3.2 SENSITIVITY MAPPING

Watercourses were delineated following the methods developed by DWAF for the delineation of wetlands and riparian areas (2008). In arid regions such as the Nama Karoo, vegetation is the best indicator for delineation of riparian zones along drainage lines as there is a very distinct change in vegetation structure characterized by robust growth forms compared to adjacent terrestrial areas. For pans (wetlands) in arid areas the conventional methods of wetland delineation are not appropriate. The soils of temporary wetlands in very arid areas are often too shallow, too saline, or too temporarily inundated to exhibit typical wetland features such as gleying and mottling (Day *et al*., 2009). Hydrophytic vegetation indicators are also not reliable indicators of wetlands in arid environments. During infrequent periods of inundation plants may include annual macrophytes and algae, but during long dry conditions, plants are typically terrestrial, often ruderal species that are not adapted to life in saturated soils (Day *et al*., 2009). As a result, the centre of arid pans in the area of inundation may be bare of vegetation. Other indices such as the presence of branchiopod crustaceans hatched from sediments of suspected wetlands can be used to confirm cryptic wetlands in arid environments. Similar to the drainage lines at Bloemsmond Farm, terrestrial vegetation surrounding pans had a distinctive, more robust growth form that was utilized for delineation of the pans. Satellite imagery was used for the delineation of all watercourses as vigorous growth associated with watercourses was easily observable. This method could be extended to the presence of alluvial washes associated with drainage lines and pans, because vegetation in these zones also displayed more robust growth forms.

Ephemeral drainage lines and to a lesser extent alluvial washes are a common feature of the landscape at Bloemsmond Farm. Therefore a system of grading drainage lines in terms of their ecological and hydrological function was developed in order to indicate drainage lines and washes of more / less importance. The grading system took the following parameters into account:

- Channel width (wider, more developed channels carry more water);
- Extent and structure of the riparian zone (width and presence of large shrubs and trees);
- Presence of vegetated sandbars and braiding along the river bed;
- Connectivity with other drainage lines;
- Evidence of degrading impacts (e.g. rubbish dumping, alien plants, vegetation removal, erosion, instream barriers);

Each system was determined to be of low, moderate or high sensitivity based on observations in the field and using satellite imagery. An example of typical drainage lines allocated these scores is provided in Figure 6**Error! Reference source not found.**. Buffers ranged depending on sensitivity with Low at 10m, Moderate at 20m and High at 30m.

All ephemeral pans are considered High sensitivity sites and are allocated a 50m buffer around the perimeter. They play an important role in providing standing (lentic) water following rainfall which supports drinking and feeding requirements for a wide range of taxa. They support specially adapted crustaceans (branchiopods) which convert detritus and algae into an important source of protein for birds. Very little is known about the taxonomy and distribution of the branchiopods of arid pans. Water infiltration from pans also replenishes ground water (Figure 7).

Figure 6. Example of drainage lines typical of Low (a), Moderate (b) and High (c) sensitivity at Bloemsmond Farm

Figure 7. A typical pan located on Bloemsmond Farm.

3.3 PRESENT ECOLOGICAL STATE DETERMINATION

3.3.1 Drainage Lines

Drainage lines were assessed collectively because they were determined to be in a very similar state with minimal impacts. The method used to determine the PES was the Index of Habitat integrity (IHI; Kleynhans, 1996) which measures the impact of human disturbance on riparian and instream habitats. The IHI is a rapid assessment of the severity of impacts affecting habitat integrity within a river reach. It can be applied to both perennial and non-perennial watercourses. The instream impacts considered were: water abstraction; flow modification; bed modification; channel modification; physico-chemical modification; inundation; alien macrophytes; and rubbish dumping. The riparian impacts assessed were: vegetation removal; exotic vegetation; bank erosion; channel modification; water abstraction; inundation; flow modification; physico-chemistry. Each of the impacts is given a score based on the degree of modification. An IHI class is then determined based on the resulting score (Table 2).

Table 2. Index of habitat integrity (IHI) classes and descriptions.

Integrity Class	Description	IHI Score (%)
A	Natural	> 90
B	Largely Natural	80 – 90
C	Moderately Modified	60 – 79
D	Largely Modified	40 – 59
E	Seriously Modified	20 – 39
F	Critically Modified	0 – 19

3.3.2 Pans

A number of small pans and one large pan complex was identified within the Bloemsmond 5 area. The RDM-99 protocol for rapid assessment of palustrine wetlands (on depressions or flats) was applied (DWAF, 1999). The Wetland Index of Habitat Integrity (IHI) and WET-Health methods (Macfarlane *et al*., 2008) were not used in this case because they were not developed for application to wetland flats or depressions. These methods were developed for floodplain, peat and valley-bottom wetlands The RDM-99 method evaluates a range of impacts potentially affecting the hydrology, water quality, geomorphology and biota of depressions and wetland flats. These impacts are scored from 0 – 5, with 0 being critically modified, and 5 being natural. Each score is allocated a level of confidence ranging from 1 being low confidence up to 4 being very high confidence. The end result is a PES score with the same categories as those presented in **Error! Reference source not found.**.

3.4 BRANCHIOPOD DIVERSITY

Given the limited understanding of the taxonomy and distribution of branchiopods in arid pans, branchiopods were collected from the site in order to positively identify them and determine whether any rare or new species occur at the site. Nauplii (juveniles) were collected from small standing pools where they had already emerged and were returned to the laboratory where they were raised to sexual maturity for identification. Sediment samples were collected from a number of dry pans at Bloemsmond Farm and were rewet in order to stimulate emergence of branchiopods and raise them to maturity.

4 RESULTS

4.1 SENSITIVITY MAPPING

Within the area proposed for Bloemsmond 5 there is a very large pan complex located towards the centre of the southern section. This area contains numerous small depressions where water accumulates, along with alluvial washes and areas of bedrock which contain small rockpools. The rockpools and pans contain branchiopods, as specimens were both collected and hatched from the site. The pans and rockpools fill up with water from rainfall and also receive surface water flows from the south-west where a low sensitivity drainage line connects to the pan system. Part of the pan has been excavated to enlarge it. There are also a number of smaller pans scattered throughout the remaining extent of the area. These have all been identified as high sensitivity sites with 50m buffer zones. These pans do not appear to have been modified in any way. A high sensitivity drainage line flows along the eastern boundary of Bloemsmond 5. Most of this drainage line is located outside of the development area apart from a section towards the middle where a number of low sensitivity drainage lines form a confluence with a number of pans that are linked to the larger system.

The sensitivity map showing these landscape features and their associated buffers is presented in Figure 8.

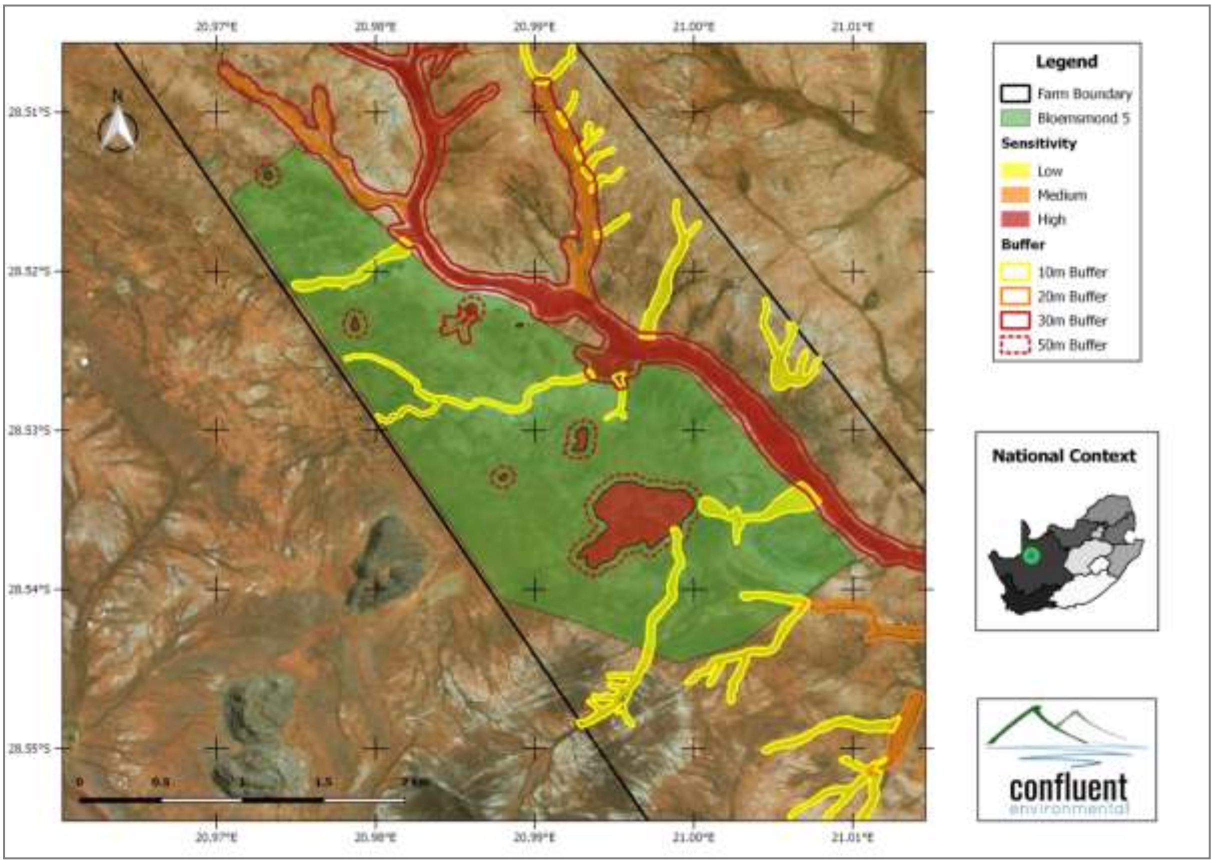

Figure 8. Sensitivity map for watercourses at Bloemsmond 5.

4.2 PRESENT ECOLOGICAL STATE

4.2.1 Drainage Lines

The drainage lines located within Bloemsmond have had very few negative impacts, restricted largely to the occasional road crossing by a dirt track (Table 3). As a result their PES was classified as **A, natural or closely approaching natural.** Riparian vegetation is mostly dominated by large shrubs and the instream habitat consists of unconsolidated sand and gravel. The riparian vegetation is conspicuous because it consists of the largest trees and shrubs in the landscape, providing habitat for a range of biota.

Table 3. Index of Habitat Integrity PES determination of instream and riparian habitat for drainage lines at Bloemsmond 5.

Habitat Modification	Score	Comments
INSTREAM HABITAT		
Water abstraction	0	Not observed
Flow modification	0	Not observed
Bed modification	3 (Small)	Few small dirt track crossings
Channel modification	3 (Small)	Few small dirt track crossings
Physico-chemistry	0	Not observed
Inundation	0	Not observed
Alien macrophytes	0	Not observed
Introduced aquatic fauna	0	Not observed
Rubbish dumping	0	Not observed
PES = A,Natural		
RIPARIAN HABITAT		
Vegetation removal	3 (Small)	Minor vegetation disturbance at dirt track crossings
Exotic vegetation	0	Not observed
Bank erosion	0	Not observed
Channel modification	3 (Small)	Localised disturbance at dirt track crossings
Water abstraction	0	Not observed
Inundation	0	Not observed
Flow modification	0	Not observed
Physico-chemistry	0	Not observed
PES = A, Natural		

4.2.2 Pans

A little standing rainwater was observed in rock pools (Figure 9 a, c and d) and pans within the pan complex at Bloemsmond 5. There was evidence that many animals utilize this standing water due to the abundance of fresh tracks observed at the site (Figure 9 a).

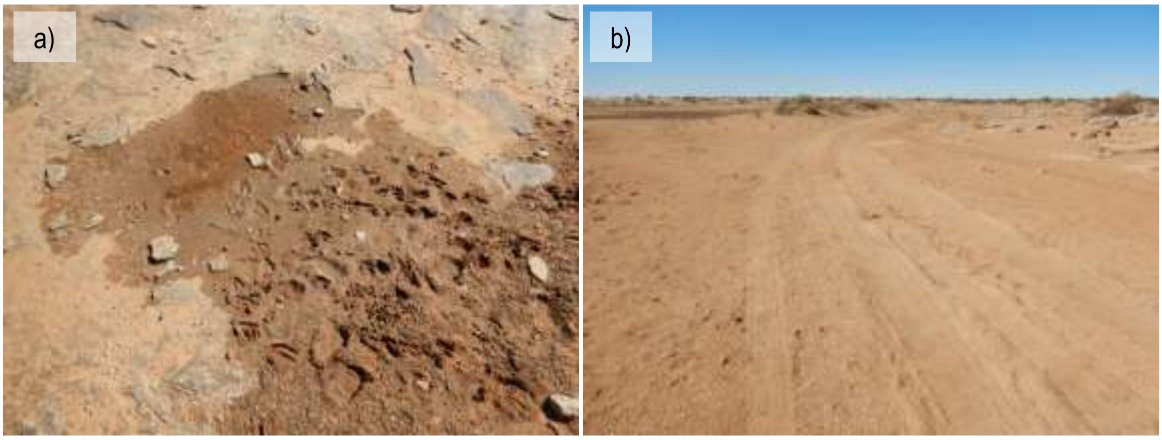

Figure 9. Pictures of different areas within the large pan complex in Bloemsmond 5 showing a) numerous animal tracks to a small pool, b) the dirt track crossing the pan complex, c) rocky areas where water pools following rains, and d) pans with small areas of water following rainfall.

Apart from rainwater, the large pan complex receives surface water from the drainage line to the south-west as there is a distinct channeled inflow. The pan area at the end of this channeled inflow has been excavated and enlarged to hold more water. Although the latter represents a modification to the hydrology and geomorphology of the pan, it has retained its main characteristic as an ephemeral pan. Other areas within the complex are not affected by any major impacts which was taken into consideration when determining the PES (Table 4). However, the enlargement of this section of the pan may result in water collecting in a single area and not dispersing over as large an area as it would have previously. This would result in other areas being more dependent on filling from rainwater alone. In addition to this impact, there are a number of minor impacts such as a dirt track that traverses through the middle of the area (Figure 9 b), and there is a minor fence running alongside the edge of the pan. Therefore the RDM-99 method classifies the PES of this pan as **A, natural or closely approaching natural**.

Table 4. PES assessment of the habitat integrity of the pan complex at Bloemsmond 5 using the RDM-99 method

Criteria	Comments	Score	Confidence
Hydrological			
Flow modification	Altered due to excavation	3	4
Permanent Inundation	Increase in hydroperiod, but not permanent	4	4
Water Quality			
Water quality modification	Increase in turbidity	4	3
Sediment load modification	Increase in suspended sediment	4	3
Geomorphology			
Canalisation	None	5	4
Topographic alteration	Main pan excavated to increase depth and capacity	3	4
Biota			
Terrestrial encroachment	Not observed	5	4
Indigenous vegetation removal	None observed	4	3
Invasive plant encroachment	None observed	5	3
Alien fauna	Goats and other livestock	4	4
Overutilisation of biota	Possible grazing / browsing pressure from livestock	4	3
Overall PES Category		**A**	**3.5**

The remaining pans within Bloemsmond 5 have almost no impacts except for possible over-utilisation by livestock, resulting in them being classified in the same category **A, natural or closely approaching natura**l.

5 BRANCHIOPOD DIVERSITY

Branchiopods were collected from rock pools and mud sediments from pans within Bloemsmond 5. The fairy shrimps and clam shrimps identified in this study were collected from the shallow rock pool shown in Figure 9 c. The species identified are likely to be found elsewhere on Bloemsmond Farm and surrounding areas in any suitable habitat such as pans, or on rocky substrates where water pools after rainfall.

The biodiversity of ephemeral pools at Bloemsmond Farm is typical of the community of crustaceans reported in arid areas of southern Africa. The species of fairy shrimps and clam shrimps identified are widespread in the Northern Cape.

A range of crustaceans adapted to extended periods of desiccation (drying out) were identified. These are presented in Table 5 with associated images in Figure 10.

Table 5. Crustaceans found at Bloemsmond Farm

Class	Order	Species (if identified)
Ostracoda (seed shrimps)		
Copepoda		
Branchiopoda	Anostraca (fairy shrimps)	*Branchipodopsis tridens*
	Conchostraca (clam shrimps)	*Leptestheriellla inermis*
	Notostraca (tadpole shrimps)	*Triops granarius*
	Cladocera (water fleas)	

The 0.2mm diameter eggs produced by these crustaceans rest in the sediment of pans and pools for extended periods (> 20 years) until they are stimulated to emerge following rewetting (Figure 10b). Development occurs rapidly so that reproduction occurs 4 – 7 days following rewetting, before the pool has a chance to dry out. If the sediments of these pools are disturbed or excavated, the egg bank could be lost. If the hydrological regime is altered from ephemeral to permanent inundation (e.g. through pumping in borehole water) the loss of desiccation phase interrupts the life cycle and these crustaceans can no longer persist.

Figure 10. Images of a copepod (a), anostracan (fairy shrimp) egg circled in sediment (b), an adult fairy shrimp (*Branchipodopsis tridens*) and male and female clam shrimps (*Leptestheriella* sp.; d).

6 IMPACT ASSESSMENT

The impact assessment considers direct, indirect and cumulative impacts to the aquatic ecosystem that may arise during the design, layout, construction and operational phases of the proposed solar array at Bloemsmond 5. Individual impacts are rated according to criteria which include their intensity, duration and extent. The ratings are then used to calculate the consequence of the impact which can be either negative or positive as follows:

Consequence = type x (intensity + duration + extent)

Where type is either negative or positive. The significance of the impact is then calculated by applying the probability of occurrence to the consequence as follows:

Significance = consequence x probability

The criteria and their associated ratings are shown in Table 6.

Table 6. Categorical descriptions for impacts and their associated ratings

Category	Description	Rating
Intensity	Negligible	1
	Very low	2
	Low	3
	Moderate	4
	High	5
	Very high	6
	Extremely high	7
Duration	Immediate	1
	Brief	2
	Short term	3
	Medium term	4
	Long term	5
	Ongoing	6
	Permanent	7
Extent	Very limited	1
	Limited	2
	Local	3
	Municipal area	4
	Regional	5
	National	6
	International	7
Probability	Highly unlikely	1
	Rare	2
	Unlikely	3

	Probably	4
	Likely	5
	Almost certain	6
	Certain	7

Categories assigned to the calculated significance ratings are presented in Table 7.

Table 7. Value ranges for significance ratings.

Significance rating	Range	
Major (-)	-147	-109
Moderate (-)	-108	-73
Minor (-)	-72	-36
Negligible (-)	-35	-1
Neutral	0	0
Negligible (+)	1	35
Minor (+)	36	72
Moderate (+)	73	108
Major (+)	109	147

Each impact is considered from the perspective of whether losses / gains would be irreversible or result in the irreplaceable loss of biodiversity of ecosystem services. The level of confidence is also determined and rated as low, medium or high (Table 8).

Table 8. Definition of reversibility, irreplaceability and confidence ratings.

Rating	Reversibility	Irreplaceability	Confidence
Low	Permanent modification, no recovery possible.	No irreparable damage and the resource isn't scarce.	Judgement based on intuition.
Medium	Recovery possible with significant intervention.	Irreparable damage, but is represented elsewhere.	Based on common sense and general knowledge
High	Recovery likely.	Irreparable damage, and is not represented elsewhere.	Substantial data supports the assessment

6.1 LAYOUT AND DESIGN PHASE IMPACTS

A summary of the impact associated with the layout and design phase with and without mitigation is presented in Table 9. The current layout proposed for Bloemsmond 5 was determined with prior inputs from both the aquatic and terrestrial specialist studies regarding known sensitive areas at the site. As a result the layout already avoids most moderate to high sensitivity features such as large drainage lines and koppies. For the most part, this upfront consultation has already mitigated many of the impacts associated with the planning and design phase. However, high sensitivity watercourses still occur in Bloemsmond 5, and developments in buffered areas should be avoided wherever possible. It is also possible that the layout could be further refined to exclude high sensitivity sites such as the pan complex and the pan and drainage line confluence on the eastern boundary (Figure 11). At Bloemsmond Farm, drainage lines and alluvial washes in particular are so numerous in the landscape that it is not realistic to expect that the development will avoid every single one. Further refinement of the development layout should consider the following mitigation measures:

<u>Mitigation Measures</u>

- Consider adjusting the boundary of Bloemsmond 5 to exclude the pan complex towards the centre of the development area, and the pan and drainage line confluence along the eastern boundary (circled in Figure 11). The latter occurs very close to the existing fence boundary and would therefore exclude the placement of panels between the boundary and the pan in any case. The area lost by these adjustments could be made up by expanding to the north and / or south of the current area.

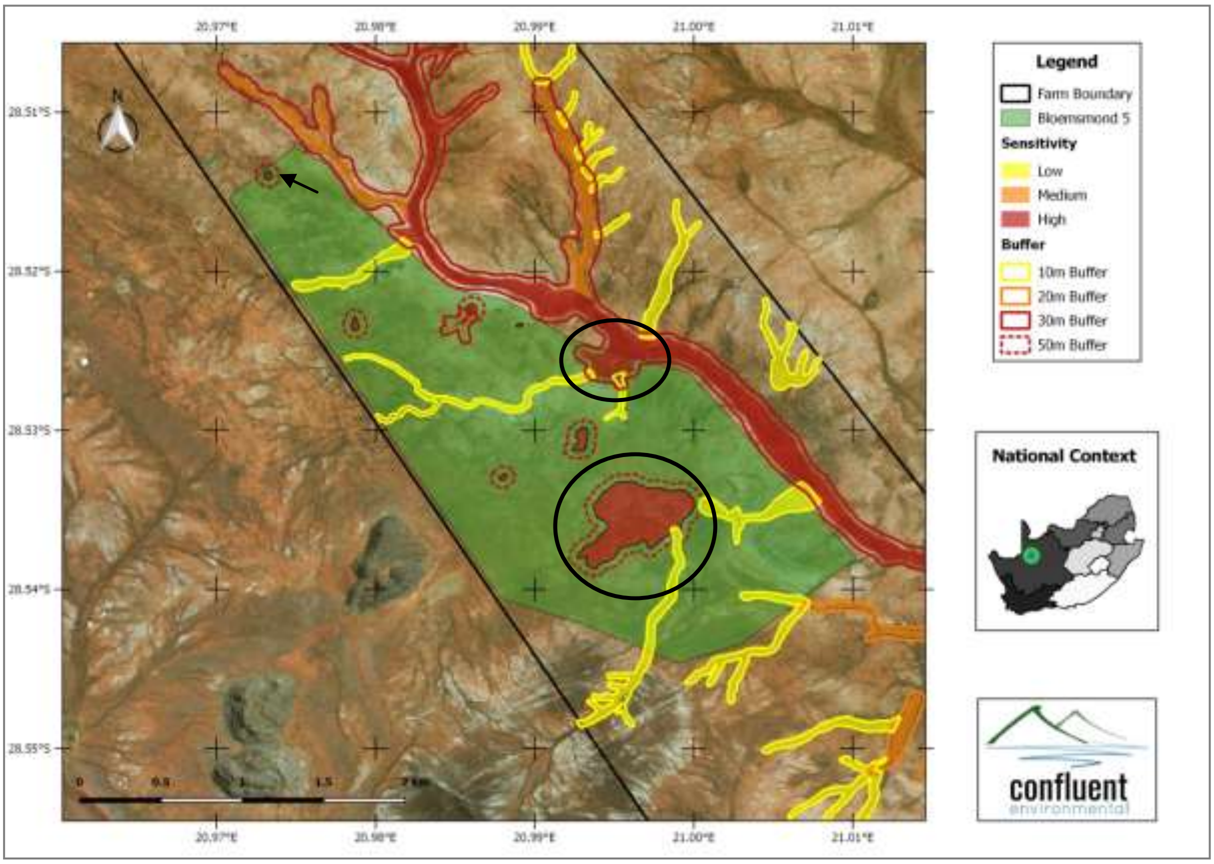

Figure 11. Sensitive watercourses at Bloemsmond 5 indicating pan areas suggested for exclusion from the development area (circled and arrow)

- Where sensitive areas such as pans occur in close proximity to fenced boundaries (example indicated by arrow in Figure 11), adjust the layout to exclude them from the development area as they occupy unnecessary space and their inclusion in the development area limits their range of ecological functions;
- No infrastructure (e.g. H beams) to be planned in any watercourse to avoid erosion as well as potential damage to infrastructure during surface flooding;

- Limit infrastructure (includes roads and torque tubes) crossing watercourses to the absolute minimum and in low sensitivity features only. These structures interrupt longitudinal connectivity resulting in habitat fragmentation and may limit the use of riparian zones as movement corridors;
- Limited development may be planned in buffer zones of low sensitivity watercourses;
- Buffer zones for pans and the pans themselves are no-go zones;
- Watercourse crossings for the proposed access road along the western boundary should be constructed in the same place as the existing road to minimize cumulative impacts; and,

6.1.1 Stormwater Management

The region is naturally arid and has low annual rainfall, but in the event of significant rainfall events stormwater from impervious surfaces will need to be effectively managed to limit erosion and conserve water. Impervious surfaces include roofs, paved parking areas, tarred roads and the PV panels themselves. Rainwater flows down the panel to the dripline, where it drips onto the underlying surface. To a large extent this impact is mitigated if trackers are used as the dripline will change position. If the surface is vegetated, the soil is well protected against erosion. However, there are expansive areas of very little vegetation cover at the site with large areas of exposed sand and gravel. Most of the area has a low gradient and sandy soils with high infiltration rates which should encourage water infiltration yielding low runoff coefficients.

Mitigation Measures

- Minimise alteration to existing drainage networks as far as possible avoiding leveling or infilling as this will alter flow paths causing flooding and erosion;
- Rainwater collection tanks should be installed on building roofs in order to reduce the risk of channeled flows from gutters, and store water for a variety of uses (e.g. dust suppression and PV panel washing);
- Consider the use of alternative materials for paved and parking areas that allow greater water infiltration rates such as gravel;
- Considering the beneficial effects of vegetation in terms of intercepting rainwater and reducing erosion, minimize the disturbance of vegetative cover underneath the PV panels; and,
- Should stormwater need to be discharged into a drainage line from any surface, methods of energy dissipation such as stilling basins should be employed to reduce flow velocities entering the watercourse.

Table 9. Summarised impact rating table for the layout and design phase at Bloemsmond 5

Impact	Intensity	Duration	Extent	Probability	Significance	Reversibility	Irreplaceability	Confidence
Impact: Further refinement of the development layout								
Without mitigation	5 (High)	6 (Ongoing)	2 (Limited)	6 (Almost certain)	Moderate (-)	Medium	Low	Medium
With mitigation	3 (Low)	3 (Short term)	2 (Very limited)	3 (Unlikely)	Negligible (-)	Medium	Low	High
Impact: Stormwater management								
Without mitigation	4 (Moderate)	4 (Medium Term)	2 (Limited)	4 (Probably)	Minor (-)	Medium	Low	High
With mitigation	2 (Low)	3 (Short Term)	2 (Local)	2 (Rare)	Negligible (-)	High	Low	High

6.2 CONSTRUCTION PHASE IMPACTS

6.2.1 Disturbance to riparian habitat

Drainage lines are distinguished as having the largest shrubs and trees in the landscape at Bloemsmond Farm. These riparian zones provide important ecological functions that must be preserved wherever possible. Where solar arrays intersect drainage lines, vegetation will be slashed to below the level of the panels as opposed to removed. This is beneficial as it minimizes soil disturbance (hence controlling erosion) and also promotes dust suppression. Although slashing vegetation reduces its functionality in the riparian zone, it is still preferable to complete removal. If drainage lines are a) to be avoided by infrastructure and b) only traversed by torque beams, then the impacts to riparian vegetation should be minimal.

Mitigation Measures

- Only slash or trim vegetation where it is absolutely necessary;
- Areas that have been cleared should be revegetated with indigenous species after construction. If necessary, erosion control through silt traps or similar should be used;
- Where vegetation has been removed along the banks of a watercourse, it will be necessary to check for alien plant establishment which needs to be cleared on a regular basis.

6.2.2 Disturbance to watercourse bed and banks

During the construction phase heavy machinery will need to access almost every area within Bloemsmond 5. In areas where there are numerous drainage lines this may result in heavy machinery entering and traversing watercourses as they manoeuvre. This may destabilize consolidated sediments resulting in erosion and downstream sedimentation. It could also result in compaction of soil and destruction of riparian vegetation.

Mitigation Measures

- Temporarily fence no-go and sensitive areas along their buffers with single-strand wire fencing, not danger tape. The aim is to exclude easy access by people and vehicles, but still allow the movement of fauna;
- Where vehicle access and work within a watercourse is unavoidable, such as the construction of a road crossing, then demarcate the access, parking and lay down areas using temporary fencing; and,
- Where excessive damage has occurred to the watercourse bed, banks or riparian zone, this must be rehabilitated immediately under the guidance of an aquatic specialist.

6.2.3 Sedimentation of downstream watercourses

A number of construction phase activities can increase erosion at the site resulting in sedimentation of downstream watercourses. In this case the downstream watercourse is the Helbrandkloofspruit. Such activities include the disturbance of soils and vegetation both in watercourses and the broader environment as large areas of disturbed soil and vegetation would be prone to erosion. These include steep slopes, access roads and recently cleared areas (e.g. laydown areas). Erosion of these areas will eventually lead to habitat degradation in watercourses downstream. This occurs where sediment accumulates, forming bars and smothering the river bed.

Creation of new sand bars also provides ideal habitat for colonisation by invasive plants (alien or indigenous) which further alters the instream habitat.

Mitigation Measures

- Limit disturbance to soil and vegetation as far as possible to reduce the risk of erosion.
- Ideally construction should be planned outside of the “wet” season to minimize the risk of erosion. However the area is naturally arid, and heavy rainfall is therefore a low risk.
- Establish sediment traps (e.g. silt fences or erosion berms) on areas prone to erosion. Although rainfall is an unlikely event, it must be planned for. Allowance must be made to clear sediment from the traps if erosion occurs during the construction period.
- If active erosion results in the formation of gullies, these areas must be infilled with topsoil and covered with hessian or a geotextile (e.g. hessian sheets or geotextiles) prior to revegetation.
- Where sedimentation downstream occurs as a direct result of construction activities this must be assessed and manual removal (using spades) under the supervision of a freshwater ecologist or environmental site officer may be recommended.

6.2.4 Water Quality Impacts

Construction activities have the risk of introducing a range of detrimental contaminants into watercourses. Even if there is no flow at the time of construction, these contaminants may leach into groundwater, or be washed into river systems during periods of flowing water. Possible contaminants include hydrocarbons (fuel and oil from vehicles) or cement waste. In addition, solid waste such as plastic litter could be dispersed by construction workers. Erosion (as described above) results in increased suspended sediment loads when rivers are flowing.

Mitigation Measures

- Vehicle parking and refuelling areas must be located > 50m from the edge of watercourses, and be clearly defined. No refuelling or vehicle maintenance should take place within 500 m of a watercourse.
- Any fuel storage areas must be bunded to prevent spills from spreading if they occur.
- Waste collection and removal must be arranged on a regular basis, and allowance must be made for conducting a litter clean-up for up to 100m downstream and upstream of the watercourses at the development site.
- Follow recommended mitigation measures for sedimentation of downstream watercourses as above.

6.2.5 Alien plant introduction

Wide-scale disturbance during construction has the potential to facilitate invasion by alien plants such as Mexican poppies (*Argemone Mexicana*) and mesquite (*Prosopis juliflora).* Mesquite was not observed at Bloemsmond 3 although it is meant to occur on and adjacent to Bloemsmond Farm according to Van den Berg (2010).

Mitigation Measures

- Any imports of foreign material to the site should be cleared with a botanical specialist to ensure they do not pose a risk and do not originate from areas with high levels of alien invasion.

- Alien plants must be continually removed from disturbed areas throughout the construction period. Any uncertainty about plant identification must be clarified with a botanical specialist.

Table 10. Summarised impact rating table for the constrution phase at Bloemsmond 3

Impact	Intensity	Duration	Extent	Probability	Significance	Reversibility	Irreplaceability	Confidence
Impact: Disturbance to riparian habitat								
Without mitigation	3 (Low)	4 (Medium term)	1 (Very limited)	4 (Probably)	Minor (-)	High	Low	High
With mitigation	2 (Very low)	3 (Short term)	1 (Very limited)	4 (Probably)	Negligible (-)	High	Low	High
Impact: Disturbance to watercourse bed and banks								
Without mitigation	5 (High)	4 (Medium term)	2 (Limited)	4 (Probably)	Minor (-)	Medium	Low	High
With mitigation	3 (Low)	3 (Short term)	2 (Very limited)	3 (Unlikely)	Negligible (-)	High	Low	High
Impact: Sedimentation of downstream watercourses								
Without mitigation	4 (Moderate)	4 (Medium term)	3 (Local)	4 (Probably)	Minor (-)	Medium	Low	High
With mitigation	3 (Low)	3 (Short term)	2 (Limited)	3 (Unlikely)	Negligible (-)	High	Low	High
Impact: Water quality impacts downstream								
Without mitigation	3 (Low)	3 (Short term)	2 (Limited)	4 (Probably)	Negligible (-)	High	Low	Medium
With mitigation	2 (Very low)	2 (Brief)	1 (Very Limited)	2 (Rare)	Negligible (-)	High	Low	Medium
Impact: Alien plant introduction								
Without mitigation	5 (High)	5 (Long term)	3 (Local)	4 (Probably)	Minor (-)	Medium	Medium	High
With mitigation	2 (Very low)	3 (Short term)	2 (Limited)	3 (Unlikely)	Negligible (-)	High	Low	High

6.3 OPERATIONAL PHASE IMPACTS

6.3.1 Alien Vegetation Management

Disturbance to soil and vegetation that occurred during construction is likely to create opportunities for the establishment of alien vegetation. If left to spread unmanaged, these plants (particularly *Prosopis* spp.) can inhibit acess to panels for maintenance and washing, and can displace indigenous plant species and degrade habitat. Furthermore, unmanaged alien vegetation provides a source for dispersal to neighboring areas.

<u>Mitigation Measures</u>

- When conducting inspections of any infrastructure on site, include a checklist of likely alien plants to check for throughout the site;
- Staff at the plant must be educated and made aware of alien vegetation that could be present and that must be eradicated;
- Depending on the species that establish, it is essential that recommended methods of control be employed and adequate stores of herbicide / tools are kept on site for this purpose. Alternatively a reputable contractor can be used for ongoing control of aliens; and,

- Alien plant control requires ongoing control and commitment. Therefore, alien plant management must form an integral part of the plant's Environmental Management Plan.

6.3.2 Solar Panel Washing

PV panels require washing periodically. This frequency ranges from plant to plant from between every 6 weeks to twice a year. Frequent washing utilizes substantial amounts of clean water.

Mitigation Measures

- Retain natural vegetation intact as far as possible as this acts as a dust suppressant;
- Wash panels only when required in order to conserve water; and,
- Avoid the use of detergents, but if required select environmentally friendly options.

6.3.3 Spills and Waste Management

During operation of the plant there may be occasional spills (e.g. petrochemicals) related to vehicles and plant infrastructure. There may be residual waste associated with the construction phase (e.g. materials) and there will also be general waste generated by staff at the plant on a day to day basis. The management of these aspects should be covered in the plant's Environmental Management Programme.

Mitigation Measures

- If spills occur (e.g. oil or hydraulic fluid) there must be a procedure for the containment and management thereof;
- Any waste construction materials must be disposed of responsibly, such as at the local landfill site;
- Human waste should be stored in septic tanks kept well away from any watercourses.
- A reliable contractor must be appointed for the removal of refuse from the plant; and,
- General refuse must be contained in animal-proof bins.

Table 11. Summarised impact rating table for the operational phase at Bloemsmond 5

Impact	Intensity	Duration	Extent	Probability	Significance	Reversibility	Irreplaceability	Confidence
Impact: Alien Vegetation Management								
Without mitigation	5 (High)	6 (Ongoing)	3 (Local)	4 (Probably)	Minor (-)	Medium	Medium	High
With mitigation	2 (Very low)	3 (Short term)	2 (Limited)	2 (Rare)	Negligible (-)	High	Low	High
Impact: Solar Panel Washing								
Without mitigation	2 (Very low)	2 (Brief)	2 (Limited)	3 (Unlikely)	Negligible (-)	High	Low	Medium
With mitigation	1 (Negligible)	1 (Immediate)	1 (Very limited)	1 (Highly unlikely)	Negligible (-)	High	Low	High
Impact: Spills and Waste Management								
Without mitigation	4 (Moderate)	4 (Medium term)	2 (Limited)	3 (Unlikely)	Negligible (-)	Medium	Medium	Medium
With mitigation	2 (Very low)	1 (Immediate)	1 (Very limited)	1 (Highly unlikely)	Negligible (-)	High	Low	High

6.4 CUMULATIVE AND LANDSCAPE-SCALE IMPACTS

This section of the impact assessment considers both the cumulative impacts of multiple PV arrays planned for Bloemsmond Farm as well as other solar developments in the vicinity. The cadastral units where solar projects have either been approved or are being processed are shown in Figure 12. . While the actual footprint of each project is not shown, this map provides an indication of the area at the landscape scale that is earmarked for developed.

While most of the environmental impacts in their mitigated state (related to aquatic ecosystem health) may be considered negligible at the scale of a single PV development, gridline or road, the accumulation of impacts at the landscape scale could be a concern. Bloemsmond Farm and surrounding areas are located within Renewable Energy Development Zone (REDZ) 7 which has been identified for large scale photovoltaic energy facilities. The increase in solar developments in REDZ zones has not been matched by an increase in the depth of understanding of associated environmental impacts, particularly the cumulative impacts (Rudman *et al*., 2017). However, the consideration of cumulative impacts is constrained by the current approach to assess developments separately.

A substantial portion of the SQR of the Helbrandkloofspruit and the Helbrandleegte Stream will potentially be affected by solar developments. Disturbance during construction phases at the very least will reduce vegetation cover and disturb soil over an extended area which is likely to increase the amount of erosion and subsequent sedimentation along this drainage line and associated tributaries, ultimately reaching the Orange River. Given the infrequency of rainfall in the area this may fortunately happen at a relatively slow rate. Wide-scale disturbance to vegetation is likely to exacerbate erosion and may lead to significant invasion by alien vegetation if this issue is not consistently managed by the various land owners and plant management.

Although the vegetation types Kalahari Karroid Shrubland and Bushmanland Arid Grassland are classified as Least Threatened, they are both in the top five vegetation types affected by solar developments. Bushmanland Arid Grassland is one of the most targeted vegetation types for solar power development (Rudman *et al*., 2017).

Figure 12. Map showing the location of DEA-registered PV (red) and CSP (pink) projects at the cadastral unit scale in the vicinity of Bloemsmond Farm.

A total of 5 PV arrays (Bloemsmond 1 – 5) have been planned for Bloemsmond Farm. In all cases specialists have been consulted upfront regarding the proposed layout of PV arrays through the provision of sensitivity maps. At Bloemsmond Farm this has ensured that the impacts affecting medium and high sensitivity watercourses (particularly pans and large wooded drainage lines) will be kept to the absolute minimum, with other impacts being unavoidable access roads crossing watercourses. This is also very important for maintaining a degree of connectivity at the landscape level, as drainage lines are frequently used for movement and other functions by a wide range of animals. They also provide additional habitat for wildlife occurring along the Orange River. A large proportion of sensitive habitat at the site will be left intact between solar arrays which will provide corridors for wildlife. Additional cumulative impacts will be related to the construction of gridlines assessed in this study. It is likely that further gridlines will be required to connect the range of other PV developments in the area.

From a hydrological and geomorphological perspective, the main cumulative impact is likely to be an overall increase in concentrated flows in drainage lines due to increased levels of runoff when it rains. The resulting effect on habitat will be to erode some stream sections and increase sediment deposits in larger river beds, which are already naturally sandy. Provided these effects are not too severe at the landscape level, they should not result in major detrimental impacts on water resources at the site or in the Orange River.

Mitigation Measures

- Future planning of solar developments should follow a similar process in that environmental specialists should be consulted during the planning and layout phase to identify any sensitive or no-go areas so they can be avoided;
- Solar developments and associated infrastructure (e.g. gridlines) should have little to no infrastructure within the medium to high sensitivity drainage lines as well as their buffers;

- Riparian vegetation along medium to high sensitivity drainage lines should be left untouched as far as possible;
- Access roads should be planned to utilize existing tracks (even between neighboring properties if possible) and limit stream crossings to the absolute minimum;
- Monitor the PES of major watercourses at specific sites in order to detect long term changes and isolate impacts requiring intervention. Focus on levels of sedimentation and erosion, a well as other habitat degradation indicators;
- Select and recommend development options that maintain connectivity in the landscape to support the movement of wildlife and limit the impact to watercourses as far as possible. The latter would include corridors to pans to ensure access by a range of fauna.

7 CONCLUSIONS

The watercourses assessed in this study were in a very good ecological state. Both drainage lines and pans provide important ecological and hydrological functions in the landscape, and it is important that these functions are preserved as far as possible. The PV developments and associated infrastructure proposed for Bloemsmond Farm have been well planned in terms of considering environmentally sensitive areas in the planning and layout phase. The layout can be further refined using the suggested mitigation measures in this report. While impacts to watercourses at Bloemsmond Farm and within the footprint of roads and gridlines are inevitable, the majority of these are considered negligible in their mitigated state. Provided the site is well managed during the construction and operational phase, following suggested mitigation measures, the development is considered as a positive contribution to the alternative energy needs of South Africa.

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