Nkurenkuru

ECOLOGY & BIODIVERSITY

PROPOSED AKERMANS KRAAL SAND MINE NEAR ALIWAL NORTH, EASTERN CAPE PROVINCE

FRESHWATER RESOURCE STUDY AND ASSESSMENT

Version: 1.0

Date: 10th March 2020

Author: Gerhard Botha

PROPOSED SAND MINE ON PORTION 0 (REMAINING EXTENT) OF THE FARM AKERMANS KRAAL 11 RD, ALIWAL NORTH, EASTERN CAPE PROVINCE

Report Title: Freshwater Resource Study and Assessment

Author: Gerhard Botha

Project Name: Proposed Akermans Kraal Sand Mine near Aliwal North, Eastern Cape Province

Status of report: Version 1.0

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I. DECLARATION OF CONSULTANT'S INDEPENDENCE

- act/ed as the independent specialist in this application;
- regard the information contained in this report as it relates to my specialist input/study to be true and correct, and
- do not have and will not have any financial interest in the undertaking of the activity, other than remuneration for work performed in terms of the NEMA, the Environmental Impact Assessment Regulations, 2014 and any specific environmental management Act;
- have and will not have any vested interest in the proposed activity proceeding;
- have disclosed, to the applicant, EAP and competent authority, any material information that have or may have the potential to influence the decision of the competent authority or the objectivity of any report, plan or document required in terms of the NEMA, the Environmental Impact Assessment Regulations, 2014 and any specific environmental management Act;
- am fully aware of and meet the responsibilities in terms of NEMA, the Environmental Impact Assessment Regulations, 2014 (specifically in terms of regulation 13 of GN No. R. 326) and any specific environmental management Act, and that failure to comply with these requirements may constitute and result in disqualification;
- have provided the competent authority with access to all information at my disposal regarding the application, whether such information is favourable to the applicant or not; and
- am aware that a false declaration is an offense in terms of regulation 48 of GN No. R. 326.

Gerhard Botha Pr.Sci.Nat 400502/14 (Botanical and Ecological Science)
March 2020

Field of expertise:

Wetland ecology, aquatic and wetland fauna & flora, terrestrial biodiversity, aquatic biomonitoring, and wetland habitat evaluations. BSc (Hons) Zoology and Botany, MSc Botany (Phytosociology) from 2011 to present.

II. REQUIREMENTS REGARDING A SPECIALIST ASSESSMENT

Requirements of Appendix 6 – GN R326 EIA Regulations of 7 April 2017	Sections where this is addressed in the Specialist Report
1. (1) A specialist report prepared in terms of these Regulations must contain- a) details of- i. the specialist who prepared the report; and ii. the expertise of that specialist to compile a specialist report including a curriculum vitae;	Page I and Appendix 6 & 7
b) a declaration that the specialist is independent in a form as may be specified by the competent authority;	Page I
c) an indication of the scope of, and the purpose for which, the report was prepared;	Section 1 (1.3, 1.4, 1.5)
(cA) an indication of the quality and age of base data used for the specialist report;	Section 2 (2.1 - 2.3)
(cB) a description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change;	Section 6 (6.2 – 6.4)
d) the duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment;	Section 2.6 and 2.8
e) a description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modeling used;	Section 2
f) details of an assessment of the specifically identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure, inclusive of a site plan identifying site alternatives;	Section 2 (2.6) and Section 5
g) an identification of any areas to be avoided, including buffers;	N/A
h) a map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	Section 5
i) a description of any assumptions made and any uncertainties or gaps in knowledge;	Section 2.8
j) a description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives on the environment or activities;	Section 5 and 6
k) any mitigation measures for inclusion in the EMPr;	Section 6
l) any conditions for inclusion in the environmental authorisation;	Section 6
m) any monitoring requirements for inclusion in the EMPr or environmental authorisation;	Section 6
n) a reasoned opinion- i. as to whether the proposed activity, activities or portions thereof should be authorised; (iA) regarding the acceptability of the proposed activity or activities; and ii. if the opinion is that the proposed activity, activities or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan;	Section 7
o) a description of any consultation process that was undertaken during the course of preparing the specialist report;	N/A
p) a summary and copies of any comments received during any consultation process and where applicable all responses thereto; and	N/A
q) any other information requested by the competent authority.	N/A
2) Where a government notice gazetted by the Minister provides for any protocol or minimum information requirement to be applied to a specialist report, the requirements as indicated in such notice will apply.	N/A

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FRESHWATER RESOURCE STUDY AND ASSESSMENT

1. INTRODUCTION

1.1 Applicant

GreenMined Environmental (Pty) Ltd. on behalf of Yellowwood Trust.

1.2 Project

The project will be known as Akermans Kraal Sand Mine.

1.3 Proposed Activity

Description of the proposed activity as provided by GreenMined Environmental (2019):

> *"Yellowwood Trust (hereinafter referred to as "the Applicant"), applied for environmental authorisation (EA) and a mining permit to mine sand from the Orange River on a portion of Portion 0 (Remaining Extent) of the farm Akermans Kraal 11 RD, Aliwal North, Eastern Cape Province.*
>
> *The proposed mining area of the Applicant will be 2.8 ha and will be developed over an area where sand has previously been mined from the riverbed. The proposed operation is representative of the small-scale mining industry where the mineral (sand) is loaded with an excavator onto tractor-drawn tippers that hauls the sand from the river to the stockpile area (within the 2.8 ha mining area). At the stockpile area the sand will be screened (if required) and stockpiled until loaded by a front-end-loader (FEL) onto trucks that will transport the material to clients. No mining, from the riverbed, will take place during the high flow periods of the Orange River, and all machinery and equipment will be removed from the river. Due to the small scale of the operation no infrastructure, other than a chemical toilet and the sand screen,*

will be established within the mining footprint. Vehicle/equipment maintenance will be done at an existing off-site workshop of the Applicant, and the mining area will be reached via an existing farm road."

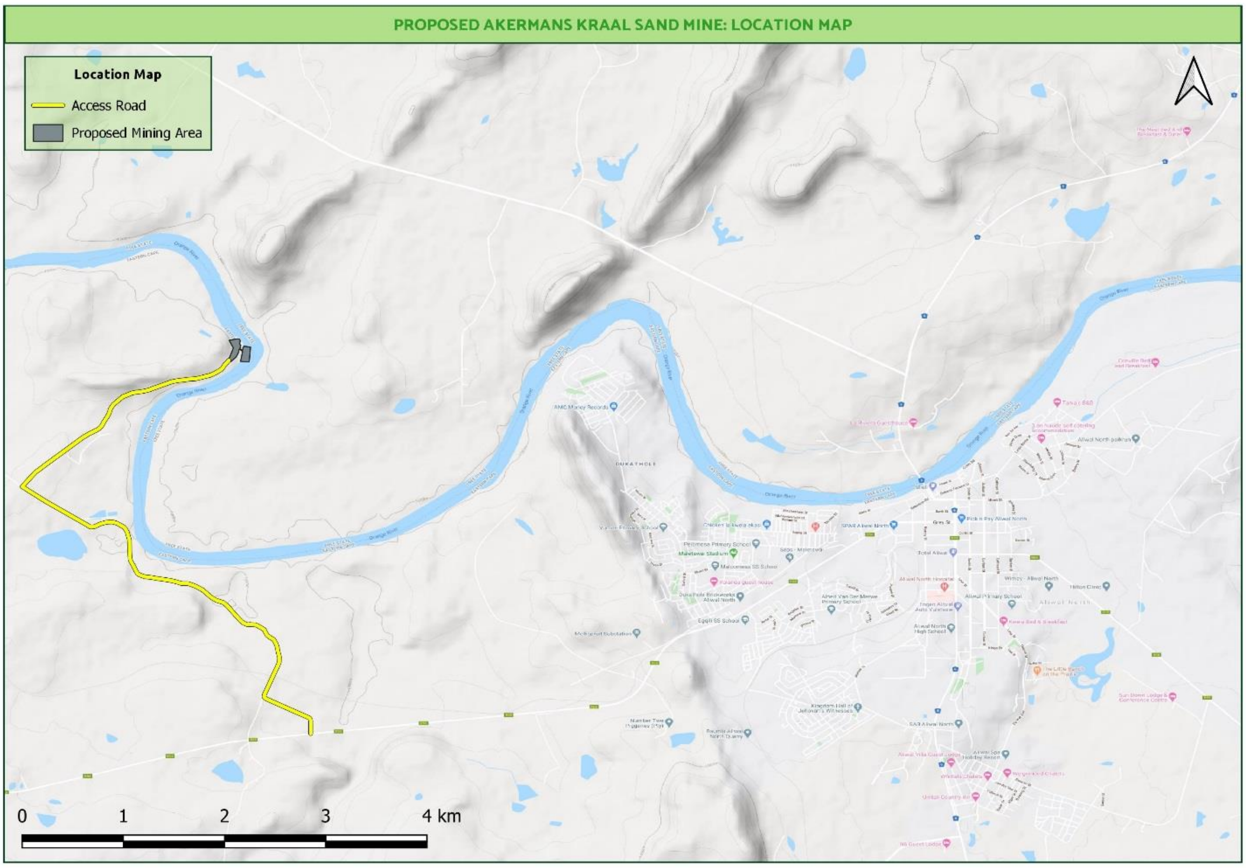

Figure 1: Location Map

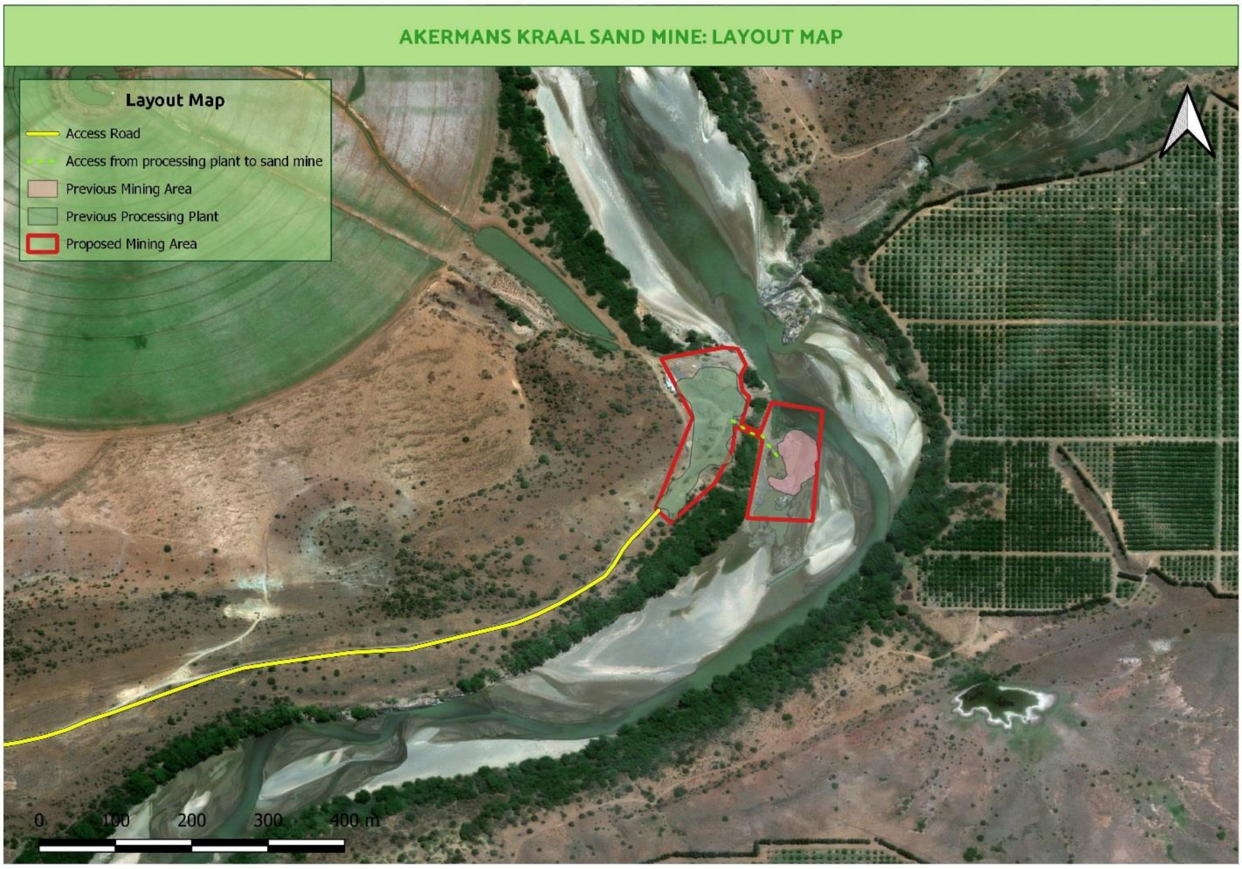

Figure 2: Layout Map

1.4 Terms of reference

The aims of this report were to:

» describe the Present Ecological State of aquatic ecosystems in the study area before development, against which the likely impacts of the sand mine can be evaluated, future changes can be compared (i.e. to collect baseline data), and to identify areas that are ecologically important and/or sensitive;
» assess the likely impacts of the proposed development on aquatic ecosystems in terms of their geographical extent, intensity, duration, probability of occurrence and overall significance for the various phases of the proposed development;
» suggest measures for mitigating the detrimental impacts of the proposed development, and enhancing positive impacts where appropriate;
» assess the overall significance of the likely impacts after mitigation measures are applied;

» identify and describe Key Performance Indicators that can be used to monitor the impacts of the various phases of the proposed development on aquatic ecosystems, where relevant.

1.5 Conditions of this report

Findings, recommendations, and conclusions provided in this report are based on the authors', as well as the other involved specialists', best scientific and professional knowledge and information available at the time of compilation. No form of this report may be amended or extended without the prior written consent of the authors. Any recommendations, statements or conclusions drawn from or based on this report must clearly cite or make reference to this report. Whenever such recommendations, statements or conclusions form part of the main report relating to the current investigation, this report must be included in its entirety.

1.6 Relevant legislation

The following legislation was taken into account whilst compiling this report:

Provincial

» The Eastern Cape Nature and Environmental Conservation Ordinance / ECNECO (Act No 19 of 1974) in its entirety, with special reference to:
  - Schedule 1: Endangered Wild Animals
  - Schedule 2: Protected Wild Animals
  - Schedule 3: Endangered Flora
  - Schedule 4: Protected Flora

The above-mentioned Nature Conservation Ordinance accompanied by all amendments is regarded by the Eastern Cape Economic Development, Environmental Affairs and Tourism (DEDEA) as the legally binding, provincial documents, providing regulations, guidelines and procedures with the aim of protecting game and fish, the conservation of flora and fauna and the destruction of problematic (vermin and invasive) species.

National

» National Environmental Management Act / NEMA (Act No 107 of 1998), and all amendments and supplementary listings and/or regulations
» Environment Conservation Act (ECA) (No 73 of 1989) and amendments
» National Environmental Management Act: Biodiversity Act / NEMA:BA (Act No. 10 of 2004) and amendments
» The National Water Act 36 of 1998

- General Authorisations (GAs): As promulgated under the National Water Act and published under GNR 398 of 26 March 2004.
- National Forest Act 1998 / NFA (No 84 of 1998)
- National Veld and Forest Fire Act (Act No. 101 of 1998)
- Conservation of Agricultural Resources Act / CARA (Act No. 43 of 1983) and amendments

International

- Convention on International Trade in Endangered Species of Fauna and Flora (CITES)
- The Convention on Biological Diversity, 1995
- The Convention on the Conservation of Migratory Species of Wild Animals
- The RAMSAR Convention
- United Nations Convention to Combat Desertification
- The Partnership for Africa's Development (NEPAD)
- The World Summit on Sustainable Development (WSSD)

2. METHODOLOGY

A detailed description of the methodology that was followed for the freshwater resource assessment are contained in the attached Appendixes 1 and 2. A summary of the data sources and GIS information consulted during this study are provide in Table 1. Bellow follows a description of the assessment approach and philosophy that were followed during this study.

Table 1: Information and data coverages used to inform the ecological assessment.

	Data/Coverage Type	Relevance	Source
Biophysical Context	**Colour Aerial Photography**	Desktop mapping of habitat/ecological features as well as drainage network.	National Geo-Spatial Information (NGI)
	Latest Google Earth™ imagery	To supplement available aerial photography	Google Earth™ On-line
	1:50 000 Relief Line (5m Elevation Contours GIS Coverage)	Desktop mapping of terrain and habitat features as well as drainage network.	Client
	1:50 000 River Line (GIS Coverage)	Highlight potential on-site and local rivers and wetlands and map local drainage network.	CSIR (2011)
	DWA Eco-regions (GIS Coverage)	Understand the regional biophysical context in which water resources within the study area occur	DWA (2005)

	South African Vegetation Map (GIS Coverage)	Classify vegetation types and determination of reference primary vegetation	Mucina & Rutherford (2012)
	NFEPA: river and wetland inventories (GIS Coverage)	Highlight potential on-site and local rivers and wetlands	CSIR (2011)
Conservation and Distribution Context	**NFEPA: River, wetland and estuarine FEPAs** (GIS Coverage)	Shows location of national aquatic ecosystems conservation priorities	CSIR (2011)
	National Biodiversity Assessment – Threatened Ecosystems (GIS Coverage)	Determination of national threat status of local vegetation types	SANBI (2011)
	Eastern Cape Biodiversity Conservation Plan (GIS Coverage)	Determination of provincial terrestrial/freshwater conservation priorities and biodiversity buffers	SANBI (2016)
	Red Data Books (Red Data Lists of Plants, Mammals, Reptiles, and Amphibians	Determination of endangered and threatened plants, mammals, reptiles and amphibians	Various sources
	Animal Demography Unit	Determination of faunal species composition within the region as well as potential conservation important faunal species	ADU, 2019
	Smither's Mammals of Southern Africa	Compilation of a species list	Apps (ed.) 2012
	The Mammals of the Southern African Subregion	Compilation of a species list	Skinner & Chimimba (2005)
	Field guide to snakes and other reptiles of southern Africa	Compilation of a species list	Branch (1998)
	A Complete Guide to the Frogs of Southern Africa	Compilation of a species list	Du Preez & Carruthers (2009)

2.1 Assessment Approach and Philosophy

2.1.1 Surface Hydrology

The delineation and classification of freshwater resources were conducted using the standards and guidelines produced by the DWS (DWAF, 2005 & 2007) and the South African National Biodiversity Institute (SANBI, 2009). These methods are contained in the attached Appendix 1, which also includes wetland definitions, wetland conservation importance and Present Ecological State (PES) assessment methods used in this report.

In addition to these guidelines the general approach to freshwater habitat assessment was furthermore based on the proposed framework for wetland assessment as proposed within the Water Research Commission's (WRC) report titled: "Development of a decision-support framework for wetland assessment in

South Africa and a Decision-Support Protocol for the rapid assessment of wetland ecological condition" (Ollis *et.* al., 2014). A schematic illustration of the proposed decision-support framework for wetland assessment in South Africa are provided in Figure 3 below.

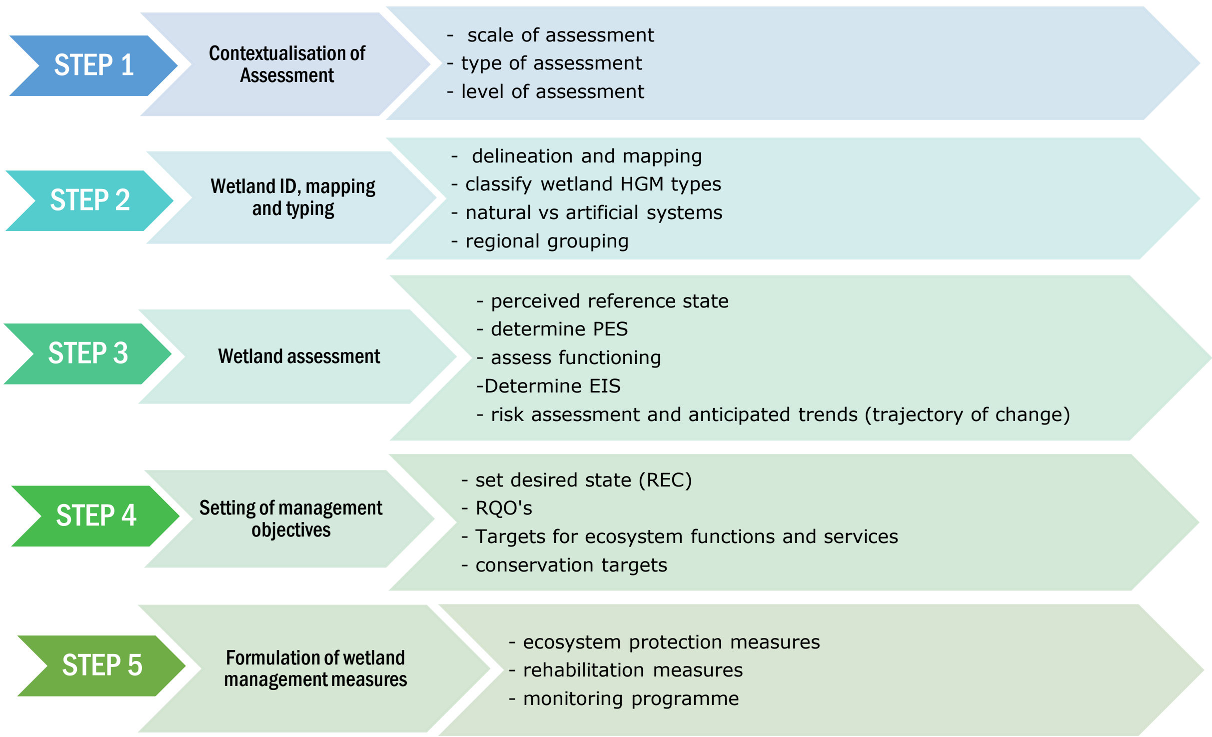

Figure 3: Proposed decision support framework for wetland assessment in South Africa (after Ollis et al., 2014)

2.2 Assumptions, Limitations and Information Gaps

2.2.1 General Assumptions and Limitations

- This report deals exclusively with a defined area and the impacts upon biodiversity and natural ecosystems in that area including all downstream freshwater / aquatic resources that may potentially be impacted and which fall within the Regulated Areas as defined by DWS.
- All relevant project information provided by the applicant and engineering design team to the ecological specialist was correct and valid at the time that it was provided.

» Additional information used to inform the assessment was limited to data and GIS coverage's available for the EC Province at the time of the assessment.

2.2.2 Sampling Limitations and Assumptions

» While disturbance and transformation of habitats can lead to shifts in the type and extent of ecosystems, it is important to note that the current extent and classification is reported on here.
» The delineation of the outer boundary of riparian areas is based on a number of indicators, including topography (macro-channel features), the presence of alluvial deposition and vegetation indicators. The boundaries mapped in this specialist report therefore represent the approximate boundary of riparian habitat as evaluated by an assessor familiar and well-practiced in the delineation technique.
» The accuracy of the delineation is based solely on the recording of the relevant onsite indicators using a GPS. GPS accuracy will therefore influence the accuracy of the mapped sampling points and therefore resource boundaries and an error of 3 – 5m can be expected. All soil/vegetation/terrain sampling points were recorded using a Garmin etrex Touch 35 Positioning System (GPS) and captured using Geographical Information Systems (GIS) for further processing.
» Infield soil and vegetation sampling was only undertaken within a specific focal area in the vicinity of the proposed development, while the remaining water resource/HGM units were delineated at a desktop level with limited accuracy.
» Any freshwater resource that fall outside of the affected catchment (but still within the 500m DWS regulated area) and are not at risk of being impacted by the specific activity were not delineated or assessed. Such features were flagged during a baseline desktop assessment prior to the site visit.
» Sampling by its nature, means that generally not all aspects of ecosystems can be assessed and identified.
» With ecology being dynamic and complex, there is the likelihood that some aspects some of which may be important) may have been overlooked.

2.2.3 Sampling Limitations and Assumptions

» Probably the most significant potential limitation associated with such a sampling approach is the narrow temporal window of sampling.
    - Ideally, a site should be visited several times, during different seasons to ensure that the full complement of plant and animal species present is captured.
    - However, this is rarely possible due to time and cost constraints and therefore, the representation of the species sampled at the time of the site visit should be critically evaluated.

- The site was sampled during a dynamic period wherein there was a sudden and recent rise in the water level (increase in water flow volume and velocity)
- The footprint was covered in detail with the result that the results are considered highly reliable and it is unlikely that there are any significant species or features present that were not recorded.

» Diatom collection was restricted to one sample in February 2020 due to very high flows which restricted suitable habitat. A sudden and recent increase in flow volume and velocity resulted in the disturbance of the algae (diatom) population and as such insufficient diatoms valve densities were sampled in order to obtain an accurate indication of the present ecological state of the area (this was most probably as a result of cobbles being moved during the high flows and diatoms being washed away from substrate). In lieu of the absence of current data, a review was provided of historic data that is available for the upper Orange River reach.

» A sudden increase in flow volume and velocity also impacted the Physico-Chemical analysis of the study area and rather provided an indication of upstream conditions rather than on-site conditions.

2.2.4 Baseline Ecological Assessment - Limitations and Assumptions

» All assessment tools utilised within this study were applied only to the resources and habitats located within 'regulated area' and which are at risk of being impacted by the proposed development. Any resource located outside of the impacted catchment and which is not a risk of being impacted was not assessed.

» It should be noted that the most appropriate assessment tools were selected for the analysis of the specific features and resources that may potentially be impacted by the proposed development. Selection was based on the assessment practitioner's knowledge and experience of these tools and their attributes and shortcomings.

» Furthermore, it should be noted that these assessment techniques and tools are currently the most appropriate currently available tools and techniques to undertake assessments of freshwater resources, they area however rapid assessment tools that rely on qualitative information and expert judgment. While these tools have been subjected to peer review processes, the methodology for these tools are ever evolving and will likely be further refined in the near future. For the purposes of this assessment, the assessments were undertaken at rapid levels with somewhat limited field verification. It therefore provides an indication of the PES of the portions of the affected systems rather than providing a definitive measure.

- PES and EIS were only determined for the affected / regulated areas even though upstream and downstream as well as catchment impacts were considered (based on available desktop information).
- The PES and EIS assessments undertaken are largely qualitative assessment tools and thus the results are open to professional opinion and interpretation. We have made an effort to substantiate all claims where applicable and necessary.
- The Ecological Importance and Sensitivity assessment did not specifically address the finer-scale biological aspects of the rivers such as fauna (amphibians and invertebrates).

3. CONSERVATION AND FUNCTIONAL IMPORTANCE OF AQUATIC ECOSYSTEMS

Water affects every activity and aspiration of human society and sustains all ecosystems. "Freshwater ecosystems" refer to all inland water bodies whether fresh or saline, including rivers, lakes, wetlands, sub-surface waters and estuaries (Driver et al., 2011). South Africa's freshwater ecosystems are diverse, ranging from sub-tropical in the north-eastern part of the country, to semi-arid and arid in the interior, to the cool and temperate rivers of the fynbos. Wetlands and rivers form a fascinating and essential part of our natural heritage, and are often referred to as the "kidneys" and "arteries" of our living landscapes and this is particularly true in semi-arid countries such as South Africa (Nel et al., 2013). Rivers and their associated riparian zones are vital for supplying freshwater (South Africa's most scare natural resource) and are important in providing additional biophysical, social, cultural, economic and aesthetic services (Nel et al., 2013). The health of our rivers and wetlands is measured by the diversity

and health of the species we share these resources with. Healthy river ecosystems can increase resilience to the impacts of climate change, by allowing ecosystems and species to adapt as naturally as possible to the changes and by buffering human settlements and activities from the impacts of extreme weather events (Nel et al., 2013). Freshwater ecosystems are likely to be particularly hard hit by rising temperatures and shifting rainfall patterns, and yet healthy, intact freshwater ecosystems are vital for maintaining resilience to climate change and mitigating its impact on human wellbeing by helping to maintain a consistent supply of water and for reducing flood risk and mitigating the impact of flash floods. We therefore need to be mindful of the fact that without the integrity of our natural river systems, there will be no sustained long-term economic growth or life (DEA et al., 2013).

Freshwater ecosystems, including rivers and wetlands, are also particularly vulnerable to anthropogenic or human activities, which can often lead to irreversible damage or longer term, gradual/cumulative changes to freshwater resources and associated aquatic ecosystems. Since channelled systems such as rivers, streams and drainage lines are generally located at the lowest point in the landscape; they are often the "receivers" of wastes, sediment and pollutants transported via surface water runoff as well as subsurface water movement (Driver et al., 2011). This combined with the strong connectivity of freshwater ecosystems, means that they are highly susceptible to upstream, downstream and upland impacts, including changes to water quality and quantity as well as changes to aquatic habitat & biota (Driver et al., 2011). South Africa's freshwater ecosystems have been mapped and classified into National Freshwater Ecosystem Priority Areas (NFEPAs). This work shows that 60% of our river ecosystems are threatened and 23% are critically endangered. The situation for wetlands is even worse: 65% of our wetland types are threatened, and 48% are critically endangered (Driver et al., 2011). Recent studies reveal that less than one third of South Africa's main rivers are considered to be in an ecologically 'natural' state, with the principal threat to freshwater systems being human activities, including river regulation, followed by catchment transformation (Rivers-Moore & Goodman, 2009). South Africa's freshwater fauna also display high levels of threat: at least one third of freshwater fish indigenous to South Africa are reported as threatened, and a recent southern African study on the conservation status of major freshwater-dependent taxonomic groups (fishes, molluscs, dragonflies, crabs and vascular plants) reported far higher levels of threat in South Africa than in the rest of the region (Darwall *et al*., 2009). Clearly, urgent attention is required to ensure that representative natural examples of the different ecosystems that make up the natural heritage of this country for current and future generations to come. The degradation of South African rivers and wetlands is a concern now recognized by Government as requiring urgent action and the protection of freshwater resources, including rivers and wetlands, is considered fundamental to the sustainable management of South Africa's water resources in the context of the reconstruction and development of the country.

4. STUDY AREA

4.1 Regional / Local Biophysical Setting

The proposed mining area will be largely located within an area that has been previously mined. The mining area will be approximately 2.8ha in extent and will be located within Portion 0 (Remaining Extent) of the Farm Akermans Kraal 11 RD. Sand will be mined from a fairly large alluvial sandbar located within the Orange

River, whilst processing of the material will occur outside of the channel or riparian fringe. Access from the processing plant to the sandbar can be gained via an existing small access road and as such there will be no need for additional access roads. The site is situated approximately 12km north west of the town of Aliwal North, within the Maletswai Local Municipality of the Eastern Cape Province. Access to the site can be gained via a gravel road turning from the R58 Road.

Landuse within the study area is dominated by livestock grazing with some dryland and irrigation cultivation restricted to areas around the Orange River. A fairly large plantation/orchards of pecan trees is present to the east of the Orange River (within the Free State Province).

The most prominent hydrological feature within this area is the Orange River draining in a predominantly east to west direction. The study site occurs within the Quaternary Catchment D14A and within the Quaternary Reach D14A-5424 which is nestled between the tributaries Sanddrifspruit River and Melkspruit River. This section of the Orange River forms part of the Upper Orange Water Management Area (WMA).

A summary of the biophysical features and the setting of the project site and surroundings are summarised in Table 2 below.

Table 2: Summary of the biophysical setting of the projects site as well as the surroundings

Biophysical Aspect	Desktop Biophysical Details	Source
Physiography		
Av. Elevation a.m.s.l	1303m	Google Earth & ArcGis
Max. Elevation a.m.s.l	1326m	Google Earth & ArcGis
Min. Elevation a.m.s.l	1291m	Google Earth & ArcGis
Av. slope	3.9%; -4.0%	Google Earth & ArcGis
Maximum slope	18.4%; -19.2%	Google Earth & ArcGis
Landscape Description	Undulating landscape characterised by grassy plains interrupted be narrow ridges (dolerite) and koppies (hills) covered by shrubs and grasses. This landscape is bisected by the Orange river which comprise of flat alluvial terraces fringed by a dense woody riparian fringe. Due to the highly dynamic sediment deposition and removal nature of this river the channel morphology is also highly variable comprising of large sandbars, low flow channels, deep pools, and shallow runs. Locally exposed bedrock also	Google Earth & Mucina and Rutherford, 2006

<table>
<tr><td></td><td colspan="4">contributes to the varying morphology. Subsequently stream flow occurs in braided form during low flow</td><td></td></tr>
<tr><td>Geomorphic Province</td><td colspan="4">Lower Vaal and Orange Valleys</td><td>Partridge et al., 2010</td></tr>
<tr><td>Geology and soils</td><td colspan="4">Mainly alluvial material with brownish red and grey mudstone and sandstone of the Tarkastad Subgroup. Some isolated areas are characterised by Karoo dolerite sills with brownish red and grey mudstone, also of the Tarkastad Subgroup.</td><td>ARC & SA Geological Dataset</td></tr>
<tr><td colspan="6">Climate</td></tr>
<tr><td>Mean annual temperature</td><td colspan="4">15.3°C</td><td>Climate-data.org</td></tr>
<tr><td>Warmest Month & Av. Temp.</td><td colspan="4">January: 22.2°C</td><td>Climate-data.org</td></tr>
<tr><td>Coldest Month & Av. Temp.</td><td colspan="4">June: 7.8°C</td><td>Climate-data.org</td></tr>
<tr><td>Rainfall Seasonality</td><td colspan="4">Mid Summer</td><td>DWAF, 2007</td></tr>
<tr><td>Mean annual precipitation</td><td colspan="4">455 mm</td><td>Schulze, 1997</td></tr>
<tr><td>Mean annual runoff</td><td colspan="4">20mm – 50mm</td><td>Schulze, 1997</td></tr>
<tr><td>Mean annual evaporation</td><td colspan="4">2000mm - 2200mm</td><td>Schulze, 1997</td></tr>
<tr><td colspan="6">Surface Hydrology</td></tr>
<tr><td rowspan="2">DWA Ecoregions</td><td colspan="2">Level 1</td><td colspan="2">Level 2</td><td rowspan="2">DWA, 2005</td></tr>
<tr><td colspan="2">Nama Karoo</td><td colspan="2">26.3</td></tr>
<tr><td>Wetland vegetation group</td><td colspan="4">Upper Nama Karoo</td><td>CSIR, 2011</td></tr>
<tr><td>Water management area</td><td colspan="4">Upper Orange WMA (12)</td><td>DWA</td></tr>
<tr><td>Sub water management area</td><td colspan="4">Kraai</td><td>DWA</td></tr>
<tr><td rowspan="2">Quaternary catchment</td><td colspan="2">Name (Symbol)</td><td colspan="2">Extent (ha)</td><td rowspan="2">DWA</td></tr>
<tr><td colspan="2">D14A</td><td colspan="2">76520</td></tr>
<tr><td>Sub Quaternary Catchment</td><td colspan="2">Name (Symbol)</td><td colspan="2">Extent (ha)</td><td rowspan="2">DWA</td></tr>
<tr><td></td><td colspan="2">5424</td><td colspan="2">2376</td></tr>
<tr><td rowspan="2">Geomorphic Class</td><td>Symbol</td><td colspan="2">Description</td><td>Slope (%)</td><td rowspan="2">CSIR, 2011</td></tr>
<tr><td>F</td><td colspan="2">Lowland River</td><td>0.001</td></tr>
</table>

4.2 Conservation Planning / Context

Understanding the conservation context and importance of the study area and surrounds is important to inform decision making regarding the management of the aquatic resources in the area. In this regard, national, provincial and regional conservation planning information is available and was used to obtain an overview of the study site. Key conservation context details of the project site and surrounds have been summarised in Table 3, below.

Table 3: Key conservation context details for the study area

NATIONAL LEVEL CONSERVATION PLANNING CONTEXT			
Conservation Planning Dataset	**Relevant Conservation Feature**	**Location in Relationship to Project Site**	**Conservation Planning Status**

National Threatened Ecosystems (SANBI & DEA, 2011) – remaining extent	Not Listed	Not Listed	Not Listed
National Vegetation Map (Mucina & Rutherford, 2006)	Upper Gariep Alluvial Vegetation	Site	Vulnerable
The National Freshwater Ecosystem Priority Area (NFEPA) Assessment (CSIR, 2011)	Orange River and Catchment area	River/catchment	FEPA River and Catchment Wetland Vegetation Group: Upper Nama Karoo Floodplain Wetland - Vulnerable
PROVINCIAL AND REGIONAL LEVEL CONSERVATION PLANNING CONTEXT			
Conservation Planning Dataset	**Relevant Conservation Feature**	**Location in Relationship to Project Site**	**Conservation Planning Status**
Eastern Cape Biodiversity Conservation Plan (Berliner *et al.* 2007)	Wetlands and catchment area	Entire site and catchment	Aquatic CBA 2

4.2.1 National Protected Areas Expansion Strategy

The National Freshwater Ecosystem Priority Area (NFEPA) project (Nel et al., 2011), is the first formally adopted national freshwater conservation plan that provides strategic spatial priorities for conserving the country's freshwater ecosystems and supporting the sustainable use of water resources that includes rivers, wetlands and estuaries. FEPA maps show various different categories, each with different management implications. The categories include river FEPAs and associated sub-quaternary catchments, wetland FEPAs, wetland clusters, Fish Support Areas (FSAs) and associated sub-quaternary catchments, fish sanctuaries, phase 2 FEPAs and associated sub-quaternary catchments, and Upstream Management Areas (UMAs). Categories relevant to this study include river FEPAs and associated catchments. This section of the Orange River is recognised nationally as an important river FEPA (Freshwater Ecosystem Priority Area) and should be managed in such a way as to protect the current state and functioning of the river system. The entire river catchment is also considered a FEPA (see Figure 4). In terms of the conservation threat status of wetland vegetation, intact wetlands within the Upper Nama Karoo Floodplain Wetland Vegetation Type are classified as Vulnerable (CSIR, 2011). While there are no identified wetlands FEPAs for the study site, the downstream floodplain wetlands area considered of conservation importance. Land-use/development implications in terms of the FEPA status of rivers, wetlands and their associated catchment areas include the following:

» River and wetland FEPAs need to be maintained in a good condition in order to achieve biodiversity goals and protect water resources from human use;
» In the absence of a national protocol, a generic 100m buffer should be established around wetland/river FEPAs; and
» The surrounding land and smaller stream network need to be managed in a way that maintains the good condition of the river reach.

Due to the fact that the mining area will be largely confined to the old disturbed mining footprint as well as the fact that mining activities will only commence as long as the sandbar is exposed (dry periods with low to zero flows) it is highly unlikely that this activity will impact downstream sensitive floodplain wetlands as well as the ecological status of, and functions and services provided by this portion of the Orange River and subsequently will not threaten the FEPA areas.

4.2.2 Aquatic Systematic Conservation Plan (CPLAN)

The study site itself is located within an Aquatic CBA2 area (Figure 5). Aquatic CBAs were identified on the basis of sub-quaternary catchments, addressing the linkages between catchments, important rivers and sensitive estuaries. Priorities were identified through a systematic conservation planning analysis.

Table 4: Criteria used to map CBAs

Aquatic Critical Biodiversity Areas		
CBA category	**Code**	**Feature used to define category**
CBA 1	A1	Critically important river sub-catchments, and all wetlands
	E1	Critically important Estuaries
CBA 2	A2a	Important sub-catchment
	A2b	Free-flowing rivers important for fish migration
	E2	Important Estuaries
CBA 3	A3a	Hydrological primary catchment management areas for E1
	A3b	Hydrological primary catchment management areas for E2 estuaries

According to the Eastern Cape CBA Map the development site is located within a A2a CBA2 Area and subsequently falls within an Aquatic Biodiversity Land Management Class 2a (ABLMC 2a). According to the ECBCP (Eastern Cape Biodiversity Conservation Plan) the recommended land use objective within ABLMC 2a area should be to maintain biodiversity in a near natural state with minimal loss of ecosystem integrity. Not transformation of natural habitat should be permitted.

Furthermore, the transformation threshold for such an ABLMC should be less than 15% of the total area of the sub-quaternary catchment.

Due to the fact that the mining area will be largely confined to the old disturbed mining footprint, resulting in very limited impacts on the natural areas, as well as the fact that mining activities will only commence as long as the sandbar is exposed (dry periods with low to zero flows), it is highly unlikely that this activity will impact the CBA2 conservation target. Appropriate mitigation measures will furthermore significantly reduce any potential impacts on the natural areas within this CBA2 area.

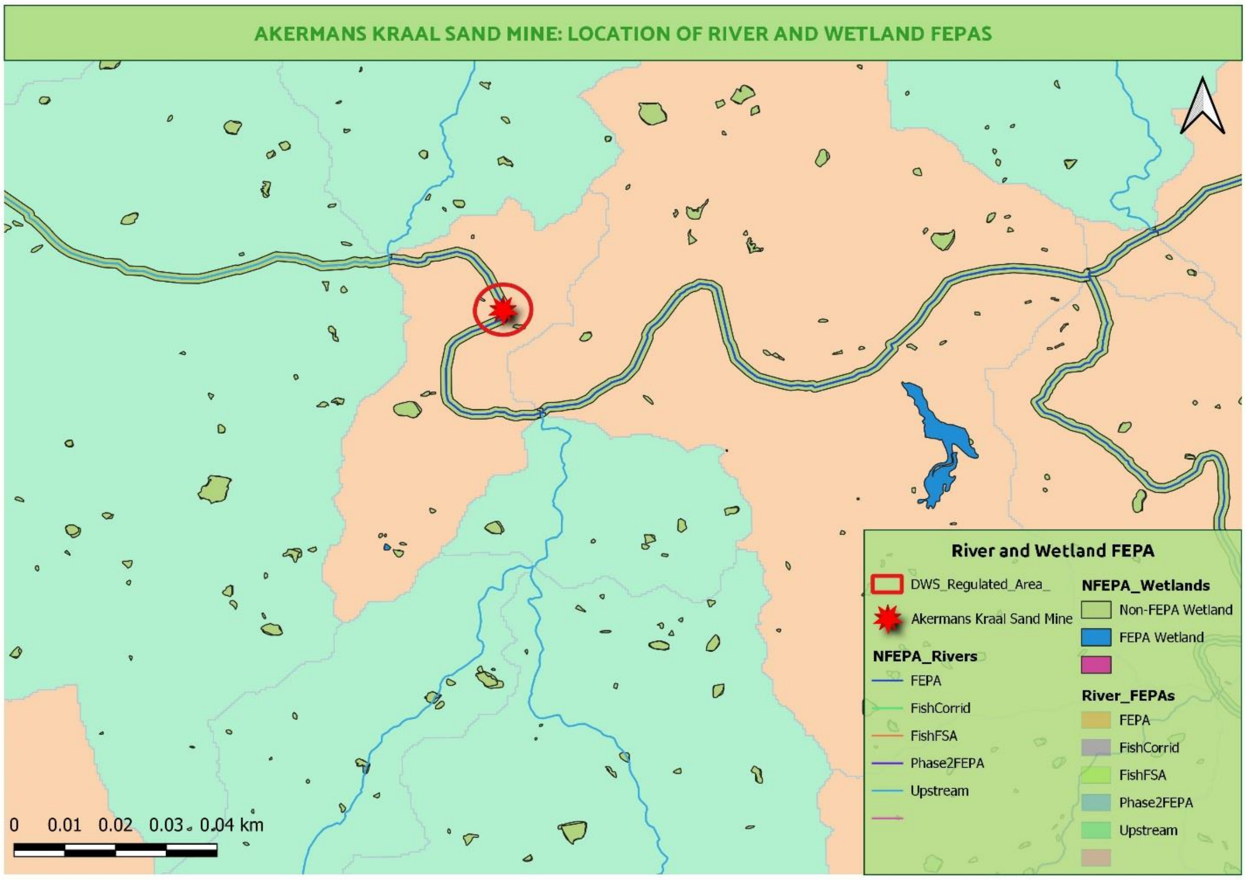

Figure 4: Local drainage setting and location of river and wetland FEPAs.

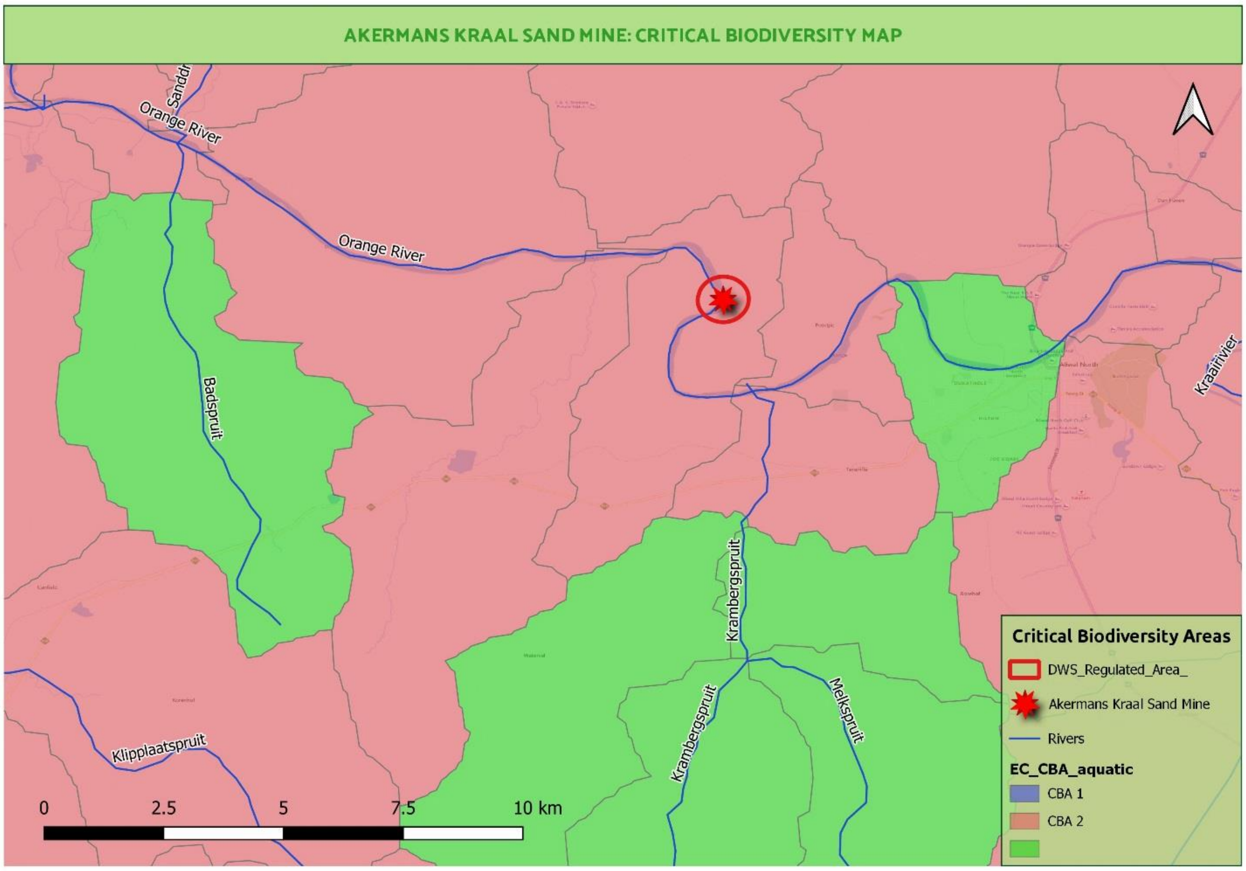

Figure 5: Aquatic Critical Biodiversity Areas Map

5. BASELINE AQUATIC ASSESSMENT FINDINGS

5.1 Delineation and Classification of Watercourse

A radius of 500m area (DWS Regulated Area) surrounding the proposed location of the mining area have been assessed and delineated (Figure 6). This portion of the rive is located within the quaternary drainage region D14A and within the Quaternary Reach D14A-5424 which covers an area of approximately 2,376ha and is situated between the tributaries Sanddrifspruit River and Melkspruit River. Furthermore, the proposed mining area is located within a micro catchment of approximately 1,063ha.

This section of the river can be classified as a Lowland River (Longitudinal Zonation) with a clear active channel and a well-developed Riparian Zone. The dominant water input within this section is overland flow and inputs from upstream tributaries. This section of the Orange River can furthermore be classified as semi-perennial system (according to nature of flow). A semi-perennial watercourse is defined as a watercourse that flows throughout most of the year (>75% of the time). The water table is located above the stream bed for most of the year. Groundwater is the primary source of water for stream flow. Even during periods of no surface flow, permanent but isolated and static pools are highly likely to often occur along the stream length. Run-off from rainfall supplement source of water for the watercourse.

The channel is between 200- and 220 meters in between 1- and 3.5 meters in depth (deepest pool up to 7m). The substrate of the channel is dominated by mineral alluvium (sandy) which is deposited during low flows from mainly upstream sources. The slower flowing inner portions of the channel bends are furthermore characterised by an alluvium matrix dominated by mixture of fine silt and sand. Extensive sediment deposition within this portion of the river has resulted in large and extensive sandbars. High sediment loads and deposition have slightly interfered with the natural braiding and sinuosity of this section of the Orange River. However, due to the sheer size of this river as well as this river being an alluvial bed some resilience is shown against upstream impacts. Furthermore, the relative well-developed riparian fringe also provides buffering against upstream impacts.

As mentioned, the channel is fringed on both sides with relative well developed, woody riparian fringes. Within the surveyed area the western riparian fringe covers an area of approximately 4.74ha whilst the eastern riparian fringe covers and area of approximately 6.87ha. Both riparian fringes comprise of tall trees and shrubs with a spare ground cover. The peripheries are typically dominated by forbs and shrubs. Furthermore, the woody component of these fringes is dominated by alien plants, especially *Salix babylonica* and *Populus deltoides*. Other alien plants recorded within the riparian fringe include; *Eucalyptus camaldulensis* (Category 1b within riparian areas), Populus x canescens (Category 2) and *Salix fragilis*. The marginal zone was relative sparsely covered and, in some areas, bare and devoid of vegetation. Where vegetation persists within this zone it is predominantly dominated by short sedges and grasses such as *Cyperus esculentis, Cynodon dactylon, Sporobolus pyramidalis* and in some locations *Phragmites australis*. The non-marginal zone is dominated by woody species such as *Salix babylonica, S. fragilis, Populus deltoides, Eucalyptus camaldulensis* and *Celtis africana*. The shrub layer is also relative well developed dominated by *Searsia pyroides, Diospyros lycioides* and climbing/scrambling shrubs such as *Asparagus setaceus, A. laricinus* and *Clematis brachiata*. The ground cover is characterised by weed forbs and grasses such as *Eragrostis curvula, Panicum maximum, Sorgum halepense, Urochloa panicoides, Achyranthes aspera var. aspera, Amaranthus viridis, Bidens bipinnata, Conyza canadensis, Schkuhria pinnata, Tagetes minuta, Chenopodium* *album, Salsola kali* (Category 1b), *Datura ferox* (Category 1b), *Convolvulus saggitatus, Tribulus terestris, Opuntia ficus-indica* (Category 1b) and *Eragrostis hetermomera.*

Longitudinal connectivity within the channel and riparian fringe is mostly continuous apart from some isolated locations where the riparian fringe interrupted. Lateral connectivity between natural upland areas and the aquatic habitat, within the study area, is interrupted more frequently through agricultural activities.

Photograph 1: View of the study area from a koppies (zero flow: shallow stagnant water between deeper pools).

Photograph 2: The deepest pool located within the study area. Sections of this pool may reach depths of up to 7m.

Photograph 3: View of the processing plant and the sandbar to be mined.

Photograph 4: Low flow channel containing stagnant water

Photograph 5: View of the processing plant and the sandbar to be mined.

Photograph 6: The previously mined portion of the sandbar.

Photograph 7: The access road through the riparian fringe

Photograph 8: Riparian vegetation fringing the sandbar to be mined. Note the low growing grass/forb marginal zone in the foreground and the taller woody vegetation of the non-marginal zone in the background.

Photograph 9: Dried up low flow channel and a tall woody riparian fringe dominated by alien vegetation.

Photograph 10: Period of high flow. The entire channel is inundated with water. Note the exposed bedrock.

Photograph 11: Period of high flow. The entire channel is inundated with water.

Photograph 12: Flowing water extending well into the marginal zone of the riparian fringe.

Photograph 13: Period of high flow. The entire channel is inundated with water.

Photograph 14: High flow extending well into the marginal zone of the riparian fringe. Note the highly disturbed weed lower non-marginal zone in the left bottom corner**.**

Photograph 15: Determining turbidity with a clarity tube**.**

Photograph 16: Clarity tube indicating high level of turbidity and total suspended solids.

Photograph 17: Determining flow velocity with a flow velocity rod

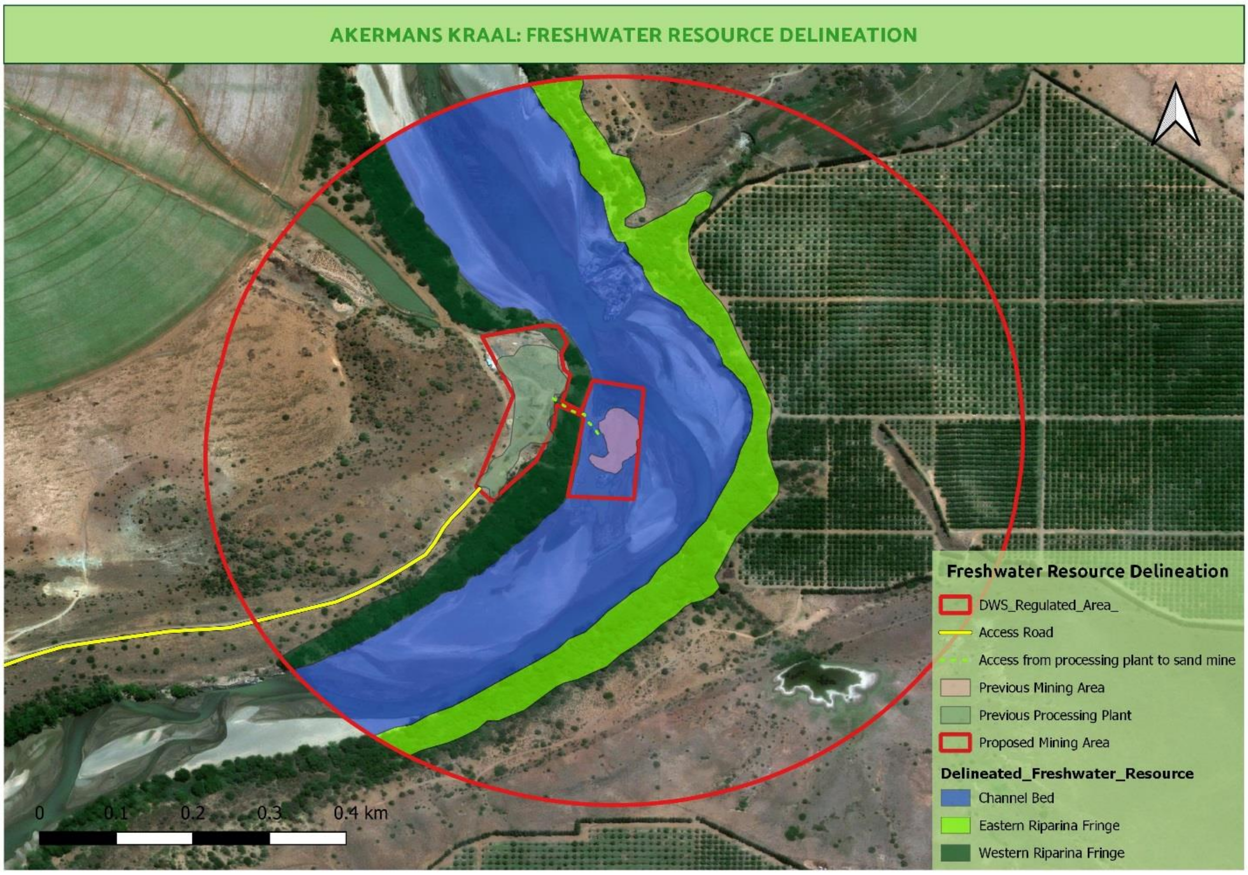

Figure 6: Freshwater resources delineated within the DWS regulated 500m area.

5.2 Water Quality

As mentioned, water sampling was conducted during a period of high flow (moderate flooding). Two samples were taken, one upstream of the proposed mining area and one sample downstream. Both samples indicated yielded more or less the same findings/results namely:

» Microbial Counts:

The heterotrophic plate count, total coliform, *E.coli* and faecal coliforms is present and exceed the limits in both the supplied water samples. This is excessive and most likely imply sewage influx from upstream sources or any animal waste that enter the river system. The chemical parameters indicate that this is not a continuous influx. To use both supplied water samples for human consumption the heterotrophic plate count should stay below 100, but maximally 1000, as well there may not be any *E.coli* and faecal coliforms present in the water. Both the supplied water sample can't be used for human consumption without treatment.

» Chemical:

The total suspended solids are extremely high and can be coupled to the higher turbidity of both the water samples. This is coupled to the higher rainfall and faster flow in the river. This portion of the Orange River is known for its high loads of suspended sediments carried from upstream sources, especially during wetter seasons. These parameters are a concern for drinking water quality. Concentration of toxicants and metals were low at both sampling points.

These high readings for heterotrophic plate count, total coliform, *E.coli* and faecal coliforms as well as for turbidity and total suspended solids will likely drop significantly as flow decreases. It is furthermore highly unlikely that the mining activity will contribute to heterotrophic plate count, total coliform, *E.coli* and faecal coliforms. However, the proposed mining activity may contribute, to some extent, to the amount of total suspended solids present within the affected aquatic environment. This impact can however be successfully mitigated.

Table 5: Summary of chemical results as provided by iWater (2020)

DETERMINANTS	UNITS	UPPER LIMITS AND RANGES		FEB 2020	FEB 2020
		Class II (Max allowable)	Class II water consumption period, max	Site 1 Downstream	Site 2 Upstream
Electrical conductivity (EC)*	mS/m	> 150 - 370	7 years	17.9	17.5
Total Dissolved Solids (TDS)	mg/L	> 1000 - 2400	7 years	103	93.8
Total Suspended Solids (TSS)*	mg/L			8566	8858
pH*	pH units	4.0 - 10.0	No health effect	7.35	7.44
Turbidity*	NTU	> 1 - 10	No limit	>1000	>1000
M-Alk as CaCO3 *				84.8	61.4
Ca & Mg Hardness	mg/L	120-180 Hard Water		88.0	86.6
Ammonia as N*	mg/L	> 1 - 2	No limit	0.84	<0.45
Calcium as Ca*	mg/L	> 150 - 300	7 years	19.0	19.2
Chloride as Cl*	mg/L	> 200 - 600	7 years	4.57	2.19
Fluoride as F*	mg/L	> 1.0 - 1.5	1 years	<0.09	0.10
Magnesium as Mg*	mg/L	> 70 - 100	7 years	9.85	9.39
Nitrate as N*	mg/L	> 10.0 - 20.0	7 years	1.42	1.04
Potassium as K*	mg/L	> 50 - 100	7 years	1.29	1.07
Sodium as Na*	mg/L	> 200 – 400	7 years	2.72	2.46
Sulphate as SO_4*	mg/L	400 - 600	7 years	9.51	8.56
Aluminium as Al*	mg/L	> 0.3 - 0.5	1 year	<0.01	<0.01
Arsenic as As*	mg/L	> 0.05 - 0.2	3 months	<0.005	<0.005
Cadmium as Cd*	mg/L	> 0.005 - 0.01	6 months	<0.002	<0.002
Chromium as Cr*	mg/L	> 0.1 - 0.5	3 months	<0.01	<0.01
Copper as Cu*	mg/L	> 1 - 2	1 year	0.01	0.01
Cyanide as CN^- (free)	mg/L	> 0.05 - 0.07	1 week	<0.01	<0.01
Iron as Fe*	mg/L	> 0.2 - 2	7 years	<0.01	<0.01
Lead as Pb*	mg/L	> 0.05 - 100	3 months	<0.01	<0.01
Manganese as M*	mg/L	> 0.1 - 1	7 years	<0.01	0.02
Selenium as Se*	mg/L	> 0.02 - 0.05	1 year	<0.01	<0.01
Zinc as Zn*	mg/L	> 5.0 - 10.0	1 year	0.01	<0.01

Table 6: Summary of microbial results as provided by iWater (2020).

1	2	3	4	5	Results	Results
		Allowable compliance contribution			Feb 2020	Feb 2020
Determinant	**Units**	**95 % of samples, min.**	**4 % of samples, max.**	**1 % of sample, max.**	**Site 1 Down Stream**	**Site 2 Up Stream**
		Upper limits				
Heterotrophic /Total plate count *	count/ml	100	1000	10000	20000	3100
Total coliform bacteria*	count/100 ml	ND	10	100	>1500	>1500
Faecal coliform bacteria*	count/100 ml	ND	1	10	620	570

E. coli *	count/100 ml	ND	ND	1	300	230

5.3 Diatoms: Biotic Indicators of Aquatic Health

Due to the high flows in January and February 2020, diatom valve densities were very low resulting in a non-viable count (NVC) at ACK 01. This was most probably as a result of cobbles being moved during the high flows and diatoms being washed away from substrate. In lieu of the absence of current data, a review is provided of historic data that is available for the upper Orange River reach.

5.3.1 Summary of Historic Diatom Results

Three diatom data sets were available for review and included:

» Water quality monitoring and status quo assessment study of the Orange-Senqu River and associated tributaries (DWA, 2009): Samples collected during April – June 2008 and during August-September 2009.

» Support to Phase 2 of the ORASECOM Basin-Wide Integrated Water Resources Management Plan. Work Package 5: Assessment of Environmental Flow Requirements - Deliverable 12. Volume 3 (Koekemoer, 2010): Environmental Flow Requirements: Samples taken at the EFR sites as part of this study during 2010.

» ORASECOM Joint Basin Survey 2 (JBS2): Aquatic Ecosystem Health and Water Quality Monitoring (ORASECOM, 2015): Samples collected in July 2015.

A summary of the applicable site locations is provided in the table below.

Table 7: 2008 – 2015: Applicable site locations in the Upper Orange River reach

Date	Site no	River	Description	SQ	Latitude	Longitude
Apr 2008	3	Orange river	4.7 km DS of Makhaleng River confluence and Lesotho border, US of Kraai River confluence just below Lesotho border	D12A-05065	-30.337700	27.3628
Aug/Sep 2009	14	Orange river	4.7 km DS of Makhaleng River confluence and Lesotho border, US of Kraai River confluence just below Lesotho border	D12A-05065	-30.337700	27.3628
Aug/Sep 2009	13	Kromspruit	At Sterkspruit town	D12B-05232	-30.526900	27.3748
Nov 2015	OSAEH_11_22	Orange river	9.5 km DS of Bamboesspruit confluence	D12C-05164	-30.488857	27.216232

Apr 2008	6	Orange river	DS of Kraai River confluence at Aliwal North	D14A-05424	-30.686300	26.70598
Aug/Sep 2009	8	Orange river	DS of Kraai River confluence at Aliwal North	D14A-05424	-30.686300	26.70598
Feb 2020		Orange river	DS of Akermans Kraal Sand Mine	D14A-05424	-30.6711	26.63482
Apr 2008	8	Wonderboomspruit	Upper reach DS of Burgersfort	D14E-05804	-31.001100	26.3532
Aug/Sep 2009	10	Wonderboomspruit	Upper reach DS of Burgersfort	D14E-05804	-31.001100	26.3532
Nov 2015	OSAEH_26_13	Stormbergspruit	12.4 km US of confluence with Orange River	D14H-05372	-30.650366	26.465192
Apr 2008	7	Orange river	33 km DS of Aliwal North. 8.5 km DS of Stormbergspruit confluence	D14J-05259	-30.576200	26.4564
Nov 2015	OSAEH_26_14	Orange river	33 km DS of Aliwal North. 8.5 km DS of Stormbergspruit confluence	D14J-05259	-30.576200	26.4564

A summary of the diatom results for 2008 – 2015 is provided in the table below.

Table 8: Summary of diatom results: 2008 - 2015

Date	Site no	%PTV	SPI	EC	Class	Deformities
Apr 2008	3	63.4	6.9	D/E	Poor quality	Not known
Aug/Sep 2009	14	4.5	14.9	B/C	Good quality	Not known
Aug/Sep 2009	13	5.0	13.6	C	Moderate quality	Not known
Nov 2015	OSAEH_11_22	51.4	11.9	C/D	Moderate quality	6.8
Apr 2008	6	NVC				
Aug/Sep 2009	8	40.8	10.9	C/D	Moderate quality	Not known
Feb 2020	ACK 01	NVC				
Apr 2008	8	41.5	9.3	D	Poor quality	Not known
Aug/Sep 2009	10	78.0	5.9	E	Bad quality	Not known
Nov 2015	OSAEH_26_13	43.8	13.9	C	Moderate quality	0
Apr 2008	7	NVC				
Nov 2015	OSAEH_26_14	22.7	12.9	C	Moderate quality	0.3

Based on the 2010 EWR study (Koekemoer, 2010) all the sites listed in Table 7 fall within Reach 1 which is delineated as the reach between the Lesotho border and Gariep Dam. The results of the 2008 – 2009 diatom data sets indicated that the biological water quality of the upper tributaries of the Orange River were in a good condition, with well oxygenated waters. These tributaries were in a B Ecological Category although it seemed that nutrient input from surrounding farming activities were problematic at times. Stormbergspruit below Aliwal North had elevated nutrient and organic pollution levels. Pollution levels were very high at times as

78% of the August 2009 sample was dominated by pollution tolerant valves. As the samples in the main stem of the Orange River were non-viable it was estimated that this reach was in a C Ecological Category and was characterised by elevated phosphate and organically bound nitrogen levels. Organic pollution was also problematic while salinity levels were elevated at times (calcium-based salinity).

The JBS2 (ORASECOM, 2015) water chemistry results for the upper Orange River indicated that:

- A slight increasing trend in conductivity was noted at the Orange River at Aliwal North.
- Total Inorganic Nitrogen generally decreased since the 1980s at the Orange River at Aliwal North. The trophic status according to the South African Water Quality Guidelines for Aquatic Ecosystems (DWAF, 1996) for Total Inorganic Nitrogen was reported as oligotrophic. The sample results for JSB2 for nitrate, nitrite and ammonia were all below the analytical detection limit.
- While an overall decreasing trend was apparent, orthophosphate results were highly variable at the Orange River at Aliwal North, with a number of highly elevated results recorded between 2007 and 2009. Notwithstanding the decreasing trend, the trophic status according to the South African Water Quality Guidelines for Aquatic Ecosystems (DWAF, 1996) for Inorganic Phosphorus varied between mesostrophic and eutrophic.
- A comparison between the JBS1 (2010) and JBS2 (2015) studies indicate a general decline in the overall EcoStatus for the sites located in the Upper Orange river reach, with most sites attaining a D EcoStatus in 2015.

The JBS2 (ORASECOM, 2015) diatom results indicated that:

- The biological water quality at OSAEH 11_12 was moderate with a C/D Ecological Category. Elevated nutrients and organic pollution levels were the main reason for deteriorated biological water quality. Turbidity was elevated and water level fluctuation was evident. Of concern was the high abundance of valve deformities which exceeded general threshold limits and suggested that metal toxicity was biologically available. Main impacts in terms of biological water quality were various environmental stresses such as reduced flows/velocities, temperature increases, herbicides, and heavy metals.
- The biological water quality at OSAEH 26_13 was moderate with a C Ecological Category. Elevated nutrients and organic pollution levels were the main reason for deteriorated biological water quality due to sewage effluent which may be originating from the Burgersdorp WWTW upstream. Main impacts in terms of biological water quality were intermittent nutrient

enrichment from return flows from water treatment settling tanks and catchment run-off.

- The biological water quality at OSAEH 26_14 was moderate with a C Ecological Category. Elevated nutrients and organic pollution levels were the main reason for deteriorated biological water quality while salinity concentrations increased within the reach. Turbidity was elevated and water level fluctuation was evident. Main impacts in terms of biological water quality were livestock Overgrazing resulting in increased turbidity and intermittent nutrient enrichment from return flows from water treatment settling tanks and catchment run-off

5.4 Rivers/streams: Baseline PES and EIS Assessment

5.4.1 Present Ecological State (PES) of Streams/Rivers

The Present Ecological State (PES) refers to the health or integrity of an ecosystem defined as a measure of deviation from the reference state. The 'habitat integrity' of a river refers to the "maintenance of a balanced composition of physic-chemical and habitat characteristics on a temporal and spatial scale that are comparable to the characteristics of natural habitats of the region" (Kleynhans, 1996). It is seen as a surrogate for the assessment of biological responses to driver changes. The Index of habitat Integrity (IHI) is a measure of the Present Ecological State (PES) which infers the health or integrity of a river system, and includes both in-stream habitat as well as riparian habitat adjacent to the main channel.
Habitat integrity for instream and riparian habitats was assessed separately based on the following indicators of habitat integrity:

» Water abstraction
» Flow modification
» Inundation
» Bed modification
» Bank erosion
» Channel modification
» Water quality
» Solid waste disposal
» Vegetation removal
» Exotic vegetation

The results of the IHI assessment are summarised in Table 9 and shown graphically in Figure 7 below.

Table 9: Summary results of the river IHI (Index of habitat Integrity)

INSTREAM IHI	
Base Flows	-1.0
Zero Flows	0.0
Floods	-1.0
HYDROLOGY RATING	**0.7**
pH	2.0
Salts	3.0
Nutrients	2.5
Water Temperature	0.0
Water clarity	4.5
Oxygen	1.5
Toxics	2.0
PC RATING	**2.0**
Sediment	3.5
Benthic Growth	1.0
BED RATING	**1.8**
Marginal	0.5
Non-marginal	1.5
BANK RATING	**1.0**
Longitudinal Connectivity	0.5
Lateral Connectivity	1.5
CONNECTIVITY RATING	**0.9**
INSTREAM IHI %	**73.9**
INSTREAM IHI EC	**C**
INSTREAM CONFIDENCE	**4.6**

RIPARIAN IHI	
Base Flows	-1.0
Zero Flows	-0.5
Moderate Floods	-1.0
Large Floods	-0.5
HYDROLOGY RATING	**0.8**
Substrate Exposure (marginal)	1.0
Substrate Exposure (non-marginal)	1.5
Invasive Alien Vegetation (marginal)	2.0
Invasive Alien Vegetation (non-marginal)	4.5
Erosion (marginal)	1.5
Erosion (non-marginal)	1.0
Physico-Chemical (marginal)	1.0
Physico-Chemical (non-marginal)	0.0
Marginal	2.0
Non-marginal	4.5
BANK STRUCTURE RATING	**4.0**
Longitudinal Connectivity	1.0
Lateral Connectivity	2.0
CONNECTIVITY RATING	**1.5**
RIPARIAN IHI %	**52.8**
RIPARIAN IHI EC	**D**
RIPARIAN CONFIDENCE	**4.8**

Instream habitat integrity within the study area was rated as Moderately Modified (C) mainly due to bed modification as a result of sedimentation deposition and removal occurring within this area. These high loads of suspended solids carried downstream during high flows significantly impact water quality during these periods, however, some stability as obtained during the low and zero flow periods.

The riparian habitat index within the study area was rated as Largely Modified (D) due to the high level of Alien Woody Plant species present within the riparian areas as well as the fact that some modification of the bank have occurred as well as some local disruption in connectivity, especially lateral connectivity.

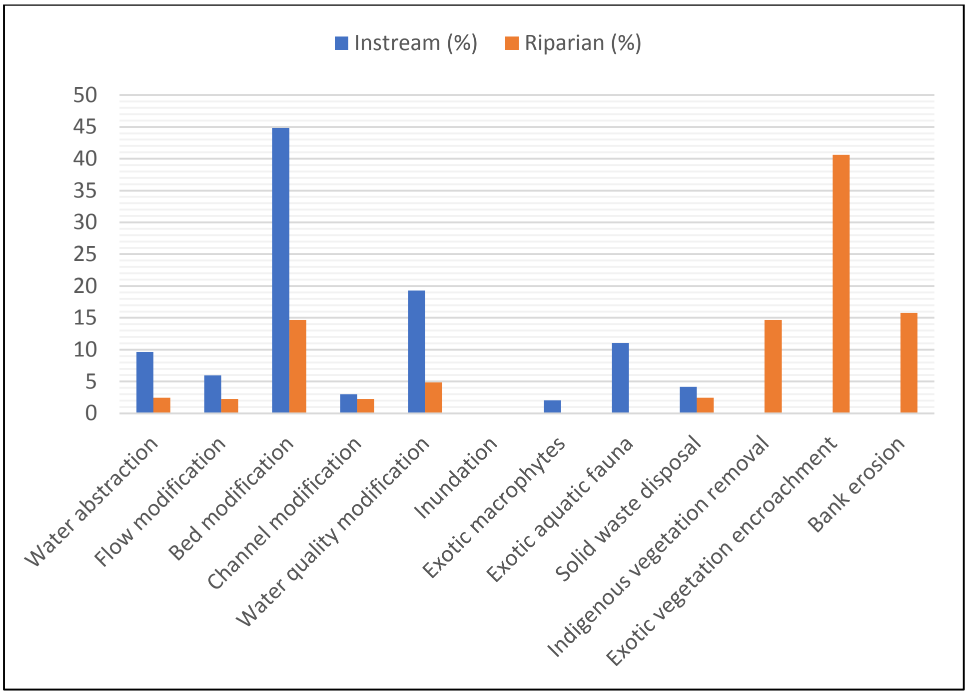

Figure 7: Graph comparing the level of instream and riparian habitat modification expressed as a percentage as a result of a number of modifying determinants for this section of the Orange River using the IHI method.

5.4.2 Ecological Importance and Sensitivity (EIS) of Rivers/Streams

The Ecological Importance and Sensitivity (EIS) of river and riparian areas is an expression of the importance of the aquatic resource for the maintenance of biological diversity and ecological functioning on local and wider scales; whilst Ecological Sensitivity (or fragility) refers to a system's ability to resist disturbance and its capability to recover from disturbance once it has occurred (Kleynhans & Louw, 2007).

The outcomes of a rapid instream and riparian habitat ecological importance and sensitivity assessment (using the DWAF EIS tool for rivers) is summarised below in Table 10 with an aquatic ecological sensitivity map for the site included as Figure 8.

In terms of ecosystem importance and ecological sensitivity, this section of the Orange River is considered to be of Moderate Importance, containing features that are considered to be ecologically important and sensitive at a local scale and typically having a small role in providing ecological services at the local scale

Table 10: Score sheet for determining the ecological importance and sensitivity for the affected aquatic ecosystem:

Determinant	**Score**	**Confidence**	**Comments**
PRIMARY DETERMINANTS			
1. Rare & Endangered Species	2	3	Potential habitat for *Labeobarbus kimberleyensis* (Near Treatened) as well as *Hydrictis maculicollis* (Near Threatened).
2. Populations of Unique Species	0	4	None recorded during survey.
3. Species/taxon Richness	2	4	Due to disturbances (Cultivation, grazing and historical mining activities). Riparian habitat highly invaded with exotic trees and shrubs. Low diversity of fish species
4. Diversity of Habitat Types or Features	3	3	Pools and runs; marginal vegetation; small riffles during high flow periods
5 Migration route/breeding and feeding site for wetland species	2	3	Potential migration route for fish species during high flow.
6. Sensitivity to Changes in the Natural Hydrological Regime	0	3	This portion of river is naturally seasonal.
7. Sensitivity to Water Quality Changes	1	3	Increase in turbidity, total suspended solids as well as microbial activity especially during high flow periods (upstream sources)
8. Flood Storage, Energy Dissipation & Particulate/Element Removal	1	3	
MODIFYING DETERMINANTS			
9. Protected Status	2	4	Critical Biodiversity Areas 2
10. Ecological Integrity	2	4	
TOTAL	15		
MEDIAN	2		
OVERALL ECOLOGICAL SENSITIVITY AND IMPORTANCE	**C**		**Moderate/Medium**

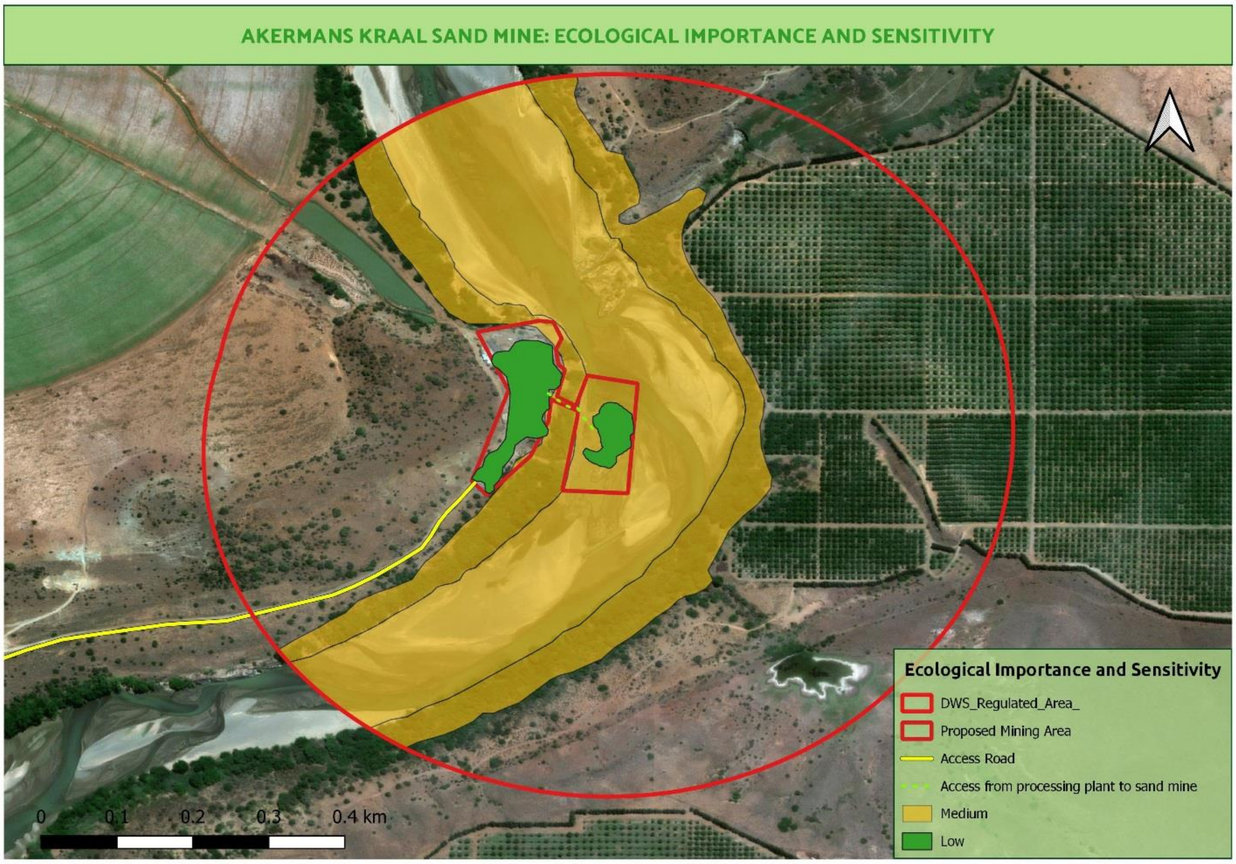

Figure 8: Ecological Importance and Sensitivity Map.

6. ASSESSMENT OF PROPOSED IMPACTS

6.1 Assessment of impacts associated with Site-establishment and Operational Phases

Impact 1: *Potential Impacts on riparian vegetation and connectivity*

Impact Nature: Clearing and disturbance of riparian vegetation during the site establishment and operational phase as a result of the expansion of the mine and processing plant as well from regular movement between the mine and the processing plant. This may lead to local loss in riparian species, habitat, diversity and reduce lateral connectivity and to a lesser extent longitudinal connectivity. Uncontrolled vegetation removal may also result in bank destabilisation resulting in bank erosion, proliferation of alien invasive plants and a reduction in downstream water quality as a result of an increase in sediment and turbidity.

	Without Mitigation	**With Mitigation**
Extent	Local (2)	Local (1)
Duration	Permanent (5)	Long-term (4)

Magnitude	Moderate (6)	Small (1)
Probability	Highly Probable (4)	Probable (3)
Significance	**Medium (52)**	**Low (18)**
Status	Negative	Neutral to slightly negative
Reversibility	Low	Low
Irreplaceable loss of resources	Unlikely	Unlikely
Can impacts be mitigated?	Reasonably but with limited full restoration potential.	
Residual Impacts	Very limited in extent (**Not Significant**): » Likely in the form of a locally altered vegetation cover.	

Impact 2 *Potential impact on local and downstream water quality.*

Impact Nature: Destabilisation of channel bank due to uncontrolled vegetation removal may result in an increase in sediment input into the aquatic ecosystems resulting in a reduction in water quality. This may in turn impact the benthic biota and aquatic macrophytes. Furthermore, uncontrolled movement and careless operation within the sandbar section may furthermore lead to uncontrolled influx of sediment into the downstream aquatic ecosystems. Accidental hazardous spillages may spread into downstream freshwater habitats and threaten local biota and downstream habitats. Contamination of runoff by poor material/waste handling practices, impacting on the surface water quality of the downstream freshwater resource.		
	Without Mitigation	**With Mitigation**
Extent	Local (3)	Local (1)
Duration	Medium-term (4)	Short-term (2)
Magnitude	Moderate (7)	Moderate (2)
Probability	Definity (5)	Improbable (2)
Significance	**High (70)**	**Low (10)**
Status	Negative	Negative
Reversibility	Moderate	High
Irreplaceable loss of resources	Likely	Unlikely
Can impacts be mitigated?	Yes. Detrimental impacts can be effectively avoided	
Residual Impacts	Residual impacts will be negligible after appropriate mitigation.	

Impact 3: *Potential increased erosion risk during and post-operational phase*

Impact Nature: Uncontrolled vegetation removal from the banks may destabilise these areas resulting in erosion of these features.

	Without Mitigation	With Mitigation
Extent	Local (2)	Local (1)
Duration	Long-term (4)	Short-term (1)
Magnitude	Moderate (6)	Minor (2)
Probability	Probable (3)	Improbable (2)
Significance	**Medium (36)**	**Low (8)**
Status	Negative	Negative
Reversibility	High	High
Irreplaceable loss of resources	Moderate Probability	Unlikely
Can impacts be mitigated?	Yes, to a large extent	
Residual Impacts	Altered vegetation structure within the riparian fringe. With appropriate avoidance and mitigation, residual impacts will be **very low**.	

Impact 4: *Increased alien plant invasion during the operational phase*

Impact Nature: Increased alien plant invasion is one of the greatest risk factors associated with this activity. The disturbed and bare ground that is likely to be present at the site during and after the operational phase would leave the site vulnerable to alien plant invasion during the operation phase if not managed. Furthermore, the National Environmental Management Biodiversity Act (Act No. 10 of 2004), as well as the Conservation of Agricultural Resources Act, (Act No. 43 of 1983) requires that listed alien species are controlled in accordance with the Act.		
	Without Mitigation	**With Mitigation**
Extent	Local and immediate surroundings (2)	Local (1)
Duration	Permanent (5)	Short-term (1)
Magnitude	Low (4)	Minor (2)
Probability	Definite (5)	Highly Probable (4)
Significance	**Medium (55)**	**Low (16)**
Status	Negative	Negative
Reversibility	Moderate	High
Irreplaceable loss of resources	Low Probability	Unlikely
Can impacts be mitigated?	Yes, to a large extent	
Residual Impacts	With appropriate mitigation such as regular monitoring and eradication residual impacts will be **very low** and will likely	

	comprise of few alien plants establishing for short periods of time between monitoring and eradication phases.

6.1.1 Assessment of Cumulative Impacts

Cumulative Impact 1: *Reduced ability to meet conservation obligations and targets*

Impact Nature: The loss of unprotected vegetation types on a cumulative basis from the broader area impacts the Province's ability to meet its conservation targets.		
	Overall impact of the proposed project considered in isolation	**Cumulative impact of the project and other projects within the area**
Extent	Local (1)	Regional (3)
Duration	Long Term (4)	Long-Term (4)
Magnitude	Small (1)	Low (4)
Probability	Improbable (2)	Improbable (2)
Significance	**Low (12)**	**Low (22)**
Status	Neutral – Slightly Negative	Slightly Negative
Reversibility	Low	Low
Irreplaceable loss of resources	Unlikely	Low Probability
Can impacts be mitigated?	Yes, to a large extent	

Cumulative Impact 2: *Impacts on Ecological Support Areas and Broad-Scale Ecological Processes*

Impact Nature: Transformation of intact habitat could potentially compromise ecological processes of CBA as well as ecological functioning of important habitats and would contribute to the fragmentation of the landscape and would potentially disrupt the connectivity of the landscape for fauna and flora and impair their ability to respond to environmental fluctuations.		
	Overall impact of the proposed project considered in isolation	**Cumulative impact of the project and other projects within the area**
Extent	Local (1)	Regional (2)
Duration	Long Term (4)	Long Term (4)
Magnitude	Small (1)	Low (4)
Probability	Improbable (2)	Improbable (2)
Significance	**Low (12)**	**Low (20)**

Status	Neutral – Slightly Negative	Slightly Negative
Reversibility	Low	Low
Irreplaceable loss of resources	Unlikely	Low Probability
Can impacts be mitigated?	Yes, to a large extent	

6.2 Impact Mitigation and Management

IMPACT	MITIGATION
Site-Establishment and Operation Phase	
Impact 1: *Potential Impacts on riparian vegetation and connectivity*	» Where possible undertake construction activities in the dry season. » Existing access roads to be used. » Maintain all activities within the proposed mining footprint. » No vegetation clearing/disturbance shall be allowed outside of this development footprint » No activities or movement of any construction vehicles shall be allowed outside of the mining footprint. » Any new infrastructure may only be erected within the existing and already disturbed plant and stockpiling area. » The "intact" riparian fringe is regarded as a NO-GO Zone and no activities within or disturbances of this area shall be allowed. Access to the sandbar only via the existing access road through the riparian fringe » A buffer of 10m should be placed around the intact riparian fringe (apart from the access road through the riparian fringe) and should also be regarded as a NO-GO Zone. Natural vegetation should be encouraged within this 10m buffer. » Any erosion problems observed, to be associated with the relating activity, should be rectified as soon as possible and monitored thereafter to ensure that they do not re-occur. Blanket clearing of vegetation must be limited to the proposed mining footprint and associated infrastructure. No clearing outside of the minimum required footprint to take place.
Impact 2: *Potential impact on local and downstream water quality.*	» Where possible undertake construction activities in the dry season. » Monitor flooding levels of river, especially around the sandbar. » All activities within the sandbar should be halted and the area cleared at least a week before the entire flooding of the sandbar.

	» A buffer of at least 20m should be placed around any waterbody (flowing or standing) associated with Orange river and no activities may be allowed within these buffer areas. This 20m buffer is regarded as a dynamic zone and should adjust with the rising and falling water level. » Maintain all activities within the proposed mining footprint. » No activities or movement of any construction vehicles shall be allowed outside of the mining footprint. » All material stockpiles should be located outside of the riparian fringe and no stockpiled material shall remain within the sandbar overnight. » No equipment of any kind may be stored within the sandbar. » Avoid pumping of water from the pit back into the river as far as possible. » If pumping of water back into the river is regarded as the only solution, this water should be tested and the results should indicate that the water is of an acceptable quality to be pumped back into the river. » The existing stockpiling areas within the processing area shall be used. » Silt traps should be used where there is a danger of topsoil or material stockpiles eroding and entering the river and other sensitive areas. » It is recommended that earthen berms / sediment traps are constructed within the downslope areas of stockpiles and screening plant areas. » Any erosion problems observed, to be associated with the relating activity, should be rectified as soon as possible and monitored thereafter to ensure that they do not re-occur. » Operate using best practices by storing hazardous substances in an adequately sized bunded area outside of the riparian fringe and active flooding area, » Ensure that appropriate safety equipment is at all times present on site; » Place spill kits on site which are operated by trained staff members for the adhoc remediation of minor chemical and hydrocarbon spillages.

	» No refuelling or servicing of vehicles and machinery may be allowed within the mining area. » Regular monitoring of mining site for potential oil spillages and prompt action (clean-up) if a spillage has been identified. » Ensure that contaminated soil is stored adequately within a bunded area along with the other hazardous substances and regularly removed by a licensed hazardous waste removal company. » Culprit vehicles and machinery responsible for such an oil spillage should be promptly removed of site to an acceptable servicing area where the vehicle/machine can be made safe. » Implement appropriate measures to ensure strict use and management of all hazardous materials used on site. » Implement appropriate measures to ensure strict management of potential sources of pollutants (e.g. litter, hydrocarbons from vehicles and machinery, cement during construction etc.). » A waste management plan will be compiled and approved for implementation of site. » This management plan should focus on the waste hierarchy of the NEM:WA; » Waste temporarily stored on site in clearly marked containers in a demarcated area. » All waste material should be removed at the end of every working day to designated waste facilities at a suitable waste disposal facility. » All waste must be disposed of offsite. » Working protocols incorporating pollution control measures (including approved method statements by the contractor) should be clearly set out in the Construction Environmental Management Plan (CEMP) for the project and strictly enforced.
Impact 3: Potential increased erosion risk during and post-operational phase	» Where possible undertake construction activities in the dry season. » No vegetation clearing/disturbance shall be allowed outside of this development footprint » Existing access roads to be used.

	» No activities or movement of any construction vehicles shall be allowed outside of the mining footprint.Any erosion problems within the mining area as a result of the mining activities observed should be rectified immediately and monitored thereafter to ensure that they do not re-occur. » Regular monitoring for erosion. » Any erosion problems observed, to be associated with the relating activity, should be rectified as soon as possible and monitored thereafter to ensure that they do not re-occur. » Silt traps should be used where there is a danger of topsoil or material stockpiles eroding and entering the river and other sensitive areas. » It is recommended that earthen berms / sediment traps are constructed within the downslope areas of stockpiles and screening plant areas.
Impact 4: Increased alien plant invasion during the operational phase	» The "intact" riparian fringe shall be regarded as a NO-GO Zone and no disturbance or destruction of vegetation within this area or within the aquatic habitat shall be allowed as these disturbed areas may become exposed to the establishment of Invasive Alien Plants. » No disturbance/destruction of vegetation outside of the mining footprint shall be allowed. » The management and eradication of IAPs should be addressed in the Management Plan. » Regular monitoring and eradication of IAPs within the mining footprint should occur on a regular basis (every second month during the dry season and on a monthly basis during the wet season). » Ensure that IAP material is disposed of in an appropriate manner (as specified with a Management Plan).
Cumulative Impacts	
Cumulative Impact 1: Reduced ability to meet conservation obligations and targets	» The activity footprints must be kept to a minimum and natural vegetation should be encouraged to return during the post-operational phase. » Avoid any impact on the "intact" riparian fringe.

Cumulative Impact 2: Impacts on Ecological Support Areas and Broad-Scale Ecological Processes	» The activity footprints must be kept to a minimum and natural vegetation should be encouraged to return during the post-operational phase. » Avoid any impact on the "intact" riparian fringe.

7. CONCLUSION

From an aquatic perspective, no objective or motives (identification of impacts of high ecological significance, etc.) were identified which would hinder the establishment of the sand mine. Activities and Impacts are regarded as acceptable from an ecological perspective and will not cause detrimental impacts to the ecological features freshwater. Therefore, it is the opinion of the specialist that the development may be authorised, subject to the implementation of the recommended mitigation measures.

From the assessment of the aquatic drivers and biotic components it can be concluded that this portion of the Orange River has undergone some form of transformation (moderate to significant) resulting in a present ecological score varying between C (Moderately Modified) and D (Largely Modified). Especially the riparian fringe has been significantly impacted, especially through the invasion with Alien Plants. Instream habitat integrity within the study are as mentioned moderately modified mainly due to bed modification as a result of sedimentation deposition and removal occurring within this area. These high loads of suspended solids carried downstream during high flows significantly impact water quality during these periods, however, some stability as obtained during the low and zero flow periods.

These findings furthermore substantiate the results of the Physico-Chemical Analysis that indicated extremely high levels of turbidity and suspended solids. However, most of these impacts can be regarded as indirect impacts as a result of upstream impacts and are rather an indication of what is happening upstream. The high readings for heterotrophic plate count, total coliform, E.coli and faecal coliforms as well as for turbidity and total suspended solids will likely drop significantly as flow decreases. It is furthermore highly unlikely that the mining activity will contribute to heterotrophic plate count, total coliform, *E.coli* and faecal coliforms. However, the proposed mining activity may contribute, to some extent, to the amount of total suspended solids present within the affected aquatic environment. This impact can however be successfully mitigated. As such with the necessary mitigation measures in place, mining of sand from the sandbar will not have a significant impact on the physico-chemical character of the affected aquatic environment.

Based on the historic diatom data, the Upper Orange River has deteriorated between 2010 and 2015. It is expected that the biological water quality in the vicinity of the Akermans Kraal Sand Mine falls within a C to D Ecological Category. In terms of future biomonitoring, main possible impacts associated with mining could be increased turbidity, water level fluctuation while increased nutrient and organic pollution may likely be present due to accumulative impacts within the reach. Diatom data for 2015 to 2020 is very limited and ecological monitoring targets for the reach, based on the identification of indicator species for key performance indicators (based on possible impacts), can only be developed once more diatom data becomes available

In terms of ecosystem importance and ecological sensitivity, this section of the Orange River is considered to be of **Moderate Importance**, containing features that are considered to be ecologically important and sensitive at a local scale and typically having a small role in providing ecological services at the local scale

In general, the impacts of the proposed development on aquatic ecosystems are moderate without mitigation and with appropriate mitigation can be significantly lowered. The most significant potential impact that may arise from the development is a reduction in local and downstream water quality most notably in the form of an increase in turbidity and suspended solids. However, strict control of movement and other activities as well as regular monitoring will significantly reduce the potential of water pollution.

The main mitigation measures focus on the avoidance of potential water pollution, alien vegetation control and streambank stability.

Monitoring is recommended for alien vegetation and streambank erosion. Initial biological monitoring should also be considered.

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9. APPENDICES

Appendix 1: Methodology:

Survey methods

The assessment was initiated with a survey of the pertinent literature, past reports and the various conservation plans that exist for the study region. Maps and Geographical Information Systems (GIS) were then employed to ascertain, which portions of the proposed development, could have the greatest impact on the wetlands and associated habitats.

The proposed site was visited on two occasion (22nd of October 2019 and 12th of February, 2020) to ground-truth the above findings, thus allowing critical comment of the development when assessing the possible impacts and delineating the freshwater resource areas.

Freshwater resource areas were then assessed on the following basis:

» Identification and delineation of wetlands and riparian areas according to the procedures specified by DWAF (2005a).
» Vegetation type – verification of type and its state or condition based, supported by species identification using Germishuizen and Meyer (2003), Vegmap (Mucina and Rutherford, 2006 as amended) and the South African Biodiversity Information Facility (SABIF) database.
» Plant species were further categorised as follows:
  - Terrestrial/Upland: species are rarely found within the riparian zone (<25% probability) and characterize the terrestrial landscape that border the riparian zones. Upland species usually occur naturally in the upper parts of the riparian zone, but with low relative abundance (DWAF, 2008).
  - Facultative riparian: species may occur in either riparian zones or the upland (25>% probability of occurrence in the riparian zone). They can habituate to more mesic conditions with a high probability of survival, or can tolerate higher levels of flooding disturbance or soil moisture. They are not good national indicators, but rather circumstantial indicators good for particular regions (DWAF, 2008).
  - Preferential riparian: these area species that are preferentially, but not exclusively, found in the riparian zone (>75% probability). They may be found in non-riparian areas as indicators of wetness. Where they do occur

in the upland, they show progressive reductions in abundance, statue and vigour farther from the riparian zone. Preferential riparian species may harden to drought conditions, but will always indicate sites with increased moisture availability, and are therefore consistent indicators across geographic boundaries (DWAF, 2008).

- Obligate: these species occur almost exclusively in the riparian zone (>90% probability). They are seldom found in non-riparian areas, but where they are outside of riparian areas, they still indicate wetness. They are not likely to occur in the upland. Obligate riparian species are conservative as such i.e. an obligate will remain an obligate throughout all geographic regions (DWAF, 2008).

» Assessment of the freshwater resources based on the method discussed below and the required buffers.

» Mitigation or recommendations required.

Classification System for Wetlands and other Aquatic Ecosystems in South Africa System (SANBI, 2013)

Since the late 1960's, wetland (including other freshwater ecosystems) classification systems have undergone a series of international and national revisions. These revisions allowed for the inclusion of additional wetland types, ecological and conservation rating metrics, together with a need for a system that would allude to the functional requirements of any given wetland (Ewart-Smith et al., 2006). Wetland function is a consequence of biotic and abiotic factors, and wetland classification should strive to capture these aspects.

The South African National Biodiversity Institute (SANBI) in collaboration with a number of specialists and stakeholders developed in 2010 the newly revised accepted National Wetland Classification Systems (NWCS, 2010). In 2013 however, this classification system (National Wetland Classification System) underwent a name change to now be known as the 'Classification System for Wetlands and other Aquatic Ecosystems in South Africa'. This was done in order to avoid confusion around the term 'wetland' which is defined differently by the RAMSAR Convention and the South Africa National Water Act (Act No. 36 of 1998). The scope of the Classification System has not been changed, however, in that it still includes all ecosystems that the RAMSAR Convention is concerned with.

This classification system includes and distinguishes between three broad types of inland aquatic/freshwater systems namely:

- Rivers, which are 'lotic' aquatic ecosystems with flowing water concentrated within a distinct channel, either permanently or periodically.
- Open waterbodies, which are permanently inundated 'lentic' aquatic ecosystems where standing water is the principal medium within which the dominant biota live. In this system, open water bodies with a maximum depth of greater than 2m are called limnetic (lake-like) systems.
- Wetlands which are transitional between aquatic and terrestrial systems, and are generally characterised by (permanently to temporarily) saturated soils and hydrophytic vegetation. These areas are, in some cases, periodically covered by shallow water and/or may lack vegetation.

The basis upon which this classification system is based are the principles of the Hydrogeomorphic (HGM) approach at higher levels, with including structural features at the finer or lower levels of classification (SANBI, 2013) (Table 11).

Table 11: Hydrogeomorphic (HGM) Units for Inland Systems, showing the primary HGM Types at Level 4A and sub-categories at Levels 4B to 4C.

Level 4: Hydrogeomorphic (HGM) Units		
HGM Type	**Longitudinal zonation/Landform/Outflow drainage**	**Landform/Inflow drainage**
River	Mountain headwater stream	Active channel
		Riparian Zone
	Mountain Stream	Active channel
		Riparian Zone
	Transitional	Active channel
		Riparian Zone
	Upper foothills	Active channel
		Riparian Zone
	Lower foothills	Active channel
		Riparian Zone
	Lowland river	Active channel
		Riparian Zone
	Rejuvenated bedrock fall	Active channel
		Riparian Zone
	Rejuvenated foothills	Active channel
		Riparian Zone
	Upland floodplain	Active channel
		Riparian Zone
Channeled valley-bottom wetland	N/A	N/A
Unchanneled valley-bottom wetland	N/A	N/A
Floodplain	Floodplain depression	N/A
	Floodplain flat	N/A
Depression	Exorheic	With channeled inflow
		Without channeled inflow
	Endroheic	With channeled inflow
		Without channeled inflow

	Dammed	With channeled inflow
		Without channeled inflow
Seep	With channeled outflow	N/A
	Without channeled outflow	N/A
Wetland Flat	N/A	N/A

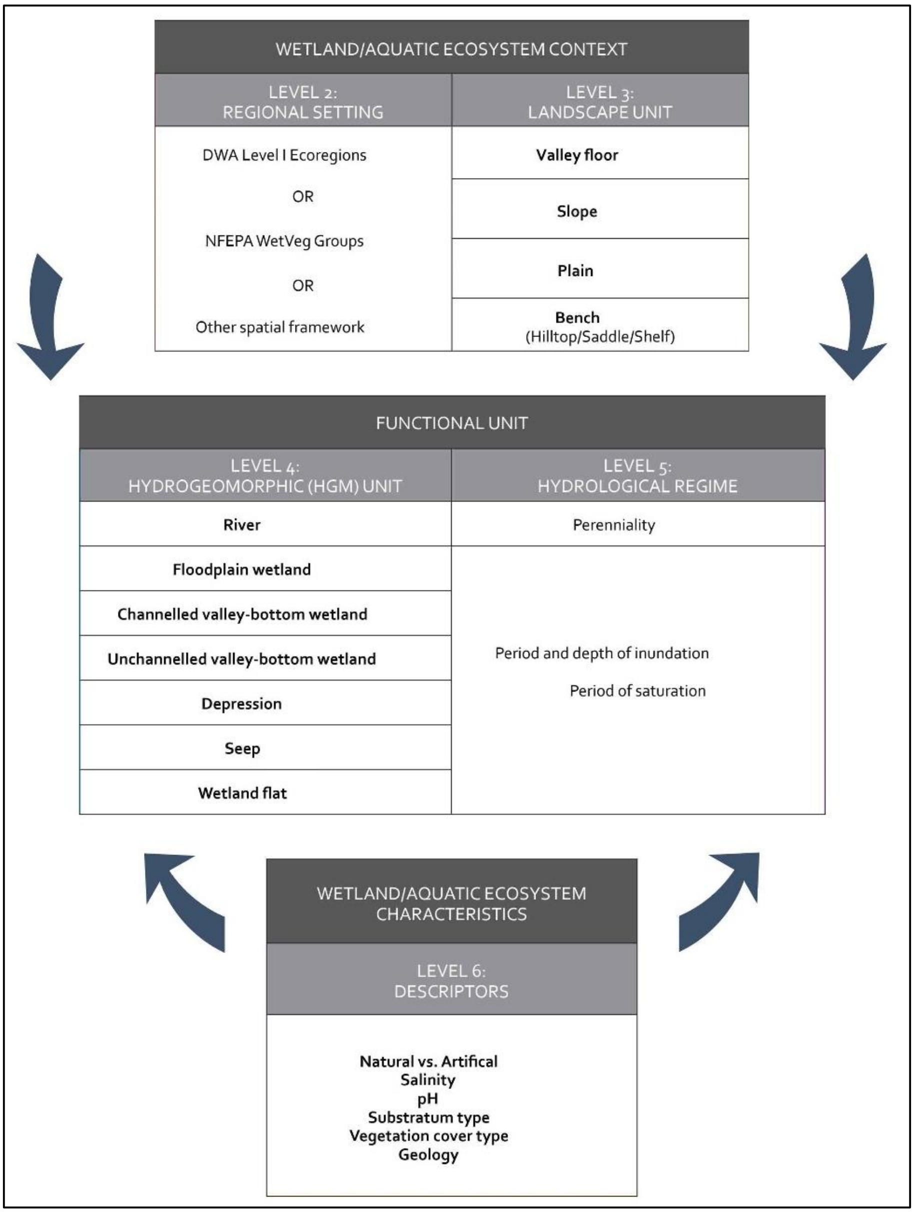

Figure 9: Basic structure of the National Wetland Classification System, showing how 'primary discriminators' are applied up to Level 4 to classify Hydrogeomorphic (HGM) Units, with 'secondary discriminators' applied at Level 5 to classify the hydrological regime, and 'descriptors' applied at Level 6 to categorise the characteristics of wetlands classified up to Level 5 (From SANBI, 2009).

It is widely accepted that hydrology (i.e. the presence or movement of water) and geomorphology (i.e. landform characteristics and processes) are the two fundamental features that determine the way in which an inland aquatic ecosystem functions, regardless of climate, soils, vegetation or origin. Subsequently, it is significant that the HGM approach has now been included in wetland classification as the HGM approach has been adopted throughout the water resources management realm with regard the determination of the Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS) and WET-Health assessments for aquatic environments. All of these systems are then easily integrated using the HGM approach in line with the Eco-classification process of river and wetland reserve determinations used by the Department of Water Affairs.

In summary the overall structure of this classification system comprises of six tiers. This tiered structure is summarised in Figure 9 with Level 4 tier (HGM Units), as mentioned, forming the focal point of this system together with Level 5 tier (hydrological regime).

Some of the terms and definitions used in this document are present below:

Wetland definition

Although the National Wetland Classification System (SANBI, 2009) is used to classify wetland types it is still necessary to understand the definition of a wetland. Wetland definitions as with classification systems have changed over the years. Terminology currently strives to characterise a wetland not only on its structure (visible form), but also to relate this to the function and value of any given wetland.

The Ramsar Convention definition of a wetland is widely accepted as "**areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres**" (Davis 1994). South Africa is a signatory to the Ramsar Convention and therefore its extremely broad definition of wetlands has been adopted for the proposed NWCS, with a few modifications.

Whereas the Ramsar Convention included marine water to a depth of six metres, the definition used for the NWCS extends to a depth of ten metres at low tide, as this is recognised seaward boundary of the shallow photic zone (Lombard et al., 2005). An additional minor adaptation of the definition is the removal of the term 'fen' as fens are considered a type of peatland. The adapted definition for the NWCS is, therefore, as follows (SANBI, 2009):

WETLAND: an area of marsh, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed ten metres.

This definition encompasses all ecosystems characterised by the permanent or periodic presence of water other than marine waters deeper than ten metres. The only legislated definition of wetlands in South Africa, however, is contained within the National Water Act (Act No. 36 of 1998) (NWA), where wetlands are 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 land in normal circumstances supports, or would support, vegetation adapted to life in saturated soil." This definition is consistent with more precise working definitions of wetlands and therefore includes only a subset of ecosystems encapsulated in the Ramsar definition. It should be noted that the NWA definition is not concerned with marine systems and clearly distinguishes wetlands from estuaries, classifying the later as a watercourse (SANBI, 2009). The DWA is however reconsidering this position with regard the management of estuaries due to the ecological needs of these systems with regard to water allocation. Table 14 provides a comparison of the various wetlands included within the main sources of wetland definition used in South Africa.

Although a subset of Ramsar-defined wetlands was used as a starting point for the compilation of the first version of the National Wetland Inventory (i.e. "wetlands", as defined by the National Water Act, together with open waterbodies), it is understood that subsequent versions of the Inventory include the full suite of Ramsar-defined wetlands in order to ensure that South Africa meets its wetland inventory obligations as a signatory to the Convention (SANBI, 2009).

Wetlands must therefore have one or more of the following attributes to meet the above definition (DWAF, 2005):

» A high-water table that results in the saturation at or near the surface, leading to anaerobic conditions developing in the top 50cm of the soil.
» Wetland or hydromorphic soils that display characteristics resulting from prolonged saturation, i.e. mottling or grey soils
» The presence of, at least occasionally, hydrophilic plants, i.e. hydrophytes (water loving plants).

It should be noted that riparian systems that are not permanently or periodically inundated are not considered true wetlands, i.e. those associated with the drainage lines.

Table 12: Comparison of ecosystems considered to be 'wetlands' as defined by the proposed NWCS, the National Water Act (Act No. 36 of 1998), and ecosystems are included in DWAF's (2005) delineation manual.

Ecosystem	NWCS "wetland"	National Water Act wetland	DWAF (2005) delineation manual
Marine	YES	NO	NO
Estuarine	YES	NO	NO
Waterbodies deeper than 2 m (i.e. limnetic habitats often describe as lakes or dams)	YES	NO	NO
Rivers, channels and canals	YES	NO[1]	NO
Inland aquatic ecosystems that are not river channels and are less than 2 m deep	YES	YES	YES
Riparian[2] areas that are permanently / periodically inundated or saturated with water within 50 cm of the surface	YES	YES	YES3
Riparian areas that are not permanently / periodically inundated or saturated with water within 50 cm of the surface	NO	NO	YES[3]

Rivers: a linear landform with clearly discernible bed and banks, which permanently or periodically carries a concentrated flow (unidirectional) of water. A river is taken to include both the active channel and the riparian zone as a unit (SANBI, 2013).

Dominant water sources for rivers include concentrated surface flow from upstream channels and tributaries. Other inputs can include diffuse surface or subsurface flow (e.g. from an upstream seepage wetland), interflow (e.g. from an upstream seepage wetland), interflow (e.g. from valley side-slopes), and/or groundwater inflow (e.g. from springs). Water moves through the system, at least periodically,

[1] Although river channels and canals would generally not be regarded as wetlands in terms of the National Water Act, they are included as a 'watercourse' in terms of the Act.
[2] According to the National Water Act and Ramsar, riparian areas are those areas that are saturated or flooded for prolonged periods would be considered riparian wetlands, opposed to non –wetland riparian areas that are only periodically inundated and the riparian vegetation persists due to having deep root systems drawing on water many meters below the surface.
[3] The delineation of 'riparian areas' (including both wetland and non-wetland components) is treated separately to the delineation of wetlands in DWAF's (2005) delineation manual.

as concentrated flow and usually exits as such, except where there is a sudden decrease in gradient causing the outflow to become diffuse (in which case the river would grade into one of the wetland types). Other water outputs from a river include evapotranspiration and infiltration (SANBI, 2013) (refer to Figure 10).

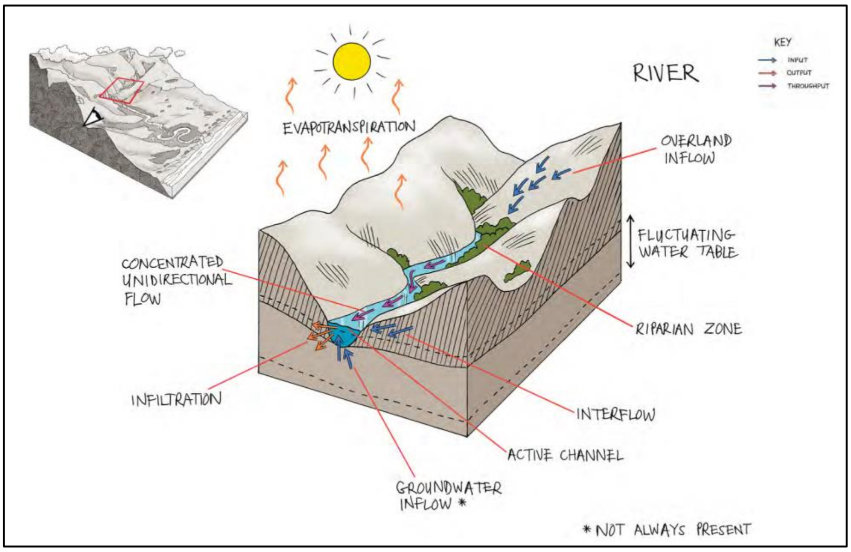

Figure 10: A conceptual illustration of a river as provided by SANBI, 2013.

River channels are typically classified according to size (Table 13) and the nature of flows through the channel (Table 14).

Table 13: Classification of channels according to channel size.

Channel Width	Resource Description
> 10m	Major Rivers
2 – 10 m	Rivers
< 2m	Streams

Table 14: Classification of channels according to nature of flows.

	Channel Section (Class)		
	"A" Type	"B" Type	"C" Type
	Ephemeral systems	Weakly ephemeral to seasonal systems	Perennial systems
Description	A water-course that has no riparian habitat and no soil hydromorphy (i.e. strongly ephemeral systems). Signs of wetness rarely persist in the soil profile	A water-course with riparian vegetation/habitat and intermittent base flow (i.e. weakly ephemeral to nonperennial/seasonal systems). These channels show signs of wetness indicating the presence of water for significant periods of time.	A water-course with permanent-type riparian vegetation/habitat, permanent base flow and permanent inundation (i.e. perennial systems).

Hydrology	A-section channels are situated well above the zone of saturation (no direct contact between surface water system and ground water system) and hence do not carry base-flows They do however carry storm water runoff following intense rainfall events (ephemeral), but this is generally short-lived	Channel bed situated within the zone of the seasonally fluctuating regional water table (i.e. intermittent base flow depending on water table). Periods of no flow may be experienced during dry periods, with residual pools often remaining within the channel.	Water course is situated within the zone of the permanent saturation, meaning flow is all year round except in the case of extreme drought.
Topographical Position	Valley head (upper reaches of catchments). Channel type also linked to steep slopes which are responsible for water leaving the system rapidly.	Mid-section of valley (middle reaches of catchments).	Valley bottom areas (middle to lower reaches of catchments).

Riparian zone: According to the definition provided by DWAF (2008), a riparian zone can be described as:

"*the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterised by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent areas*"

Furthermore DWAF (2008) states that:

"*unlike wetland areas, riparian zones are usually not saturated for a long enough duration for redoxymorphic features to develop. Riparian zones instead develop in response to (and are adapted to) the physical disturbances caused by frequent overbank flooding from the associated river or stream channel*."

Riparian vegetation may be associated with both perennial and non-perennial watercourses/rivers. Riparian areas furthermore represent the transitional area between aquatic and terrestrial habitats. The vegetation associated with riparian zones typically require ample water and are adapted to shallow water table conditions as well as periodical flooding. Due to water availability and rich alluvial soils, riparian areas are usually very productive. Tree growth rate is high and the vegetation under the trees is usually lush in comparison to the upland terrestrial vegetation (refer to Figure 11).

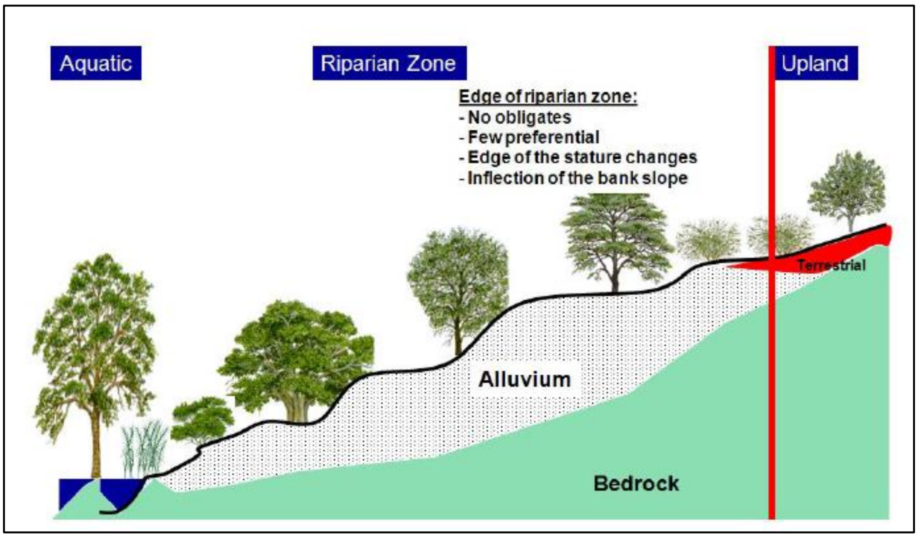

Figure 11: A schematic diagram illustrating the edge of the riparian zone on one bank of a large river (DWAF, 2008).

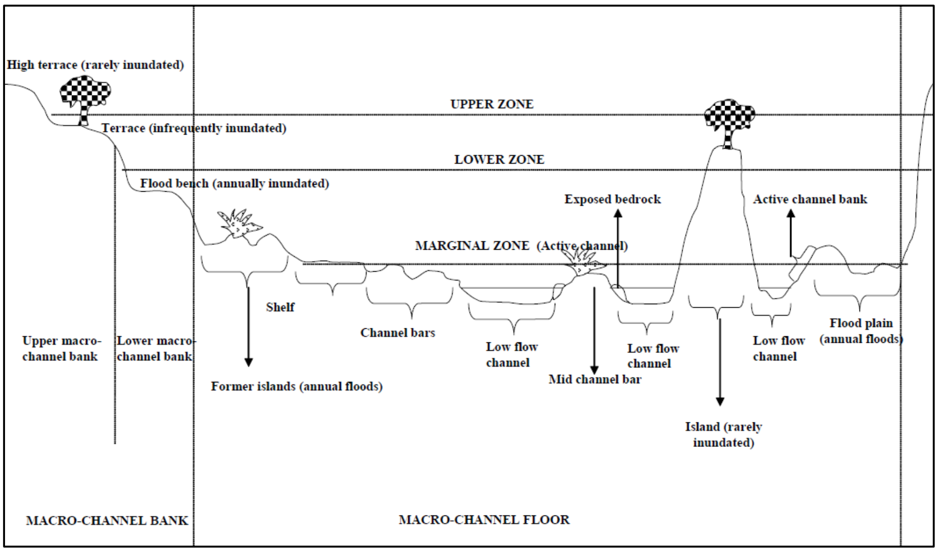

Figure 12: A schematic diagram illustrating (example) the different riparian zones relative to the different geomorphic zones typically associated with a river (Kleynhans *et al*., 2008).

The structure and dynamics of riparian zones are highly variable and are mostly an expression of the hydrological and geomorphological nature of watercourse (Figure 12 and Table 15). As such DWAF (2008) has recommended that they type or river or stream channel with which the riparian zone is associated be considered (Table 16).

Indicators of riparian areas include:

» Landscape position:
  - Riparian areas are associated with valley bottom landscape units (i.e. adjacent to the river/stream channel and floodplains).

- » Alluvial soils and recently deposited material:
  - Alluvial soils are soils derived from material deposited by flowing water.
  - Alluvial soils cannot always be used as a primary indicator to accurately delineate riparian areas but it can be used to confirm the topographical and vegetative indicators.
- » Topography:
  - The National Water Act definition of riparian zones refers to the structure of the banks and likely presence of alluvium.
  - A good indicator of the presence of riparian zones is the presence of alluvial deposited material adjacent to the active channel (such as benches and terraces), as well as the wider incised "macro-channels" which are typical of many of southern Africa's eastern seaboard rivers.
  - Recently deposited alluvial material outside of the main active channel banks can indicate a currently active flooding area; and thus, the likely presence of wetlands.
- » Vegetation:
  - The identification of riparian areas relies heavily on vegetative indicators (Unlike wetland delineation which relies on redoximorphic features in soil).
  - Using vegetation, the outer boundary of a riparian area can be defined as the point where a distinctive change occurs:
    - in species composition relative to the adjacent terrestrial area; and
    - in the physical structure, such as vigour or robustness of growth forms of species similar to that of adjacent terrestrial areas. Growth form refers to the health, compactness, crowding, size, structure and/or numbers of individual plants.
  - In addition to indicators of structural differences in vegetation, indicator species themselves can be used to denote riparian areas (e.g. Obligate-, Preferential- and Facultative riparian species).

Table 15: Geomorphological longitudinal river zones for South African rivers as characterized by Rowntree & Wadeson (2000) (SANBI, 2013).

Longitudinal Zone (and zone class)	Characteristic gradient	Diagnostic channel characteristics
Zonation associated with a normal profile		
Source zone	Not specified	Low-gradient, upland plateau or upland basin able to store water. Spongy or peaty hydromorphic soils.
Mountain headwater stream	>0.1	A very steep-gradient stream dominated by vertical flow over bedrock with waterfalls and plunge pools. Normally first or second order. Reach types include bedrock fall and cascades.
Mountain stream	0.040-0.099	Steep-gradient steam dominated by bedrock and boulders, locally cobble or coarse gravels in pools. Reach types include cascades, bedrock fall, step-pool, plane bed. Approximate equal distribution of 'vertical' and 'horizontal' flow components.

Transitional	0.020-0.039	Moderately steep stream dominated by bedrock or boulders. Reach types include plane bed, pool-rapid or pool-riffle. Confident or semi-confined valley floor with limited floodplain development.
Upper foothills	0.005-0.019	Moderately steep cobble-bed or mixed bedrock-cobble bed channel, with plane bed, pool-riffle reach types. Length of pools and riffles/rapids similar. Narrow floodplain of sand, gravel or cobble often present.
Lower foothills	0.001-0.005	Lower gradient, mixed-bed alluvial channel with sand and gravel dominating the bed, locally may be bedrock-controlled. Reach types typically include pool-riffle or pool-rapid, sand bars common in pools. Pools of significantly greater extent than rapids or riffles. Floodplain often present.
Lowland River	0.0001-0.0010	Low-gradient, alluvial sand-bed channel, typically regime reach type. Often confined, but fully developed meandering pattern within a distinct floodplain develops in unconfined reaches where there is an increase in silt content in bed or banks.
B. Additional zones associated with a rejuvenated profile		
Rejuvenated bedrock fall/cascades	>0.02	Moderate to steep gradient, often confined channel (gorge) resulting from uplift in the middle to lower reaches of the long profile, limited lateral development of alluvial features, reach types include bedrock fall, cascades and pool-rapid.
Rejuvenated foothills	0.001-0.020	Steepened section within middle reaches of the river caused by uplift, often within or downstream of gorge; characteristic similar to foothills (gravel/cobble-bed rivers with pool-riffle/pool-rapid morphology) but of a higher order. A compound channel is often present with an active channel contained within a macro-channel activated only during infrequent flood events. A floodplain may be present between the active and macro-channel.
Upland floodplain	<0.005	An upland low-gradient channel, often associated with uplifted plateau areas as occur beneath the eastern escarpment.

Table 16: A description of the different riparian vegetation zones typically associated with a river/stream system (Kleynhans *et al.*, 2008).

	Marginal	Lower	Upper
Alternative Description	Active features (Wet bank)	Seasonal features (Wet bank)	Ephemeral features (Dry bank)
Extends from	Water level at <u>low flow</u>	Marginal Zone	Lower Zone
Extends to	Geomorphic features / substrates that are hydrologically activated (inundated or moistened) for the greater part of the year	Usually a marked increase in lateral elevation.	Usually a marked decrease in lateral elevation
Characterized by	See above; Moist substrates next to water's edge; water loving-	Geomorphic features that are hydrologically activated (inundated or	Geomorphic features that are hydrological activated (inundated or moistened)

	species usually vigorous due to near permanent access to soil moisture	moistened) on a seasonal basis. May have different species than marginal zone	on an ephemeral basis. Presence of riparian and terrestrial species with increased stature.

Importance and functions of riparian areas

Riparian areas perform a variety of functions that are of value to society, especially the protection and enhancement of water resources, and provision of habitat for plant and animal species.

Riparian areas can variously:

- store water and help reduce flood peaks;
- stabilize stream banks;
- improve water quality by trapping sediment and nutrients;
- maintain natural water temperature through shading for aquatic species;
- provide shelter, food and migration corridors for movement of both aquatic and terrestrial species;
- act as a buffer between aquatic ecosystems and adjacent upslope land uses;
- can be used as recreational sites; and
- provide material for building, muti, crafts and curios.

However, as mentioned, structure and dynamics of riparian zones are highly variable and as such not all riparian areas are capable of fulfilling all of these functions or to the same extent.

Habitat Integrity and Condition of the Affected Freshwater Resources:

Habitat is one of the most important factors that determine the health of river ecosystems since the availability and diversity of habitats (in-stream and riparian areas) are important determinants of the biota that are present in a river system (Kleynhans, 1996). The 'habitat integrity' of a river refers to the "maintenance of a balanced composition of physic-chemical and habitat characteristics on a temporal and spatial scale that are comparable to the characteristics of natural habitats of the region" (Kleynhans, 1996). It is seen as a surrogate for the assessment of biological responses to driver changes.

- ***Larger seasonal to perennial streams:***

For larger seasonal to perennial streams the IHI (Index of Habitat Integrity) 1996, version 2 (Kleynhans, 2012) was used to assess habitat integrity and is based on an interpretation of the deviation from the reference condition for the river reach assessed and is approached from both an instream and riparian zone perspective. Specification of the reference state is followed by an impact-based approach, whereby the extent and intensity of anthropogenic impacts are interrogated to interpret the level of modification to the primary drivers of river health, namely hydrology, geomorphology and physic-chemical conditions. Naturally, the severity of impacts on habitat integrity will vary according to the natural characteristics of different rivers, with particular river types being inherently more sensitive to certain types of impacts than others. The IHI assessment involved the assessment and rating of a range of criteria for instream and riparian habitat (see Table 17, below) scored individually (using an impact magnitude rating scale from 0-25) using Table 1 as a guide. This assessment is informed by a site visit to a specific section of the river but is refined based on a desktop review of reach and catchment-scale impacts based on available aerial photography and land cover information.

Table 17: Criteria used in the assessment of habitat integrity (after Kleynhans, 1998)

Criterion	Diagnostic channel characteristics
Water abstraction	Direct impact on habitat type, abundance and size. Also implicated in flow, bed, channel and water quality characteristics. Riparian vegetation may be influenced by a decrease in the supply of water.
Flow modification	Consequence of abstraction or regulation by impoundments. Changes in temporal and spatial characteristics of flow can have an impact on habitat attributes such as an increase in duration of low flow season, resulting in low availability of certain habitat types or water at the start of the breeding, flowering or growing season.
Bed modification	Regarded as the result of increased input of sediment from the catchment or a decrease in the ability of the river to transport sediment. Indirect indications of sedimentation are stream bank and catchment erosion. Purposeful alteration of the stream bed, e.g. the removal of rapids for navigation is also included.
Channel modification	May be the result of a change in flow, which may alter channel characteristics causing a change in marginal instream and riparian habitat. Purposeful channel modification to improve drainage is also included.
Water quality modification	Originates from point and diffuse point sources. Measured directly or alternatively agricultural activities, human settlements and industrial activities may indicate the likelihood of modification. Aggravated by a decrease in the volume of water during low or no flow conditions.
Inundation	Destruction of riffle, rapid and riparian zone habitat. Obstruction to the movement of aquatic fauna and influences water quality and the movement of sediments.
Exotic macrophytes	Alteration of habitat by obstruction of flow and may influence water quality. Dependent upon the species involved and scale of infestation.
Exotic aquatic fauna	The disturbance of the stream bottom during feeding may influence the water quality and increase turbidity. Dependent upon the species involved and their abundance.
Solid waste disposal	A direct anthropogenic impact which may alter habitat structurally. Also, a general indication of the misuse and mismanagement of the river.

Indigenous vegetation removal	Impairment of the buffer the vegetation forms to the movement of sediment and other catchment runoff products into the river. Refers to physical removal for farming, firewood and overgrazing.
Exotic vegetation encroachment	Excludes natural vegetation due to vigorous growth, causing bank instability and decreasing the buffering function of the riparian zone. Allochthonous organic matter input will also be changed. Riparian zone habitat diversity is also reduced.
Bank erosion	Decrease in bank stability will cause sedimentation and possible collapse of the river bank resulting in a loss or modification of both instream and riparian habitats. Increased erosion can be the result of natural vegetation removal, overgrazing or exotic vegetation encroachment.

Table 18: Rating table used to assess impacts to river systems

Criterion	Diagnostic channel characteristics	Score
A: Natural	No discernible impact, or the modification is located in such a way that it has no impact on habitat quality, diversity, size and variability.	0
B: Good	The modification is limited to very few localities and the impact on habitat quality, diversity, size and variability is also very small.	1-5
C: Fair	The modifications are present at a small number of localities and the impact on habitat quality, diversity, size and variability is also limited.	6-10
D: Poor	The modification is generally present with a clearly detrimental impact on habitat quality, diversity, size and variability. Large areas are, however, not influenced.	11-15
E: Seriously Modified	The modification is frequently present and the habitat quality, diversity, size and variability in almost the whole of the defined area is affected. Only small areas are not influenced.	16-20
F: Critically Modified	The modification is present overall with a high intensity. The habitat quality, diversity, size and variability in almost the whole of the defined section are influenced detrimentally.	21-25

Aquatic Health and Water Quality:

» ***Physico-chemical water quality sampling and analysis:***

The results discussed in this report are from samples collected from Site 1 Akermans Kraal (GPS S 30°6711 – E26°63482) downstream from the proposed location of the sand mine and Site 2 Akermans Kraal (GPS S 30°67619 – E26°63091) upstream from the proposed mining location in the Orange river on the 12th of February 2020. On the day of sampling the river was flowing due to rainfall in the area

.

The following in situ physic-chemical water quality variables were measured and recorded at elected sites:

- Water clarity (Water Clarity Tube)
- Water Temperature
- Steam flow velocity (Stream Velocity Rod)

In addition, water samples were collected and analysed at SANAS accredited laboratory by iWater. These parameters were sampled to provide prevailing physico-chemical water quality, as well as to provide ancillary data to interpret Diatom analyses. Water quality results were compared to the Target Water Quality Range (TWQR) for aquatic ecosystems as set out by DWAF (1996).

Water samples for chemical analysis were collected in clean 500 ml plastic bottles and samples for microbial analysis in clean 500 ml plastic sterilized bottles. The samples were then couriered to the laboratory within 24-48 hours with ice packs for parameter analyses.

» ***Diatom Analysis:***

Diatoms have been shown to be reliable indicators of specific water quality problems such as organic pollution, eutrophication, acidification and metal pollution, as well as for general water quality. Diatoms are commonly employed in monitoring efforts as sensitive biological indicators to determine the anthropogenic impact on aquatic ecosystems, and have for a long time been used in bio-assessments (Kasperovičienė and Vaikutienė, 2007). As benthic diatom assemblages are sessile they are exposed to water quality at a site over a period antecedent to sampling. They therefore indicate recent as well as current water quality (Philibert et al., 2006). Diatoms (as a biological response variable) are included in biomonitoring as it provides additional information on the water quality assessment in terms of current pollution levels and possible trends in physical chemical variables. Diatoms also provide a general description of the water quality related habitat specifications linked to ecologically sensitive species requirements. Diatom-based water quality indices for riverine ecosystems have been implemented in South Africa since 2004 as there is a measurable relationship between water quality variables such as pH, electrical conductivity, phosphorus and nitrogen, and the structure of diatom communities as reflected by diatom index scores, allowing for inferences to be drawn about water quality (Taylor, 2004; De la Rey et al. 2004).

The specific water quality tolerances of diatoms have been resolved into different diatom-based water quality indices, used around the world. Most indices are based on a weighted average equation (Zelinka and Marvan, 1961). In general, each diatom species used in the calculation of the index is assigned two values; the first value (s value) reflects the tolerance or affinity of the particular diatom species to a certain water quality (good or bad) while the second value (v value) indicates how strong (or weak) the relationship is (Taylor, 2004). These values are then weighted by the abundance of the particular diatom species in the sample (Lavoie et al., 2006; Besse, 2007). The main difference between indices is in the indicator sets (number of indicators and list of taxa) used in calculations (Eloranta and Soininen, 2002). These indices form the foundation for developing computer software to estimate biological water quality. OMNIDIA (Lecointe et al., 1993) is one such software package; it has been approved by the European Union and is used with increasing frequency in Europe and will be used for this study.

Aims of a Diatom Analysis

The aim of the diatom sampling and analysis is to provide biological water quality information for conditions on the day of biological component sampling regarding the aquatic health and functioning of the aquatic system, and providing additional input to the physico-chemical component of the study as a response variable. The overall objective of this report is to assess the impacts of anthropogenic activities on the Present Ecological State of the receiving aquatic ecosystem

Important Terminology

Several key ecological terms used in South African diatomology are summarised in the table below for the meaningful reading and understanding of the diatom results.

Table 19: Diatoms: Key ecological terms Taylor et al. (2007a)

Trophy	
Dystrophic	Rich in organic matter, usually in the form of suspended plant colloids, but of a low nutrient content.
Oligotrophic	Low levels or primary productivity, containing low levels of mineral nutrients required by plants.
Mesotrophic	Intermediate levels of primary productivity, with intermediate levels of mineral nutrients required by plants.
Eutrophic	High primary productivity, rich in mineral nutrients required by plants.
Hypereutrophic	Very high primary productivity, constantly elevated supply of mineral nutrients required by plants.
Mineral content	
Very electrolyte poor	< 50 µS/cm
Electrolyte-poor (low electrolyte content)	50 - 100 µS/cm
Moderate electrolyte content	100 - 500 µS/cm
Electrolyte-rich (high electrolyte content)	> 500 µS/cm
Brackish (very high electrolyte content)	> 1000 µS/cm
Saline	6000 µS/cm
Pollution (Saprobity)	
Unpolluted to slightly polluted	BOD <2, O_2 deficit <15% (oligosaprobic)
Moderately polluted	BOD <4, O_2 deficit <30% (β-mesosaprobic)
Critical level of pollution	BOD <7 (10), O_2 deficit <50% (β-ȧ-mesosaprobic)
Strongly polluted	BOD <13, O_2 deficit <75% (ȧ-mesosaprobic)
Very heavily polluted	BOD <22, O_2 deficit <90% (ȧ-meso-polysaprobic)
Extremely polluted	BOD >22, O_2 deficit >90% (polysaprobic)

Sampling and Analysis

Epilithic and/or Epiphytic substrate was sampled as outlined in Taylor et al. (2007a). Diatom samples were taken at the site by scrubbing the substrate with a small brush and rinsing both the brush and the substrate with distilled water.

Preparation of diatom slides followed the Hot HCl and KMnO4 method as outlined in Taylor et al. (2007a). A Nikon Eclipse E100 microscope with phase contrast optics (1000x) was used to identify diatom valves on slides. The aim of the data analysis was to count 400 diatom valves to produce semi-quantitative data from which ecological conclusions can be drawn (Taylor et al., 2007a). This range is supported by Prygiel et al. (2002), Schoeman (1973) and Battarbee (1986) as satisfactory for the calculation of relative abundance of diatom species. Nomenclature followed Krammer and Lange-Bertalot (1986-91). Diatom index values were calculated in the database programme OMNIDIA (Lecointe et al., 1993) for epilithon data in order to generate index scores to general water quality variables.

Diatom Based Water Quality Score

The European numerical diatom index, the Specific Pollution sensitivity Index (SPI) was used to assign biological water quality Ecological Categories (ECs) and associated water quality classes. Classes based on the class limits provided in Table 2.1. Other indices housed within the OMNIDIA programme used to characterise biological water quality included:

- Biological Diatom Index (BDI): Primarily a practical index, as it treats morphologically related taxa as one group and composes so-called associated taxa eliminating species that are difficult to identify.
- The ecological characterisation of diatom species based on Van Dam *et al.* (1994): Includes the preferences of 948 freshwater and brackish water diatom species in terms of pH, nitrogen, oxygen, salinity, humidity, saprobity and trophic state.
- Trophic Diatom Index (TDI) (Kelly and Whitton, 1995): This index provides the percentage pollution tolerant diatom valves (PTVs) in a sample and was developed for monitoring sewage outfall (orthophosphate-phosphorus concentrations), and not general stream quality. The presence of more than 20% PTVs shows significant organic impact.
- Valve deformities were also noted as it is an indication of possible metal toxicity that may be present within the system. According to Luís *et al*. (2008) several studies on metal polluted rivers have shown that diatoms respond to perturbations not only at the community but also at the individual level with alteration in cell wall morphology. In particular, size

reduction and frustule deformations have been sometimes associated with high metal concentrations. The general threshold for the occurrence of valve deformities in a sample is usually considered between 1 - 2% and is regarded as potentially hazardous (Taylor, *pers. comm*.).

Table 20: Class limit boundaries for the SPI index applied in this study

Interpretation of index scores		
Ecological Category (EC)	**Class**	**Index Score (SPI Score)**
A	High quality	18 - 20
A/B		17 - 18
B	Good quality	15 - 17
B/C		14 - 15
C	Moderate quality	12 - 14
C/D		10 - 12
D	Poor quality	8 - 10
D/E		6 - 8
E	Bad quality	5 - 6
E/F		4 - 5
F		<4

Sampling Site

Site name	***Description***	***Latitude***	***Longitude***
ACK 01	*Located downstream of the proposed area for the Akermans Kraal Sand Mine. Sample collected from small riffle area within Orange River. The site was selected as an impact site.*	*-30.6711°*	*26.63482°*

Wetland Ecological Importance and Sensitivity (EIS)

The outcomes of the wetland functional assessment were used to inform an assessment of the importance and sensitivity of wetland systems using the Wetland EIS (Ecological Importance and Sensitivity) assessment tool. The Wetland EIS tool includes an assessment of three components:

- Biodiversity support;
- Landscape scale importance;
- Sensitivity of the wetland to floods and water quality changes.

The maximum score for these components was taken as the importance rating for the wetland which is rated using Table 16.

RATING	IMPORTANCE OR LEVEL OF SUPPLY OF ECOSYSTEM SERVICES
None, Rating=0	Rarely sensitive to changes in water quality/hydrological regime.
Low, Rating=1	One or a few elements sensitive to changes in water quality/hydrological regime.
Moderate, Rating=2	Some elements sensitive to changes in water quality/hydrological regime.
High, Rating=3	Many elements sensitive to changes in water, quality/hydrological regime.
Very High, Rating=4	Vary many elements sensitive to changes in water quality/hydrological regime.

Appendix 2: Methodology: Assessment of Impacts

The Environmental Impact Assessment methodology assists in the evaluation of the overall effect of a proposed activity on the environment. This includes an assessment of the significant direct, indirect, and cumulative impacts. The significance of environmental impacts is to be assessed by means of the criteria of extent (scale), duration, magnitude (severity), probability (certainty) and direction (negative, neutral or positive).

» The **nature**, which includes a description of what causes the effect, what will be affected and how it will be affected.

» The **extent**, wherein it is indicated whether the impact will be local (limited to the immediate area or site of development) or regional,

Immediate area	1
Whole site (entire surface right)	2
Neighboring areas	3
Regional	4
Global (Impact beyond provincial boundary and even beyond SA boundary)	5

» The **duration**, wherein it was indicated whether:

Lifetime of the impact will be of a very short duration (0 – 1 years)	1
The lifetime of the impact will be of a short duration (2 – 5 years)	2
Medium-term (5 -15 years)	3
Long term (> 15 years)	4
Permanent	5

» The **magnitude**, quantified on a scale from 0 – 10,

small and will have no effect on the environment	2
minor and will not result in an impact on processes	4
moderate and will result in processes continuing but in a modified way	6
high (processes are altered to the extent that they temporarily cease)	8
very high and results in complete destruction of patterns and permanent cessation of processes	10

» The **probability** of occurrence, which describes the likelihood of the impact actually occurring. Probability was estimated on a scale of 1 -5,

very improbable (probably will not happen)	1
improbable (some possibility, but low likelihood)	2
probable (distinct possibility)	3
highly probable (most likely)	4
definite (impact will occur regardless of any prevention measures)	5

» The **significance**, was determined through a synthesis of the characteristics described above and can be assessed as;

- **LOW**,
- **MEDIUM** or
- **HIGH**;

» the **status**, which was described as either positive, negative or neutral.
» the degree of which the impact can be reversed,
» the degree to which the impact may cause irreplaceable loss of resources,
» the degree to which the impact can be mitigated.

The significance was calculated by combining the criteria in the following formula:

S=(E+D+M)P where;

» S = Significance weighting
» E = Extent
» D = Duration
» M = Magnitude
» P = Probability

The significance weightings for each potential impact are as follows;

Table 21: Rating table used to rate level of significance.

RATING	CLASS	MANAGEMENT DESCRIPTION
< 30	**Low (L)**	Where the impact would not have a direct influence on the decision to develop the area.
30 - 60	**Medium (M)**	Where the impact could influence the decision to develop in the area unless it is effectively mitigated.
> High	**High (H)**	Where the impact must have an influence on the decision process to develop in the area.

Appendix 3. Specialist CV.

CURRICULUM VITAE:

Gerhard Botha

Name:	:	Gerhardus Alfred Botha
Date of Birth	:	11 April 1986
Identity Number	:	860411 5136 088
Postal Address	:	PO Box 12500 Brandhof 9324
Residential Address	:	3 Jock Meiring Street Park West Bloemfontein 9301
Cell Phone Number	:	084 207 3454
Email Address	:	gabotha11@gmail.com
Profession/Specialisation	:	Ecological and Biodiversity Consultant
Nationality:	:	South African
Years Experience:	:	8
Bilingualism	:	Very good – English and Afrikaans

Professional Profile:

Gerhard is a Managing Director of Nkurenkuru Ecology and Biodiversity (Pty) Ltd. He has a BSc Honours degree in Botany from the University of the Free State Province and is currently completing a MSc Degree in Botany. He began working as an environmental specialist in 2010 and has since gained extensive experience in conducting ecological and biodiversity assessments in various development field, especially in the fields of conventional as well as renewable energy generation, mining and infrastructure development. Gerhard is a registered Professional Natural Scientist (Pr. Sci. Nat.)

Key Responsibilities:

Specific responsibilities as an Ecological and Biodiversity Specialist include, inter alia, professional execution of specialist consulting services (including flora, wetland and fauna studies, where required), impact assessment reporting, walk through surveys/ground-truthing to inform final design, compilation of management plans, compliance monitoring and audit reporting, in-house ecological awareness training to on-site personnel, and the development of project proposals for procuring new work/projects.

Skills Base and Core Competencies

- Research Project Management
- Botanical researcher in projects involving the description of terrestrial and coastal ecosystems.
- Broad expertise in the ecology and conservation of grasslands, savannahs, karroid wetland, and aquatic ecosystems.
- Ecological and Biodiversity assessments for developmental purposes (BAR, EIA), with extensive knowledge and experience in the renewable energy field (Refer to Work Experiences and References)
- Over 3 years of avifaunal monitoring and assessment experience.
- Mapping and Infield delineation of wetlands, riparian zones and aquatic habitats (according to methods stipulated by DWA, 2008) within various South African provinces of KwaZulu-Natal, Mpumalanga, Free State, Gauteng and Northern Cape Province for inventory and management purposes.
- Wetland and aquatic buffer allocations according to industry best practice guidelines.
- Working knowledge of environmental planning policies, regulatory frameworks, and legislation
- Identification and assessment of potential environmental impacts and benefits.
- Assessment of various wetland ecosystems to highlight potential impacts, within current and proposed landscape settings, and recommend appropriate mitigation and offsets based on assessing wetland ecosystem service delivery (functions) and ecological health/integrity.
- Development of practical and achievable mitigation measures and management plans and evaluation of risk to execution
- Qualitative and Quantitative Research
- Experienced in field research and monitoring
- Working knowledge of GIS applications and analysis of satellite imagery data
- Completed projects in several Provinces of South Africa and include a number of projects located in sensitive and ecological unique regions.

Education and Professional Status

Degrees:

- *2015:* Currently completing a M.Sc. degree in Botany (Vegetation Ecology), University of the Free State, Bloemfontein, RSA.
- *2009:* B.Sc. Hons in Botany (Vegetation Ecology), University of the Free State, Bloemfontein, RSA.
- *2008:* B.Sc. in Zoology and Botany, University of the Free State, University of the Free State, Bloemfontein,

RSA.

Courses:

- *2013*: Wetland Management (ecology, hydrology, biodiversity, and delineation) – University of the Free State accredited course.
- *2014*: Introduction to GIS and GPS (Code: GISA 1500S) – University of the Free State accredited course.

Professional Society Affiliations:

- The South African Council of Natural Scientific Professions: Pr. Sci. Nat. Reg. No. 400502/14 (Botany and Ecology).

Employment History

- December 2017 – Current: Nkurenkuru Ecology and Biodiversity (Pty) Ltd
- 2016 – November 2017: ECO-CARE Consultancy
- *2015 - 2016*: Ecologist, Savannah Environmental (Pty) Ltd
- *2013 – 2014*: Working as ecologist on a freelance basis, involved in part-time and contractual positions for the following companies
  - Enviroworks (Pty) Ltd
  - GreenMined (Pty) Ltd
  - Eco-Care Consultancy (Pty) Ltd
  - Enviro-Niche Consulting (Pty) Ltd
  - Savannah Environmental (Pty) Ltd
  - Esicongweni Environmental Services (EES) cc
- *2010 - 2012*: Enviroworks (Pty) Ltd

Publications

Publications:

- Botha, G.A. & Du Preez, P.J. 2015. A description of the wetland and riparian vegetation of the Nxamasere palaeo-river's backflooded section, Okavango Delta, Botswana. S. *Afr. J. Bot*., **98**: 172-173.

Congress papers/posters/presentations:

- Botha, G.A. 2015. A description of the wetland and riparian vegetation of the Nxamasere palaeo-river's backflooded section, Okavango Delta, Botswana. 41st Annual Congress of South African Association of Botanists (SAAB). Tshipise, 11-15 Jan. 2015.
- Botha, G.A. 2014. A description of the vegetation of the Nxamasere floodplain, Okavango Delta, Botswana. 10st Annual University of Johannesburg (UJ) Postgraduate Botany Symposium. Johannesburg, 28 Oct. 2014.

Other

- Guest speaker at IAIAsa Free State Branch Event (29 March 2017)

- Guest speaker at the University of the Free State Province: Department of Plant Sciences (3 March 2017):

References:

- Christine Fouché
  Manager: GreenMined (Pty) LTD
  Cell: 084 663 2399
- Professor J du Preez
  Senior lecturer: Department of Plant Sciences
  University of the Free State
  Cell: 082 376 4404

Appendix 7. Specialist's Work Experience and References

WORK EXPERIENCES

&

References

Gerhard Botha

ECOLOGICAL RELATED STUDIES AND SURVEYS

Date Completed	Project Description	Type of Assessment/Study	Client
2019	Sirius Three Solar PV Facility near Upington, Northern Cape	Ecological Assessment (Basic Assessment)	Aurora Power Solutions
2019	Sirius Four Solar PV Facility near Upington, Northern Cape	Ecological Assessment (Basic Assessment)	Aurora Power Solutions
2019	Lichtenburg 1 100MW Solar PV Facility, Lichtenburg, North-West Province	Ecological Assessment (Scoping and EIA Phase Assessments)	Atlantic Renewable Energy Partners
2019	Lichtenburg 2 100MW Solar PV Facility, Lichtenburg, North-West Province	Ecological Assessment (Scoping and EIA Phase Assessments)	Atlantic Renewable Energy Partners
2019	Lichtenburg 3 100MW Solar PV Facility, Lichtenburg, North-West Province	Ecological Assessment (Scoping and EIA Phase Assessments)	Atlantic Renewable Energy Partners
2019	Moeding Solar PV Facility near Vryburg, North-West Province	Ecological Assessment (Basic Assessment)	Moeding Solar

2019	Expansion of the Raumix Aliwal North Quarry, Eastern Cape Province	Fauna and Flora Pre-Construction Walk-Through Assessment	GreenMined
2018	Kruisvallei Hydroelectric 22kV Overhead Power Line, Clarens, Free State Province	Faunal and Flora Rescue and Protection Plan	Zevobuzz
2018	Kruisvallei Hydroelectric 22kV Overhead Power Line, Clarens, Free State Province	Fauna and Flora Pre-Construction Walk-Through Assessment	Zevobuzz
2018	Proposed Kruisvallei Hydroelectric Power Generation Scheme in the Ash River, Free State Province	Ecological Assessment (Basic Assessment)	Zevobuzz
2018	Proposed Zonnebloem Switching Station (132/22kV) and 2X Loop-in Loop-out Power Lines (132kV), Mpumalanga Province	Ecological Assessment (Basic Assessment)	Eskom
2018	Clayville Thermal Plant within the Clayville Industrial Area, Gauteng Province	Ecological Comments Letter	Savannah Environmental
2018	Iziduli Emoyeni Wind Farm near Bedford, Eastern Cape Province	Ecological Assessment (Re-assessment)	Emoyeni Wid Farm Renewable Energy
2018	Msenge Wind Farm near Bedford, Eastern Cape Province	Ecological Assessment (Re-assessment)	Amakhala Emoyeni Renewable Energy
2017	H2 Energy Power Station near Kwamhlanga, Mpumalanga Province	Ecological Assessment (Scoping and EIA phase assessments)	Eskom
2017	Karusa Wind Farm (Phase 1 of the Hidden Valley Wind Energy Facility near Sutherland, Northern Cape Province)	Ecological Assessment (Re-assessment)	ACED Renewables Hidden Valley
2017	Soetwater Wind Farm (Phase 2 of the Hidden Valley Wind Energy Facility near Sutherland, Northern Cape Province)	Ecological Assessment (Re-assessment)	ACED Renewables Hidden Valley
2017	S24G for the unlawful commencement or continuation of activities within a watercourse, Honeydew, Gauteng Province	Ecological Assessment	Savannah Environmental
2016 - 2017	Noupoort CSP Facility near Noupoort, Northern Cape Province	Ecological Assessment (Scoping and EIA phase assessments)	Cresco
2016	Buffels Solar 2 PV Facility near Orkney, North West Province	Ecological Assessment (Scoping and EIA phase assessments)	Kabi Solar
2016	Buffels Solar 1 PV Facility near Orkney, North West Province	Ecological Assessment (Scoping and EIA phase assessments)	Kabi Solar
2016	132kV Power Line and On-Site Substation for the Authorised Golden Valley II Wind Energy Facility near Bedford, Eastern Cape Province	Ecological Assessment (Basic Assessment)	Terra Wind Energy
2016	Kalahari CSP Facility: 132kV Ferrum–Kalahari–UNTU & 132kV Kathu IPP–Kathu 1 Overhead Power Lines, Kathu, Northern Cape Province	Fauna and Flora Pre-Construction Walk-Through Assessment	Kathu Solar Park
2016	Kalahari CSP Facility: Access Roads, Kathu, Northern Cape Province	Fauna and Flora Pre-Construction Walk-Through Assessment	Kathu Solar Park
2016	Karoshoek Solar Valley Development – Additional CSP Facility including tower infrastructure associated with authorised CSP Site 2 near Upington, Northern Cape Province	Ecological Assessment (Scoping Assessment)	Emvelo
2016	Karoshoek Solar Valley Development –Ilanga CSP 7 and 8 Facilities near Upington, Northern Cape Province	Ecological Assessment (Scoping Assessment)	Emvelo
2016	Karoshoek Solar Valley Development –Ilanga CSP 9 Facility near Upington, Northern Cape Province	Ecological Assessment (Scoping Assessment)	Emvelo

2016	Lehae Training Academy and Fire Station, Gauteng Province	Ecological Assessment	Savannah Environmental
2016	Metal Industrial Cluster and Associated Infrastructure near Kuruman, Northern Cape Province	Ecological Assessment (Scoping Assessment)	Northern Cape Department of Economic Development and Tourism
2016	Semonkong Wind Energy Facility near Semonkong, Maseru District, Lesotho	Ecological Pre-Feasibility Study	Savannah Environmental
2015 - 2016	Orkney Solar PV Facility near Orkney, North West Province	Ecological Assessment (Scoping and EIA phase assessments)	Genesis Eco-Energy
2015 - 2016	Woodhouse 1 and Woodhouse 2 PV Facilities near Vryburg, North West Province	Ecological Assessment (Scoping and EIA phase assessments)	Genesis Eco-Energy
2015	CAMCO Clean Energy 100kW PV Solar Facility, Thaba Eco Lodge near Johannesburg, Gauteng Province	Ecological Assessment (Basic Assessment)	CAMCO Clean Energy
2015	CAMCO Clean Energy 100kW PV Solar Facility, Thaba Eco Lodge near Johannesburg, Gauteng Province	Ecological Assessment (Basic Assessment)	CAMCO Clean Energy
2015	Sirius 1 Solar PV Project near Upington, Northern Cape Province	Fauna and Flora Pre-Construction Walk-Through Assessment	Aurora Power Solutions
2015	Sirius 2 Solar PV Project near Upington, Northern Cape Province	Fauna and Flora Pre-Construction Walk-Through Assessment	Aurora Power Solutions
2015	Sirius 1 Solar PV Project near Upington, Northern Cape Province	Invasive Plant Management Plan	Aurora Power Solutions
2015	Sirius 2 Solar PV Project near Upington, Northern Cape Province	Invasive Plant Management Plan	Aurora Power Solutions
2015	Sirius 1 Solar PV Project near Upington, Northern Cape Province	Plant Rehabilitation Management Plan	Aurora Power Solutions
2015	Sirius Phase 2 Solar PV Project near Upington, Northern Cape Province	Plant Rehabilitation Management Plan	Aurora Power Solutions
2015	Sirius 1 Solar PV Project near Upington, Northern Cape Province	Plant Rescue and Protection Plan	Aurora Power Solutions
2015	Sirius Phase 2 Solar PV Project near Upington, Northern Cape Province	Plant Rescue and Protection Plan	Aurora Power Solutions
2015	Expansion of the existing Komsberg Main Transmission Substation near Sutherland, Northern Cape Province	Ecological Assessment (Basic Assessment)	ESKOM
2015	Karusa Wind Farm near Sutherland, Northern Cape Province)	Invasive Plant Management Plan	ACED Renewables Hidden Valley
2015	Proposed Karusa Facility Substation and Ancillaries near Sutherland, Northern Cape Province	Ecological Assessment (Basic Assessment)	ACED Renewables Hidden Valley
2015	Eskom Karusa Switching Station and 132kV Double Circuit Overhead Power Line near Sutherland, Northern Cape Province	Ecological Assessment (Basic Assessment)	ESKOM
2015	Karusa Wind Farm near Sutherland, Northern Cape Province)	Plant Search and Rescue and Rehabilitation Management Plan	ACED Renewables Hidden Valley
2015	Karusa Wind Energy Facility near Sutherland, Northern Cape Province	Fauna and Flora Pre-Construction Walk-Through Assessment	ACED Renewables Hidden Valley
2015	Soetwater Facility Substation, 132kV Overhead Power Line and Ancillaries, near Sutherland, Northern Cape Province	Ecological Assessment (Basic Assessment)	ACED Renewables Hidden Valley
2015	Soetwater Wind Farm near Sutherland, Northern Cape Province)	Invasive Plant Management Plan	ACED Renewables Hidden Valley

2015	Soetwater Wind Energy Facility near Sutherland, Northern Cape Province	Fauna and Flora Pre-Construction Walk-Through Assessment	ACED Renewables Hidden Valley
2015	Soetwater Wind Farm near Sutherland, Northern Cape Province	Plant Search and Rescue and Rehabilitation Management Plan	ACED Renewables Hidden Valley
2015	Expansion of the existing Scottburgh quarry near Amandawe, KwaZulu-Natal	Botanical Assessment (for EIA)	GreenMined Environmental
2015	Expansion of the existing AFRIMAT quarry near Hluhluwe, KwaZulu-Natal	Botanical Assessment (for EIA)	GreenMined Environmental
2014	Tshepong 5MW PV facility within Harmony Gold's mining rights areas, Odendaalsrus	Ecological Assessment (Basic Assessment)	BBEnergy
2014	Nyala 5MW PV facility within Harmony Gold's mining rights areas, Odendaalsrus	Ecological Assessment (Basic Assessment)	BBEnergy
2014	Eland 5MW PV facility within Harmony Gold's mining rights areas, Odendaalsrus	Ecological Assessment (Basic Assessment)	BBEnergy
2014	Transalloys circulating fluidised bed power station near Emalahleni, Mpumalanga Province	Ecological Assessment (for EIA)	Trans-Alloys
2014	Umbani circulating fluidised bed power station near Kriel, Mpumalanga Province	Ecological Assessment (Scoping and EIA)	Eskom
2014	Gihon 75MW Solar Farm: Bela-Bela, Limpopo Province	Ecological Assessment (for EIA)	NETWORX Renewables
2014	Steelpoort Integration Project & Steelpoort to Wolwekraal 400kV Power Line	Fauna and Flora Pre-Construction Walk-Through Assessment	Eskom
2014	Audit of protected *Acacia erioloba* trees within the Assmang Wrenchville housing development footprint area	Botanical Audit	Eco-Care Consultancy
2014	Rehabilitation of the N1 National Road between Sydenham and Glen Lyon	Peer review of the ecological report	EKO Environmental
2014	Rehabilitation of the N6 National Road between Onze Rust and Bloemfontein	Peer review of the ecological report	EKO Environmental
2011	Illegally ploughed land on the Farm Wolwekop 2353, Bloemfontein	Vegetation Rehabilitation Plan	EnviroWorks
2011	Rocks Farm chicken broiler houses	Botanical Assessment (for EIA)	EnviroWorks
2011	Botshabelo 132 kV line	Ecological Assessment (for EIA)	CENTLEC
2011	De Aar Freight Transport Hub	Ecological Scoping and Feasibility Study	EnviroWorks
2011	The proposed establishment of the Tugela Ridge Eco Estate on the farm Kruisfontein, Bergville	Ecological Assessment (for EIA)	EnviroWorks
2010 - 2011	National long-haul optic fibre infrastructure network project, Bloemfontein to Beaufort West	Vegetation Rehabilitation Plan for illegally cleared areas	NEOTEL
2010 - 2011	National long-haul optic fibre infrastructure network project, Bloemfontein to Beaufort West	Invasive Plant Management Plan	NEOTEL
2010 - 2011	National long-haul optic fibre infrastructure network project, Bloemfontein to Beaufort West	Protected and Endangered Species Walk-Through Survey	NEOTEL
2011	Optic Fibre Infrastructure Network, Swartland Municipality	Botanical Assessment (for EIA) - Assisted Dr. Dave McDonald	Dark Fibre Africa
2011	Optic Fibre Infrastructure Network, City of Cape Town Municipality	Botanical Assessment (for EIA) - Assisted Dr. Dave McDonald	Dark Fibre Africa
2010	Construction of an icon at the southernmost tip of Africa, Agulhas National Park	Botanical Assessment (for EIA)	SANPARKS
2010	New boardwalk from Suiderstrand Gravel Road to Rasperpunt, Agulhas National Park	Botanical Assessment (for EIA)	SANPARKS
2010	Farm development for academic purposes (Maluti FET College) on the Farm Rosedale 107, Harrismith	Ecological Assessment (Screening and Feasibility Study)	Agri Development Solutions
2010	Basic Assessment: Barcelona 88/11kV substation and 88kV loop-in lines	Botanical Assessment (for EIA)	Eskom Distribution
2011	Illegally ploughed land on the Farm Wolwekop 2353, Bloemfontein	Vegetation Rehabilitation Plan	EnviroWorks

WETLAND DELINEATION AND HYDROLOGICAL ASSESSMENTS

Date Completed	Project Description	Type of Assessment/Study	Client
In progress	Steynsrus PV 1 & 2 Solar Energy Facilities near Steynsrus, Free State Province	Wetland Assessment	Cronimet Mining Power Solutions
2019	Lichtenburg 1 100MW Solar PV Facility, Lichtenburg, North-West Province	Surface Hydrological Assessment (Scoping and EIA Phase)	Atlantic Renewable Energy Partners
2019	Lichtenburg 2 100MW Solar PV Facility, Lichtenburg, North-West Province	Surface Hydrological Assessment (Scoping and EIA Phase)	Atlantic Renewable Energy Partners
2019	Lichtenburg 3 100MW Solar PV Facility, Lichtenburg, North-West Province	Surface Hydrological Assessment (Scoping and EIA Phase)	Atlantic Renewable Energy Partners
2019	Moeding Solar PV Facility near Vryburg, North-West Province	Wetland Assessment (Basic Assessment)	Moeding Solar
2018	Kruisvallei Hydroelectric 22kV Overhead Power Line, Clarens, Free State Province	Wetland Assessment (Basic Assessment	Zevobuzz
2017	Nyala 5MW PV facility within Harmony Gold's mining rights areas, Odendaalsrus	Wetland Assessment	BBEnergy
2017	Eland 5MW PV facility within Harmony Gold's mining rights areas, Odendaalsrus	Wetland Assessment	BBEnergy
2017	Olifantshoek 10MVA 132/11kV Substation and 31km Power Line	Surface Hydrological Assessment (Basic Assessment)	Eskom
2017	Expansion of the Elandspruit Quarry near Ladysmith, KwaZulu-Natal Province	Wetland Assessment	Raumix
2017	S24G for the unlawful commencement or continuation of activities within a watercourse, Honeydew, Gauteng Province	Aquatic Assessment & Flood Plain Delineation	Savannah Environmental
2017	Noupoort CSP Facility near Noupoort, Northern Cape Province	Surface Hydrological Assessment (EIA phase)	Cresco
2016	Wolmaransstad Municipality 75MW PV Solar Energy Facility in the North West Province	Wetland Assessment (Basic Assessment)	BlueWave Capital
2016	BlueWave 75MW PV Plant near Welkom Free State Province	Wetland Delineation	BlueWave Capital
2016	Harmony Solar Energy Facilities: Amendment of Pipeline and Overhead Power Line Route	Wetland Assessment (Basic Assessment)	BBEnergy

AVIFAUNAL ASSESSMENTS

Date Completed	Project Description	Type of Assessment/Study	Client
2019	Sirius Three Solar PV Facility near Upington, Northern Cape	Avifauna Assessment (Basic Assessment)	Aurora Power Solutions
2019	Sirius Four Solar PV Facility near Upington, Northern Cape	Avifauna Assessment (Basic Assessment)	Aurora Power Solutions
2019	Moeding Solar PV Facility near Vryburg, North-West Province	Avifauna Assessment (Basic Assessment)	Moeding Solar

2018	Proposed Zonnebloem Switching Station (132/22kV) and 2X Loop-in Loop-out Power Lines (132kV), Mpumalanga Province	Avifauna Assessment (Basic Assessment)	Eskom
2017	Olifantshoek 10MVA 132/11kV Substation and 31km Power Line	Avifauna Assessment (Basic Assessment)	Eskom
2016	TEWA Solar 1 Facility, east of Upington, Northern Cape Province	Wetland Assessment (Basic Assessment	Tewa Isitha Solar 1
2016	TEWA Solar 2 Facility, east of Upington, Northern Cape Province	Wetland Assessment	Tewa Isitha Solar 2

ENVIRONMENTAL IMPACT ASSESSMENT

- Barcelona 88/11kV substation and 88kV loop-in lines – BA (for Eskom).
- Thabong Bulk 132kV sub-transmission inter-connector line – EIA (for Eskom).
- Groenwater 45 000 unit chicken broiler farm – BA (for Areemeng Mmogo Cooperative).
- Optic Fibre Infrastructure Network, City of Cape Town Municipality – BA (for Dark Fibre Africa (Pty) Ltd).
- Optic Fibre Infrastructure Network, Swartland Municipality – BA (for Dark Fibre Africa).
- Construction and refurbishment of the existing 66kV network between Ruigtevallei Substation and Reddersburg Substation – EMP (for Eskom).
- Lower Kruisvallei Hydroelectric Power Scheme (Ash river) – EIA (for Kruisvallei Hydro (Pty) Ltd).
- Construction of egg hatchery and associated infrastructure – BA (For Supreme Poultry).
- Construction of the Klipplaatdrif flow gauging (Vaal river) – EMP (DWAF).

ENVIRONMENTAL COMPLIANCE AUDITING AND ECO

- National long haul optic fibre infrastructure network project, Bloemfontein to Laingsburg – ECO (for Enviroworks (Pty) Ltd.).
- National long haul optic fibre infrastructure network project, Wolmaransstad to Klerksdorp – ECO (for Enviroworks (Pty) Ltd.).
- Construction and refurbishment of the existing 66kV network between Ruigtevallei Substation and Reddersburg Substation – ECO (for Enviroworks (Pty) Ltd.).
- Construction and refurbishment of the Vredefort/Nooitgedacht 11kV power line – ECO (for Enviroworks (Pty) Ltd.).
- Mining of Dolerite (Stone Aggregate) by Raumix (Pty) Ltd. on a portion of Portion 0 of the farm Hillside 2830, Bloemfontein – ECO (for GreenMined Environmental (Pty) Ltd.).
- Construction of an Egg Production Facility by Bainsvlei Poultry (Pty) Ltd on Portions 9 & 10 of the farm, Mooivlakte, Bloemfontein – ECO (for Enviro-Niche Consulting (Pty) Ltd.).
- Environmental compliance audit and botanical account of Afrisam's premises in Bloemfontein – Environmental Compliance Auditing (for Enviroworks (Pty) Ltd.).

OTHER PROJECTS:

- Keeping and breeding of lions (*Panthera leo*) on the farm Maxico 135, Ficksburg – Management and Business Plan (for Enviroworks (Pty) Ltd.)
- Keeping and breeding of lions (*Panthera leo*) on the farm Mooihoek 292, Theunissen – Management and Business Plan (for Enviroworks (Pty) Ltd.)
- Keeping and breeding of wild dogs (*Lycaon pictus*) on the farm Mooihoek 292, Theunissen – Management and Business Plan (for Enviroworks (Pty) Ltd.)
- Existing underground and aboveground fuel storage tanks, TWK AGRI: Pongola – Environmental Management Plan (for TWK Agricultural Ltd).
- Existing underground fuel storage tanks on Erf 171, TWK AGRI: Amsterdam – Environmental Management Plan (for TWK Agricultural Ltd).
- Proposed storage of 14 000 L of fuel (diesel) aboveground on Erf 32, TWK AGRI: Carolina – Environmental Management Plan (for TWK Agricultural Ltd).
- Proposed storage of 23 000 L of fuel (diesel) above ground on Portion 10 of the Farm Oude Bosch, Humansdorp – Environmental Management Plan (for TWK Agricultural Ltd).
- Proposed storage of 16 000 L of fuel (diesel) aboveground at Panbult Depot – Environmental Management Plan (for TWK Agricultural Ltd).
- Existing underground fuel storage tanks, TWK AGRI: Mechanisation and Engineering, Piet Retief – Environmental Management Plan (for TWK Agricultural Ltd).
- Existing underground fuel storage tanks on Portion 38 of the Farm Lothair, TWK AGRI: Lothair – Environmental Management Plan (for TWK Agricultural Ltd).