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Steenkampspan : Wetland Delineation and Assessment

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DECLARATION OF INDEPENDENCE

The specialist/s appointed in terms of the National Environmental Management Act (NEMA), 1998 (Act No. 107 of 1998), as amended and the Environmental Impact Assessment Regulations, 2014. Furthermore, Section 41 of the National Water Amended Act (Act 27 of 2014) specifies compliance with Regulations 24(5) and 44 of NEMA:

I/We Piet-Louis Grundling declare that:

General declaration

- I act as the independent specialist/s in this application;
- I do not have and will not have any vested interest (either business, financial, personal or other) in the undertaking of the proposed activity, other than remuneration for work performed in terms of the Environmental Impact Assessment Regulations, 2014;
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my/our objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, regulations and all other applicable legislation;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my/our possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself/ourselves for submission to the competent authority;
- All the particulars furnished by me/us in this form are true and correct; and
- I realise that a false declaration is an offence in terms of Regulation 71 and is punishable in terms of section 24F of the Act.

Wetland specialist

EXECUTIVE SUMMARY

Ixhaphozi Environmental Services CC was appointed by HydroScience CC to determine the occurrence of wetlands on part of the farm Steenkampspan 30 km north east of Upington. A desktop study of Google Earth imagery has indicated various depression like feature in the project area. A field assessment was done from 24 to 26 September 2014 to verify if the identified features were indeed wetlands.

In assessing the wetlands in the study area, the following activities were conducted:

- Identification of wetlands in the study area;
- Delineation of wetland and associated hydrological buffer area;
- Classification of the wetlands;
- An assessment of the Present Ecological State (PES) or integrity of the wetlands;
- Assessment of Ecological Importance and Sensitivity (EIS) of wetlands;
- A characterization of flora found in the specific wetlands and riparian areas as per the site visit; and
- Classifying the soil type in the study area.

Various sites on the property were assessed and follow up field visits conducted due to the complexity of ephemeral wetlands in an arid landscape such as the study area. Only one site, an interdune depression (a pan wetland) of 6.8ha was positively identified as wetland and delineated. Pans are common in this region but locally infrequent. As such the pan has an EIS status of 2.4, it has a PES value of B and it is recommended that the pan be conserved. Furthermore due to its sensitive nature and dependence on hillslope intermediate flows a buffer zone of 68 ha, linked to a corridor through the planned mining area, is recommended

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GLOSSARY

Anaerobic	Without air.
Biodiversity	The variety of life: the different plants, animals and micro-organisms, their genes and the ecosystems of which they are a part.
Catchment	Area from which rainfall flows into river.
Connectivity	In this context, referring to either the upstream-downstream or lateral (between the channel and the adjacent floodplain) connectivity of a drainage line. Upstream-downstream connectivity is an important consideration for the movement of sediment as well as migratory aquatic biota. Lateral connectivity is important for the floodplain species dependent on the wetting and nutrients associated with overbank flooding.
Exotic	From another part of the world; foreign and/or alien.
Geology	The study of the composition, structure, physical properties, dynamics, and history of earth materials, and the processes by which they are formed, moved, and changed.
Gleyed soil	A material that has been or is subject to intense reduction as a result of prolonged saturation with water. Grey colours are due to an absence of iron compounds.
Hydro-geomorphic	Refers to the water source and geology forms.
Invasive	Any alien species of insect, animal, plant or pathogen, including its seeds, eggs, spores, or other biological material capable of propagating that species.
Palustrine	Relating to a system of inland, non-tidal wetlands characterized by the presence of trees, shrubs and emergent vegetation.
Pedology	The branch of soil science that treats soils and all their properties as natural phenomena.
Soils	Dynamic natural body composed of mineral and organic materials (as well as living organisms) in which plants grow. It can also be described as the collection of natural bodies occupying parts of the earth's surface that supports plants and that has properties resulting from the integrated effect of climate and living matter acting upon parent material, as conditioned by relief, over periods of time.

Topographical maps	Detailed depiction of land features shown on a map.
Topography	Detailed description of land features.

1.0 INTRODUCTION

Ixhaphozi Environmental Services CC was appointed by HydroScience CC to determine the occurrence of wetlands on part of the farm Steenkampspan 30 km north east of Upington (Figure 1). A desktop study of Google Earth imagery has indicated various depression like features in the project area (Figure 1). A field assessment was done from 24 to 26 September 2014 to verify if the identified features were indeed wetlands. This was followed up with a second visit after some rain, from 23 to 25 November with a wetland ecologist and vegetation specialist.

Wetlands are not expected in this arid Kalahari Duneveld Bioregion (Gordonia Duneveld) where the Mean Annual Potential Evaporation (2912 mm) is 15 times the Mean Annual Precipitation (182 mm)(Mucina and Rutherford, 2006). However, the highly permeable dune sand underlain by shallow impermeable layers of calcrete result in rapid inundation of depression features with impermeable calcrete lined floors, during relatively high rainfall events. A high rate of evaporation occurs but inundation is just deep and long enough for temporary wetland features to develop in places.

This report clarifies the presence of wetlands on the property.

Figure 1: The proximity of the study area to Upington

2.0 TERMS OF REFERENCE

Determine the presence of wetlands in the Steenkampspan study area, delineate the relevant wetlands and prepare PES and EIS assessments for Water Use License Application (WULA) requirements (Section 21, National Water Act 36 of 1998).

3.0 SCOPE OF WORK

In assessing the wetlands in the study area, the following activities were conducted:

- Identification of wetlands in the study area;
- Delineation of wetlands zone;
- Classification of the wetlands;
- An assessment of the Present Ecological State (PES) or integrity of the wetlands;
- Assessment of Ecological Importance and Sensitivity (EIS) of wetlands;
- A characterization of flora found in the specific wetlands

4.0 LIMITATIONS OF THIS INVESTIGATION

The following limitations were placed on the wetland ecosystem and biodiversity study of this project:

- Two short field visits were conducted at the start of the rainy season, thus limiting the amount of biota identified at the site;
- Accuracy of the maps, aquatic ecosystems, routes and desktop assessments was limited to the current 1:50 000 topographical map series of South Africa;
- Accuracy of Global Positioning System (GPS) coordinates was limited to 15 m accuracy in the field;
- Delineations and related spatial data generated will be supplied in GIS (shape file) format only and will be for use in conceptual planning purposes only and not detailed design. If the client requires that data be accurate to detailed design level, this can be negotiated and budgeted for separately;
- Time and costs related to surveys have been calculated based on the proposed area (route) as indicated by the client;
- "Whilst every care is taken to ensure that the data presented are qualitatively adequate, inevitably conditions are never such that that is possible. Under the circumstances it must be pointed out that the nature of the vegetation, the time of year, human intervention and the like limit the veracity of the material presented".

5.0 METHODOLOGY

5.1 Wetland Delineation

The wetland delineation was conducted according to the guidelines set out by the Department of Water Affairs and Forestry (DWAF, 2005). Due to the transitional nature of wetland boundaries, they are often not clearly apparent and the delineations should therefore be regarded as of human construct. However, the delineations are based on scientifically defensible criteria, thus providing a tool to facilitate the decision making process regarding the assessment of the significance of impacts on wetlands that may be associated with the proposed developments.

According to DWAF (2005), the following general principles should be applied as the basis of wetland delineation:

> "A wetland is defined 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 under normal circumstances supports or would support vegetation typically adapted to life in saturated soil" (National Water Act 36 of 1998 in DWAF, 2005).

A wetland can be defined in terms of hydrology (flooded or saturated soils), plants (adapted to saturated soils) and soil (saturated). Due to the variable nature of South Africa's climate, the direct presence of water is often an unreliable indicator of wetland conditions. Prolonged saturation of soil has a characteristic effect on soil morphology, affecting soil matrix chroma and mottling in particular.

The wetlands were delineated by making use of the following wetland indicators (DWAF, 2005):

- **Terrain unit** indicator helps to identify those parts of the landscape where wetlands are most likely to occur. Wetlands occupy characteristic positions in the landscape and can occur on the following terrain units: crest, midslope, footslope and valley bottom.
- The **Soil form** indicator identifies the soil forms, as defined by the Soil Classification Working Group (1991), which are associated with prolonged and frequent saturation.
- **Soil wetness** indicator identifies the morphological signatures developed in the soil profile as a result of prolonged and frequent saturation. Notes were taken on soil chroma to a depth of 50 cm and this was related to hydrological conditions in terms of the criteria for distinguishing different soil saturation zones within a wetland (Table 1) (Kotze *et al.*, 1994).
- The **Vegetation** indicator identifies hydrophytic vegetation associated with frequently saturated soils (Table 1). The characterisation of wetland vegetation indicators provided by DWAF (2005) is however not applicable to this part of the arid Kalahari region and was therefore of little use to the current study.

Table 1: Criteria for distinguishing different soil saturation zones and hydric vegetation within a wetland (from Kotze *et al.*, 1994).

SOIL	**DEGREE OF WETNESS**		
	Temporary	**Seasonal**	**Permanent/Semi-permanent**
Soil depth 0-20cm	Matrix brown to greyish-brown (chroma 0-3, usually 1 or 2). Few/no mottles. Non-sulphuric.	Matrix brownish-grey to grey (chroma 0-2). Many mottles. Sometimes sulphuric.	Matrix grey (chroma 0-1). Few/no mottles. Often sulphuric.
Soil depth 20-40cm	Matrix greyish-brown (chroma 0-2, usually 1). Few/many mottles.	Matrix brownish-grey to grey (chroma 0-1). Many mottles.	Matrix grey (chroma 0-1). No/few mottles.
VEGETATION			
If herbaceous:	Predominantly grass species; mixture of species that occur extensively in non-wetland areas and hydrophytic plant species, which are restricted largely to wetland areas.	Hydrophytic sedge and grass species that are restricted to wetland areas, usually <1 m tall.	Dominated by: (1) emergent plants, including reeds (*Phragmites* sp.), sedges and bulrushes (*Typha* sp.), usually >1 m tall (marsh); or (2) floating or submerged aquatic plants.

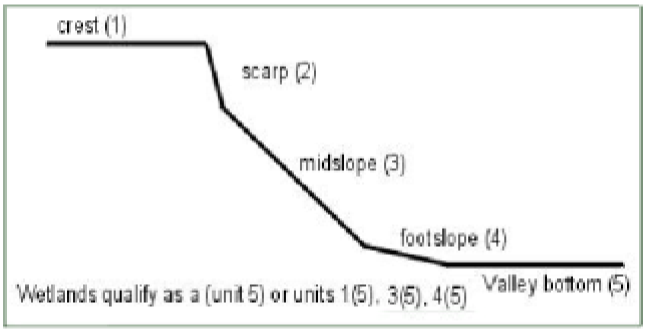

Figure 2: Terrain units.

5.2 Soil Classification

The study area was traversed and observations regarding the landscape and occurrence of soils were made continuously. Specific soil characteristics were noted and logged. Augering was done to a maximum of 120 cm. The soils were classified according to the South African Soil Classification System (MacVicar et al., 1994).

Thirty-two sample points were taken with coordinates and altitude taken by Garmin Montana 650 non-differential GPS.

5.3 Wetland Vegetation

The study area was visited by both an ecological and vegetation specialist from 23 to 25 November 2014 together with the wetland and soil specialists. Seven sampling sites were re-surveyed at the four localities of uncertainty identified in the 1st field visit. Observations regarding the landscape and vegetation were made whilst travelling between the selected localities. The following data pertaining to the vegetation, ecological status and biophysical habitat, was gathered at each of the seven sampling sites:

1. A list of species identifiable at the time of the survey.
2. Stratification of the vegetation of each site into broad scale physiognomic units using the methodology of Edwards (1983) and Kent & Coker (1996). Physiognomic units were further described using species composition (α-diversity), species dominance and physical habitat characteristics (e.g. position in landscape, aspect, gradient, rockiness and soil depth, colour and texture.
3. Visual estimates of cover-abundance and density of identified species.
4. Notes pertaining to land-use and ecological status (i.e. overgrazing, alien invasive plant species and erosion).
5. Photographs and geo-referencing using a handheld GPS receiver.

The potential occurrence of plant 'species of conservation concern' (*sensu* Raimondo *et al*., 2009) within the wetland habitat identified within the study area was assessed through use of historical records for such species within the two quarter degree grid squares within which the study area is situated, namely 2821AB and 2821BA. Historical records of all species recorded within the grids 2821AB and 28121BA were obtained from the PRECIS database of the South African National Biodiversity Institute (http://posa.sanbi.org).

The site visit was conducted in early November 2014, before any significant rainfall (rainfall in October and November was on par with average rainfall), and the veld was heavily grazed at the time of the survey. The brief floristic descriptions provided here can therefore by no means be regarded as comprehensive. The ideal time for the conduction of floristic surveys in the xeric southern Kalahari region is in late April or early May after the peak rainfall period. It should also be borne in mind that rainfall in this region is very erratic and the accuracy of a floristic survey conducted in April or May is largely dependent on average to good rainfall during the rainy season.

5.4 Wetland Classification

Wetlands are described in terms of their position in the landscape, and the classification was done according to their hydro-geomorphic (HGM) characteristics (Kotze *et al.*, 2004). The HGM classification (Table 2) considers landscape position, geomorphological and hydrology (especially the movement of water through the wetland and associated landscape). Aerial photos, 1:50 000 topographic maps, satellite photos and GPS points are used to guide on-screen delineation of wetlands in ArcView GIS 3.2. A first estimation of the extent of wet soils can be made from aerial photos, largely based on differences in vegetation and topography, indicating differences in species composition or more vigorous growth. This delineation needs to be verified during field sampling, making use of soil samples and vegetation line transects, as well as spot checks between transects.

Field verification consisted of several line transect surveys to ensure representative sampling of the area. In each line transect survey soils and vegetation were used to assess the edge of the wetland. Areas between transects were also assessed by doing soil and vegetation spot checks on the perceived wetland marginal zone. It is important to note that, according to the wetland definition used in the South African National Water Act, vegetation is the primary indicator, which must be present under normal circumstances. However, in practice the soil wetness indicator tends to be the most important, and the other three indicators have a confirmatory role (DWAF, 2005).

Table 2: Wetland Unit types based on hydro-geomorphic characteristics (Adapted from Kotze *et al.* 2005).

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

5.5 Wetland Integrity Assessments

5.5.1 Present Ecological State (PES)

In terms of pan assessments, no specific method or index is currently prescribed in South Africa for the purposes of determining the Present Ecological State (PES) of a pan, as is the case for other types of wetlands (DWAF 1999; DWAF 2007; Macfarlane *et al.,* 2008). Kleynhans (DWAF 1999) provided a method for determining, at the 'Intermediate level', the Present Ecological Status of palustrine wetlands according to a modified 'Habitat Integrity' approach developed in 1996 and 1999 by the same author. Though this simple and rapid method is still widely used, this method, as well as subsequent PES wetland assessment techniques, do not provide a direct determination or estimate of biological integrity, but rather relies heavily on selected habitat characteristics such as 'types of development and land use', hydrology (probable modifications to flow regime), water quality and erosion and sedimentation levels to estimate 'Present Ecological Status'.

In the absence of a formal PES method to assess pans, information obtained from the vegetation assessment was combined with recorded observations of geomorphological and hydrological impacts within the wetland and its surrounding catchment. This information and observations were used to qualitatively quantify changes to the health (integrity) of the interdune wetland at Site SP6 by following an approach adapted from the DWAF (1999) PES method for palustrine wetlands. The underlying approach in all PES methods compares the current condition of a wetland to its perceived (or inferred) reference condition, in order to determine the extent to which the wetland has been modified from its pristine (reference) condition. This poses a particularly difficult challenge to assess pan wetlands, as their hydrological parameters, such as inundation duration and frequency can vary widely within a single year or across different years. The result from the PES assessment for each wetland is rated into one of six categories ranging from an unmodified/pristine wetlands (Class A) to a critically transformed category (Class F), (Table 3).

The Ecological Importance and Sensitivity (EIS) assessments for the interdune pan was undertaken to provide an indication of the conservation value and sensitivity of the pan. The applied EIS wetland assessment was based on the following criteria, as derived from an adaptation of the method proposed by Rountree & Malan (2010):

1. Habitat uniqueness
2. Species of conservation concern
3. Habitat fragmentation with regard ecological corridors
4. Ecosystem service (social and ecological)

The calculated EIS categories for the twenty-four HGM units were assigned to one of four classes that range between Very high to Low/marginal (Table 4).

Table 3: Description of A – F ecological categories for wetlands based on Kleynhans *et al*., (1999

Mean*	**Category**	**Explanation**	**Management Perspective**
Within generally acceptable range			
>4	A	Unmodified, or approximates natural condition	Protected systems; relatively untouched by human hands; no discharges or impoundments allowed
>3 and <=4	B	Largely natural with few modifications, but with some loss of natural habitats	Some human-related disturbance, but mostly of low impact potential
>2.5 and <=3	C	Moderately modified, but with some loss of natural habitats	Multiple disturbances associated with need for socio-economic development, e.g. impoundment, habitat modification and water quality degradation
<=2.5 and >1.5	D	Largely modified. A large loss of natural habitat and basic ecosystem function has occurred.	
>0 and <=1.5	E	Seriously modified. The losses of natural habitat and ecosystem functions are extensive	Often characterized by high human densities or extensive resource exploitation. Management intervention is needed to improve health, e.g. to restore flow patterns, river habitats or water quality
0	F	Critically modified. Modification has reached a critical level and the system has been modified completely with almost complete loss of natural habitat.	

*: If any of the attributes are rated <2, then the lowest rating for the attribute should be taken as indicative of the PES category and not the mean.

Table 4: Ecological importance and sensitivity (EIS) categories. Interpretation of median scores for biotic and habitat determinants.

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

5.5.2 Ecological Importance and Sensitivity (EIS)

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

In the method outlined by DWAF, a series of determinants for EIS are assessed for the wetlands on a scale of 0 to 4 (Table 5), where 0 indicates no importance and 4 indicates very high importance. The median of the determinants is used to determine the EIS of the wetland unit (

Table 6).

Table 5: Score sheet for determining Ecological Importance and Sensitivity (DWAF, 1999c).

Determinant
Primary determinants
Rare and endangered species
Species/taxon richness
Diversity of habitat types or features
Migration route/breeding and feeding site for wetland species
Sensitivity to changes in the natural hydrological regime
Sensitivity to water quality changes
Flood storage, energy dissipation and particulate/element removal
Modifying determinants
Protected status
Ecological integrity

Table 6: Ecological Importance and Sensitivity categories. Interpretation of median scores for biotic and habitat determinants (DWAF, 1999c)

Range of Median	EIS Category	Category Description
>3 and <=4	**Very High**	Wetlands that are considered to be 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.
>2 and <=3	**High**	Wetlands that are considered to be ecologically important and sensitive. The biodiversity of these wetlands is usually very sensitive to flow and habitat modifications. They play a role in moderating the quantity and quality of water in major rivers.
>1 and <=2	**Moderate**	Wetlands that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these wetlands is not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water in major rivers.
>0 and <=1	**Low/ Marginal**	Wetlands that is not ecologically important or sensitive at any level. 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.

6.0 RESULTS AND DISCUSSION

6.1 Study Area

The study area is a 13 000 ha arid dune landscape located 30 km northeast of Upington in the Northern Cape Province (Figure 3). This site was assessed by a multi-disciplinary team on 23-25 September with a follow-up assessment on 23-25 November.

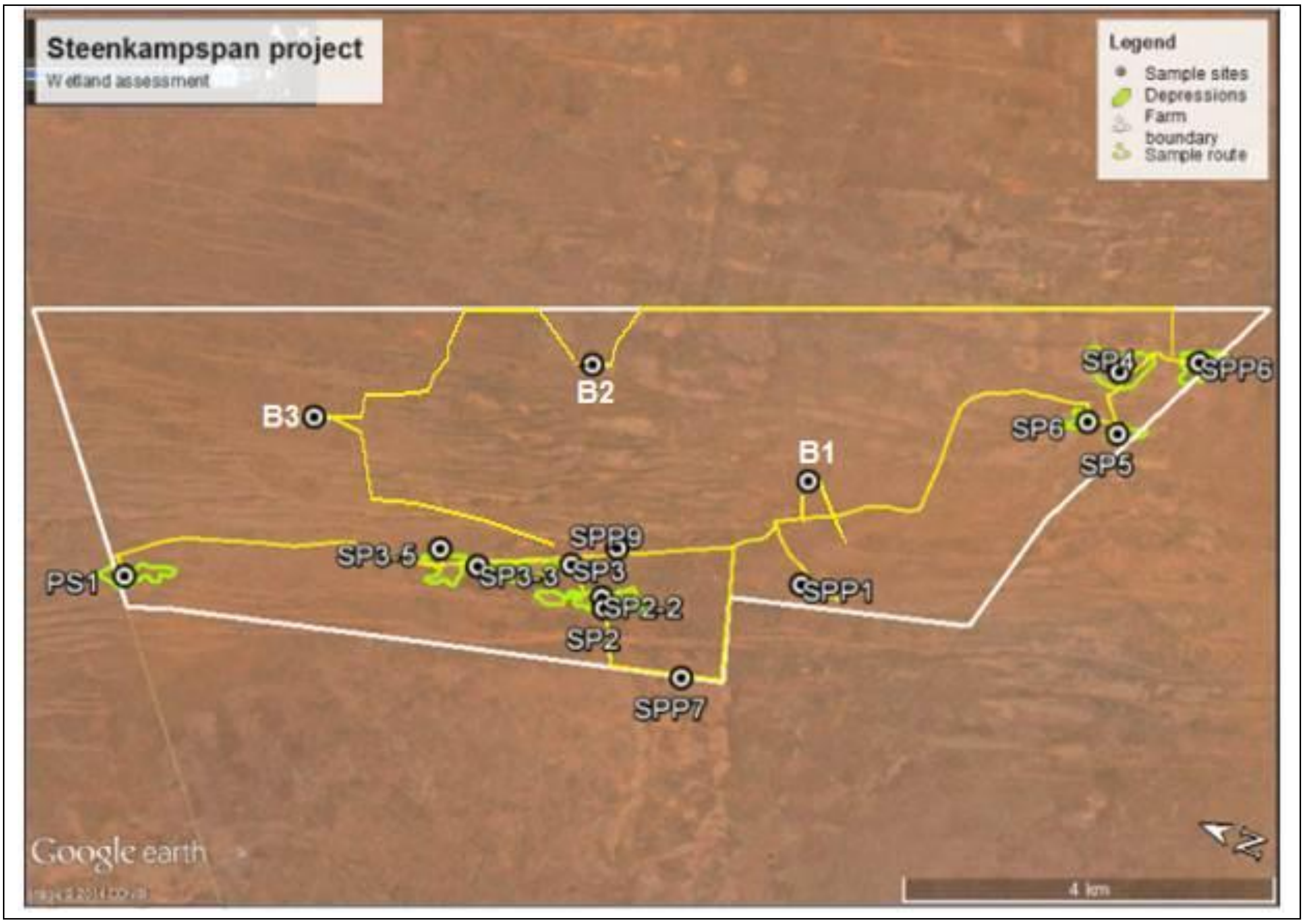

Figure 3: Location of the study sites

6.2 Wetland delineation

The wetland system (Figure 4) was delineated according to the method statement described in paragraph 5.1. The area was transverse on foot and assessments done at various random points (Table 7) to determine the presence of hydromorpic vegetation, hydric soils while positioning in the landscape was another key indicator that was looked at to delineate and determine the boundaries of the system.

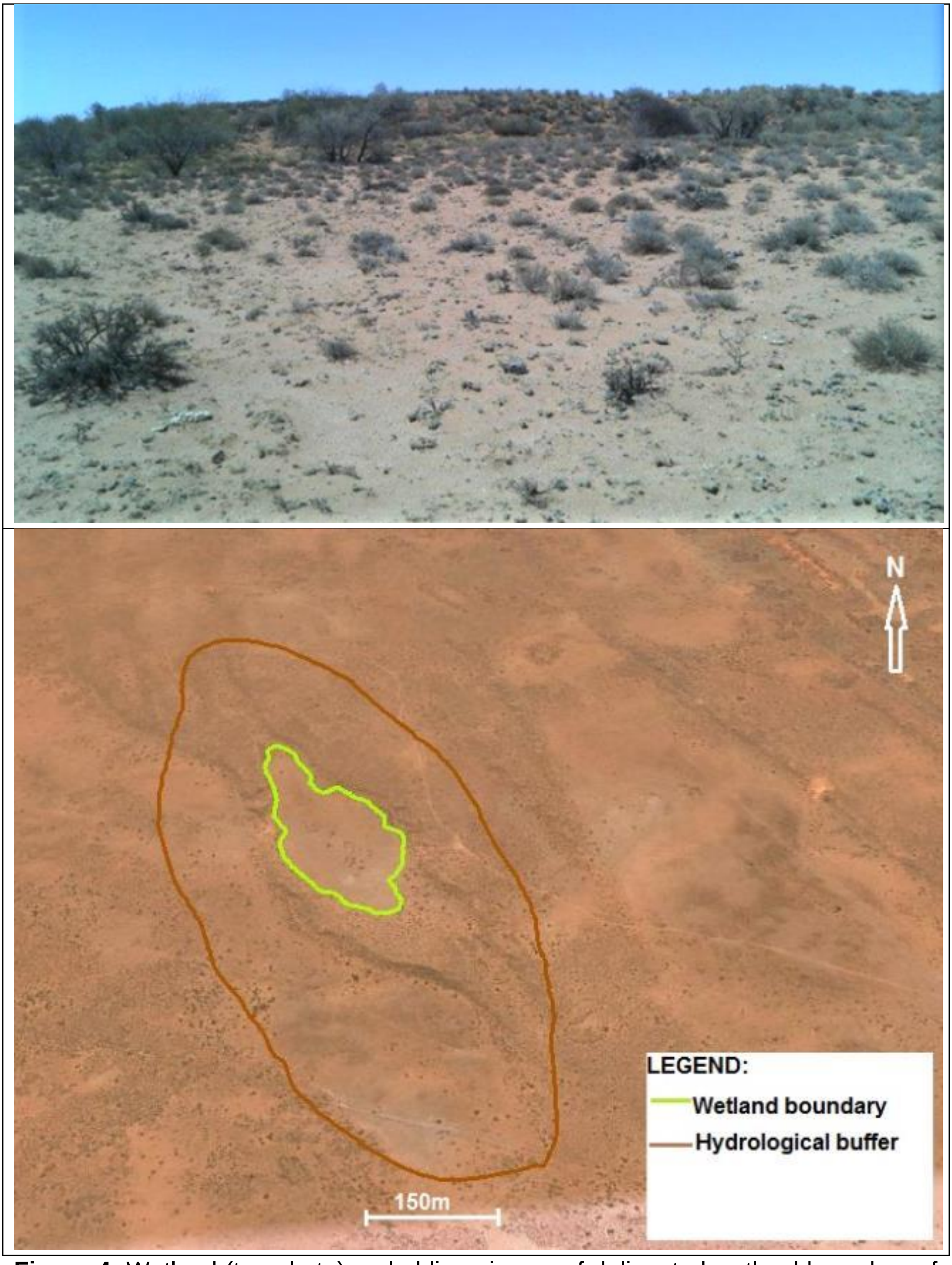

Figure 4: Wetland (top photo) and oblique image of delineated wetland boundary of SP6 and recommended buffer (bottom photo).

6.3 Soil classification

Thirty-two sample points were assessed during the surveys (Figure 3 and Table 7). The following soil forms where identified during the site visit:

1. The <u>Namib soil form</u> (SP4.1, SP4.2, SPP1, SPP1.1, SPP6.3, SPP6.5, SP3.3, SP3.4) comprises an orthic A-horizon that overlies regic sand. The term regic (from the Greek *rhegos* which means blanket) is used to described aeolian sands which has undergone no or limited pedogenic development. In the case of the study area, these soils are red in colouration and do not contain sufficient levels of free lime for it to be reactive in the presence of a 10% HCl solution. These soils are therefore classified on series level as soils of the Kalahari soil series. The soils occur as dunes in the area. The soils are typically deeper than three meters at the crest of the dunes and deeper than 1.2 m closer to the lower lying areas.

These soils are sandy in nature (Figure 5) and exhibit a high saturated hydraulic conductivity and low water holding capacity. These soils are indicative of well-drained areas where waterlogging seldom occurs. The soils are probably underlain by calcrete. Rainwater percolates through these sandy soils at a high rate until it reaches the calcrete layer where it perches and drains laterally to lower lying areas. Water, during high rainfall events, daylights at the base (toe) of the dunes.

Table 7: Sample sites and description

Site	Latitude	Longitude	Comment
PS1	-28.1562030	21.4642670	Red sand- +80cm
SP2	-28.1996350	21.4802030	Red sand. Gravel
SP2-1	-28.1979670	21.4815090	Red sand. Gravel at 50cm
SP2-2	-28.1990830	21.4812220	Calcrete
SP3	-28.1951890	21.4832860	Red sand with gravel
SP3-1	-28.1959110	21.4825270	Red sand with gravel
SP3-2	-28.1971870	21.4808830	Red sand with gravel
SP3-3	-28.1869490	21.4793550	Deep red sand
SP3-4	-28.1834430	21.4790170	Red sand shallower than sp3-3
SP3-5	-28.1830250	21.4796190	Red sand deeper 60cm gravel/rock?
SP4	-28.2370280	21.5250000	Shallow red on calcrete
SP4-1	-28.2369390	21.5260220	Deep red soil
SP4-2	-28.2386800	21.5247890	Red sand deeper
SP5	-28.2390830	21.5186670	Shallow red on calcrete
SP6	-28.2359720	21.5186670	Grey sand.greenish
SP6-1	-28.2361650	21.5188100	Grey sand.greenish
SP6-2	-28.2356090	21.5186870	Grey sand.greenish with more calcareous content
SPP1 BOORGAT-1	-28.2198550	21.4902920	Red sand
SPP1	-28.2163160	21.4905480	Red sand deep

SPP1-1	-28.2171910	21.4907290	Deep red sand
SPP6	-28.2437860	21.5291910	Orthic a on calcrete with thin organic algae crust indicating drying out cracks
SPP6-3	-28.2443000	21.5299680	Red sand deep
SPP6-4	-28.2444650	21.5287410	Shallow dry with thin organic algae crust indicating drying out cracks
SPP6-5	-28.2450550	21.5289430	Sand red close to dune edge
SPP6-6	-28.2455660	21.5286480	Calcrete crest
SPP6-DUIN	-28.2437020	21.5302600	Dune edge
SPP7	-28.2090000	21.4762780	Shallow red on calcrete
SPP7-1	-28.2092210	21.4763100	Red sand with calcrete
SPP9	-28.1986670	21.4868060	Red sand with calcrete
B1	-28.2191390	21.5067170	Red sand
B2	-28.1926670	21.5065560	Red sand
B3	-28.1727860	21.4947610	Red sand

2. The Brandvlei soil form (SP1, SP6, SP6.1, SP6.2, P3) comprises an orthic A-horizon which overlies a soft carbonate B-horizon. These soils are encountered in a pan system and indicate temporary wetland conditions.

Figure 5: Photo left- The red, apedal and sandy nature of Namib soil form. **Photo right**- The white-greenish colouration of the Brandvlei soils form which is ascribed to presence of free lime.

The soft carbonate B-horizon exhibits a morphology which is dominated by calcium and/or potassium–magnesium carbonates. These carbonates can be present as a powder in which case it dominates the colouration of the horizon, nodules, honeycombed structured material or blocks. In the case of the study area the carbonates are mainly present as a powder which lends a white-greenish colouration to the soils (Figure 5). When reacted with 10 % HCl, the carbonate horizon bubbles (Figure 6).

Figure 6: Photo left-Free lime in soil fizzes when reacted with 10% HCl, Photo right-Calcrete daylight in areas where the Coega soil form dominates

No signs of wetness were encountered in these soils, thus leading to the classification of the soils as soils of the Grootvloer soil series. Signs of wetness does not relate to the presence of water or moisture at the time of the survey, but to the bleaching of sand particles as Fe(III) mineral phases are reduced to Fe(II) phases under conditions of prolonged inundation. The Fe(II) phases are mobile and transported to zones of higher oxidation state within the soil matrix where it re-precipitates as Fe(III) mineral phases.

In soils with an acidic or neutral pH, red, yellow, brown and black mottles are often encountered if the soils are seasonally or temporarily wet. In high pH environments, such as is the case of the study area, mottling is seldom noted – even in soils that are often inundated. Under acidic conditions, the dominant Fe mineral phases under oxidised conditions are hematite, lepidocrosite and goethite which all exhibit clearly visible red, yellow and brown colours (mottles). Under alkaline conditions, the dominant secondary Fe mineral phase is siderite which is colourless. Furthermore, the low organic matter content of the Kalahari soils inhibits Fe reduction processes in the following manner:

i) organic matter is necessary for Fe reduction to occur (Fe accepts an electron that is donated by organic matter) and

ii) microbial activity (which facilitates the reduction of Fe) is low in soils where organic matter is present at low concentrations. Mottling and bleaching are therefore not used to assess wetness in areas rich in lime and low in organic matter.

The area which comprises soils of the Brandvlei soil form are more often inundated than the surrounding soils. The following processes must be present for the formation of the soft carbonate B-horizon:

1. Soluble Ca and Mg salts must be present in higher lying soils;
2. Water, during and after rainfall events, must pass through these soils, dissolve the Ca and Mg salts (mineral phases) and accumulate at a lower lying point in the landscape;
3. Where the water accumulates, in this case in a pan system, the dominant mechanism of water loss must be evaporation/evapotranspiration which leads to an accumulation of Ca and Mg. These elements react with the carbonate and bicarbonate in the soils to form calcitic and dolomitic lime. The carbonate and bicarbonate phases in the soil solution are the result of atmospheric CO_2 equilibrating with the soil solution. The formation of a soft carbonate B-horizon therefore removes CO_2 from the atmosphere. The pan is a sink for CO_2.
4. The accumulation of free lime in these soils leads to a finer textured soil which has a higher water holding capacity and lower saturated hydraulic conductivity when compared to the surrounding soils of the Namib soil form. Water retention in these soils therefore increases as the soils mature. The system therefore holds water for longer periods of time as it ages.

If this area was not shaped as a pan, the volume of water accumulating at this point would have been too low to induce the formation of the soft carbonate B-horizon. If the area was free draining and evaporation was not the dominant force driving water loss, lime accumulation would not have occurred and the soils would not have been inundated for long enough periods, often enough for the soil morphology and vegetation structure to change significantly.

The lime present in these soils is not the result of weathering calcrete, but rather the neoformation of Ca and Ca-Mg carbonates as explained above. Many of the soils of the area are underlain by calcrete, but do not react with a 10 % HCl solution – even where calcrete shards are present.

3. The <u>Coega soil form (SP3.5, SP4, SP4.2, SP 5, SPP6, SSP6.4, SPP6.5, SPP7, SPP7.1, SPP9)</u> comprises an orthic A-horizon that overlies a hardpan carbonate B-horizon. The hardpan carbonate B-horizon or calcrete horizon comprises a horizon where calcium and/or calcium–magnesium carbonates have become cemented to such an extent that it has become impenetrable for plant roots. The A-horizons in these soils are not calcareous and the soils are therefore classified as the Nabies soil series. In some cases (SP2, SP2.1, SP3, SP3.1, SP3.2) gravel are encountered at a depth of approximately 15 to 30 cm. In certain areas, the A-horizon has been removed to leave the calcrete at the surface (SP2.2, SP4, SPP6.6, SP5) as shown in Figure 6. These are areas of high surface runoff.

At point SPP6.4 a biological crust (Figure 7) was noted on the soil surface and clay illuviation (Figure 7) was noted in the soil profile. This is an indication that the soils become saturated with water after rainfall events owing to water perching on top of the calcrete layer. Algal growth occurs and when the soils dry, the algae die to leave a thin layer of crust on the soil surface. These periods of inundation is not long or often enough for the morphology of the soils to change and this area is not seen as a wetland system.

Figure 7: Photo left-Biological crusting owing to the growth of algal during times of inundation at point SPP6.4, Photo right- Illuviation noted in soils at point SPP6.4

1. The <u>Prieska soil form</u> (PS1, Br1, Br15, Br18, Br21, Br23, Br26, Br27, Br31, Br33) comprises an orthic A-horizon which overlies a neocarbonate B-horizon and a hardpan carbonate B-horizon. The neocarbonate horizon differs from the soft carbonate B-horizon in that the carbonates do not dominate the colouration of the soil. The horizon, however, reacts with 10 % HCl. The neocarbonate B-horizon is red in colouration and exhibits non-luvic characteristics. The soil therefore falls into the Naawte soil series.

In this case, the Prieska soil form is encountered in an interdune depression. The neoformation of the Ca and Ca-Mg carbonates indicate an area of preferential waterflow that is very seldom inundated. This area is not regarded as a wetland system.

2. The Plooysburg soil form (Br2, Br3, Br4, Br5, Br6, Br8, Br9, Br10, Br11, Br12 Br13, Br14, Br16, Br17, Br19, Br20, Br22, Br24, Br26, Br28, Br29, Br30, Br32) are encountered amongst pockets of soils of the Prieska soil form. These soils comprise an orthic A-horizon overlying a red apedal B-horizon and hardpan carbonate B-horizon. The red apedal B-horizon is without structure exhibits a sandy texture and is indicative of a dry environment. At least 15 % of the Fe fraction in these soils comprises hematite (Fe_2O_3). The soils exibit non-luvic characteristics and fall into the Brakkies soil series.

The soils of the Brandvlei soil form, which were encountered in a pan-like structure, are regarded as wetlands soils and indicative of temporary inundation.

6.4 Vegetation classification

The site visit was conducted in November 2014, before any significant rainfall, and the veld was heavily grazed at the time of the survey. The brief floristic descriptions provided here can therefore by no means be regarded as comprehensive. The ideal time for the conduction of floristic surveys in the xeric southern Kalahari region is in late April or early May after the peak rainfall period. It should also be borne in mind that rainfall in this region is very erratic and the accuracy of a floristic survey conducted in April or May is largely dependent on average to good rainfall during the rainy season. Seven sampling sites were surveyed to determine the occurrence of wetland vegetation (Table 8).

Table 8: Seven sampling sites surveyed at four localities on the 4th of November 2014. Refer to Appendix 1

Site no.	Co-ordinates	Notes
T1a	28° 09’ 22.8” S & 21° 27’ 50.5” E	No wetland habitat.
T1b	28° 09’ 21.9” S & 21° 27’ 53.4” E	No wetland habitat.
T2a	28° 11’ 45.9” S & 21° 29’ 06.5” E	No wetland habitat.
T2b	28° 11’ 54.2” S & 21° 29’ 09.9” E	No wetland habitat.
T3 (SP6)	28° 14’ 04.9” S & 21° 31’ 08.6” E	Ephemeral pan which is periodically inundated (at intervals many years).
T4a	28° 14’ 35.8” S & 21° 31’ 44.1” E	No wetland habitat.
T4b	28° 14’ 33.9” S & 21° 31’ 45.0” E	No wetland habitat.

According to the latest vegetation map of South Africa (Mucina and Rutherford, 2006), the study area is situated entirely within the Gordonia Duneveld vegetation unit of the Kalahari Duneveld Bioregion that forms part of the Savanna Biome. This conservation status of this vegetation unit is categorised as Least Threatened (Mucina & Rutherford, 2006). The vegetation of the study area conforms well to the description of Gordonia Duneveld provided by Mucina and Rutherford (2006), but the calcrete flats in the interdune depressions display floristic and structural elements of the Kalahari Karroid Shrubland vegetation unit of the Nama-Karoo Biome, which occurs some 10 km to the west of the study area. The conservation status of Kalahari Karroid Shrubland is also categorised as Least Threatened (Mucina & Rutherford, 2006).

Signs of heavy grazing (but not severe overgrazing such as that which typically leads to dune erosion) were recorded at all localities visited. Such signs included the grazing of the highly palatable grass *Stipagrostis obtusa* down to a height of 1cm or less and large areas encroached by the indigenous shrub *Rhigozum trichotomum,* which is usually a sign of overgrazing where it occurs in large, almost monospecific (in terms of shrubs) stands. Almost monospecific stands of *Rhigozum trichotomum* cover well over 100 ha of the interdune depression at Site T1a (see Figure 3 of Appendix 1).

Alien plant species have not transformed any significant area of indigenous vegetation within the study area. The small alien invasive tree *Prosopis glandulosa* var. *torryena* does however occur throughout the study area, albeit largely restricted to the footslopes of dunes and interdune flats where it always occurs at relatively low densities and is never dominant. *Prosopis glandulosa* var. *torryena* is listed as a Category 3 invasive species in the Regulations on Alien and Invasive Species [National Environmental Management: Biodiversity Act (August 2014)]. As a Category 3 species, *Prosopis glandulosa* var. *torryena* must be controlled by the landowner unless exemption is obtained in terms of Section 71 (3) of the Act.

Presence of wetland vegetation

With the exception of salt pans, wetlands are not frequent in the arid Kalahari Duneveld Bioregion within which the study area is situated and where the Mean Annual Potential Evaporation (2912 mm) is 15 times the Mean Annual Precipitation (182 mm) (Mucina and Rutherford, 2006). However, the highly permeable dune sands (Namib soil form) are interspersed with interdune depressions where shallow, impermeable calcrete horizons may result in rapid saturation and even inundation of the shallow, overlying soils during rare high rainfall events.

Vegetation that potentially indicates wetland conditions was found at only one of the seven sites surveyed during the current study, namely site SP6. At this site, the vegetation of a shallow depression in an interdune depression, is distinctive in terms of a combination of physiognomy (vegetation structure), species composition and species dominance, and is considered indicative of unique (within the study area) abiotic habitat conditions associated with endorheic (no channelled inlet or outlet) pans. Pans are also referred to as playas in international literature (Allan *et al*., 1995).

In arid regions such as the southern Kalahari, inundation of pans is characteristically ephemeral and pans can be dry for years between short periods of flooding (Allan *et al*., 1995). The periodic, ephemeral inundation and/or soil saturation experienced by pans, and the fact that they have no channelled outlet and water loss occurs largely through evaporation, typically causes the development of increased soil salinity (Allan *et al*., 1995 and Leistner, 1967). Increased soil salinity together with periodic inundation and/or soil saturation creates a unique habitat which is unsuitable for most plant species and only species with physiological adaptations for hostile conditions such as increased salinity (halophytes) are able to survive in such habitats. A gradient in salinity levels and the frequency and duration of inundation and/or soil saturation from the centre to the outer margins of the periodically inundated or saturated area, causes great variations in abiotic habitat conditions which in turn leads to the development of distinct plant communities in concentric zones. The concentric vegetation zones of typical southern Kalahari salt pans have been well described by Leistner (1967). An annotated diagram describing typical concentric zonation of plant communities in Kalahari salt pans is provided in Figure 8.

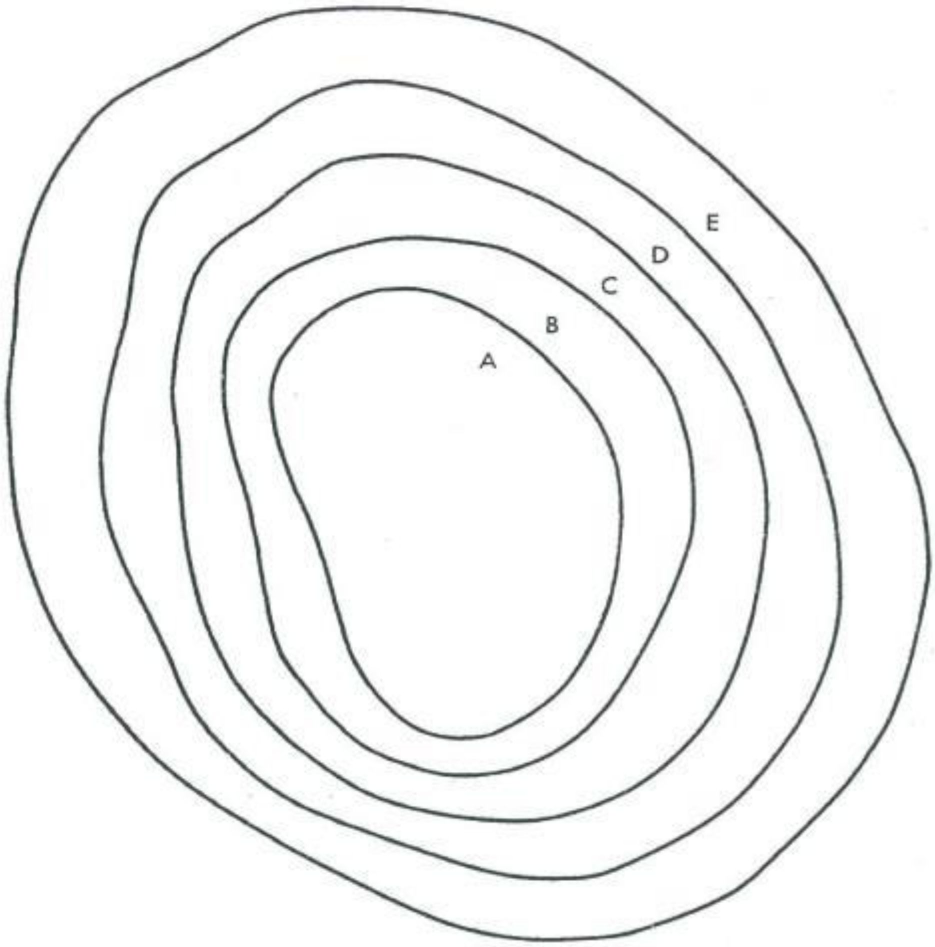

FIG. 6.—Diagram showing zonation of vegetation on and around a typical calc-pan:—

Pan surface:—

(A) Bare surface

(B) *Sporobolus rangei* or *S. ioclados* var. *usitatus*

(C) *Eragrostis truncata* (only present in northern and eastern regions), *Stipagrostis obtusa*

Intermediate zone:—

(D) *Stipagrostis obtusa*, *Rhigozum trichotomum* and often *Monechma australe*

Pan surroundings:—

(E) *Stipagrostis ciliata*, *Rhigozum trichotomum* and often *Monechma incanum*.

Figure 8: Typical concentric zonation of plant communities in southern Kalahari salt pans, as described by Leistner (1967). *Monechma australe* is a synonym for *Monechma genistifolium* subsp. *australe*.

The vegetation found in the interdune depression at site SP6 is indicative of a small, endorheic pan that experiences brief soil saturation, or possibly even briefer soil inundation, periodically at very long intervals of many years or even decades. The pan can therefore be described as a pan which experiences ephemeral soil saturation or inundation periodically at long intervals. The pan is not inundated frequently enough and does not hold sufficient volumes of water to have formed a highly saline central zone comprising unvegetated (bare) soils, as is found in the typical salt pans of the southern Kalahari described by Leistner (1967) (see Figure 8). Ephemeral pans such as that found at site SP6 are abundant in the southern Kalahari but represent a unique and spatially restricted habitat within the study area and its immediate surrounds.

A diagrammatic representation of a cross-section of the typical vegetation found in the ephemeral pan and its surrounding terrestrial habitat at site SP6, is provided in Figure 9. The vegetation and principal habitat characteristics of the three broad-scale zones are briefly described below.

Zone A

Comprises an unique (for the study area) Low Open Shrubland vegetation on the pan surface or floor (lowest parts of the interdune depression). The soils of this zone comprise very shallow, grey, sandy soils overlying calcrete rock at a depth of less than 40cm. The soil form is Brandvlei, a soil form which typically indicates wetland conditions in the arid regions of the Northern Cape (see soil section). The soils of Zone A are characterised by the presence of free lime (referred to calcium carbonate as defined in soil science) which is indicative of periodic saturation or inundation, and is usually associated with elevated salinity levels. The dominant species are the low shrub (seldom taller than 40cm) *Monechma genistifolium* subsp. *australe* and the grass *Stipagrostis obtusa*, both of which are facultative halophytes (Van Rooyen 2001 and Leistner, 1967). These two species are completely dominant in terms of cover and density, and few other species contribute significantly to vegetation cover. Species richness (α-diversity) is far lower than that found in Zones B and C, and only seven plant species were recorded within the central zone.

Zone A comprises the pan surface or floor, which is very homogenous and shows floristic and structural characteristics of both Zone C (outer parts of pan surface) and Zone D (intermediate zone) described for typical salt pans of the southern Kalahari by Leistner (see Figure 8). According to Leistner (1967) *Stipagrostis obtusa* is typically dominant in the outer zone of the surface of salt pans (Leistners's Zone C) and the Intermediate Zone (Leistner's Zone D) surrounding salt pans, and *Monechma genistifolium* subsp. *australe* is also typically dominant in the Intermediate Zone (Leistner's Zone D) surrounding salt pans.

Zone B

Comprises Short Closed Shrubland (*sensu* Edwards, 1983) on fairly shallow, grey, sandy soils on the footslopes of the dunes and margins of the interdune depression. The dominant shrub is *Rhigozum trichotomum*, which seldom exceeds 1m in height and forms dense, almost monospecific stands in places. Common shrubs, all of which rarely exceed 1m in height, include *Parkinsonia aculeata, Acacia* *haematoxylon, Lycium* cf. *cinereum, Gnidia sericocephala, Salsola* cf. *tuberculata, Zygophyllum pubescens, Monechma genistifolium* and *Peliostomum leucorrhizum.* The alien invasive shrub or small tree, *Prosopis glandulosa* var. *torryena*, occurs at low densities and contributes little to vegetation cover. Common forbs include *Tribulus zeyheri* and *Heliotropium ciliatum*. Common grasses include *Schmidtia kalahariensis, Stipagrostis* cf. *uniplumis* and *Stipagrostis obtusa*. This zone seemingly equates to the 'Intermediate Zone' around typical salt pans of the southern Kalahari as described by Leistner (see Figure 8).

Zone C

Comprises typical Gordonia Duneveld vegetation of deep, red sands (Namib soil form) of the crests and slopes of dunes, as described by Mucina and Rutherford (2009) and Leistner (1967). The vegetation can be described as Tall Open/Closed Shrubland (*sensu* Edwards, 1983). The dominant large shrub is *Acacia haematoxylon.* Common large shrubs include *Acacia mellifera* and *Parkinsonia aculeata*. Common small shrubs (‹ca. 1m) include *Lycium* cf. *bosciifolium*, *Gnidia polycephala* and *Sericoma remotiflora.* Common forbs include *Tribulus zeyheri* subsp. *zeyheri, Citrullus lanatus, Senna italica* subsp. *arachoides* and *Heliotropium ciliatum*. Common grasses include *Eragrostis trichophora, Eragrostis lehmanniana, Stipagrostis* cf*. amabilis* and *Schmidtia kalahariensis*.

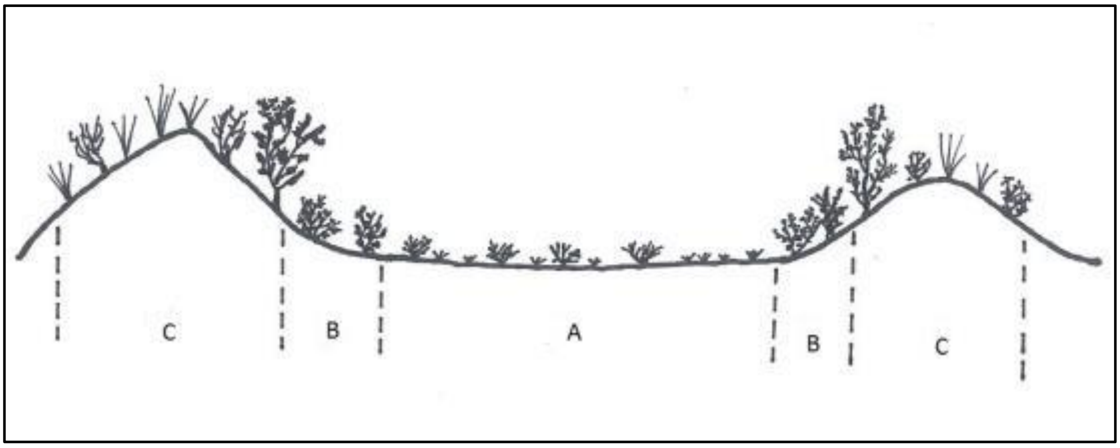

Figure 9: Diagram of the typical zonation of vegetation found in the pan and its surrounding Terrestrial habitat at site SP6. Zone C comprises terrestrial vegetation of dunes, Zone B comprises the transitional or intermediate zone and Zone A comprises the pan floor which is very homogenous and shows floristic and structural characteristics of both Zones C (outer parts of pan floor) and D (intermediate zone) described for typical salt pans of the southern Kalahari by Leistner (see Figure 10).

Figure 10: Site SP6, showing dune vegetation at left and on the horizon and pan vegetation in interdune depression at right of photograph.

The evidence in support of the statement that the vegetation of the interdune depression at site SP6 is indicative of a small endorheic pan which experiences ephemeral soil saturation or inundation periodically at long intervals, can be summarised as follows:

1. The Low Open Shrubland vegetation on the pan surface or floor (Zone A) is unique within the parts of the study area visited, both in terms of physiognomy and species composition and dominance.
2. The dominant species on the pan surface (Zone A) are the low shrub *Monechma genistifolium* subsp. *australe* and the grass *Stipagrostis obtusa*, both of which are facultative halophytes (Van Rooyen 2001 and Leistner, 1967). These two species are completely dominant in terms of cover and density, and few other species contribute significantly to vegetation cover.
3. Zone A (pan surface or floor) shows floristic and structural characteristics of the vegetation of typical salt pans of the southern Kalahari as described by Leistner (see Figure 1). According to Leistner (1967) *Stipagrostis obtusa* is typically dominant in the outer zone of the surface of salt pans (Leistners's Zone C) and the Intermediate Zone (Leistner's Zone D) surrounding salt pans, and *Monechma genistifolium* subsp. *australe* is also typically dominant in the Intermediate Zone (Leistner's Zone D) surrounding salt pans.

4. Species richness (α-diversity) on the pan floor (Zone A) is far lower than that found in Zones B and C, and only seven plant species were recorded within this zone.
5. The soil form of the pan surface (Zone A) is Brandvlei, a soil form which typically indicates wetland conditions in the arid regions of the northern Cape (see soil section of report). The soils of Zone A are characterised by the presence of free lime (calcium carbonate) which is indicative of periodic saturation or inundation, and is usually associated with elevated salinity levels.

Plant 'species of conservation concern'

The Red List of South African Plants (Raimondo*et al*., 2009) provides an assessment of all South African Plant taxa. The Red List therefore contains species that are currently regarded as being threatened with extinction (Critically Endangered, Endangered and Vulnerable) or are close to being threatened with extinction (Near Threatened), as well as species that are currently not regarded as being threatened with extinction (Least Concern), in accordance with IUCN Version 3.1 criteria (IUCN, 2001). In addition to the IUCN categories, the South African Red List also includes unique categories for species which do not currently qualify as Threatened or Near Threatened in accordance with IUCN criteria, and are thus categorised as Least Concern by the IUCN, but which are of some conservation concern (Raimondo *et al*., 2009). These South Africa categories are Critically Rare, Rare and Declining, and were developed specifically to highlight species that though not threatened with extinction possibly require some conservation effort and monitoring. In terms of the recommended methodology provided by Raimondo*et al*. (2009), the term 'species of conservation concern' includes the IUCN threatened and Near Threatened categories as well as the South African Red List categories (i.e. Critically Rare, Rare and Declining) and this approach is followed here.

Lists of plant species historically recorded within the two quarter degree grid squares within which the study area is situated, namely 2821AB and 28121BA, were obtained from the PRECIS database of the South African National Biodiversity Institute (http://posa.sanbi.org). The lists for these two grids contained only nine species and seven species, respectively, indicating that the area is severely under-collected from a botanical point of view and that little reliance can be placed on these lists. These lists contained only one plant 'species of conservation concern', namely *Boophone disticha*, which is not a threatened or Near Threatened species, but is categorized as Declining (Raimondo *et al*., 2009 and http://redlist.sanbi.org, downloaded December 2014). *Boophone disticha* was not recorded at any of the surveyed sites and this mesophytic species is certainly absent from the only wetland habitat (the ephemeral pan at site SP6) recorded within the study area.

A reasonably substantiated statement as to the presence or absence of plant "species of conservation concern" within the pan at site SP6 or its catchment, can only be provided if the pan and its catchment must be searched for such species in late April or early May during a rainy season with average to high rainfall.

Vegetation that potentially indicates wetland conditions was found at only one of the seven sites surveyed during the current study, namely site SP6. The vegetation found in the interdune depression at site SP6 is indicative of a small, endorheic pan that experiences brief soil saturation, or possibly even more brief soil inundation, periodically at very long intervals of many years or even decades. The pan can therefore be described as a pan which experiences ephemeral soil saturation or inundation periodically at long intervals. The pan is not inundated frequently enough and does not hold sufficient volumes of water to have formed a highly saline central zone comprising unvegetated (bare) soils, as is found in the typical salt pans of the southern Kalahari described by Leistner (1967). Ephemeral pans such as that found at site SP6 are abundant in the southern Kalahari but represent a unique and spatially restricted habitat within the study area and its immediate surrounds. The pan at site SP6 therefore merits conservation effort.

6.5 Present Ecological State (PES) and Ecological Importance Sensitivity (EIS)

The interdune pan and its surrounding catchment contain few noticeable disturbances and is almost entirely free of hard surface development. Catchment impacts, especially hydrological modifications that could affect the pan, are regarded as negligible. Impacts within the pan include a high grazing pressure and a low density of the invasive alien plant species *Prosopis glandulosa* var. *torreyana*, which contributes little to vegetation cover.

Based on the available information, the interdune pan at Site SP6 has a Largely natural PES (class B), which can improve to a class A PES through the reduction and maintenance of a moderate grazing pressure, as well as the successful control of the invasive *P. glandulosa* var. *torreyana* (Table 10). In order to help ensure that *P. glandulosa* var. *torreyana* does not become re-established within the pan after initial control, follow-up control will be required, as well as control within the remainder of the property. It is therefore recommended that an alien control plan for the study area is developed and maintained. The level of confidence associated with the assigned PES category is regarded as moderate due to the presence of only a few impacts of minor magnitude, which have a small overall significance (Table 10).

The Ecological Importance and Sensitivity (EIS) class of the interdune pan is regarded as High (class B), (Table 11). No plant ‘species of conservation concern’ were recorded during the vegetation survey, nor were any historical records identified for pan associated 'species of conservation concern' for quarter degree grid references 2821AB and 2821BA in the PRECIS database of the South African National Biodiversity Institute (http://posa.sanbi.org), .

The level of confidence associated with the presence of 'species of conservation concern' or populations of unique species in the pan is low due to the survey occurring outside of the optimal growing season (April-May) and what appears to be under-collected quarter degree grids that contain only nine and seven plant species, respectively. Ephemeral pans such as that found at Site SP6 are abundant in the southern Kalahari but represent a unique and spatially restricted habitat within the study area and its immediate surrounds. The pan represents a watercourse that is of conservation value and should therefore be protected.

Table 9: Displays the results of the PES assessment for the interdune pan at Site SP6

PES criteria & attributes	Interdune Pan at Site SP6	Confidence level
Hydrologic		
Flow modification [e.g. changes in the flow regime, volumes, velocity that affect inundation of wetland habitats]	5	3
Permanent Inundation (as a result of impoundments)	Not applicable to pans in general (excluded from this assessment)	-
Water Quality		
Water quality modification (e.g. from point or diffuse sources)	4	2
Sediment load modification (e.g. due to increased erosion, accretion or **infilling** of wetlands habitats.)	5	3
Hydraulic/ Geomorphic		
Canalisation (e.g. channel diversions or drainage that result in desiccation)	Not applicable to pans in general (excluded from this assessment)	-
Topographic alteration (e.g. as a result of infilling, ploughing, bridges, roads, and railway lines)	4	3
Biota		
Terrestrial encroachment / Loss of species richness(e.g. due to the desiccation of wetland habitat)	Not applicable to pans in general (excluded from this assessment)	-
Indigenous vegetation removal (e.g. due to land use activities)	3	2
Invasive plant encroachment	4	2
Over utilisation of biota	3	3
TOTAL	28	18
MEAN	4	2.6
Motivation for an adjustment, and general comments	The presence of two seriously modified scores results in an automatic E (seriously modified) PES for Pan 1.	
PES	**B**	**High confidence**

Scoring guidelines per attribute:

natural, unmodified = 5; Largely natural = 4, Moderately modified = 3; largely modified = 2; seriously modified = 1; Critically modified = 0.

Relative confidence of score:

Very high confidence = 4; High confidence = 3; Moderate confidence = 2; Marginal/low confidence = 1.

Table 10: Indicates the rated scores and the associated level of confidence for EIS calculations for the interdune pan at Site SP6 l

EIS categories	**Confidence level**	**Interdune Pan at Site SP6**
Biodiversity support (average value)		**2.33**
Rare & Endangered Species	1	2.00
Populations of Unique Species	1	3.00
Migration/breeding/feeding sites for wetland species	1	2.00
Landscape scale (average value)		**2.40**
Protection status of the wetland	4	3
Protection status of the vegetation type	4	1
Regional context of the ecological integrity (PES)	3	4
Size and rarity of the wetland type/s present	3	2
Diversity of Habitat Types or Features	3	2
Sensitivity of the wetland (average value)		**1**
Sensitivity to changes in floods	3	0
Sensitivity to changes in low flows/dry season	2	1
Sensitivity to changes in water quality	2	2
Confidence average; and the maximum value of the average scores for the three EIS components	2.2	**2.4**
Overall Ecological Sensitivity and Importance (EIS)	**Moderate confidence**	**B (High)**

Relative confidence of score:

Very high confidence = 4; High confidence = 3; Moderate confidence = 2; Marginal/low confidence = 1.

Table 11: Habitat integrity assessment criteria for wetlands (Adapted from DWAF, 2005).

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

6.6 Recommendations

1. This interdune wetland (pan) should not be degraded due to the proposed development.
2. A buffer zone should be established to ensure the pan receives adequate water from its catchment.
3. The catchment of the pan should be the minimum boundary of the buffer zone.
4. The pan and related buffer zone should form a corridor linking the inner track area with the outer undeveloped (natural area) to ensure that fauna and flora movement are not totally disrupted by the development (Appendix 2).
5. The water tract along SP3 should be defined as part of the stormwater management plan and mitigation defined accordingly.

7.0 CONCLUSION

The project area occurs in an arid and marginal region in terms of wetland distribution. However, one pan wetland was identified based on landscape setting, vegetation and soil form. This wetland is locally important in terms of biodiversity and should be conserved; and an adequate buffer provided for. The track and mining (if restricted to outside the buffer area) will not have a detrimental impact on the wetland. Therefore a fatal flaw is not foreseen.

8.0 ACKNOWLEDGEMENT

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9.0 LITERATURE

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APPENDIX 1: Photographs of selected sampling sites.

Figure A1: Site SP6, showing dune vegetation at left and on the horizon and pan vegetation in interdune depression at right of photograph.

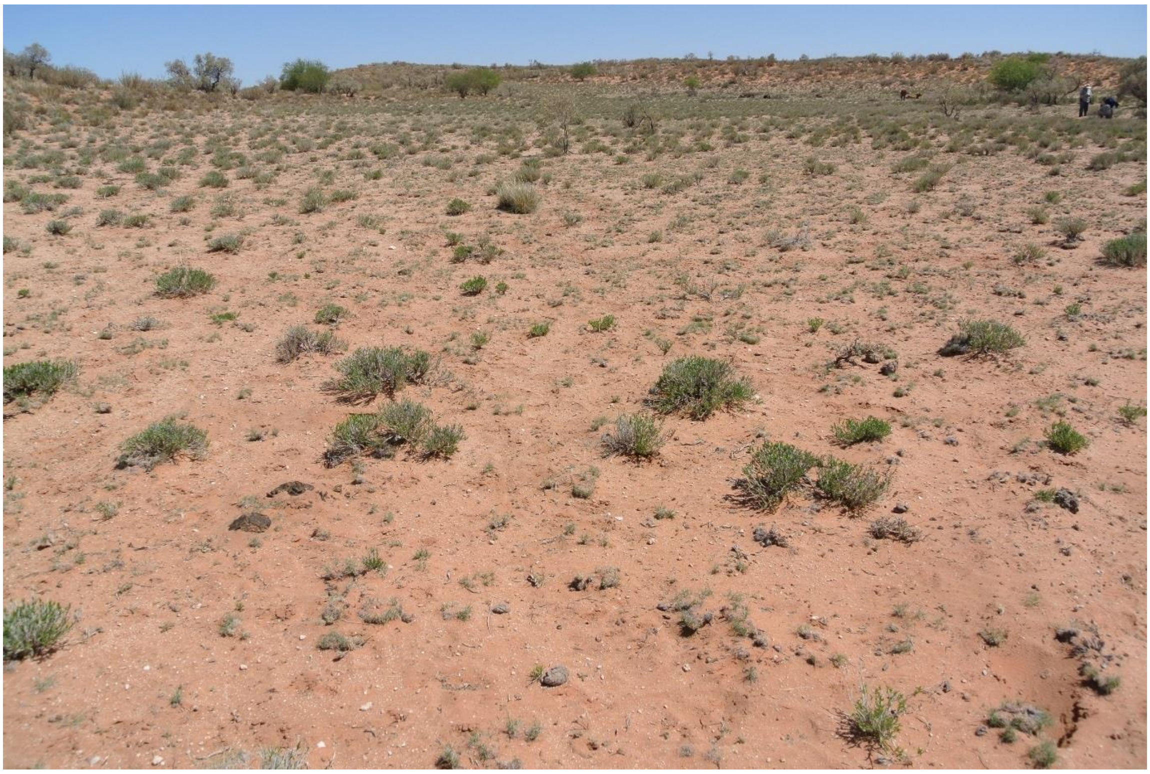

Figure A2: Site SP6 (T3), taken from middle of ephemeral pan and showing low vegetation cover comprising Low Open/Closed Shrubland with very low species richness.

Figure A3: *Rhigozum trichotomum* Short Closed Shrubland on grey sands of overgrazed interdune depression at Site T1a.

Figure 4A: Google Earth image showing seven sampling sites surveyed at four localities (T3 = SP6) within the study area on the 4th November 2014.

APPENDIX 2: Proposed corridor relative to Pan SP6 – buffer zone, oval and the mining area.