APPENDIX

H-5 AQUATIC

AQUATIC BIODIVERSITY SPECIALIST SCOPING REPORT INPUTS:

Scoping and Environmental Impact Assessment (EIA) Processes for the Proposed Development of the 300 MW Mukondeleli Wind Energy Facility and associated infrastructure, near Secunda, Province of Mpumalanga

---

Report prepared for:	*Report prepared by:*
CSIR – Environmental Management Services P O Box 320 Stellenbosch 7599 South Africa	Iggdrasil Scientific Services & Limosella Consulting Postnet Suite #409, Private Bag X37 Lynnwood Ridge 0040 South Africa

5 August 2022

Executive Summary

This report serves as the Aquatic Biodiversity Assessment Scoping Report input that was prepared as part of the Scoping and Environmental Impact Assessment (S&EIA) for the proposed development of a 300 MW Mukondeleli Wind Energy Facility (WEF) and associated infrastructure, near Secunda, Mpumalanga Province.

The terms of reference for the current study were as follows:

- Delineate the wetland and riparian areas to inform the placement of infrastructure;
- Determine the aquatic macro invertebrate assemblages present within the proposed development footprint;
- Assess the habitat of the rivers/streams of the area in terms of habitat suitability for the relevant macro invertebrate assemblages;
- Classify the rivers or streams where possible with the use of the biological bands method as described by Dallas (2007);
- Classify the watercourse according to the system proposed in the national wetlands inventory if relevant;
- Compile a baseline description of the aquatic environment potentially impacted by the development as specified in GN320, March 2020;
- Undertake functional and integrity assessment of wetlands and riparian areas as specified in General Notice 267 of 24 March 2017;
- Undertake an impact assessment as specified in the NEMA 2014 regulations, as amended and GN320, March 2020;
- Undertake a Risk Assessment as specified in General Notice 267 of 24 March 2017;
- Recommend suitable buffer zones as specified in General Notice 267 of 24 March 2017, following Macfarlane et al., 2015; and
- Discuss appropriate mitigation and management procedures relevant to the conserving wetland areas on the site as specified in GN320, March 2020.

The proposed Muondeleli WEF is located in the Govan Mbeki Municipality, near the town of Secunda, in the Mpumalanga Province of South Africa. The project area covers 21 property portions. The details of the properties associated with the proposed Mukondeleli WEF, including the 21-digit Surveyor General (SG) codes for the cadastral land parcels are outlined in the table below. The approximate central coordinates are Lat 26°33'10.33"S; Long 29°15'38.46"E (Figure 3)

Portion Number	Farm Number	Farm Names	21 Digit Surveyor General Code of each cadastral land parcel
0	314	Knoppies	T0IS00000000031400000
1	317	van Tondershoek	T0IS00000000031700001
2	317	van Tondershoek	T0IS00000000031700002
2	316	Brandwacht	T0IS00000000031600002
2	291	Bosjesspruit	T0IS00000000029100002
3	316	Brandwacht	T0IS00000000031600003
4	316	Brandwacht	T0IS00000000031600004
5	321	Tweefontein	T0IS00000000032100005
6	291	Bosjesspruit	T0IS00000000029100006
7	317	van Tondershoek	T0IS00000000031700007
8	317	van Tondershoek	T0IS00000000031700008
8	291	Bosjesspruit	T0IS00000000029100008
9	313	Knoppiesfontein	T0IS00000000031300009

Portion Number	Farm Number	Farm Names	21 Digit Surveyor General Code of each cadastral land parcel
9	291	Bosjesspruit	T0IS00000000029100009
10	291	Bosjesspruit	T0IS00000000029100010
11	291	Bosjesspruit	T0IS00000000029100011
11	317	van Tondershoek	T0IS00000000031700011
12	291	Bosjesspruit	T0IS00000000029100012
12	317	van Tondershoek	T0IS00000000031700012
13	316	Brandwacht	T0IS00000000031600013
13	291	Bosjesspruit	T0IS00000000029100013
14	291	Bosjesspruit	T0IS00000000029100014

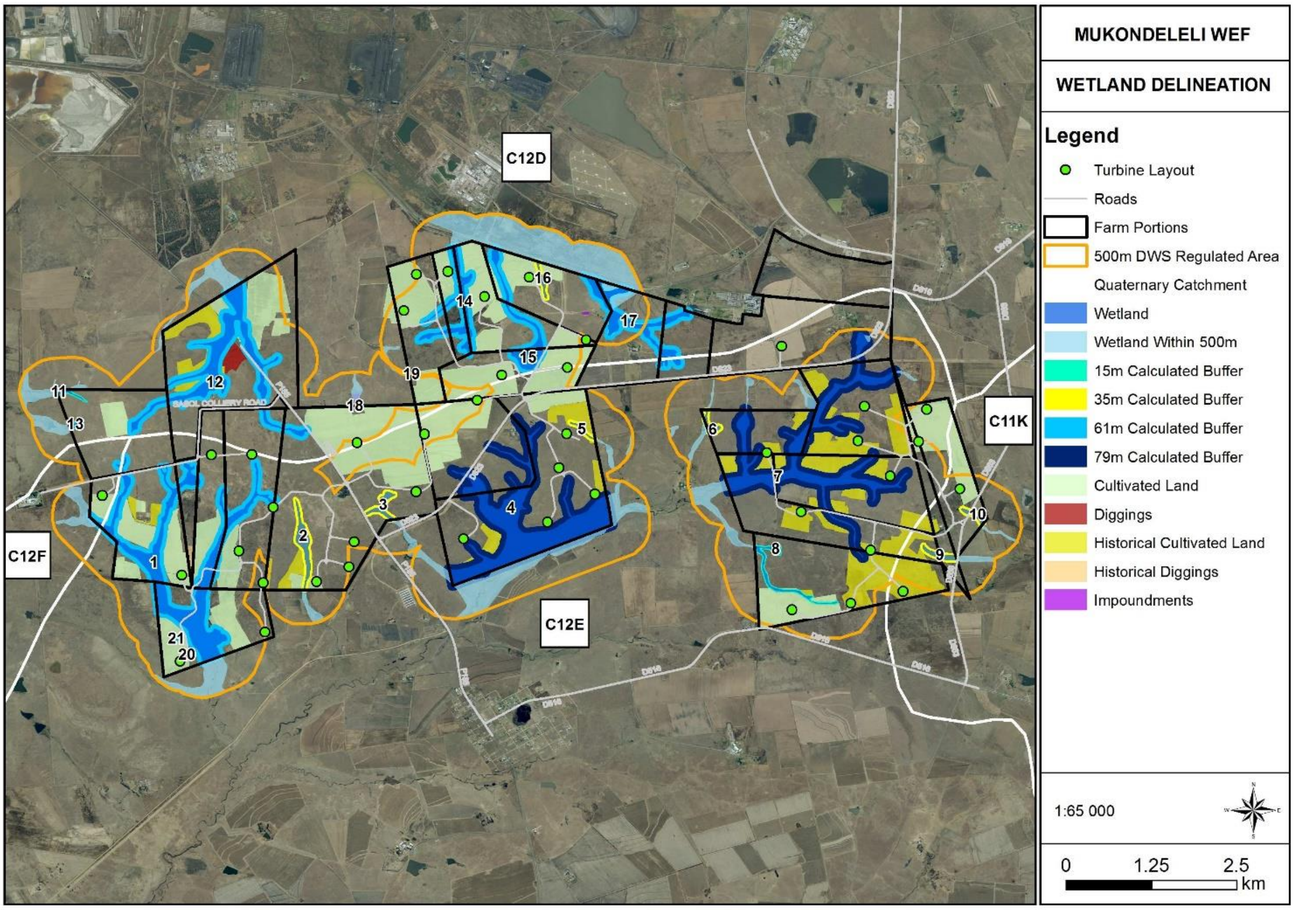
Prior to commencing with the fieldwork a desktop assessment was conducted. The findings of the desktop assessment indicated that the study site has conservation significance on both a provincial, Critical Biodiversity Area (CBA), and national (Threatened Ecosystems and Freshwater Ecosystem Priority Area Wetlands), level. The screening tool also indicated that the aquatic ecosystems surrounding the study site have a high sensitivity.

The site visit was conducted in the week of the 1st to the 4th of February 2022 by the wetland specialist, Rudi Bezuidenhoudt. The aquatic specialist, Andre Strydom, conducted the site visits on the 6th of January 2022 but not all sites could be sampled due to access issues. An additional site visit was conducted on 4th of February 2022, but the aquatic ecosystems were in flood and hence the survey aborted. The final site visit was conducted on the 22nd of February 2022. The surveys were therefore conducted in the summer or high flow season. No dry season surveys were conducted as part of the assessment. Several changes were made to the proposed layout after the initial site visit. Not all these areas were surveyed and extrapolation was thus used to delineate wetlands in these areas. It thus recommended that additional surveys be conducted at the footprint of each WES to ensure these structures remain outside any watercourse areas.

Results of the fieldwork include:
A large number of wetlands were recorded on the study site. The wetlands were divided into several types including:

- Seepage wetlands;
- Valley Bottom Wetlands; and
- Depressional Pan wetlands.

Only one Wind Energy Turbines was found to be recorded within a wetland buffer: MK – 37. The remainder of the structures are well enough buffered to have minimal impacts on the wetlands and although the majority still remain within the DWS regulated area of 500 m, some (MK – 03 , MK – 07, MK – 08 , MK – 09, MK – 25) are located distances of 500 m or more from a wetland and thus has very little chance of impacting on any watercourse.



Nine sampling points were selected for sampling for Macroinvertebrates, habitat and in-situ water quality. A summary of the findings of this report relevant to the application is provided in the table below.

<table>
<tr><td rowspan="2"></td><td colspan="2">Quaternary Catchment and WMA areas</td><td colspan="2">Important Rivers possibly affected</td></tr>
<tr><td colspan="2">C11K, C12D, C12E, #5: Vaal Major.</td><td colspan="2">The wetlands fall into three distinct catchment areas, with wetland 1-8, located in catchment C12E and all draining into Boesmanspruit System. Furthermore, wetland 7 forms the headwaters of the Boesmanspruit System. Wetlands 9 and 10 are located in catchment C11K and drains into the Leeuspruit System. Lastly the remaining wetlands (Wetland 11-19) all drain into the Grootspruit System. Wetlands 20 and 21 are also located in catchment C12E but are hydrologically isolated as pan wetlands that drain inward and do not flow into any nearby wetland system.</td></tr>
<tr><td rowspan="11">Watercourse classification & Integrity scores</td><td>#</td><td>Wetland Type and Drainage</td><td>WetHealth V2 (EC/PES) (Macfarlane et al., 2020)</td><td>Environmental Importance and Sensitivity category (EIS) (Kotze et al., 2020)</td></tr>
<tr><td>1</td><td>Combination of Seepage and Valley Bottom Wetlands</td><td>D - Largely Modified</td><td>Moderate</td></tr>
<tr><td>2</td><td>Unchannelled Valley Bottom</td><td>D - Largely Modified</td><td>Moderate</td></tr>
<tr><td>3</td><td>Seepage</td><td>E - Seriously Modified</td><td>Low</td></tr>
<tr><td>4</td><td>Combination of Seepage and Valley Bottom Wetlands</td><td>C -Moderately Modified</td><td>High</td></tr>
<tr><td>5</td><td>Seepage</td><td>C -Moderately Modified</td><td>Low</td></tr>
<tr><td>6</td><td>Seepage</td><td>C -Moderately Modified</td><td>Low</td></tr>
<tr><td>7</td><td>Seepage and Valley Bottom Wetlands</td><td>C -Moderately Modified</td><td>High</td></tr>
<tr><td>8</td><td>Valley Bottom</td><td>D - Largely Modified</td><td>Low</td></tr>
<tr><td>9</td><td>Seepage</td><td>D - Largely Modified</td><td>Low</td></tr>
<tr><td>10</td><td>Seepage</td><td>E - Seriously Modified</td><td>Low</td></tr>
</table>

	11	Seepage	C -Moderately Modified	Low
	12	Combination of Seepage and Valley Bottom Wetlands	E - Seriously Modified	Moderate
	13	Seepage	D - Largely Modified	Low
	14	Combination of Seepage and Valley Bottom Wetlands	D - Largely Modified	Low
	15	Combination of Seepage and Valley Bottom Wetlands	D - Largely Modified	Low
	16	Seepage	D - Largely Modified	Low
	17	Valley Bottom	D - Largely Modified	Low
	18	Seepage	E - Seriously Modified	Low
	19	Seepage	E - Seriously Modified	Low
	20	Depressional Pan	E - Seriously Modified	Low
	21	Depressional Pan	E - Seriously Modified	Low
Calculated Buffer zones: (Macfarlane *et al.*, 2015):	1. Combination of Seepage and Valley Bottom Wetlands – 61 m 2. Unchannelled Valley Bottom – 35 m 3. Seepage – 35m			

4. Combination of Seepage and Valley Bottom Wetlands – 79m
5. Seepage – 35m
6. Seepage – 35m
7. Combination of Seepage and Valley Bottom Wetlands – 79m
8. Valley Bottom – 15m
9. Seepage – 35m
10. Seepage - 35m
11. Seepage – 15 m
12. Combination of Seepage and Valley Bottom Wetlands – 61 m
13. Seepage – 15 m
14. Combination of Seepage and Valley Bottom Wetlands – 61 m
15. Combination of Seepage and Valley Bottom Wetlands – 61 m
16. Seepage – 35m
17. Valley Bottom – 61m
18. Seepage – 15 m
19. Seepage – 15 m
20. Depressional Pan - 15m
21. Depressional Pan - 15m

Aquatic Assessment results

Sampling Point	IHAS	SASS5 EC	Site Description
MUB1	No access on all three site visits		Upstream reference point for the proposed WEF In non-perennial tributary of the Klipspruit River
MUB2	Insufficient – 43%	E/F – Seriously Modified°	Downstream affected site for the proposed WEF In non-perennial tributary of the Boesmanspruit River
MUB3	Insufficient – 48%	E/F – Seriously Modified°	Downstream affected site for the proposed WEF In non-perennial tributary of the Boesmanspruit River
MUB4	No flow		Downstream affected site for the proposed WEF In non-perennial tributary of the Boesmanspruit River
MUB5	Insufficient – 56%	E/F – Seriously Modified°	Downstream affected site for the proposed WEF In the Boesmansprruit River
MUB6	Insufficient – 47%	E/F – Seriously Modified°	Downstream affected site for the proposed WEF In the Boesmanspruit River
MUB7	No flow		Downstream affected site for the proposed WEF In perennial tributary of the Grootbossiespruit River
MUB8	Insufficient – 39%	B- Largely Natural	Downstream affected site for the proposed WEF In perennial tributary of the Grootbossiespruit River
GRB1	Insufficient – 43%	D – Largely Modified	Downstream affected site for the proposed WEF In non-perennial tributary of the Grootbossiespruit River

NEMA 2014 Impact Assessment

The impact scores for the following aspects are relevant:		Without Mitigation	With Mitigation
Changes to flow dynamics	Construction Phase	M	L
	Operation Phase	M	L

		Decommissioning	M	L
	Sedimentation	Construction Phase	M	L
		Operation Phase	M	L
		Decommissioning	M	L
	Establishment of alien plants	Construction Phase	M	L
		Operation Phase	M	L
		Decommissioning		
	Pollution of watercourses	Construction Phase	M	L
		Operation Phase	M	L
		Decommissioning	M	L
	Loss of fringe vegetation and habitat	Construction Phase	M	L
		Operation Phase	M	L
		Decommissioning	M	L
	Loss of aquatic biota	Construction Phase	M	L
		Operation Phase	M	L
		Decommissioning	M	L
Site verification	The desktop assessment conducted by DWS indicated that the sub quaternary reaches surrounding the study site are largely natural (B) to moderately modified (C). The site verification indicated that the wetlands are moderately (C) to seriously modified (E) whilst the aquatic macroinvertebrates indicated that the aquatic ecosystems are mostly seriously/critically (E/F) modified with only one tributary of the Grootbossiespruit being largely natural (B). Therefore, the wetland and aquatic ecosystems surrounding the study site are more impacted than expected. Although the wetland and aquatic ecosystems are impacted, they still fulfil important ecosystem services and also form part of national and provincial conservation targets and therefore are still considered as sensitive			
Does the specialist support the development?	Yes. Given that the mitigation measures are adhered to, and that the footprint does not encroach into any wetland or wetland buffer zone.			
Recommendations	Alternative layouts should be considered where the current footprints encroach into wetlands or wetland buffer zones. It is recommended that monitoring in terms of wetland PES as well as biomonitoring be conducted to consider the cumulative impacts of the proposed Vhuvhili SEF (subject to a separate EIA process), the proposed Mukondeleli WEF as well as the gridline solution (subject to a separate BA process). Monitoring should be conducted in both the construction and operational phases of the project. It is imperative that an Alien Invasive Species (AIS) plant management plan be developed for the SEF, WEF and gridlines as prior to the construction phase. Clearing and/treatment of these species occurs prior to any construction activities which will curb the spread of AIS plants due to the disturbance events caused by construction.			

Contents

List of Figures

List of Tables

List of Abbreviations

AIS	Alien Invasive Species
ASPT	Average score per taxon
CBAs	Critical Biodiversity Areas
CSIR	Council for Scientific and Industrial Research
DEA	Department of Environmental Affairs
DO	Dissolved Oxygen
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
EC	Ecological Category
EIA	Environmental Impact Assessment
EIS	Ecological Integrity and Sensitivity
ES	Ecosystem Services
ESAs	Ecological Support Areas
ETS	Ecosystem Threat Status
EPL	Ecosystem Protection Level
FEPA	Freshwater Ecosystem Priority Areas
FSA	Fish Support Area
GSM	Gravel, Sand and Mud
GPS	Global Positioning System
IHAS	Integrated Habitat Assessment System
ISS	Iggdrasil Scientific Services
mamsl	Metres above mean sea level
MBSP	Mpumalanga Biodiversity Sector Plan
NAEHMP	National Aquatic Ecosystem Health Monitoring Programme
NBA	National Biodiversity Assessment
NEMA	National Environmental Management Act 107 of 1998
NFEPA	National Freshwater Ecosystem Priority Areas
NWA	National Water Act 36 of 1998
PES/C	Present Ecological State/Category
RHP	River Health Programme
REC	Recommended Ecological Category
RWQO	Receiving Water Quality Objective
SANBI	South African National Biodiversity Institute
SASS5	South African Scoring System version 5
SAWQG	South African Water Quality Guideline
SEF	Solar Energy Facility
SQR	Sub Quaternary Reaches
SWSAs	Strategic Water Source Areas
SWSA-sw	Strategic Water Source Areas for surface water
SWSA-gw	Strategic Water Source Areas for groundwater
TDS	Total Dissolved Salts
TWQR	Target Water Quality Range
UFS	University of the Free State
UNISA	University of South Africa
UP	University of Pretoria
VEGRAI	Riparian Vegetation Response Assessment Index
WMA	Water Management Area
WEF	Wind Energy Facility

Glossary

Definitions	
Aquatic Ecosystems	Aquatic ecosystems are defined as the abiotic (physical and chemical) and biotic components, habitats and ecological processes contained within rivers and their riparian zones, reservoirs, lakes and wetlands and their fringing vegetation.
Aquatic Biomonitoring	Aquatic biomonitoring is the science of inferring the ecological condition of rivers and streams by examining the types of organisms that live there, such as invertebrates, algae, aquatic and non-aquatic vegetation, fish, or amphibians. The method is based on the principle that different aquatic organisms have different tolerances to pollutants, and that certain organisms will appear under conditions of pollution, while others will disappear. The assessment of biota in freshwater ecosystems is a widely recognised means of determining the condition, or 'health' of the ecosystem.
Benthic	Relating to or characteristic of the bottom of a water body, or the animals and plants that live there.
Bioaccumulation	The accumulation of a harmful substance in an organism that forms part of the food chain.
Biota	The animal and plant life of a particular region, habitat, or geological period.
Buffer	A strip of land surrounding a wetland or riparian area in which activities are controlled or restricted, in order to reduce the impact of adjacent land uses on the wetland or riparian area
Ecoregions	Regions that share similar ecological characteristics and are based on the understanding that ecosystems and their biota display regional patterns that mirror causal factors such as climate, soils, geology, physical land surface and vegetation.
FRAI	An assessment index based on the environmental intolerances and preferences of the reference fish assemblages and the response of the constituent species of the assemblage to particular groups of environmental determinants or drivers.
Hydrophyte	any plant that grows in water or on a substratum that is at least periodically deficient in oxygen as a result of soil saturation or flooding; plants typically found in wet habitats
Hydromorphic soil	soil that in its undrained condition is saturated or flooded long enough during the growing season to develop anaerobic conditions favouring the growth and regeneration of hydrophytic vegetation (vegetation adapted to living in anaerobic soils)
Macroinvertebrates	Invertebrates include all animals without backbones. In rivers this includes aquatic insects, larvae of insects with terrestrial (often flying) adult forms, as well as mussels, clams, snails and worms that are aquatic throughout their life cycle.
Seepage	A type of wetland occurring on slopes, usually characterised by diffuse (i.e. unchannelled, and often subsurface) flows.
Sedges	Grass-like plants belonging to the family Cyperaceae, sometimes referred to as nutgrasses. Papyrus is a member of this family.
Soil profile	the vertically sectioned sample through the soil mantle, usually consisting of two or three horizons (Soil Classification Working Group, 1991)
Spruit	A small tributary stream or watercourse that is usually non-perennial
Trophic level	The position an organism occupies on the food chain. Examples include omnivores, herbivores, insectivores, planktivores, and piscivores.
Vegetation	Plants of an area or region.
VEGRAI	A model which determines the response of vegetation to impacts in a way which can be defended by sound scientific methods.
Wetland:	"*land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil*." (National Water Act; Act 36 of 1998).

Definitions	
Wetland delineation	the determination and marking of the boundary of a wetland on a map using the DWAF (2005) methodology. This assessment includes identification of suggested buffer zones and is usually done in conjunction with a wetland functional assessment. The impact of the proposed development, together with appropriate mitigation measures are included in impact assessment tables.

This report serves as the Aquatic Biodiversity Assessment Scoping Report input that was prepared as part of the Scoping and Environmental Impact Assessment (S&EIA) for the proposed development of a 200 MW Mukondeleli Wind Energy Facility and associated infrastructure, near Secunda Mpumalanga Province.

1. Introduction

1.1. Scope, Purpose and Objectives of this Specialist Report

Prior to commencing with the Aquatic Biodiversity and Species Specialist Assessment in accordance with the Specialist Assessment and Minimum Report Content Requirements for Environmental Impacts on Aquatic Biodiversity (Government Notice 320, dated 20 March 2020), a site sensitivity verification was undertaken in order to confirm the current land use and environmental sensitivity of the proposed project area as identified by the National Web-Based Environmental Screening Tool (Screening Tool).

The scope of the report is to provide aquatic input into the draft scoping report as required by 2014 NEMA EIA regulations, as amended.

1.2. Details of Specialist

This specialist assessment has been undertaken by a team of specialist lead by Lorainmari den Boogert of Iggdrasil Scientific Services. Lorainmari den Boogert is registered with the South African Council for Natural and Scientific Professions (SACNASP), with Registration Number 400003/13 in the field of Ecology and Botany. The wetland assessment was conducted by Antoinette Bootsma and Rudi Bezuidenhoudt. Antoinette (Professional, 400222/09, Ecology and Botany) and Rudi (Professional, 500024/13, Botany) are registered with SACNASP. Andre Strydom conducted the field surveys for the aquatic zoology and is a SASS5 registered practitioner with the Department of Water and Sanitation (DWS). A summary of the specialist's team and the relevant input is provided in Table 1below. A curriculum vitae of the core team is included in Appendix A of this specialist assessment.

Table 1: Summary of the aquatic biodiversity team

Person	Highest Qualification	SACNASP or other information	Role
Lorainmari den Boogert	MSc. Geohydrology (UFS) MSc. Plant Science (UP)	Pr.Sci.Nat (400003/13) Botany and Ecology	Project Management Aquatic zoological reporting and overall report integration
Antoinette Bootsma	MSc. Environmental Science (UNISA)	Pr.Sci.Nat (400222/09) Botany and Ecology	Technical Review of wetland assessment
Rudi Bezuidenhoudt	BSc. Hons Botany (UNISA)	Pr.Sci.Nat (008867) Botany	Wetland fieldwork and reporting
Andre Strydom	B. Tech. Nature Conservation (UNISA)	SASS5 Accredited 2020	Aquatic Zoology field assessment and data input

In addition, a signed specialist statement of independence is included in Appendix B of this specialist assessment.

1.3. Terms of Reference

The terms of reference for the current study were as follows:

- Delineate the wetland and riparian areas to inform the placement of project infrastructure;
- Determine the aquatic macro invertebrate assemblages present within the proposed development footprint;
- Assess the habitat of the rivers/streams of the area in terms of habitat suitability for the relevant macro invertebrate assemblages;
- Classify the rivers or streams where possible with the use of the biological bands method as described by Dallas (2007);
- Classify the watercourse according to the system proposed in the national wetlands inventory if relevant;
- Compile a baseline description of the aquatic environment potentially impacted by the development as specified in GN320, March 2020;
- Undertake functional and integrity assessment of wetlands and riparian areas as specified in General Notice 267 of 24 March 2017;
- Undertake an impact assessment as specified in the NEMA 2014 regulations, as amended and GN320, March 2020;
- Undertake a Risk Assessment as specified in General Notice 267 of 24 March 2017;
- Recommend suitable buffer zones as specified in General Notice 267 of 24 March 2017, following Macfarlane et al., 2015; and
- Discuss appropriate mitigation and management procedures relevant to the conserving wetland areas on the site as specified in GN320, March 2020.

1.3.1. Scoping phase

The full terms of reference were covered in the Scoping phase.

1.3.2. EIA Phase

Any comments from the interested and affected parties will be reviewed and included in the EIA phase of the project.

2. Approach and Methodology

The wetland delineation method documented by the DWS in their document "Updated manual for identification and delineation of wetlands and riparian areas" (DWAF, 2008), as well as the Classification System for Wetlands and other Aquatic Ecosystems in South Africa. User Manual: Inland Systems (Ollis *et al.*, 2013) was followed throughout the field survey. These guidelines describe the use of indicators to determine the outer edge of the wetland and riparian areas such as soil and vegetation forms as well as the terrain unit indicator.

A handheld Garmin Montana 650 and/or a Samsung S10 smartphone was used to capture GPS co-ordinates in the field. 1:50 000 cadastral maps and available GIS data were used as reference material for the mapping of the preliminary watercourse boundaries. These were converted to digital image backdrops and delineation lines and boundaries were imposed accordingly after the field survey. Applications used on the smartphone includes GPX Viewer Pro and Google Earth.

Following a desktop assessment highlighting wetland areas to be groundtruthed in the field, soil and vegetation sampling on site informed a fine scale delineation. With regards to large study areas selective points are surveyed using fine scale techniques and extrapolation is used for the rest of the wetland sections and in some instances where survey was limited to external conditions extrapolation is also used for areas where surveys could not be conducted. Information is also drawn from previous work in the area, and any additional reports or information available Functional and integrity assessments were conducted to indicate the baseline status of the wetlands identified. In the current study the wetland area was assessed using, WET-Health (Macfarlane et al., 2020), EIS (DWAF, 1999) and WetEcoServices, (Kotze et al., 2006). The assessment of potential impacts follows the 2014 NEMA regulations (as amended). In order to ease the legibility of the report, details regarding the methods used in each phase of the wetland assessment are presented in Appendix A.

Aquatic biomonitoring is an integral component of ecological risk assessment, and is the science of determining the condition, or 'health' of an aquatic ecosystem by examining the organisms that live there, including their habitats, occurrence and composition. It is based on the principle that different aquatic organisms have different responses to stressors to their habitats, and that certain organisms will appear under conditions of stress, while others will disappear. Stressors include aspects such as increased or decreased flow (resulting from the abstraction of water, or the discharge of clean stormwater); changes in water quality (resulting from the discharge of stormwater or the introduction of contaminants through the discharge and disposal of effluents or seepage, and littering); bed and channel modification; changes in vegetation (resulting from the reduction of indigenous riparian plants and the presence of invasive alien plants and fauna).

A variety of aquatic organisms requires specific habitat types and habitat conditions for at least part of their life cycles. The availability and diversity of suitable habitats for aquatic biota will therefore determine the presence and species composition of the organisms living in the aquatic ecosystem. Habitat conditions for aquatic biota are influenced by drivers such as climate, geomorphology, and land use. The disturbance of the habitats of aquatic biota will result in stress to the aquatic population, which can affect the occurrence and species composition of the organisms living in the aquatic ecosystem (species response).
These relationships can be depicted as follows (adapted from Kleynhans and Louw, 2008) (Figure 1):

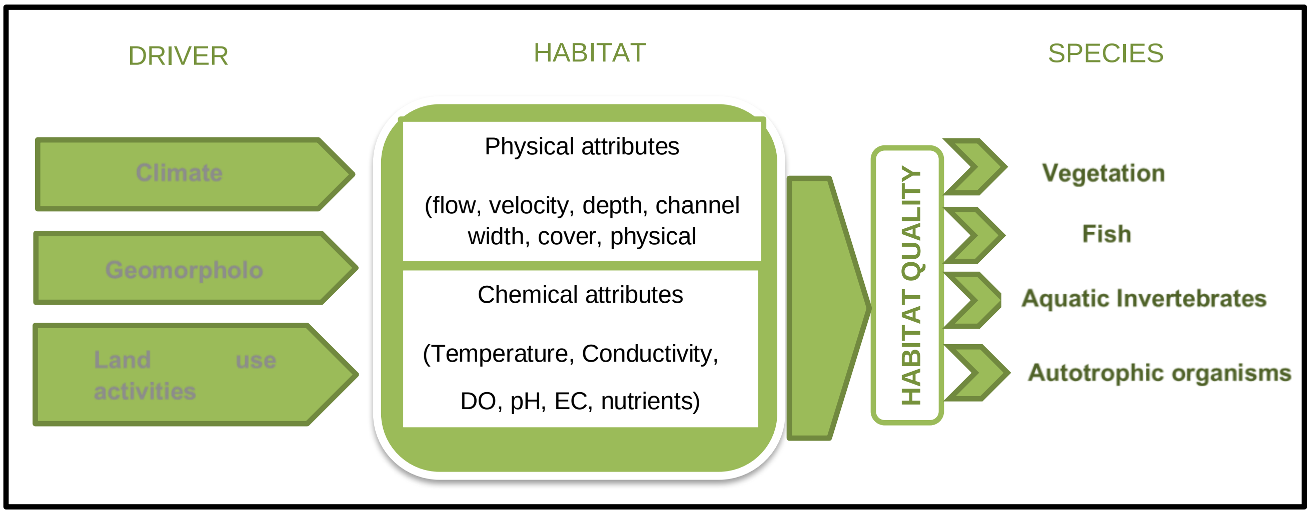


Figure 1: Relationships between ecosystem responses to drivers of change

Impacts on freshwater ecosystems can be measured by determining the presence or absence of certain indicator species of an aquatic ecosystem (riparian vegetation, fish, and invertebrates), and recording the species composition over time in order to determine changes in species composition, and to relate any observed changes to changes in the habitats of these species, taking cognisance of the drivers that influence the habitats in the first place. The occurrence and composition of species of flora and fauna in aquatic ecosystems therefore reflect both the present and history of the water resource at a particular site, allowing detection of disturbances that might otherwise be missed.

During a typical baseline survey at a specific location in an aquatic ecosystem, both the physical and chemical attributes of the aquatic habitat, as well as the species response of different types of aquatic biota, are therefore evaluated. Two aspects are of importance in this regard, namely the methods used for the evaluation of the physical and chemical attributes of the habitat, as well as for the determination of the species response of different types of aquatic biota at a specific survey site, and the selection of biomonitoring sampling points.

These aspects are discussed in more detail below.

Methods for Conducting aquatic zoological surveys

Because biological communities integrate the effects of physical and chemical changes to the environment in the long-term, different methods, typically based on assessment indices, are used as indicators of changes in habitat quality, as well as indicators of species responses (Ferreira and Graca, 2008).

The current methods used for the evaluation of the physical and chemical attributes of the habitat at a specific biomonitoring survey site can be summarised as follows:

- Evaluation of the physical attributes of the aquatic habitat: The physical attributes of the instream and riparian habitat has a direct influence on the occurrence and composition the aquatic community. Physical habitat features such as colour, anthropogenic disturbances and riparian vegetation, as well as stream hydrology, average width and depth are established by means of and evaluated with the Integrated Habitat Assessment System (IHAS). IHAS was developed in 1998 by McMillan, and version 2 is the currently used assessment index; and
- Evaluation of the chemical attributes of the aquatic habitat: Although available water quality monitoring data on variables such as pH, salinity (EC or TDS) and nutrients will give an indication of the influence of these variables on the aquatic ecosystem, variables such as Temperature, Dissolved Oxygen (DO), and Turbidity need to be determined in situ, as these variables cannot be established away from the survey site.

The standardised, quantitative and replicable methods currently used for the species response of the different aquatic organisms at a specific survey site can be summarised as follows:

- The South African Scoring System, version 5 (SASS5) is a rapid bioassessment method used to identify changes in species composition of aquatic invertebrates (e.g. snails, crabs, worms, insect larvae, mussels, beetles). As most invertebrate species are fairly short-lived and have limited migration patterns or are not free-moving during their aquatic life phase, they are good indicators of localised conditions in a river over the short term and can be used to assess site-specific impacts (Dickens and Graham, 2002).

- Vegetation is a readily observable expression of the ecology and relationships as well as a series of interactions between biotic organisms and their abiotic environment, and thus provide a physical representation of the health of an ecosystem. Healthy riparian vegetation zones maintain channel form and serve as filters for light, nutrients and sediment. Changes in the structure and function of riparian vegetation commonly result from changes in the flow regime of a river, flooding, exploitation for firewood, mining, or use of the riparian zone for grazing or ploughing. The Riparian Vegetation Response Assessment Index (VEGRAI) is a model developed by the DWS for the qualitative assessment of the response of riparian vegetation to impacts (Kleynhans et al., 2007). It must be noted that there is a distinct difference between a VEGRAI and the evaluation of vegetation as part of the IHAS, as the IHAS merely records vegetation as one of the physical attributes of the aquatic habitat, while VEGRAI evaluates and assigns a rating to indicate species composition and diversity. As vegetation can undergo rapid changes, for example due to flooding, veld fires or overgrazing, the VEGRAI-method will record such changes in species composition, which will not be determined by the IHAS method.

- Fish are good indicators of long-term (several years) effects and broad habitat conditions, and changes in the available habitat conditions (Karr, 1981). This is because fish are "top of the food chain," relatively long-lived and mostly highly mobile. Fish bio-accumulate the effects of anthropogenic activities on lower trophic levels; thus, fish assemblage structures are indicative of the integrated health of the aquatic ecosystem. Assemblages include a range of species that represent a variety of trophic levels (omnivores, herbivores, insectivores, planktivores, piscivores). The Fish Response Assessment Index (FRAI) is a rule-based model developed by the DWS based on the environmental intolerances and preferences of reference fish assemblages and the response of the species of the assemblage to particular groups of environmental determinants or drivers. Intolerance and preference attributes are categorized into metric groups with constituent metrics that relate to the environmental requirements and preferences of individual species. Changes in environmental conditions are related to fish stress and form the basis of ecological response interpretation. Reference conditions with regard to expected fish species and species compositions have been published for most of South Africa (Kleynhans, 2007).

- Acute (and short-chronic) toxicity testing is applied by exposing biota to water sources in order to determine the potential risk of such waters to the biota/biological integrity of the receiving water bodies. A risk category is determined based on the percentage of mortalities (or inhibition-stimulation) of the exposed biota. It is important to note that the hazard classification is based on the standardised battery of selected test biota and therefore represents the risk/hazard towards similar biota in the receiving aquatic environment. The toxicity hazard is therefore in terms of the aquatic biotic integrity and does in no way represent toxicology towards humans or other mammals.

- Diatom-based water quality indices have recently been evaluated and implemented in South Africa (Taylor, 2004; River Health Programme, 2005) for riverine ecosystems. De la Rey *et al.* (2004) and Taylor (2004) showed that diatom-based pollution indices may be good bio-indicators of water quality in aquatic ecosystems in South Africa by demonstrating 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 conclusions to be drawn about water quality. Diatoms can also indicate whether heavy metals are present in aquatic systems. According to Luís *et al.* (2008) several studies on metal polluted waters 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.

For the 2022 baseline aquatic assessment, the IHAS and the SASS5 methodologies were used to assess the biotic integrity of the study area. These were selected as due to budgetary constraints as well as the fact that the area is not situated in a National Freshwater Protected Area (NFEPA) and the desktop assessment did not indicate that a presence of sensitive fish taxa.

In order to ease the legibility of the report, details regarding the methods used in each phase of the watercourse assessment are presented in Appendix E.

Prior to the site visit the sampling points for the aquatic assessment were selected based on hydrology, the area of influence as well as current land use and site access. Two sets of data are required in order to interpret the results of biomonitoring surveys, namely data from a reference condition site, where habitat conditions are expected to be relatively undisturbed, and data from an affected condition site (or affected site), where the influences resulting from a land-use is expected to have created stressors in the habitats of the aquatic biota. For Mukondeleli however the site is situated in headwaters. Therefore, an upstream site is not available and all of the sites will be affected by the proposed Mukondeleli WEF.

A total of nine (9) sampling points were selected for the 2022 baseline aquatic assessment positioned upstream and downstream of the proposed WEF. Table 2 indicates the number, GPS coordinates, and a description of each of the sampling points. Locations of these sampling points are illustrated in Figure 2.

Table 2: Sampling points for the baseline aquatic assessment

Sampling Point	Latitude	Longitude	Site Description
MUB1	-26.630862°	29.215476°	Downstream affected site for the proposed WEF ▪ In the Boesmanspruit River
MUB2	-26.664621°	29.150269°	Downstream affected site for the proposed WEF ▪ In non-perennial tributary of the Boesmanspruit River
MUB3	-26.653076°	29.163548°	Downstream affected site for the proposed WEF ▪ In non-perennial tributary of the Boesmanspruit River
MUB4	-26.636274°	29.172226°	Downstream affected site for the proposed WEF ▪ In non-perennial tributary of the Boesmanspruit River
MUB5	-26.650356°	29.179276°	Downstream affected site for the proposed WEF ▪ In the Boesmansprruit River
MUB6	-26.674289°	29.148882°	Downstream affected site for the proposed WEF ▪ In the Boesmanspruit River
MUB7	-26.584721°	29.139135°	Downstream affected site for the proposed WEF ▪ In perennial tributary of the Grootbossiespruit River
MUB8	-26.597947°	29.179494°	Downstream affected site for the proposed WEF ▪ In perennial tributary of the Grootbossiespruit River
GRB1	-26.587170°	29.166208°	Downstream affected site for the proposed WEF ▪ In non-perennial tributary of the Grootbossiespruit River

The site visit was conducted in the week of the 1st to the 4th of February 2022 by the wetland specialist, Rudi Bezuidenhoudt. The aquatic specialist, Andre Strydom, conducted the site visits on the 6th of January 2022 but not all sites could be sampled due to access issues. An additional site visit was conducted on 4th of February 2022, but the aquatic ecosystems were in flood and hence the survey aborted. The final site visit was conducted on the 22nd of February 2022. The surveys were therefore conducted in the summer or high flow season. No dry season surveys were conducted as part of the assessment.

Impact assessment methodology used was supplied by the CSIR and is in Appendix D.

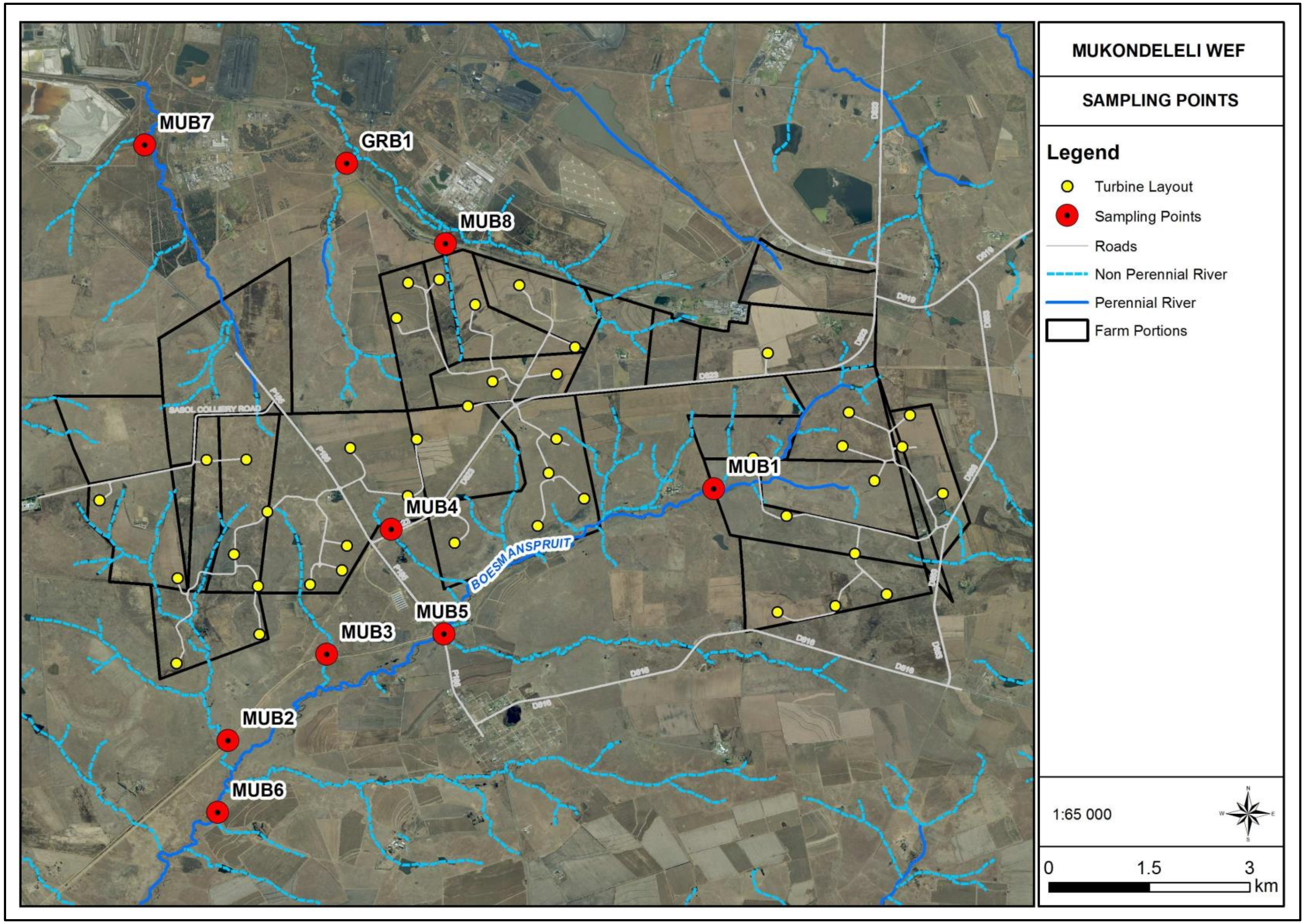


Figure 2: Aquatic sampling points for the baseline aquatic assessment of the proposed Mukondeleli WEF.

2.1. Information Sources

Table 3 below list the main maps and databases used during the desktop phase of this assessment. Literature used is referred to in the reference list.

Table 3: Summary of the main information sources used during the desktop assessment

Data / Information	Source	Date	Type	Description
Environmental Potential Atlas	DFFE	1997	Report & Spatial	Geology and soils data used for to inform the wetland assessment was obtained from the Environmental Potential Atlas
National List of Threatened Terrestrial Ecosystems for South Africa (2011)	National Environmental Management: Biodiversity Act: (G 34809, GN 1002)	2011	Report & Spatial	National list of ecosystems that are threatened and in need of protection,
National Freshwater Ecosystems Priority Areas	CSIR	2011	Report & Spatial	National Freshwater Priority Areas classified for South Africa
Present Ecological State, Ecological Importance & Ecological Sensitivity	Department of Water and Sanitation	2014	Report & Spatial	A Desktop Assessment of the Present Ecological State, Ecological Importance and Ecological Sensitivity per Sub Quaternary Reaches for Secondary Catchments in South Africa
Mpumalanga Biodiversity Sector Plan (MBSP)	Mpumalanga Tourism and Parks Agency	2014	Report & Spatial	MBSP is a spatial tool with land-use guidelines that forms part of a broader set of national biodiversity planning tools and initiatives that are provided for in national legislation and policies
Water Management Areas	National Water Act (G40279	2016	Report	Description of the nine water management areas of South Africa
National Strategic Water Source Areas	Water Research Commission	2017	Report & Spatial	National Strategic Water Source Areas (SWSAs) for surface water (SWSA-sw) and groundwater (SWSA-gw) that have

Data / Information	Source	Date	Type	Description
				been delineated as part of a Water Research Commission (WRC) project (K5/2431).
Vegetation Map of South Africa, Lesotho and Swaziland	South African National Biodiversity Institute	2018	Report and Spatial data	The third and latest update to the original 2006 Vegetation Map of South Africa, Lesotho and Swaziland
National Biodiversity Assessment (NBA)	South African National Biodiversity Institute	2018	Report and Spatial	Latest assessment of South African biodiversity and ecosystems, including, vegetation types, wetlands and rivers.
South African National Protected Areas Database (SAPAD)	Department of Forestry Fisheries and the Environment	2020, Q2	Spatial	Spatial delineation of protected areas in South Africa. Updated quarterly
National EIA Screening Tool	Department of Forestry Fisheries and the Environment	2022, Q1	Spatial	Spatial database depicting aquatic biodiversity of the country as high or low sensitivity areas

2.2. Assumptions, Knowledge Gaps and Limitations

- The information provided by the client forms the basis of the planning and layouts discussed.
- All watercourses within 500 m of any developmental activities should be identified as per the DWS authorization regulations. In order to meet the timeframes and budget constraints for the project, watercourses within the study sites were delineated on a fine scale based on detailed soil and vegetation sampling. Watercourses that fall outside of the site, but that fall within 100 m of the proposed activities were delineated based on desktop analysis of vegetation gradients visible from aerial imagery.
- For the aquatic zoological site visit conducted on the 3rd to the 7th of January 2022, site access was an issue and not all sites could be visited. Access was arranged to sites situated within the Sasol boundary and the sites were revisited on the 3rd and 5th of February 2022, during this site visit water levels were too high and flood conditions were observed. The site visit was re-scheduled and conducted on the 22nd to the 24th of February 2022.
- This report as well as impact assessment methodology was provided to the specialist by the CSIR as per contractual agreement.
- The detailed field visit for the wetland specialist was conducted from a once off field trip and thus would not depict any seasonal variation in the wetland plant species composition and richness.
- In order to obtain a comprehensive understanding of the dynamics of the aquatic ecosystem in an area, ecological assessments should always consider investigations at different time scales (across seasons/years) and through replication, as river systems are in constant change.
- As aquatic systems are directly linked to the frequency and quantity of rain it will influence the systems drastically. If studies are done during dry months or dry seasons, the accuracy of the report's findings could be affected.

- Description of the depth of the regional water table and geohydrological and hydropedological processes falls outside the scope of the current assessment
- Floodline calculations fall outside the scope of the current assessment.
- A Red Data scan, fauna and flora, and aquatic assessments were not included in the current study
- Species composition described for landscape units aimed at depicting characteristic species and did not include a survey for cryptic or rare species.
- The recreation grade GPS used for wetland and riparian delineations is accurate to within five meters.
- Watercourses delineation plotted digitally may be offset by at least five meters to either side. Furthermore, it is important to note that, during the course of converting spatial data to final drawings, several steps in the process may affect the accuracy of areas delineated in the current report. It is therefore suggested that the no-go areas identified in the current report be pegged in the field in collaboration with the surveyor for precise boundaries. The scale at which maps and drawings are presented in the current report may become distorted should they be reproduced by for example photocopying and printing.
- The calculation of buffer zones does not take into account climate change or future changes to watercourses resulting from increasing catchment transformation.
- No Mitigation Hierarchy or alternative layouts were discussed since this information was not available at the time of the assessment. This constitutes an important limitation to the study and should be included in an updated version of the assessment in order to provide a 'big picture 'view of the project.
- Findings, recommendations and conclusions provided in this report are based on the authors' best scientific and professional knowledge and information available at the time of compilation. The methods used for biomonitoring often require the author to make a predicted estimation based on prior knowledge and learning. These are however the methods as requested by the client and also accepted methods in the field of aquatic ecology.
- Sampling by its nature means that the entire study area cannot be assessed. In this case, the entirety of the study site could not be assessed due to time constraints and access restrictions. Therefore, the assessment findings are only applicable to the areas sampled and extrapolated to the rest of the study site.
- Due to the large extent of the study site several areas did not have access, and extrapolation was used here it is advised that additional studies be conducted during the installation phase and the footprint of each wind turbine is assessed and possibly moved if need be.
- Several changes were made to the initial layout and these areas were thus not assessed during the field work extrapolation was thus used here again.

2.3. Consultation Processes Undertaken

The environmental department of Sasol Secunda Operations were consulted for historic reports related to biomonitoring as well as wetland delineation.

3. Description of Project Aspects relevant to the Aquatic Biodiversity Assessment

The following information regarding the proposed development was received by ENERTRAG South Africa (Pty) Ltd (hereinafter referred to as "ENERTRAG") and is copied here verbatim:

Mukondeleli Wind RF (Pty) Ltd is proposing to develop the Mukondeleli Wind Energy Facility (WEF), with a maximum capacity of up to 200 MW, located in the Govan Mbeki Municipality in the Mpumalanga Province of South Africa. The proposed WEF and associated infrastructure are subject to a full Scoping and EIA process in terms of the 2014 NEMA EIA Regulations, as amended.

The proposed Mukondeleli WEF and associated infrastructure include the following components:

- Up to 54 wind turbine generators (WTGs) with a maximum capacity of up to 200 MW.

- Turbines with a hub height of up to 200m and a rotor diameter of up to 200 m.
- Hardstand areas of approximately 1 500m^2 per turbine.
- Temporary construction laydown and storage area of approximately 4 500m^2 per turbine.
- Medium voltage cabling connecting the turbines will be laid underground.
- A Battery Energy Storage System (BESS) comprising of several utility scale battery modules within shipping containers or an applicable housing structure on a concrete foundation. Lithium-Ion Phosphate, Lithium Nickel Manganese Cobalt oxides or Vanadium Redox flow technologies will be considered as the preferred battery technology, however, the specific technology will only be determined following EPC procurement
- Internal roads with a width of up to 10 m providing access to each turbine, the BESS, on-site substation (SS), step-down SS and laydown area. The roads will accommodate cable trenches and stormwater channels (as required) and will include turning circle/bypass areas of up to 20 m at some sections during the construction phase. As such, the roads and cables will be positioned within a 20 m wide corridor. Existing roads will be upgraded wherever possible, although new roads will be constructed where necessary.
- A temporary construction laydown/staging area of approximately 4.5 hectares (ha) which will also accommodate the operation and maintenance (O&M) buildings.
- A 33/132kV on-site SS to feed electricity generated by the proposed Mukondeleli WEF into the step-down substation at the Sasol facility. The on-site SS will accommodate 1 x 132 kV incoming feeder bay, 1x 132 kV outgoing feeder bay and a motorised isolator with protection and metering

In addition to the wind turbines to be installed on the project site, the proposed development also comprises a 132 kV overhead power line and a step-down SS to feed the electricity generated by the project into the proposed Green Hydrogen Electrolyser facility located at Sasol Secunda which is between 5 and 10 km from the on-site SS. The 132 kV power line and step-down SS at Sasol is subject to a separate Basic Assessment Application to be undertaken by the applicant.

The key technical details for the Mukondeleli WEF is tabulated below:

Component	**Description / Dimensions**
Site coordinates (centre point)	Lat 26°37'34.04"S; Long 29°10'24.53"E
Affected farm portion/s	*Bosjesspruit 291 (Portions 2, 6, 8, 9, 10, 11, 12, 13 and 14)* *Brandwacht 316 (Portions 2, 3, 4, 5 and 13)* *Knoppies 314 (Portion 0)* *Knoppiesfontein 313 (Portion 9)* *Tweefontein 321 (Portion 5)* *Van Tondershoek (Portions 1, 2, 5, 7, 8, 11 & 12)*
Application site area	Approximately 3600 ha
Total project footprint area (including the internal roads, but excluding access roads leading to the site)	To be determined during dEIA prior to phase
Total WEF capacity	Up to 300 MW
BESS capacity	Up to 200 MW/800 MWh
BESS technology	Lithium-Ion Phosphate, Lithium Nickel Manganese Cobalt oxides or Vanadium Redox flow technologies will be considered as the preferred battery technology, however, the specific technology will only be determined following EPC procurement.
Proposed technology	Wind turbines and associated infrastructure, including a BESS
Number of turbines	Up to 54 turbines
Turbine hub height from ground	Up to 200 m
Turbine rotor diameter	Up to 200 m
Turbine blade length	Up to 100 m
Height of BESS	Approximately 5-10 m
Height of the on-site Substation	Approximately 7 – 10 m Up to 22 m (including lighting)
On-site SS and BESS complex area	Approximately 4 ha
Construction laydown area	Approximately 3 ha

Component	Description / Dimensions
Concrete tower manufacturing	Part of the construction laydown area. The applicability of a concrete tower manufacturing facility will only be confirmed following EPC procurement.
Temporary laydown area	Approximately 2haTo be determined based on the final layout
O&M building area	Part of the construction laydown area
Turbine hardstand area	Approximately 1 500 m² per turbine
Width of internal access roads	Up to 10 m, including turning circle/bypass areas of up to 20 m. The roads and cables will be positioned within a 20 m wide corridor.
Length of internal access roads	To be determined based on the final layout
Site access	R546
Grid connection and proximity	Connection to step-down substation (to be built at Sasol facility) Approximately 17 km
Height of substation fencing	Up to 3 m high
Type of fencing	Galvanized steel / nonelectric diamond mesh (clearVu)

Port of entry for the wind turbines
The wind turbines are to be shipped to the Durban or Richards Bay port, both ports are approximately 500 km away from the site.

Construction timeframe
The anticipated timeframe is a minimum of 36 months.

Services to be accommodated on site
Below are the list of services, facilities and manpower required during construction:

- Changing rooms;
- Sanitary facilities (hand washing basins, toilets, showers);
- Potable water facilities;
- Canteen or similar space with adequate ventilation and cooling for personnel to have breaks lunch;
- Sewage and wastewater facility;
- Emergency room equipped for first aid;
- Site manager's office equipped with printer, scanner, Wi-Fi connection, HVAC system;
- Security office with surveillance monitors, suitable data and phone connection and HVAC system;
- Septic tank;
- Wheel washing facilities at the entrance of the site for trucks and cars;
- Storage container for minor parts;
- Car parks;
- Loading / unloading and storage area; and
- Security facilities.

4. Baseline Environmental Description

In this section the baseline environment will firstly be described based on the desktop assessment conducted prior to the site visit as well as the project specific description which is based on the findings of the field assessments conducted by the wetland and aquatic specialist.

The proposed WEF is located in the Govan Mbeki Municipality, near the town of Secunda, in the Mpumalanga Province of South Africa. The project area covers 21 property portions. The details of the properties associated with the proposed Mukondeleli WEF, including the 21-digit Surveyor General (SG) codes for the cadastral land parcels are outlined in the table below (Table 4):

Table 4: Proposed properties.

Portion Number	Farm Number	Farm Names	21 Digit Surveyor General Code of each cadastral land parcel
0	314	Knoppies	T0IS00000000031400000
1	317	van Tondershoek	T0IS00000000031700001
2	317	van Tondershoek	T0IS00000000031700002
2	316	Brandwacht	T0IS00000000031600002
2	291	Bosjesspruit	T0IS00000000029100002
3	316	Brandwacht	T0IS00000000031600003
4	316	Brandwacht	T0IS00000000031600004
5	321	Tweefontein	T0IS00000000032100005
6	291	Bosjesspruit	T0IS00000000029100006
7	317	van Tondershoek	T0IS00000000031700007
8	317	van Tondershoek	T0IS00000000031700008
8	291	Bosjesspruit	T0IS00000000029100008
9	313	Knoppiesfontein	T0IS00000000031300009
9	291	Bosjesspruit	T0IS00000000029100009
10	291	Bosjesspruit	T0IS00000000029100010
11	291	Bosjesspruit	T0IS00000000029100011
11	317	van Tondershoek	T0IS00000000031700011
12	291	Bosjesspruit	T0IS00000000029100012
12	317	van Tondershoek	T0IS00000000031700012
13	316	Brandwacht	T0IS00000000031600013
13	291	Bosjesspruit	T0IS00000000029100013
14	291	Bosjesspruit	T0IS00000000029100014

The approximate central coordinates are Lat 26°37'39.49"S; Long 29°11'23.94"E(Figure 3).

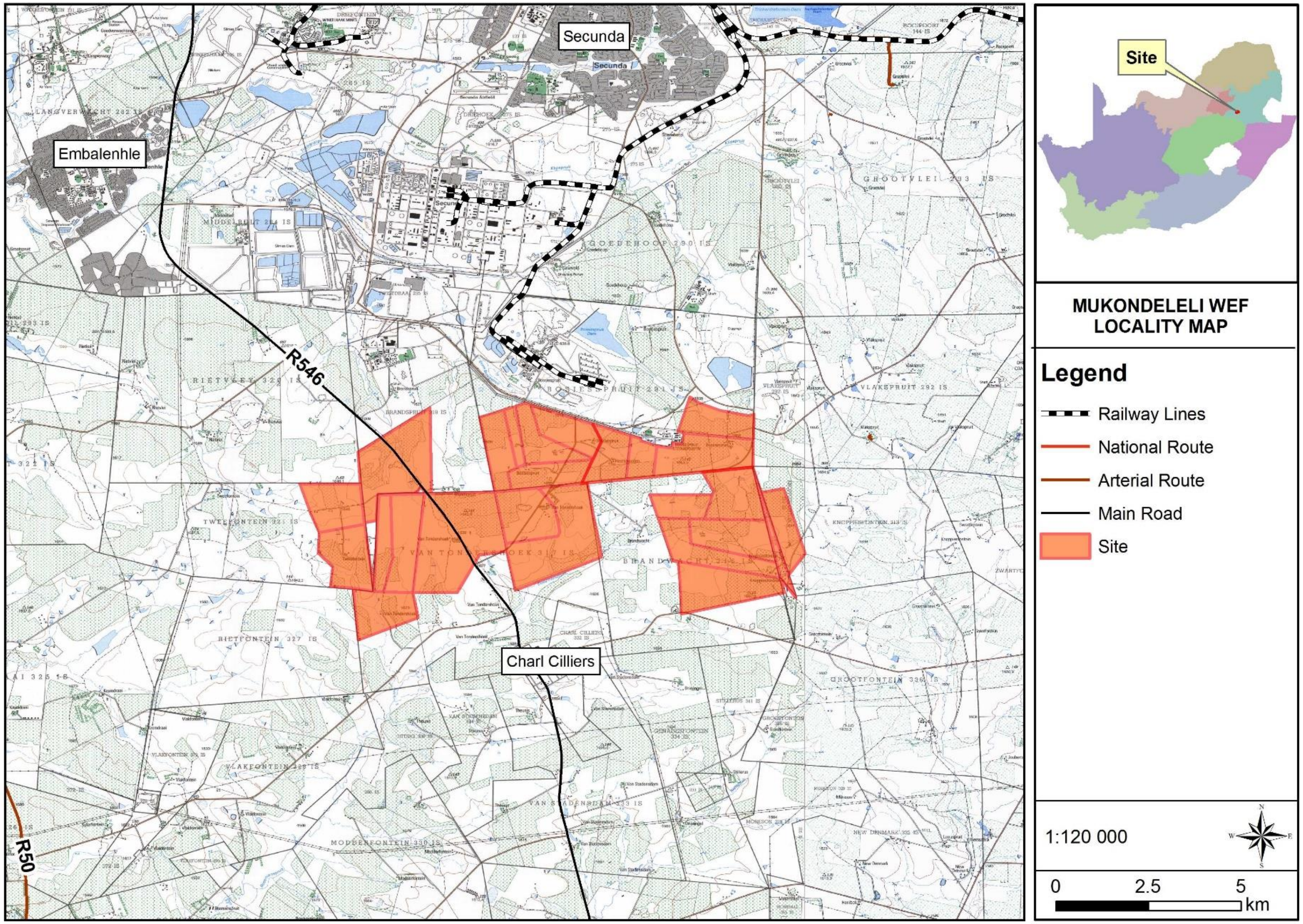


Figure 3: Locality Map of the proposed Mulondeleli WEF

4.1. General Description

A review of available literature and spatial data formed the basis of a characterisation of the biophysical environment Table 5 below provides a summary of the important aspects.

Table 5: Summary of the desktop analysis of the study site

Level of significance	Information or Source	Significance specific to the study site	Figure and Reference
International	RAMSAR	No World Heritage sites within 50km of site. The Blesbokspruit RAMSAR wetlands are approximately 100 km west of site.	(Ramsar)
National	Protected Areas	There are no protected areas in close proximity to the study site.	(South African Protected Areas Database)
	Threatened Ecosystems	The study site is situated within the Soweto Highveld Grassland which is Vulnerable.	(RSA, 2011)
	Water Management Area	Vaal and C11K, C12D, C12E and C12F quaternary catchment	(Figure 4, DWS)
	National Freshwater Priority Areas	The study site is situated within an upstream FEPA. Upstream FEPA's are areas in which human activities need to be managed to prevent damage to downstream FEPA's. The Boesmanspruit and associated wetlands that drain into the Boesmanspruit River are all classified as NFEPA Wetlands.	(Nel et al., 2011)
	Strategic Water Resources Areas	Strategic Water Source Areas (SWSAs) surface and ground water areas have been identified for South Africa. Strategic Water areas. Strategic water areas are defined as follows: "Surface water SWSAs (SWSA-sw): Areas of land that supply a disproportionate (i.e. relatively large) quantity of mean annual surface water runoff in relation to their size. Groundwater SWSAs(SWSA-gw): Are areas which combine areas with high groundwater availability as well as where this groundwater forms a nationally important resource". (Le Maitre, 2018)	(Figure 5, Le Maitre, 2018)

Level of significance	Information or Source	Significance specific to the study site	Figure and Reference
		The study site is not within a SWSA. Two of the Upper Vaal SWSA-sw are situated to the north west and to the south east.	
	Vegetation	The study site overlays the Soweto Highveld Grassland (Gm8). Gently to moderately undulating landscape on the Highveld plateau supporting short to medium-high, dense, tufted grassland dominated almost entirely by *Themeda triandra* and accompanied by a variety of other grasses such as *Elionurus muticus*, *Eragrostis racemosa, Heteropogon contortus and Tristachya leucothrix.* In places not disturbed, only scattered small wetlands, narrow stream alluvia, pans and occasional ridges or rocky outcrops interrupt the continuous grassland cover.	(Mucina & Rutherford 2006, SANBI 2006-)
	National Biodiversity Assessment (NBA) 2018	Critically Endangered, Endangered and Vulnerable ecosystems are collectively referred to as threatened ecosystems and may be listed as such in terms of the Biodiversity Act. In terms of rivers the Boesmanspruit River has a Present Ecological State (PES) of C-F indicating they are largely natural to critically modified. The majority of the Boesmanspruit River have a PES of C therefore it is expected that IT will be moderately modified. The Ecosystem Threat Status (ETS) is Critically Endangered, and the Ecosystem Protection Level (EPL) of the Boesmanspruit River is poorly protected. The Grootbossiespruit River has a PES of E/F indicating it is seriously to critically modified. ETS of Endangered and the EPL is poorly protected The wetlands in and around the study site have been classified as Mesic Highveld Grassland Group 3 wetlands	(Figure 6, Skowno *et al.,* 2018, Van Deventer, *et al., 2019)*
	PES 2014	The Present Ecological State (PES), Ecological Importance (EI) and Ecological Sensitivity (ES) was determined per Sub Quaternary Reaches (SQR) for Secondary Catchments in South Africa. The SQRs within close proximity to the site are as follows: SQR 1657(PES=E), (EI=Low), (ES=Moderate) SQR 1713(PES=D), (EI=Low), (ES=Moderate) SQR 1712(PES=C), (EI=High), (ES=High)) SQR 1709(PES=B), (EI=High), (ES=High) A PES of a B indicates the reach is largely natural, C indicates the reach is moderately modified, D indicates the reach is largely modified and a PES of E indicates that the reach is seriously modified.	(DWS, 2014).

Level of significance	Information or Source	Significance specific to the study site	Figure and Reference
Provincial	Mpumalanga Biodiversity Sector Plan (MBSP)	In 2014, the Mpumalanga Parks and Tourism Agency developed the MBSP. In essence the MBSP is a map guiding areas of conservation concern for the Mpumalanga Province. Two maps have been developed, namely one for terrestrial biodiversity, and the other for freshwater biodiversity. The MBSP maps the freshwater ecosystems of Mpumalanga into the following categories: • Critical Biodiversity Areas (CBAs) – areas of high biodiversity value, needed to meet biodiversity targets. These areas should be maintained in natural or near natural state; • Ecological Support Areas – these areas support CBAs, but are not essential for meeting conservation targets; • Other Natural Areas – these areas have natural characteristics but have not been earmarked as priority areas for conservation but perform a range of biological as well as ecological functions; • Heavily Modified Areas – Areas that have been impacted and have had a significant or complete loss of natural habitat and ecological function. In terms of the terrestrial MBSP the majority of the proposed site is classified as CBA irreplaceable and CBA optimal. Other categories include heavily modified, moderately modified, ESA landscape corridors. In terms of the freshwater assessment of the MBSP, the site includes mostly other natural areas and heavily modified areas. The site does contain an ESA and there is a small CBA present to the south of the center of the site.	(Figure 7, Figure 8, Lötter *et al.,* 2014))

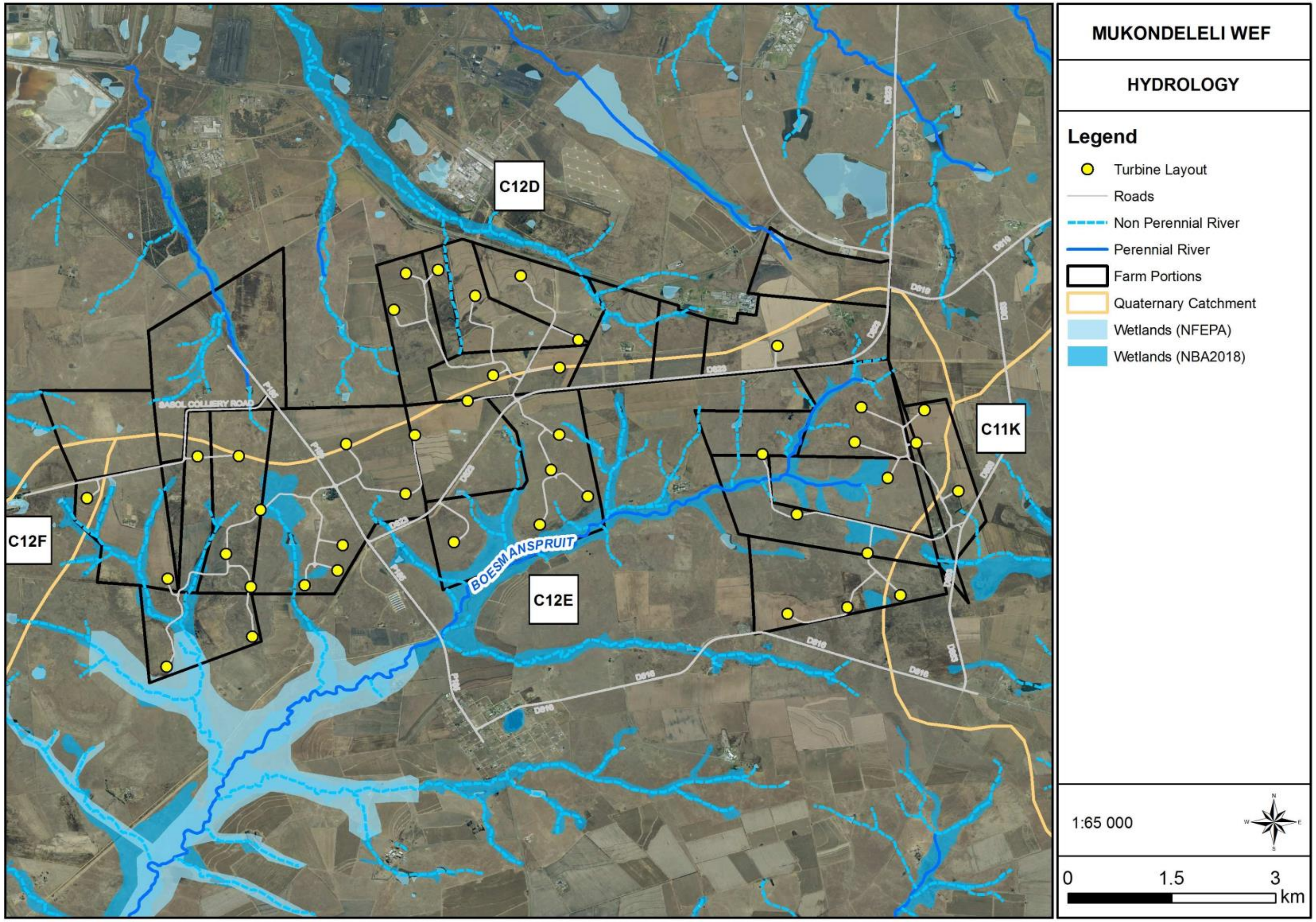


Figure 4: **Hydrology of the study site and surrounds as per existing spatial layers**

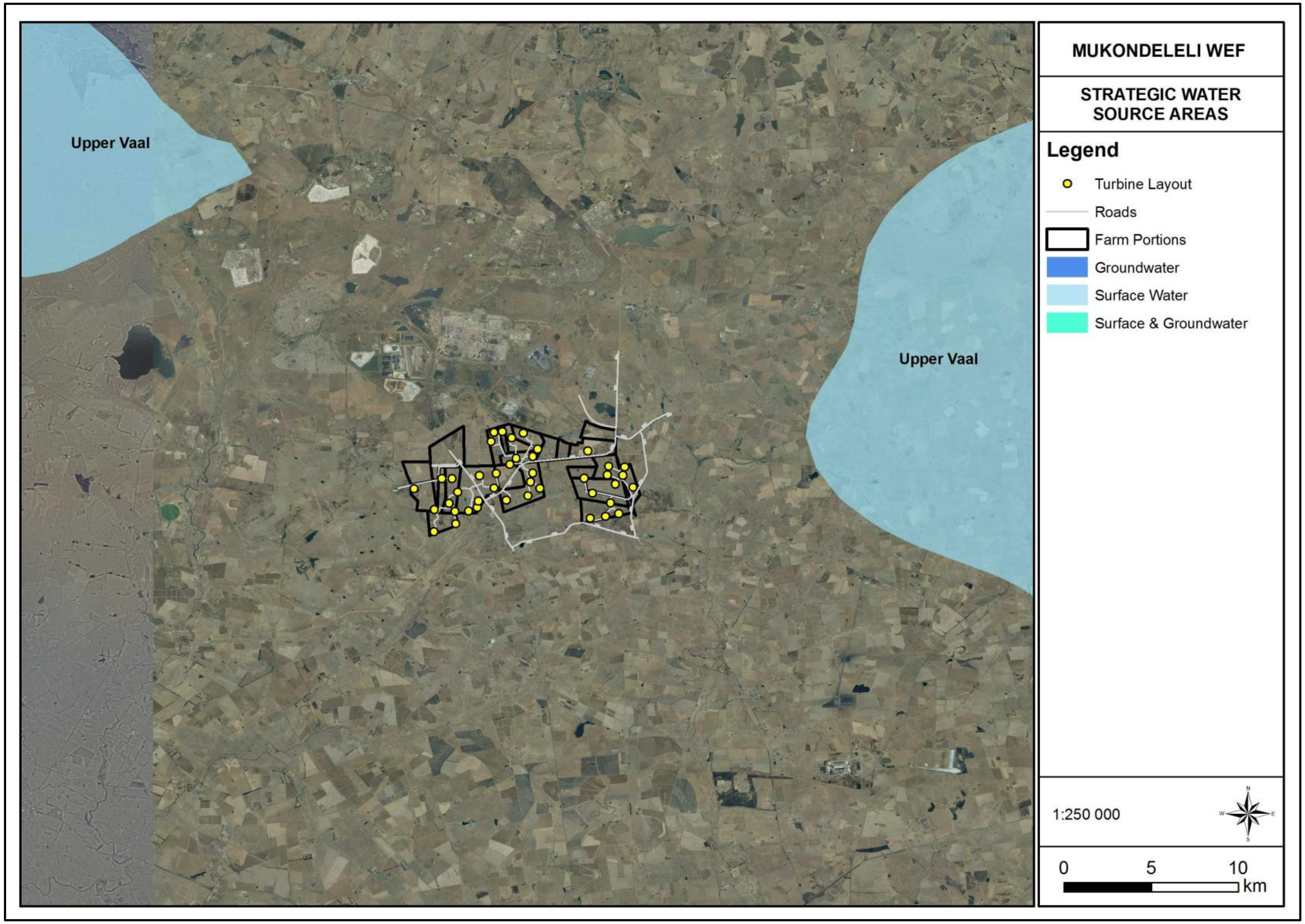


Figure 5: Locality of Strategic Water Source Areas relevant to the study site

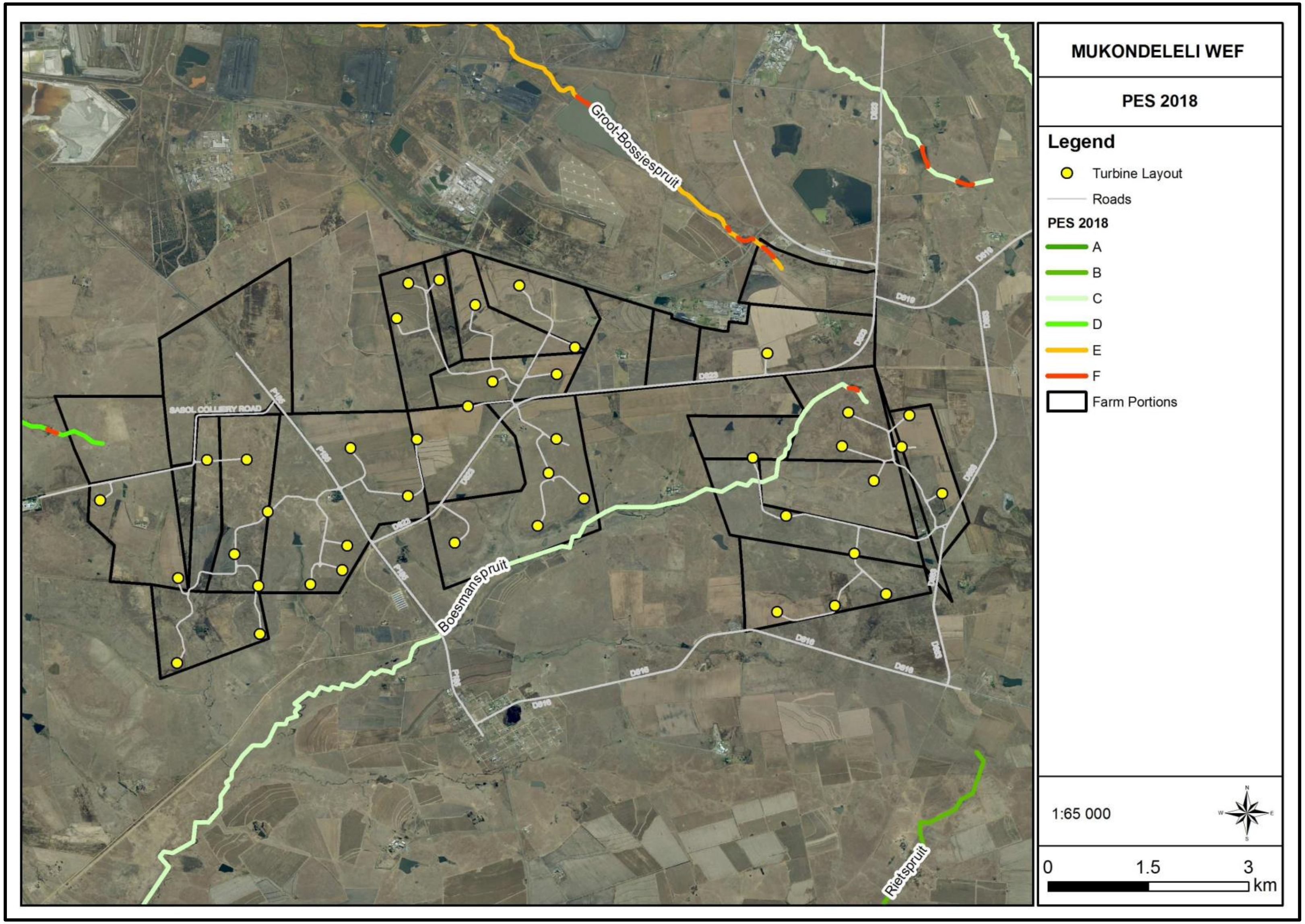


Figure 6: Present Ecological state of the rivers and streams surrounding the study site based on the 2018 National Biodiversity Assessment

\

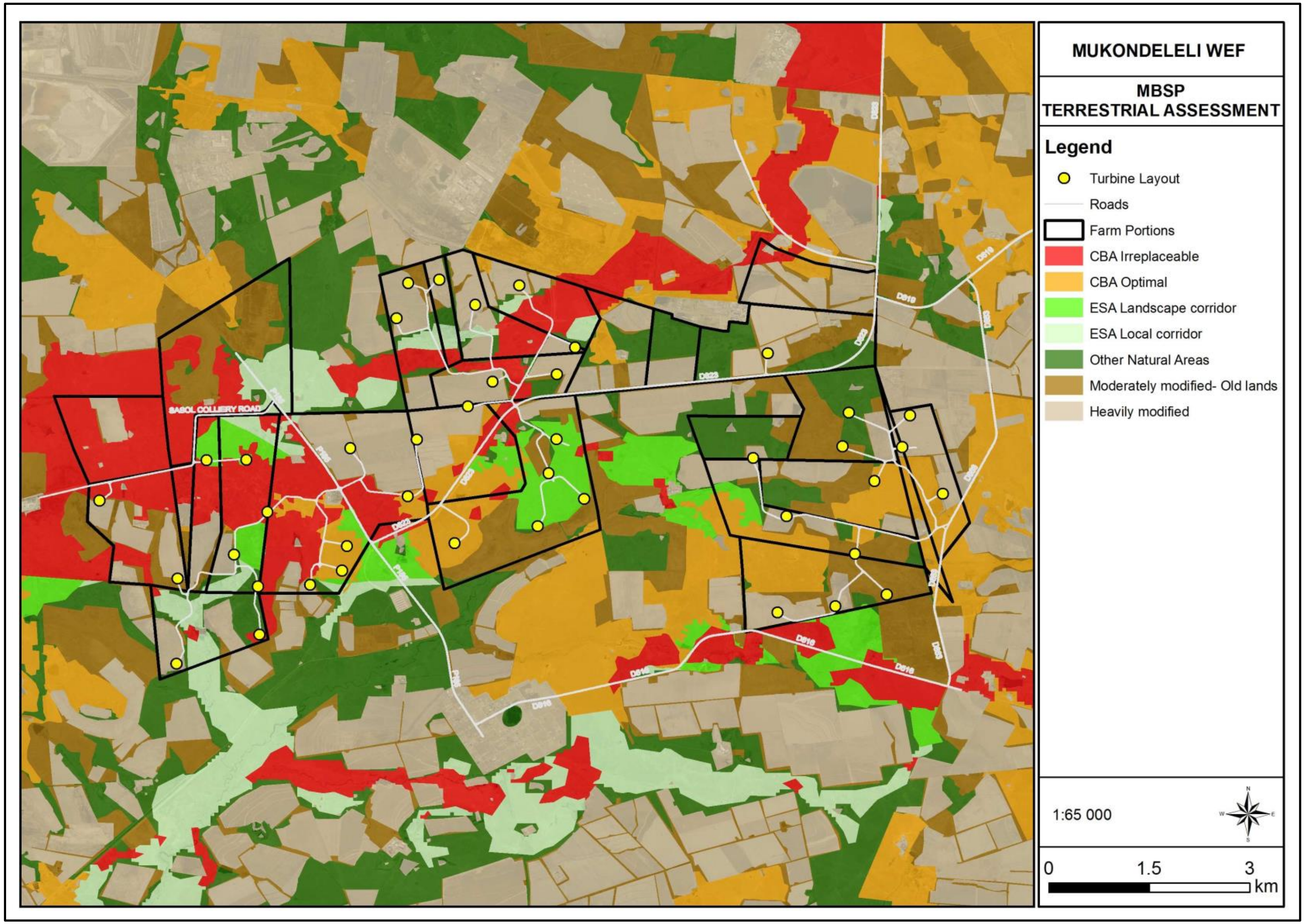


Figure 7: The proposed Mukondeleli WEF site in relation to the MBSP terrestrial

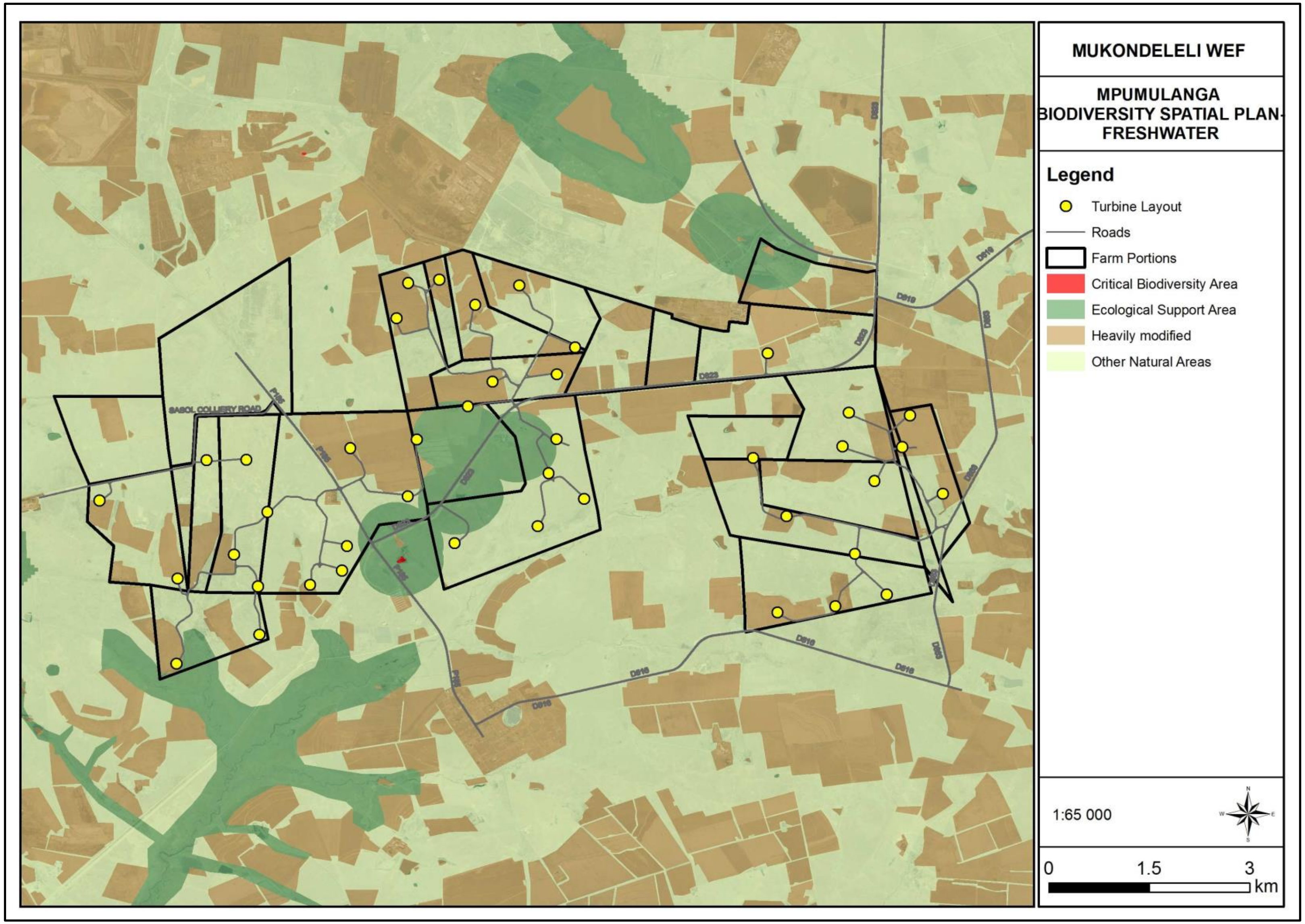


Figure 8: **The proposed Mukondeleli WEF site in relation to the MBSP aquatic**

In addition to the relevant international, national and provincial conservation importance of the aquatic ecosystems which could potentially be affected by the proposed development the following abiotic aspects are relevant to the study site (Table 5).

Table 6: A summary of abiotic aspects which informed the report

Abiotic Feature	Description	Figure and or reference
Climate	Summer-rainfall region (MAP 662 mm). Cool-temperate climate with thermic continentality (high extremes between maximum summer and minimum winter temperatures, frequent occurrence of frost, large thermic diurnal differences (	Mucina & Rutherford, 2006
Geology	The study site is underlain by Arenite and Dolorite	Figure 9, ENPAT
Soil	The majority of the study site is underlain by the soil/land type Ea17 - One or more of: vertic, melanic, red structured diagnostic horizons, undifferentiated. The northernmost section is underlain by the soil/land type Ea20 which has the same characteristics as the aforementioned soil/land type.	ENPAT
Hydrology and Drainage	Several wetlands and rivers are located on the study site and all drain into the Boesmanspruit River in the middle of the study site.	Figure 4

In addition to the abiotic aspects as well as conservation significance of the site historical imagery dating back to 1955 was consulted.

Historical imagery of the study site indicates that large sections of the study area was historically and currently impacted by farming including agriculture and grazing (
Figure 10, Figure 11). The total area of the study area is 3588 ha. Significantly, the current cultivated lands amount to 861.84 ha, while the historical cultivated lands (not currently cultivated) amount to 464,47 ha. This amounts to 37 of the study site being impacted by some degree. The current cultivated lands are heavily degraded and would be ideal for a development such as Wind Energy Turbines while the historically cultivated lands are slightly improved from an ecological point of view, it remains impacted and may also be ideal for Wind Energy Turbines compared to any of the other less impacted sections of the study site. From a watercourse point of view, it should be noted that a large proportion of these current and historical cultivated lands borders on watercourse areas, and therefore impacts on the functionality of these wetlands and rivers.

Additionally, very few man made impoundments could be seen on historical maps, while the current impoundments total 15 on the study area alone and does not include a significantly larger number in the catchment of the watercourses. Several current and historical diggings were also noted.

Figure 9: Geology of the proposed Mukondeleli WEF site and proposed activities

Figure 10: Historical image of 1955 indicating prolonged farming activities on the study site, the majority of these farm plots have been discontinued.

Figure 11: Historical image of 1955 indicating prolonged farming activities on the study site, the majority of these farm plots are still in operation.

4.2. Project Specific Description

This section describes the baseline aquatic environment surrounding the Mukondeleli Wind Energy Facility and associated study areas based on the fieldwork conducted.

4.2.1. Watercourse classification and delineation

A large number of wetlands were recorded on the study site. The wetlands were divided into several types including:

- Seepage wetlands;
- Valley Bottom Wetlands; and
- Depressional Pan wetlands.

The wetlands fall into three distinct catchment areas, with wetland 1-8, located in catchment C12E and all draining into Boesmanspruit System. Furthermore, wetland 7 forms the headwaters of the Boesmanspruit System. Wetland 9 and 10 are located in the catchment C11K and drains into the Leeuspruit System. Lastly the remaining wetlands (Wetland 11-19) all drain into the Grootspruit System. Wetland 20 and 21 are also located in catchment C12E but are hydrologically isolated as pan wetlands that drain inward and does not flow into any nearby wetland system.

Buffer zones were calculated for the wetlands following Macfarlane *et al.,* (2015):

1. Combination of Seepage and Valley Bottom Wetlands – 61 m
2. Unchannelled Valley Bottom – 35 m
3. Seepage – 35m
4. Combination of Seepage and Valley Bottom Wetlands – 79m
5. Seepage – 35m
6. Seepage – 35m
7. Combination of Seepage and Valley Bottom Wetlands – 79m
8. Valley Bottom – 15m
9. Seepage – 35m
10. Seepage - 35m
11. Seepage – 15 m
12. Combination of Seepage and Valley Bottom Wetlands – 61 m
13. Seepage – 15 m
14. Combination of Seepage and Valley Bottom Wetlands – 61 m
15. Combination of Seepage and Valley Bottom Wetlands – 61 m
16. Seepage – 35m
17. Valley Bottom – 61m
18. Seepage – 15 m
19. Seepage – 15 m
20. Depressional Pan - 15m
21. Depressional Pan - 15m

Figure 12 shows the delineated watercourses relative to the study areas together with buffer zones and the 500m DWS regulated area. Sections 4.2.1 to 4.2.4 discuss the wetlands briefly.

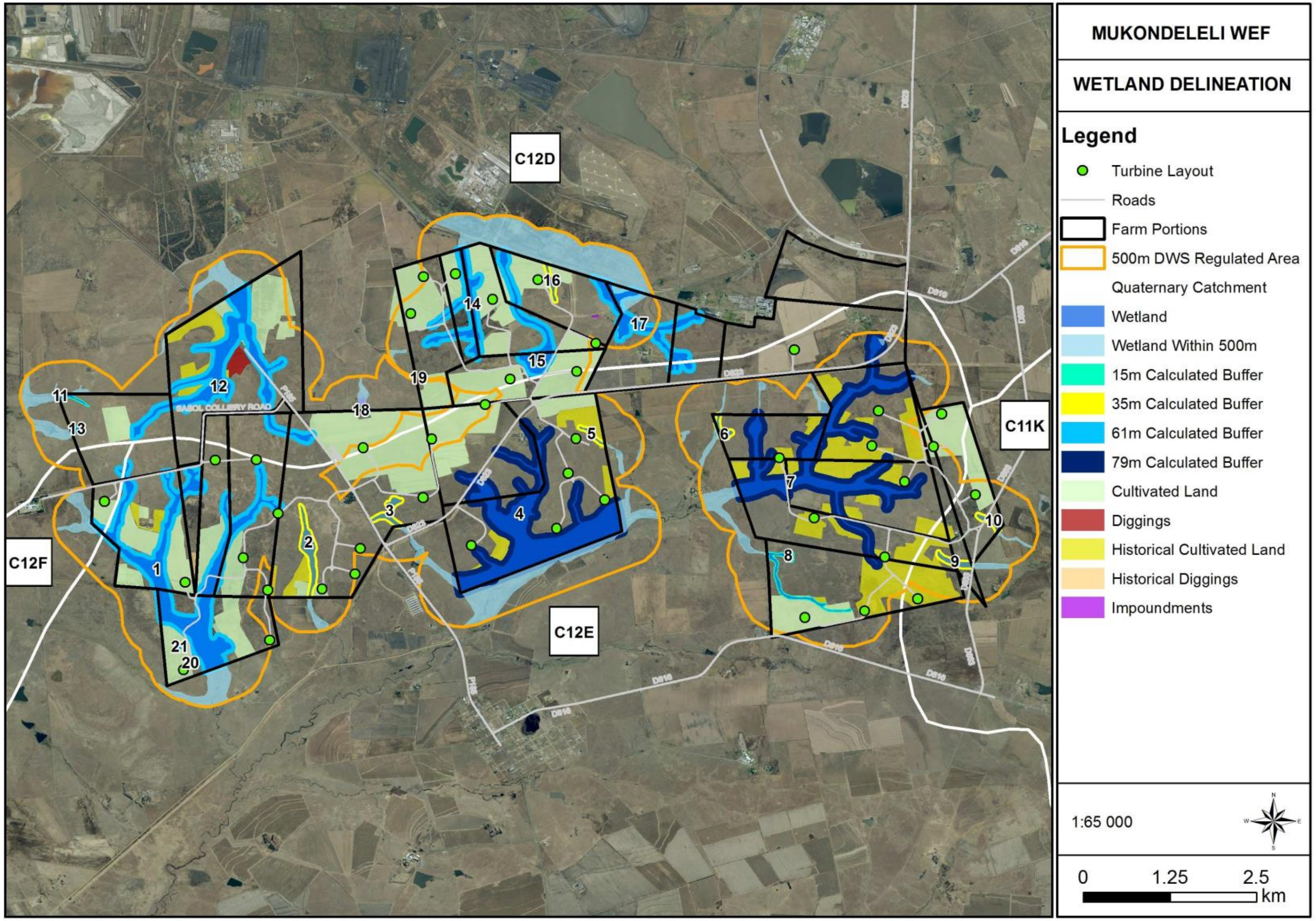


Figure 12: Delineated watercourses together with their calculated buffer zones and the 500 m DWS regulated area

4.2.2. Watercourse Composition

It should be noted that the study occurred during a particularly high rainfall season and the vegetation growth was robust and similar in composition in the wetlands with few exceptions. Due to the high rainfall a few hydrophytic wetland species occurred in areas with poor drainage and prolonged saturation (such as roadsides and small depressions) that would not normally sustain wetland species. The soil of the study areas was characterised by dark clay soils which also may form temporary wet areas during high rainfall events.

Many of the wetlands were fragmented and/or encroached by current and historical agricultural lands. In the case of active agricultural fields where aerial images indicate potential wetness signature, the vegetation and soil was completely transformed and impacted and wetland species were not recorded here, although hydrologically the shallow flow of water in the soil is still a potentially important feature. The wetlands all occur on the same vegetation type known as Soweto Highveld Grassland (Mucina & Rutherford 2006), as well as previously being classified as Moist Clay Highveld Grassland (Low & Rebelo, 1996) and although individual wetlands had some degree of unique vegetation growth, the dominant species were similar in composition. As previously mentioned, the agriculture and grazing, as well as many other recorded impacts affects the plant species composition and increases Alien Invasive Species (AIS) recorded at and near these impacts.

The wetland areas were generally devoid of woody species and where they were recorded dominant species were predominantly AIS such as *Eucalyptus spp., Acacia mearnsii, Populus canescens and Salix babylonica.*

The wetlands were characterized by medium species richness with many species recorded with only two potential species of concern recorded*: Crinum bulbispermum, Hypoxis hemerocallidea.* It should also be noted that several plant species of conservation concern including *Kniphofia typhoides, Boophone disticha and Eucomis autumnalis.* are known to occur in the area.

The dominant grasses and sedges recorded include: *Aristida congesta, Cynodon dactylon, Cyperus sexangularis, Cyperus congestus, Cyperus esculentus, Cyperus haematocephalus, Cyperus laevigatus, Cyperus longus,* var. *longus, Cyperus fastigiatus, Harpochloa falx, Imperata cylindrica , Digitaria eriantha, Eragrostis curvula, Eragrostis gummiflua, Eragrostis plana, Eragrostis racemose, Hyparrhenia hirta, Kyllinga erecta Paspalum urvillei, Paspalum dilatatum, Phragmites australis, Schoenoplectus corymbosus, Setaria sphacelata, Sporobolus africanus, Themeda triandra, Typha capensis.*

The dominant forb species recorded include: *Berkheya radula, Berula erecta Crinum bulbispermum, Gladiolus spp, Haplocarpha scaposa, Helichrysum nudifolium, Helichrysum rugulosum, Hypoxis rigidula, Ipomoea crassipes, Monopsis decipiens, Oenothera rosea Oxalis obliquifolia, Persicaria spp, Persicaria lapathifolia Ranunculus multifidus Rumex crispus Vernonia oligocephala.*

Although the wetland areas were dominated by grass and sedges, some AIS were also recorded, especially adjacent to agricultural land and other impacted areas. The dominant AIS recorded include*: Bidens Formosa, Bidens pilosa, Cirsium vulgaris, Conyza bonariensis, Datura stramonium , Senecio inaequidens, Schkuhria pinnata, Solanum spp, Verbena bonariensis, Tagetes minuta, Xanthium strumarium.*

4.2.3. Watercourse Functional Assessment

Some of the impacts recorded during the site visit include increased hardened surfaces from roads and service roads, diggings, current and historical farming and grazing, sedimentation, increased water input from artificial channels and slime dams (and other sources from the Sasol Mine), large densities of AIS, numerous furrows and trenches leading to and from the wetland, foreign material input such as sewerage and mine sediment. Some of these impacts relate to reduced water quality such as slime dams and other mining infrastructure.

The integrity and function scores calculated for the wetlands are presented in the section below. Table 7 presents a summary of the assessment methodologies applied to determine scores for the components of watercourse function and integrity. A summary of the integrity scores for each wetland is listed in Table 7 as well as in Figure 13,Figure 14 and Figure 15.

Table 7: Summary of the methodologies used to determine function and integrity scores for the watercourses associated with the study site.

Unchannelled Valley Bottom Wetland
WetHealth V2 (EC/PES) (Macfarlane *et al*., 2020)
Environmental Importance and Sensitivity category (EIS) (Kotze *et al*., 2020)
WetEcosystem Services V2 (ES) (Kotze *et al*., 2020)
Ecological Importance (EI) (Rountree & Kotze., 2013 and DWAF, 1999)
Recommended Ecological Category (REC) Rountree *et al.*, (2013)
Site Ecological Importance (SANBI, 2020)

Table 8: Summary of the scores of the wetland units

#	Size (Ha) excluding buffer	Wetland Type and Drainage	Wetland System	Calculated Buffer Zone	WetHealth V2 (EC/PES) (Macfarlane *et al.*, 2020)	Ecological Importance (EI) (Rountree & Kotze., 2013 and DWAF, 1999)	WetEcosystem Services V2 (ES) (Kotze *et al.*, 2020)	Environmental Importance and Sensitivity category (EIS) (Kotze *et al.*, 2020)	Recommended Ecological Category (REC) Rountree *et al.*, (2013)
1	87	Combination of Seepage and Valley Bottom Wetlands	Drains into Boesmanspruit River. Wetland 7 forms the headwaters of the Boesmanspruit. Wetlands drain south to south east Part of catchmen C12E	61m	D - Largely Modified	*Ecological Importance & Sensitivity* - High *Hydro-Functional Importance* - High *Direct Human Benefits* - Moderate	*Biodiversity maintenance importance* – High *Regulating services importance* - High *Provisioning and cultural services importance - Moderate*	Moderate	D – Maintain at D
2	9	Unchannelled Valley Bottom		35m	D - Largely Modified	*Ecological Importance & Sensitivity* - Low *Hydro-Functional Importance* - Moderate *Direct Human Benefits* - Low	*Biodiversity maintenance importance* – Low *Regulating services importance* - Moderate *Provisioning and cultural services importance - Moderate*	Moderate	D – Maintain at D

#	Size (Ha) excluding buffer	Wetland Type and Drainage	Wetland System	Calculated Buffer Zone	WetHealth V2 (EC/PES) (Macfarlane *et al.*, 2020)	Ecological Importance (EI) (Rountree & Kotze., 2013 and DWAF, 1999)	WetEcosystem Services V2 (ES) (Kotze *et al.*, 2020)	Environmental Importance and Sensitivity category (EIS) (Kotze *et al.*, 2020)	Recommended Ecological Category (REC) Rountree *et al.*, (2013)
3	4.33	Seepage		35m	E - Seriously Modified	*Ecological Importance & Sensitivity* - Low *Hydro-Functional Importance* - Low *Direct Human Benefits* - Low	*Biodiversity maintenance importance* – Low *Regulating services importance* - Low *Provisioning and cultural services importance - Low*	Low	Improve to D
4	102	Combination of Seepage and Valley Bottom Wetlands		79m	C - Moderately Modified	*Ecological Importance & Sensitivity – Very* High *Hydro-Functional Importance* - High *Direct Human Benefits* - High	*Biodiversity maintenance importance* – High *Regulating services importance* - High *Provisioning and cultural services importance - Moderate*	High	Maintain at C
5	1.1	Seepage		35m	C - Moderately Modified	*Ecological Importance*	*Biodiversity maintenance*	Low	Maintain at C

#	Size (Ha) excluding buffer	Wetland Type and Drainage	Wetland System	Calculated Buffer Zone	WetHealth V2 (EC/PES) (Macfarlane *et al.*, 2020)	Ecological Importance (EI) (Rountree & Kotze., 2013 and DWAF, 1999)	WetEcosystem Services V2 (ES) (Kotze *et al.*, 2020)	Environmental Importance and Sensitivity category (EIS) (Kotze *et al.*, 2020)	Recommended Ecological Category (REC) Rountree *et al.*, (2013)
						& Sensitivity - Low *Hydro-Functional Importance* - Low *Direct Human Benefits* - Low	*importance* – Low *Regulating services importance* - Low *Provisioning and cultural services importance* - *Low*		
6	2.2	Seepage		35m	C - Moderately Modified	*Ecological Importance & Sensitivity* - Low *Hydro-Functional Importance* - Low *Direct Human Benefits* - Low	*Biodiversity maintenance importance* – Low *Regulating services importance* - Low *Provisioning and cultural services importance* - *Low*	Low	Maintain at C

#	Size (Ha) excluding buffer	Wetland Type and Drainage	Wetland System	Calculated Buffer Zone	WetHealth V2 (EC/PES) (Macfarlane *et al.*, 2020)	Ecological Importance (EI) (Rountree & Kotze., 2013 and DWAF, 1999)	WetEcosystem Services V2 (ES) (Kotze *et al.*, 2020)	Environmental Importance and Sensitivity category (EIS) (Kotze *et al.*, 2020)	Recommended Ecological Category (REC) Rountree *et al.*, (2013)
7	66	Seepage and Valley Bottom Wetlands		79m	C - Moderately Modified	*Ecological Importance & Sensitivity – Very* High *Hydro-Functional Importance* - High *Direct Human Benefits* - High	*Biodiversity maintenance importance* – High *Regulating services importance* - High *Provisioning and cultural services importance - Moderate*	High	Maintain at C
8	6.25	Valley Bottom		15m	D - Largely Modified	*Ecological Importance & Sensitivity* - Moderate *Hydro-Functional Importance* - Moderate *Direct Human Benefits* - Low	*Biodiversity maintenance importance* – Low *Regulating services importance* - Moderate *Provisioning and cultural services importance - Low*	Low	Maintain at D

#	Size (Ha) excluding buffer	Wetland Type and Drainage	Wetland System	Calculated Buffer Zone	WetHealth V2 (EC/PES) (Macfarlane *et al.*, 2020)	Ecological Importance (EI) (Rountree & Kotze., 2013 and DWAF, 1999)	WetEcosystem Services V2 (ES) (Kotze *et al.*, 2020)	Environmental Importance and Sensitivity category (EIS) (Kotze *et al.*, 2020)	Recommended Ecological Category (REC) Rountree *et al.,* (2013)
9	3.0	Seepage	Leeuspruit System. Wetlands drain west. Part of catchment C11K	35m	D - Largely Modified	*Ecological Importance & Sensitivity* - Low *Hydro-Functional Importance* - Low *Direct Human Benefits* - Low	*Biodiversity maintenance importance* – Low *Regulating services importance* - Low *Provisioning and cultural services importance - Low*	Low	Maintain at D
10	2.13	Seepage		35m	E - Seriously Modified	*Ecological Importance & Sensitivity* - Low *Hydro-Functional Importance* - Low *Direct Human Benefits* - Low	*Biodiversity maintenance importance* – Low *Regulating services importance* - Low *Provisioning and cultural services importance - Low*	Low	Improve to D

#	Size (Ha) excluding buffer	Wetland Type and Drainage	Wetland System	Calculated Buffer Zone	WetHealth V2 (EC/PES) (Macfarlane *et al.*, 2020)	Ecological Importance (EI) (Rountree & Kotze., 2013 and DWAF, 1999)	WetEcosystem Services V2 (ES) (Kotze *et al.*, 2020)	Environmental Importance and Sensitivity category (EIS) (Kotze *et al.*, 2020)	Recommended Ecological Category (REC) Rountree *et al.,* (2013)
11	0.96	Seepage	Grootbessiespruit System. Wetlands drain North. Part of catchmen C12D	15m	C - Moderately Modified	*Ecological Importance & Sensitivity* - Low *Hydro-Functional Importance* - Low *Direct Human Benefits* - Low	*Biodiversity maintenance importance* – Low *Regulating services importance* - Low *Provisioning and cultural services importance - Low*	Low	Maintain at C
12	49.3	Combination of Seepage and Valley Bottom Wetlands		61m	E - Seriously Modified	*Ecological Importance & Sensitivity* - Moderate *Hydro-Functional Importance* - Moderate *Direct Human Benefits* - Moderate	*Biodiversity maintenance importance* – Moderate *Regulating services importance* - Moderate *Provisioning and cultural services importance - Moderate*	Moderate	Improve to D
13	0.81	Seepage		15m	D - Largely Modified	*Ecological Importance*	*Biodiversity maintenance*	Low	Maintain at D

#	Size (Ha) excluding buffer	Wetland Type and Drainage	Wetland System	Calculated Buffer Zone	WetHealth V2 (EC/PES) (Macfarlane *et al.*, 2020)	Ecological Importance (EI) (Rountree & Kotze., 2013 and DWAF, 1999)	WetEcosystem Services V2 (ES) (Kotze *et al.*, 2020)	Environmental Importance and Sensitivity category (EIS) (Kotze *et al.*, 2020)	Recommended Ecological Category (REC) Rountree *et al.*, (2013)
						& Sensitivity - Low *Hydro-Functional Importance* - Low *Direct Human Benefits* - Low	*importance* – Low *Regulating services importance* - Low *Provisioning and cultural services importance - Low*		
14	18.3	Combination of Seepage and Valley Bottom Wetlands		61m	D - Largely Modified	*Ecological Importance & Sensitivity* - Low *Hydro-Functional Importance* - Low *Direct Human Benefits* - Moderate	*Biodiversity maintenance importance* – Low *Regulating services importance* - Low *Provisioning and cultural services importance* - *Moderate*	Low	Maintain at D

#	Size (Ha) excluding buffer	Wetland Type and Drainage	Wetland System	Calculated Buffer Zone	WetHealth V2 (EC/PES) (Macfarlane *et al.*, 2020)	Ecological Importance (EI) (Rountree & Kotze., 2013 and DWAF, 1999)	WetEcosystem Services V2 (ES) (Kotze *et al.*, 2020)	Environmental Importance and Sensitivity category (EIS) (Kotze *et al.*, 2020)	Recommended Ecological Category (REC) Rountree *et al.*, (2013)
15	16.8	Combination of Seepage and Valley Bottom Wetlands		61m	D - Largely Modified	*Ecological Importance & Sensitivity* - Low *Hydro-Functional Importance* - Low *Direct Human Benefits* - Moderate	*Biodiversity maintenance importance* – Low *Regulating services importance* - Low *Provisioning and cultural services importance - Moderate*	Low	Maintain at D
16	1.9	Seepage		35m	D - Largely Modified	*Ecological Importance & Sensitivity* - Low *Hydro-Functional Importance* - Low *Direct Human Benefits* - Moderate	*Biodiversity maintenance importance* – Low *Regulating services importance* - Low *Provisioning and cultural services importance - Moderate*	Low	Maintain at D

#	Size (Ha) excluding buffer	Wetland Type and Drainage	Wetland System	Calculated Buffer Zone	WetHealth V2 (EC/PES) (Macfarlane *et al.*, 2020)	Ecological Importance (EI) (Rountree & Kotze., 2013 and DWAF, 1999)	WetEcosystem Services V2 (ES) (Kotze *et al.*, 2020)	Environmental Importance and Sensitivity category (EIS) (Kotze *et al.*, 2020)	Recommended Ecological Category (REC) Rountree *et al.*, (2013)
17	4.13	Valley Bottom		61m	D - Largely Modified	*Ecological Importance & Sensitivity* - Low *Hydro-Functional Importance* - Low *Direct Human Benefits* - Moderate	*Biodiversity maintenance importance* – Low *Regulating services importance* - Low *Provisioning and cultural services importance - Moderate*	Low	Maintain at D
18	0.1	Seepage		15m	E - Seriously Modified	*Ecological Importance & Sensitivity* - Low *Hydro-Functional Importance* - Low *Direct Human Benefits* - Low	*Biodiversity maintenance importance* – Low *Regulating services importance* - Low *Provisioning and cultural services importance - Low*	Low	Improve to D

#	Size (Ha) excluding buffer	Wetland Type and Drainage	Wetland System	Calculated Buffer Zone	WetHealth V2 (EC/PES) (Macfarlane *et al.*, 2020)	Ecological Importance (EI) (Rountree & Kotze., 2013 and DWAF, 1999)	WetEcosystem Services V2 (ES) (Kotze *et al.*, 2020)	Environmental Importance and Sensitivity category (EIS) (Kotze *et al.*, 2020)	Recommended Ecological Category (REC) Rountree *et al.,* (2013)
19	0.19	Seepage		15m	E - Seriously Modified	*Ecological Importance & Sensitivity* - Low *Hydro-Functional Importance* - Low *Direct Human Benefits* - Low	*Biodiversity maintenance importance* – Low *Regulating services importance* - Low *Provisioning and cultural services importance - Low*	Low	Improve to D
20	0.16	Depressional Pan	None	15m	E - Seriously Modified	*Ecological Importance & Sensitivity* - Low *Hydro-Functional Importance* - Low *Direct Human Benefits* - Low	*Biodiversity maintenance importance* – Low *Regulating services importance* - Low *Provisioning and cultural services importance - Low*	Low	Improve to D

#	Size (Ha) excluding buffer	Wetland Type and Drainage	Wetland System	Calculated Buffer Zone	WetHealth V2 (EC/PES) (Macfarlane *et al.*, 2020)	Ecological Importance (EI) (Rountree & Kotze., 2013 and DWAF, 1999)	WetEcosystem Services V2 (ES) (Kotze *et al.*, 2020)	Environmental Importance and Sensitivity category (EIS) (Kotze *et al.*, 2020)	Recommended Ecological Category (REC) Rountree *et al.*, (2013)
21		Depressional Pan		15m	E - Seriously Modified	*Ecological Importance & Sensitivity* - Low *Hydro-Functional Importance* - Low *Direct Human Benefits* - Low	*Biodiversity maintenance importance* – Low *Regulating services importance* - Low *Provisioning and cultural services importance* - *Low*	Low	Improve to D

4.2.4. Site Ecological Importance

Based on the Species Environmental Assessment Guideline (SANBI, 2020) wetlands and specialised habitats should be assessed based on their Site Ecological Importance (SEI). The SEI is based on several factors (Annexure E).

Based on these methods the wetlands are determined as per the following (Table 9 and Figure 13):

Table 9: Ecological Importance of all wetland areas recorded on the study site

Habitat	Conservation Importance (CI)	Functional Integrity (FI)	Biodiversity Importance	Receptor Resilience	Site Ecological Importance
Wetland Area	High – Confirmed occurrence of wetlands within the development footprint	Medium – Some historical impacts and AIS recorded	Medium – Based on CI and FI	Very Low – Wetlands are not easily restored without significant rehabilitation. Many species are dependent on functional wetland habitat.	Based on BI – Medium and RR – Very Low = High

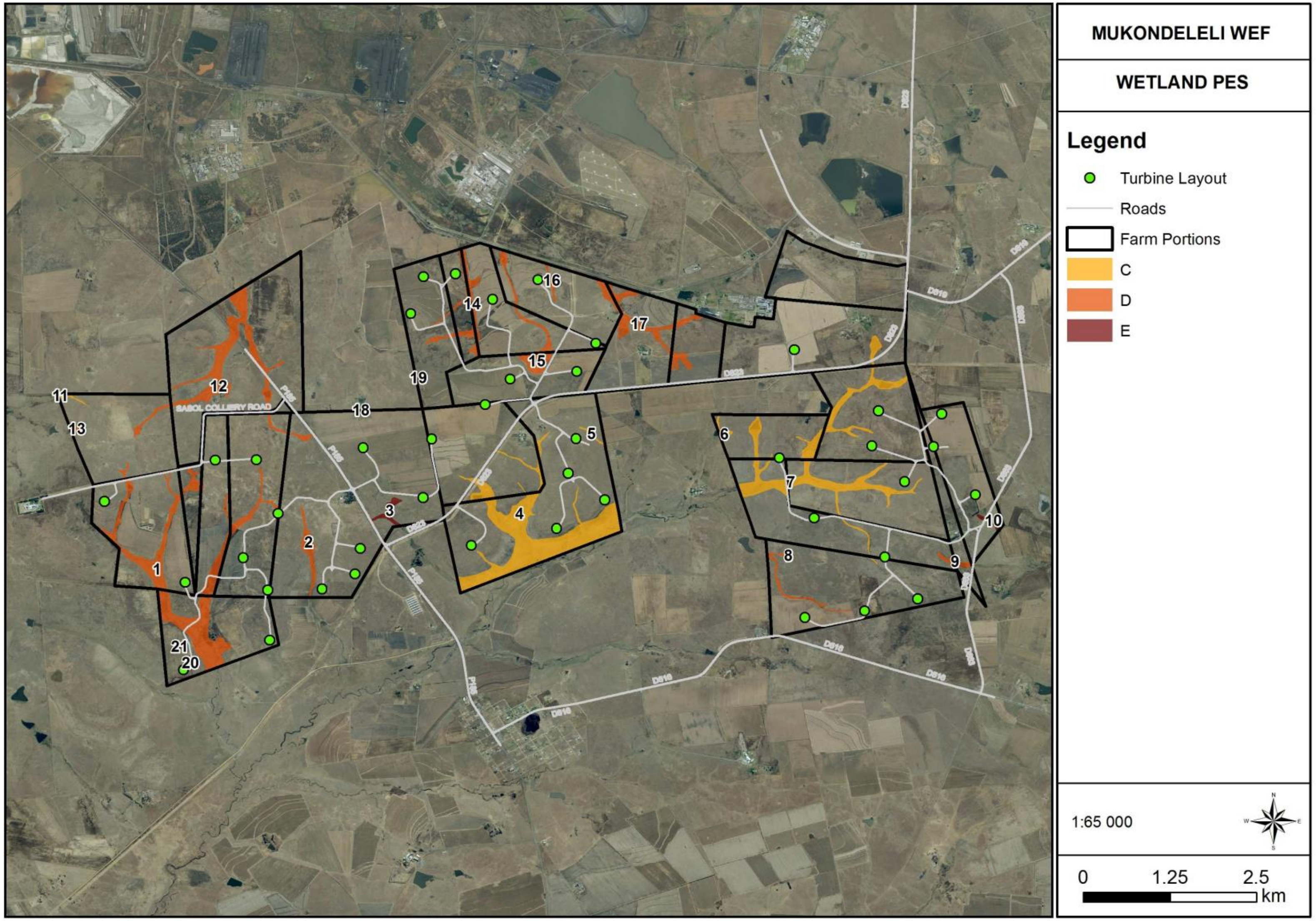


Figure 13: Present ecological state of each wetland unit in the proposed Mukondeleli WEF study area (Macfarlane *et al.*, 2020)

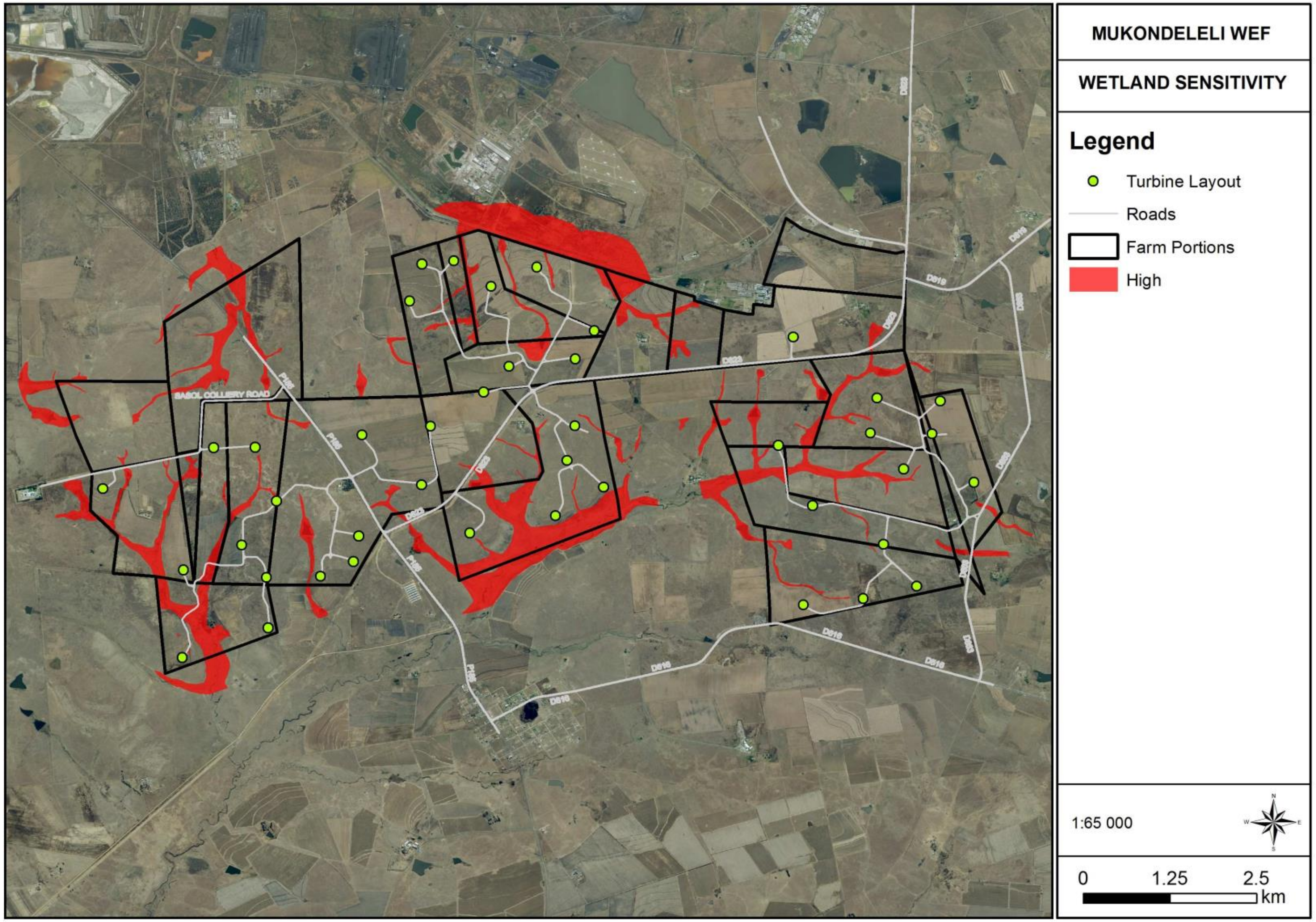


Figure 14: Environmental Importance and Sensitivity category (EIS) of the proposed Mukondeleli WEF study area (*Kotze et al*., 2020)

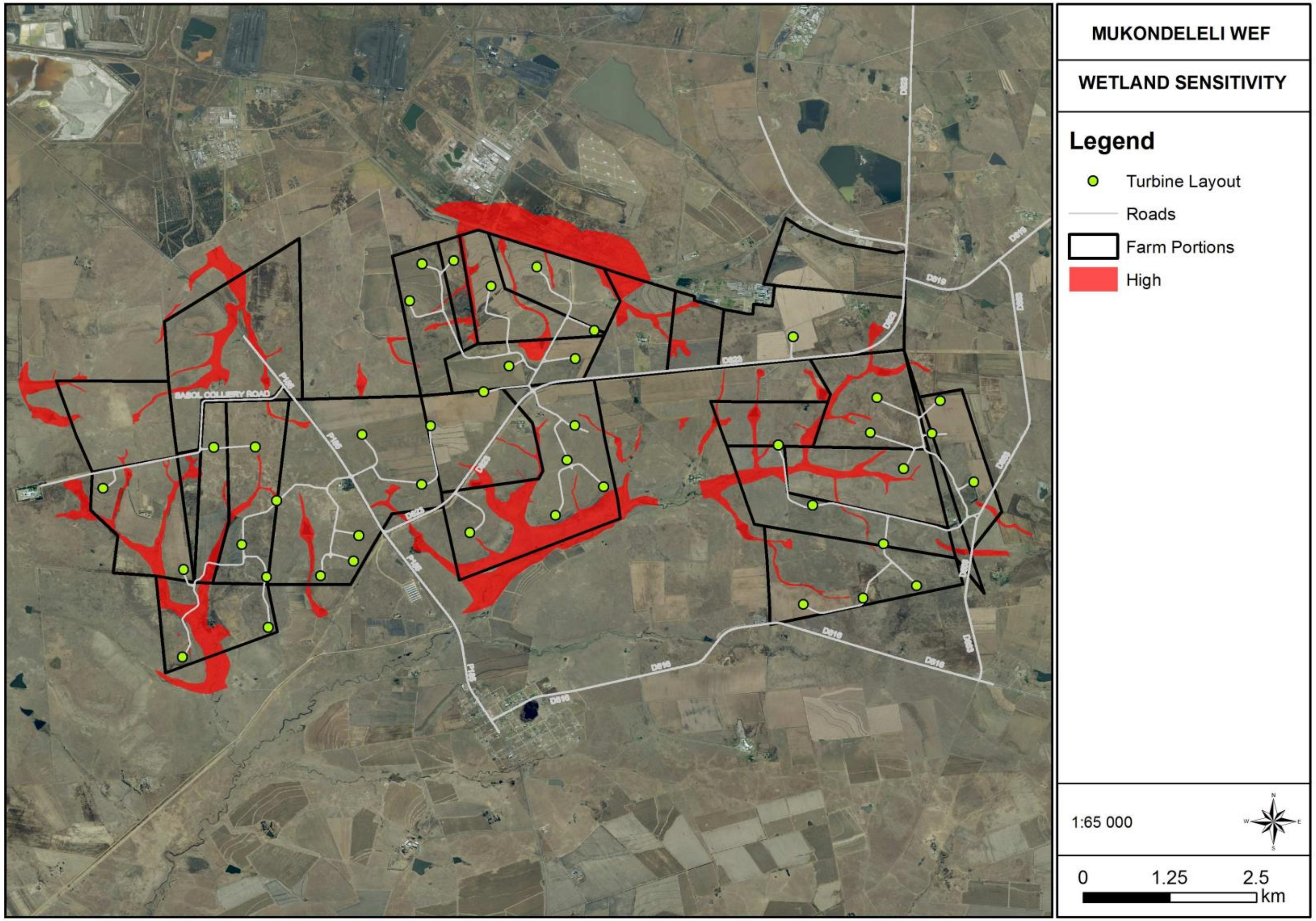


Figure 15: Wetland sensitivity based on the Site Ecological Importance (SANBI, 2020) for the proposed Mukondeleli WEF study area.

Figure 16: Characteristics of wetlands recorded on the proposed Mukondeleli WEF study site

4.2.5. Existing impacts noted on watercourses during site visit

Development has several impacts on the surrounding environment and particularly on a wetland. Particularly mining affects surface and subsurface water flow in a catchment and consequently affects recharge and discharge of water and the hydrological expression in wetlands. The main impacts associated with the wetlands on the study are current and historical agriculture, as well as grazing animals. Several other impacts such as roads, stormwater and other surface water inputs has an impact on the hydrology and water quality of the wetlands. Current and historical diggings and trenches have an impact on the geomorphology while the invasive species negatively impacts the vegetation composition of the wetlands. Some of the recorded impacts are visually represented in the image below (Figure 17)

Figure 17: Recorded impacts associated with the wetlands on the Mukondeleli WEF study site

The exact size of the base of the Wind Energy Turbine was not known at the time of writing, however in the following table (Table 10) each wind turbine is discussed in terms of distance to the nearest wetland and thus if the current proposed footprint is preferred or not. In terms of the risk assessment it is assumed that no structures will be built within a wetland or wetland buffer. It should further be noted that the exact method of construction is not known and it is assumed that no new service roads will be built. Only one Wind Energy Turbines was recorded in a wetland buffer. These are (highlighted in red in the table below):

- MK - 37

The remaining Wind Energy Turbines are located outside of wetlands and their buffer zones and are thus ideal in terms of wetland protection. A few Wind Energy Turbines were found to be farther than 500 m away from any wetland and thus not within the DWS Regulated area, these include (highlighted in green in the Table below):

- MK – 01
- MK – 03
- MK – 07
- MK – 08
- MK – 09
- MK – 25

The remaining wetlands are located outside of wetlands and their buffer zones.

Table 10: Wind Energy Turbine infrastructure in relation to nearby wetlands.

Wind Energy Turbine Number	Relation to wetlands	Order of Preference	Within 500 m DWS Regulated area
MK - 01	Approximately 600 m from the nearest wetland	Ideally located	No
MK - 02	Approximately 300 m from the nearest wetland	Ideally located	Yes
MK - 03	Approximately 500 m from the nearest wetland	Ideally located	No
MK - 04	Approximately 250 m from nearest wetland	Ideally located	Yes
MK - 05	Approximately 120 m from the nearest wetland	Ideally located	Yes
MK - 06	Approximately 400 m from the nearest wetland	Ideally located	Yes
MK - 07	Approximately 600 m from the nearest wetland	Ideally located	No
MK - 08	Approximately 650 m from the nearest wetland	Ideally located	No
MK - 09	Approximately 650 m from the nearest wetland	Ideally located	No
MK - 10	Approximately 250 m from nearest wetland	Ideally located	Yes
MK - 11	Approximately 100 m from the nearest wetland	Ideally located	Yes
MK - 12	Approximately 480 m from the nearest wetland	Ideally located	Yes
MK - 13	Approximately 80 m from the nearest wetland	Ideally located	Yes
MK - 14	Approximately 160 m from the nearest wetland	Ideally located	Yes
MK - 15	Approximately 220 m from nearest wetland	Ideally located	Yes
MK - 16	Approximately 290 m from nearest wetland	Ideally located	Yes
MK - 17	Approximately 430 m from the nearest wetland	Ideally located	Yes
MK - 18	Approximately 300 m from nearest wetland	Ideally located	Yes
MK - 19	Approximately 130 m from nearest wetland	Ideally located	Yes
MK - 20	Approximately 480 m from nearest wetland	Ideally located	Yes
MK - 21	Approximately 130 m from nearest wetland	Ideally located	Yes

Wind Energy Turbine Number	Relation to wetlands	Order of Preference	Within 500 m DWS Regulated area
MK - 22	Approximately 170 m from nearest wetland	Ideally located	Yes
MK - 23	Approximately 250 m from nearest wetland	Ideally located	Yes
MK - 24	Approximately 250 m from nearest wetland	Ideally located	Yes
MK - 25	Approximately 600 m from nearest wetland	Ideally located	No
MK - 26	Approximately 400 m from nearest wetland	Ideally located	Yes
MK - 27	Approximately 250 m from nearest wetland	Ideally located	Yes
MK - 28	Approximately 480 m from nearest wetland	Ideally located	Yes
MK - 29	Approximately 90 m from nearest wetland	Ideally located	Yes
MK - 30	Approximately 250 m from nearest wetland	Ideally located	Yes
MK - 31	Approximately 200 m from nearest wetland	Ideally located	Yes
MK - 32	Approximately 270 m from nearest wetland	Ideally located	Yes
MK - 33	Approximately 100 m from nearest wetland	Ideally located	Yes
MK - 34	Approximately 70 m from nearest wetland	Ideally located	Yes
MK - 35	Approximately 250 m from nearest wetland	Ideally located	Yes
MK - 36	Approximately 260 m from nearest wetland	Ideally located	Yes
MK – 37	Within buffer of wetland 61 m	Move south of access road	Yes
MK - 38	Approximately 90 m from nearest wetland	Ideally located	Yes
MK - 39	Approximately 130 m from nearest wetland	Ideally located	Yes
MK - 40	Approximately 130 m from nearest wetland	Ideally located	Yes
MK - 41	Approximately 380 m from nearest wetland	Ideally located	Yes
MK - 42	Approximately 90 m from nearest wetland	Ideally located	Yes

4.2.6. DWS 2016 Risk Assessment

An extract from the Risk Matrix spreadsheet presented in Table 11 indicates that the expected risk score for the proposed Wind Energy Structures, assuming that the structures will not be placed within a wetland area or any wetland buffer zones. The scores fall within the Low risk category. This category refers to risk and impact on watercourses that can be managed so as to have a low nett impact on the affected watercourses. This score is based on the assumption that the effective rehabilitation of disturbed watercourses on a site specific rehabilitation plan will be implemented and that monitoring will be undertaken to establish success of reestablishment of vegetation cover and water flow dynamics. An extract from the Risk Matrix spreadsheet is presented in Table 11 below.

Table 11: The DWS (2016) risk assessment matrix for the proposed development. Risk is determined after considering all listed control / mitigation measures

RISK MATRIX (Based on DWS 2016 publication: Section 21 c and I water use Risk Assessment Protocol): Proposed Mukondelei Wind Energy Facility and associated Infrastructure, near Secunda

NAME and REGISTRATION No of SACNASP Professional member: A Bootsma SACNASP # 400222/09

Phases	Activity	Aspect	Impact	Flow Regime (Severity)	Physico & Chemical (Water Quality) (Severity)	Habitat (Geomorph+Vegetation) (Severity)	Biota (Severity)	Severity	Spatial scale	Duration	Consequence	Frequency of activity	Frequency of impact	Legal Issues	Detection	Likelihood	Significance	Risk Rating	Confidence level	Control Measures	Borderline LOW MODERATE Rating Classes	PES AND EIS OF WATERCOURSE
C	Construction phase of the Wind Energy Structures development	Preparation for construction, including vegetation clearing,	Changing the water flow characteristics, removal of vegetation, soil compaction, sedimentation and erosion of downstream areas	1	0	2	1	2	1	2	5	2	2	0	5	9	45	L	80%	• Implement best practice and mitigation measures as specified in the rehabilitation plan • Standard best practice mitigation measures should be implemented during the construction phase • Implement effective rehabilitation to reverse construction related impacts. WES should not encroach into	N	**Not expected to decrease scores**
		Earthwork activities		1	0	2	1	1	1	2	4	2	2	0	2	6	24	L	80%		N	
		Storm Water Management		2	2	1	2	2	2	2	6	2	1	5	2	10	58	L	80%		N	
O	Operation of the Wind Energy Facility plant	Day to day activities of the wind energy operation including stormwater managament	Possible permanent changes to the hydrology of the watercourse and unintended downstream effects such as erosion and sedimentation	2	1	1	1	1	2	2	5	2	1	5	2	10	53	L	80%	• Design of structures should aim to have the least impact on habitat quality and hydrology of the watercourses and should include attenuation structures to contribute to regional flood control and rehabilitation • Control of alien invasive plants should form part of the maintenance plan - WES should not encroach into watercourse areas or watercourse buffer zones. • Install litter traps	N	Not expected to decrease scores
		Maintenance of infrastructure		1	1	1	1	1	1	1	3	1	1	5	2	9	27	L	80%		N	

4.2.7. Baseline aquatic assessment results

The 2022 baseline aquatic assessment was conducted by Andre Strydom (*B.Tech. Nature Conservation, UNISA*) and all the sampling points listed in Table 2 were visited during the various site visit as mentioned in section 2. The habitats at all sampling points were firstly evaluated by means of observations with regard to their surroundings, possible causes of stressors or disturbances on aquatic ecosystems.

The outcome of this evaluation indicated that MUB2, MUB3, MUB5, MUB6, MUB8 and GRB1 could be further assessed by means of the sampling methods described in paragraph 2 on page 17 (a detailed description of how these methods are executed, and how results obtained from each of these methods are interpreted, is contained in Annexure E). No entry could be obtained at all three separate sampling dates at MUB1. MUB4 was dry but water quality readings were taken in a dam downstream of MUB4. No flow was present at site MUB7 and conditions were therefore unsuitable for sampling.

The following methods were used in this biomonitoring survey at these sampling points:

- Habitat evaluations:
- Observations regarding possible impacts and effects at each survey site;
- Measuring relevant *in-situ* water quality parameters and comparing the results obtained with the TWQRs for aquatic ecosystems; and
- IHAS evaluation (Appendix E).

Species Response evaluations:
Aquatic Invertebrate response evaluation, making use of SASS5 (Appendix E).

The results obtained from the *in situ* measurement of temperature, pH, Electrical Conductivity, and DO are summarised in Appendix F. The results obtained from the IHAS-scorecards are attached as Annexure F and the SASS5 Score-sheets are attached as Appendix F.

The results obtained during this 2022 baseline aquatic assessment at these sites are discussed below.

<u>Results of downstream site MUB2</u>

Site MUB2 is located in a non-perennial tributary of the Boesmanspruit River. Impacts that could potentially affect the site include residential areas located close to the site, invasive plant species, dams, roads and farming activities located upstream from the site.

Table 12 contains an overview of the conditions observed at MUB2. The drivers and biotic responses observed at MUB2 are summarised in Table 13.

Table 12: Overview of conditions observed at downstream site MUB2

GEOMORPHOLOGICAL ZONE	VEGETATION	QUATERNARY CATCHMENT
Lower	Soweto Highveld Grassland	C12E

Table 13: Drivers and biotic responses at downstream site MUB2

INDICATOR	DESCRIPTION
PHYSICO-CHEMICAL DRIVERS	
IN SITU WATER QUALITY	The visual appearance of the water prior to sampling was discoloured. The *in situ* chemical parameters measured were all within the TWQRs for aquatic ecosystems (**Annexure F**).
HABITAT	The flow was limited to a trickle at the time of the survey. Habitats were affected by exotic vegetation, surrounding residential areas, and farming activities upstream. The substrate consisted mostly of GSM, with mud and gravel being dominant. Bedrock and stones out of current were absent from the site. The IHAS score was 43%, which indicates a habitat that is insufficient for supporting a diverse macroinvertebrate community **(Annexure F).**
SPECIES RESPONSE	

<table>
<tr>
<td>INVERTEBRATE
S</td>
<td>The SASS5 results obtained during this survey can be summarised as follows:
<table>
<tr><th></th><th>Feb 2022</th></tr>
<tr><td>SASS5 EC</td><td>E/F</td></tr>
<tr><td>SASS5 score</td><td>20</td></tr>
<tr><td>Number of Taxa</td><td>5</td></tr>
<tr><td>ASPT</td><td>4</td></tr>
</table>
Taxa present at this biomonitoring point during the 2022 baseline survey included Oligochaeta, Corixidae, Notonectidae, Velidae, Gyrinidae, Taxa that occurred in abundances between 10 - 100 individuals were limited to Corixidae. Taxa that occurred in abundances between 2-10 individuals included Velidae, Oligochaetae. One individual of Notonectidae and Gyrinidae were recorded (Annexure F).
The SASS5 EC reflected a E/F category, which suggests a seriously to critically modified system at the time of the survey.
</td>
</tr>
</table>

<u>Results of downstream site MUB3</u>

Site MUB3 is located in the non-perennial tributary of the Boesmanspriut River. It is situated downstream of the proposed WEF. Surrounding land use that could potentially affect the site includes dirt roads, bridges, invasive plant species, dams and agricultural activities. Surrounding land use includes agriculture and roads.

Table 14 contains an overview of the conditions observed at MUB3. The drivers and biotic response observed at MUB3 are summarised in Table 15.

Table 14: Overview of conditions observed at downstream site MUB3

GEOMORPHOLOGICAL ZONE	VEGETATION	QUATERNARY CATCHMENT
Lower	Soweto Highveld Grassland	C12E

Table 15: Drivers and biotic responses at upstream site MUB3

INDICATOR	DESCRIPTION
PHYSICO-CHEMICAL DRIVERS	
IN SITU WATER QUALITY	The visual appearance of the water prior to sampling was discoloured. The *in situ* chemical parameters measured were all within the TWQRs for aquatic ecosystems (**Annexure F**).
HABITAT	The flow was low at the time of the survey. The substrate consisted primarily of mud. The IHAS score was 47%, which indicates a habitat that is insufficient for supporting a diverse macroinvertebrate community **(Annexure F)**.
SPECIES RESPONSE	

<table>
<tr>
<td>INVERTEBRATES</td>
<td>
The SASS5 results obtained during this survey can be summarised as follows:
<table>
<tr><th></th><th>Feb 2022</th></tr>
<tr><td>SASS5 EC</td><td>E/F</td></tr>
<tr><td>SASS5 score</td><td>27</td></tr>
<tr><td>Number of Taxa</td><td>8</td></tr>
<tr><td>ASPT</td><td>3.37</td></tr>
</table>

Taxa present at this biomonitoring point during the 2022 baseline survey included Oligochaeta, Potamonautidae, Coenagrionidae, Corixidae, Gerridae, Veliidae, Gyrinidae and Culicidae. The abundance of these taxa were low with Culicidae, Gyrinidae and Gerridae each only having one individual present, The only taxon that occurred in abundances between 10 - 100 individuals was Corixidae, Taxa that occurred in abundances between 2-10 individuals included Coenagrionidae, Veliidae, Oligochaeta (Annexure F).

The SASS5 EC reflected a E/F category, which suggests a seriously to critically modified system at the time of the survey.
</td>
</tr>
</table>

<u>Results of downstream site MUB5</u>

Site MUB5 is situated within the Boesmanspruit River downstream of a section of the planned WEF layout. The system is perennial and it is envisaged that in future MUB5 will act as a monitoring point. Land use surrounding MUB5 includes roads, agricultural activities and a residential area.

Table 16 contains an overview of the conditions observed at MUB5. The drivers and biotic response observed at MUB5 are summarised in Table 17.

Table 16: Overview of conditions observed at downstream site MUB5

GEOMORPHOLOGICAL ZONE	VEGETATION	QUATERNARY CATCHMENT
Lower	Soweto Highveld Grassland	C12E

Table 17: Drivers and biotic responses at downstream site MUB5

INDICATOR	DESCRIPTION
PHYSICO-CHEMICAL DRIVERS	
IN SITU WATER QUALITY	The visual appearance of the water prior to sampling was murky. The *in situ* chemical parameters measured were all within the TWQRs for aquatic ecosystems (**Annexure F**).
HABITAT	The flow was moderate at the time of the survey. Invasive species were present. The substrate consisted primarily of sones and GSM. Limited stones out of current and bedrock was sampled at the site. The IHAS score was 56%, which indicates a habitat that is insufficient for supporting a diverse macroinvertebrate community **(Annexure F)**.
SPECIES RESPONSE	

<table>
<tr>
<td>INVERTEBRATES</td>
<td>The SASS5 results obtained during this survey can be summarised as follows:
<table>
<tr><th></th><th>Feb 2022</th></tr>
<tr><td>SASS5 EC</td><td>E/F</td></tr>
<tr><td>SASS5 score</td><td>32</td></tr>
<tr><td>Number of Taxa</td><td>9</td></tr>
<tr><td>ASPT</td><td>3.55</td></tr>
</table>

Taxa present at this biomonitoring point during the 2022 baseline survey included Oligochaeta Hirudinea, Baetidae, Corixidae, Gerridae, Notonectidae, Veliidae, Dytiscidae, Physidae (Annexure F).

The SASS5 EC reflected a E/F category, which suggests a seriously to critically modified system at the time of the survey.</td>
</tr>
</table>

<u>Results of downstream site MUB6</u>

Site MUB6 is situated within the Boesmanspruit River downstream of a section of the planned WEF layout. The system is perennial and it is envisaged that in future MUB6 will act as a monitoring point. Land use surrounding MUB6 includes roads and agricultural activities.

Table 18 contains an overview of the conditions observed at MUB6. The drivers and biotic response observed at MUB6 are summarised in Table 19.

Table 18: Overview of conditions observed at downstream site MUB6

GEOMORPHOLOGICAL ZONE	VEGETATION	QUATERNARY CATCHMENT
Lower	Soweto Highveld Grassland	C12E

Table 19: Drivers and biotic responses at downstream site MUB6

INDICATOR	DESCRIPTION
PHYSICO-CHEMICAL DRIVERS	
IN SITU WATER QUALITY	The visual appearance of the water prior to sampling was discoloured. The *in situ* chemical parameters measured were all within the TWQRs for aquatic ecosystems (**Annexure F**).
HABITAT	The flow was moderate at the time of the survey. Bank scouring was evident as week as trampling of river banks by livestock. The substrate consisted mostly of mud and stones out of current. Limited bedrock was sampled. The IHAS score was 47%, which indicates a habitat that is acceptable for supporting a diverse macroinvertebrate community **(Annexure F)**.
SPECIES RESPONSE	

<table>
<tr>
<td>INVERTEBRATES</td>
<td>The SASS5 results obtained during this survey can be summarised as follows:
<table>
<tr><th></th><th>Feb 2022</th></tr>
<tr><td>SASS5 EC</td><td>E/F</td></tr>
<tr><td>SASS5 score</td><td>27</td></tr>
<tr><td>Number of Taxa</td><td>8</td></tr>
<tr><td>ASPT</td><td>3.37</td></tr>
</table>

Taxa present at this biomonitoring point during the 2022 baseline survey included Hirudinea, Baetidae Corixidae, Notonectidae, Dytiscidae, Gyrinidae. Culicidae and Physidae (Annexure F).

The SASS5 EC reflected a E/F category, which suggests a seriously to critically modified system at the time of the survey.</td>
</tr>
</table>

<u>Results of downstream site MUB8</u>

Site MUB8 is situated within a perennial tributary of the Grootbossiespruit River. The system is perennial, and it is envisaged that in future MUB8 will act as a monitoring point in future. Land use surrounding MUB8 includes roads, Sasol Secunda operations and agricultural activities.

Table 14 contains an overview of the conditions observed at MUB8. The drivers and biotic response observed at MUB8 are summarised in Table 21.

Table 20: Overview of conditions observed at upstream site MUB8

GEOMORPHOLOGICAL ZONE	VEGETATION	QUATERNARY CATCHMENT
Lower	Soweto Highveld Grassland	C12D

Table 21: Drivers and biotic responses at downstream site MUB8

INDICATOR	DESCRIPTION
PHYSICO-CHEMICAL DRIVERS	
IN SITU WATER QUALITY	The visual appearance of the water prior to sampling was discoloured. The *in situ* chemical parameters measured were all within the TWQRs for aquatic ecosystems except for the measured oxygen saturation (DO%) that above sub lethal limits (66.4%) (**Annexure F**).
HABITAT	The flow was moderate at the time of the survey. Bank covers were well vegetated and aquatic vegetation was sampled in stream. The substrate was predominantly mud. Stones in and out of current were not present at the site. The IHAS score was 39%, which indicates a habitat that is insufficient for supporting a diverse macroinvertebrate community **(Annexure F)**.
SPECIES RESPONSE	

<table>
<tr>
<td>INVERTEBRATE
S</td>
<td>The SASS5 results obtained during this survey can be summarised as follows:
<table>
<tr><th></th><th>Feb2022</th></tr>
<tr><td>SASS5 EC</td><td>B</td></tr>
<tr><td>SASS5 score</td><td>35</td></tr>
<tr><td>Number of Taxa</td><td>7</td></tr>
<tr><td>ASPT</td><td>4.85</td></tr>
</table>

Taxa present at this biomonitoring point during the 2022 baseline survey included Atyidae Baetidae, Coenagrionidae, Belostomatidae, Corixidae, Nepidae, Physidae. (Annexure F).

The SASS5 EC reflected an B category which suggests that the system was largely natural with few modifications at the time of the survey.</td>
</tr>
</table>

Results of downstream site GRB1

Site GRB1 is situated within the non-perennial tributary of the Grootbossiespruit River. It acts as a reference site on the north-eastern perennial tributary of the Klipspruit River. The system is perennial, and it is envisaged that in future MUB8 will act as a monitoring point in future. Land use surrounding GB1 includes roads, Sasol Secunda operations and agricultural activities.

Table 22 contains an overview of the conditions observed at GRB1. The drivers and biotic response observed at GRB1 are summarised in Table 23.

Table 22: Overview of conditions observed at downstream site GRB1

GEOMORPHOLOGICAL ZONE	VEGETATION	QUATERNARY CATCHMENT
Lower	Soweto Highveld Grassland	C12D

Table 23: Drivers and biotic responses at downstream site GRB1

INDICATOR	DESCRIPTION
PHYSICO-CHEMICAL DRIVERS	
IN SITU WATER QUALITY	The visual appearance of the water prior to sampling was discoloured. The *in situ* chemical parameters measured were all within the TWQRs for aquatic ecosystems (**Annexure F**).
HABITAT	The flow was moderate at the time of the survey. The substrate consisted primarily of mud. Riparian vegetation was largely intact and aquatic vegetation was sampled. The IHAS score was 46%, which indicates a habitat that is insufficient for supporting a diverse macroinvertebrate community **(Annexure F)**.
SPECIES RESPONSE	

<table>
<tr>
<td>INVERTEBRATES</td>
<td>
The SASS5 results obtained during this survey can be summarised as follows:
<table>
<tr><td></td><td>Feb 2022</td></tr>
<tr><td>SASS5 EC</td><td>E/F</td></tr>
<tr><td>SASS5 score</td><td>35</td></tr>
<tr><td>Number of Taxa</td><td>10</td></tr>
<tr><td>ASPT</td><td>3.5</td></tr>
</table>

Taxa present at this biomonitoring point during the 2022 basseline survey included Oligochaeta, Hydracarina, Baetidae, Coenagrionidae, Corixidae, Pleidae, Dytiscidae, Ceratopogonidae, Culicidae, Simuliidae.. Taxa that occurred in an abundance of between 10 – 100 individuals included Corixidae, and Simuliidae. Taxa that occurred in an abundance of between 2 – 10 individuals included Potamonautidae, Hydracarina, Baetidae, Dytiscidae, Chironomidae, Physidae, Planorbinae, and Sphaeridae. One individual of Hirudinea, Libelludae, and Muscidae were recorded (Annexure F).

The SASS5 EC reflected an E/F category that suggests that the system was seriously to critically modified at the time of the survey.
</td>
</tr>
</table>

4.3. Identification of Environmental Sensitivities

4.3.1. Sensitivities identified by the National Web-Based Environmental Screening Tool

Based on the National Web-Based Environmental Screening tool the majority of the watercourses and aquatic ecosystems surrounding the study site is classified as high in terms of aquatic biodiversity (Figure 18).

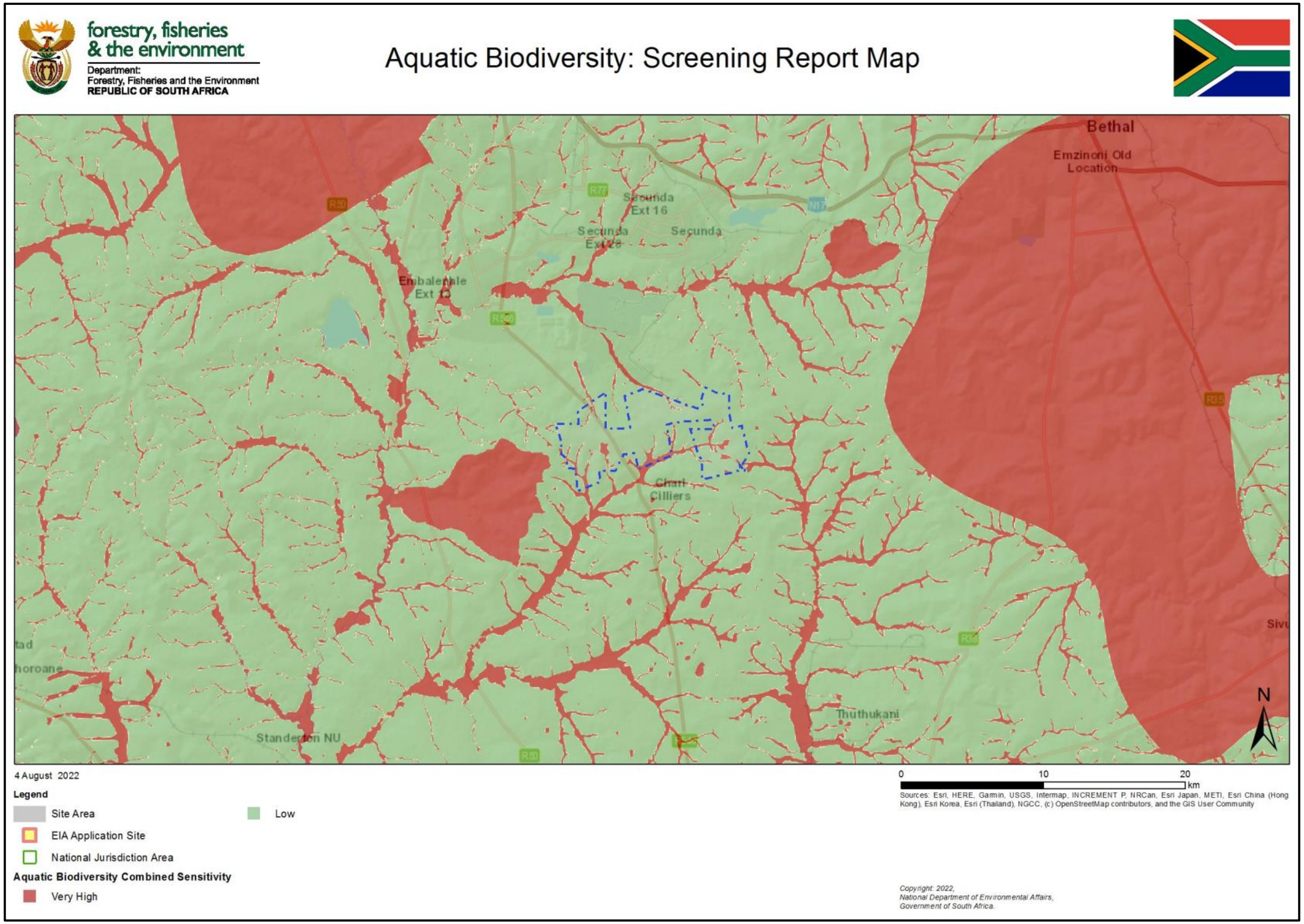


Figure 18: Results of the National Web Based Screening Tool in terms of Aquatic Biodiversity

4.3.2. Outcome of the Specialist Site Sensitivity Analysis and Verification

In terms of the desktop assessment the study site has conservation significance both in terms of national as well as provincial conservation planning. The site verification assessment indicated that the proposed layout encroaches on the wetlands and their associated buffer areas.

The desktop assessment conducted by DWS indicated that the sub quaternary reaches surrounding the study site are largely natural (B) to moderately modified (C). The site verification indicated that the wetlands are moderately (C) to seriously modified (E) whilst the aquatic macroinvertebrates indicated that the aquatic ecosystems are mostly seriously/critically (E/F) modified. Therefore, the wetland and aquatic ecosystems surrounding the study site are more impacted than expected.

Based on the field assessments, the wetland delineation and buffer indicate that the current layout encroaches on the wetlands as well as their respective buffer areas. Although the wetland and aquatic ecosystems are impacted, they still fulfil important ecosystem services and also form part of national and provincial conservation targets. It is therefore recommended that the layout plans should be updated to remove the footprint of the WEF out of the wetlands and buffer areas. No site alternatives were provided to the specialists for consideration.

The areas where the WEF layout encroaches on the wetlands and their buffer areas are highlighted in Figure 12.

4.3.3. Sensitivity Analysis Summary Statement

Although the wetland and aquatic ecosystems are impacted, they still fulfil important ecosystem services and also form part of national and provincial conservation targets. It is therefore recommended that the wetlands, aquatic ecosystems and the buffer areas as indicated in Figure 12 are considered of high sensitivity.

5. Alternative Development Footprints

As indicated in Figure 12 some of the planned WEF footprint encroaches on the wetlands and buffer zones. It is therefore recommended that the development footprint should be altered to exclude wetlands and their buffer zones.

6. Issues, Risks and Impacts

6.1. Identification of Potential Impacts/Risks

It is important to note that the proposed photovoltaic development will include Solar PV panels on a 60°rotational tracker and the tracker height will be up to 6m. Although the exact footprint and installation methods of the infrastructure was not known at the time of compiling this report, it assumed that vegetation will be removed and that surface water will not be greatly impeded by these structures.

The largest impact is thought to be during the construction phase, the proposed construction timeframe is estimated to be 36 months, according to the information received. The major impacts are as follow:

Construction Phase:

a) Alteration in flow regime;
b) Changes in sediment regimes;
c) Introduction and spread of alien vegetation;
d) Loss and disturbance of riparian/watercourse habitat and vegetation;
e) Alteration in water quality due to pollution; and

f) Loss of aquatic biota.

Operational Phase:

a) Alteration in flow regime;
b) Changes in sediment regimes;
c) Introduction and spread of alien vegetation;
d) Loss and disturbance of riparian/watercourse habitat and vegetation;
e) Alteration in water quality due to pollution; and
f) Loss of aquatic biota.

Decommissioning Phase:

a) Alteration in flow regime;
b) Changes in sediment regimes;
c) Introduction and spread of alien vegetation;
d) Loss and disturbance of riparian/watercourse habitat and vegetation;
e) Alteration in water quality due to pollution; and
f) Loss of aquatic biota.

Cumulative Impacts:

a) Alteration in flow regime.

7. Impact Assessment

Currently the WEF layout does infringe on the wetlands as well as their respective buffer areas. One of the largest mitigation measures will be to remedy the layout in the design phase of the project and exclude wetlands and their associated buffer zones from the WEF layout.

The area around the WEF is already altered, large sections of the layout of the WEF are situated in agricultural fields and previously disturbed areas.
Considering the no-go alternative for the WEF would either be that the infrastructure be placed in other areas which might be green field areas or due to the limited energy generation capacity South Africa is facing the use of other forms of energy such as coal or nuclear power. The environmental footprint of coal fired power stations are far greater than that of WEF.

The advantages of the no-go alternative would be that there will be less disturbance to the aquatic ecosystems than with the proposed WEF. An advantage of the proposed WEF would be that adherence to the mitigation measures and the EMPr will be monitored, and corrective measures will be taken where required.

6.1. Potential Impacts during the Construction Phase

Changes in flow regime arises from the compaction of soil, the removal of vegetation and surface water redirection. Changes to hydrological function at a landscape level which can arise from changes to flood regimes (i.e. suppression of floods, loss of flood attenuation capacity, unseasonal flooding or destruction of floodplain processes). The extent of the modification in relation to the overall aquatic ecosystem (i.e. at the source, upstream or downstream portion, in the temporary, seasonal, permanent zone of a wetland, in the riparian zone or within the channel of a watercourse, etc.). Changes to base flows i.e. too little/too much water in terms of characteristics and requirements of system). Fragmentation (i.e. road or pipeline crossing a wetland) and loss of ecological connectivity (lateral and longitudinal).

Changing the amount of sediment entering water resource and associated change in turbidity (increasing or decreasing the amount). Construction and operational activities will result in earthworks and soil disturbance as well as the removal of natural vegetation. This could result in the loss of topsoil, sedimentation of the watercourse and increase the turbidity of the water. Possible sources of the impacts include:

- Earthwork activities during construction
- Clearing of surface vegetation will expose the soils, which in rainy events would wash through the watercourse, causing sedimentation. In addition, indigenous vegetation communities are unlikely to colonise eroded soils successfully and seeds from proximate alien invasive trees can spread easily into these eroded soil.
- Disturbance of soil surface
- Disturbance of slopes through creation of roads and tracks adjacent to the watercourse
- Erosion (e.g. gully formation, bank collapse)

Changes in sediment regimes of the aquatic ecosystem and its sub -catchment by for example sand movement, meandering river mouth /estuary, changing flooding or sedimentation patterns.

The moving of soil and vegetation resulting in opportunistic invasions after disturbance. Invasions of alien plants can impact on hydrology, by reducing the quantity of water entering a watercourse, and outcompete natural vegetation, decreasing the natural biodiversity. Once in a system, alien invasive plants can spread through the catchment. If allowed to seed before control measures are implemented alien plants can easily colonise and impact on downstream users.

Loss and disturbance of watercourse habitat and fringe vegetation due to direct development on the watercourse as well as changes in management, fire regime and habitat fragmentation.

Changes in water quality due to input of foreign materials i.e. due to increased sediment load, contamination by chemical and /or organic effluent, and /or eutrophication. During the construction phase a large amount of waste will be produced including sewerage, domestic waste, wash-water, used oils and grease, diesel or lubricant spills, etc. Waste generally contains pollutants and present a potential risk to the water and surrounding environment if not managed effectively. Oil and diesel spillages may occur during the construction phase which can contaminate surface water. Other potential contaminants (i.e. from chemical toilets, domestic waste, storage facilities, workshop facilities, etc.) can reduce surface water quality or result in discharge that exceeds the maximum concentrations permitted by the National Water Act. Changes to the water quality could result in changes to the ecosystem structure and function as well as a potential loss of biodiversity. Water quality deterioration often leads to modification of the species composition where sensitive species are lost and organisms tolerant to environmental changes dominate the community structure.

Aquatic biota can be lost due to the disturbance of the habitat and direct impacts on the watercourse/ rivers/ streams. This can be attributed to Loss and disturbance of biota due to direct development on the watercourse as well as changes in habitat including water quality, the water column, increased sediment, increased alien vegetation fire regime and habitat fragmentation.

The impact assessment was conducted using the impact assessment methodology provided by WSP as described in Appendix D.

CONSTRUCTION

Impact number	Aspect	Stage	Character	Ease of Mitigation	Pre-Mitigation							Post-Mitigation						
					(M +	E +	R +	D) x	P =	S	Rating	(M +	E +	R +	D) x	P =	S	Rating
Impact 1:	*Changes in water flow regime*	Construction	Negative	Moderate	3	3	3	4	4	**52**	**N3**	2	2	3	4	2	**22**	**N2**
				Significance	**N3 - Moderate**							**N2 - Low**						
Impact 2:	*Changes in sediment entering and exiting the system*	Construction	Negative	Moderate	3	2	3	3	3	**33**	**N3**	2	2	3	3	2	**20**	**N2**
				Significance	**N3 - Moderate**							**N2 - Low**						
Impact 3:	*Introduction and spread of alien vegetation*	Construction	Negative	Moderate	3	2	3	3	3	**33**	**N3**	2	2	3	3	2	**20**	**N2**
				Significance	**N3 - Moderate**							**N2 - Low**						
Impact 4:	*Loss and disturbance of watercourse habitat and fringe vegetation*	Construction	Negative	Moderate	3	2	3	4	3	**36**	**N3**	2	2	3	3	2	**20**	**N2**
				Significance	**N3 - Moderate**							**N2 - Low**						
Impact 5:	*Changes in water quality due to pollution*	Construction	Negative	Moderate	3	2	3	3	3	**33**	**N3**	2	2	3	3	2	**20**	**N2**
				Significance	**N3 - Moderate**							**N2 - Low**						
Impact 6:	*Loss of aquatic biota*	Construction	Negative	Moderate	3	2	3	3	3	**33**	**N3**	2	2	3	3	2	**20**	**N2**
				Significance	**N3 - Moderate**							**N2 - Low**						

6.2. Potential Impacts during the Operational Phase

During the operational phase the constructed WEF as well as associated infrastructure as depicted in section 3 can potentially have an impact on the watercourses / aquatic ecosystems. The major mitigation measure for the operational phase will still be related to move the WEF structures currently known to be located in a wetland or within the wetland buffer layout. The remaining structures are mostly located in degraded areas such as current or historical agricultural lands and is not likely to impact on the nearby watercourses if mitigation measures are adhered to. The impacts expected in the operational phase are expected to be similar to the construction phase but not as severe in most instances.

The impacts are limited to:

a) Alteration in flow regime;
b) Changes in sediment regimes;
c) Introduction and spread of alien vegetation;
d) Loss and disturbance of riparian/watercourse habitat and vegetation;
e) Alteration in water quality due to pollution; and
f) Loss of aquatic biota.

A description of these have been provide in section 6.1.

Alteration in flow regime is possible during the operational phase due to the increase in hardened surfaces. Changes in sediment is still likely especially in the early phase
The impact assessment was conducted using the impact assessment methodology provided by the CSIR as described in Appendix D.

Operational Phase

Impact number	Aspect	Stage	Character	Ease of Mitigation	Pre-Mitigation							Post-Mitigation						
					(M+	E+	R+	D)x	P=	S	Rating	(M+	E+	R+	D)x	P=	S	Rating
Impact 1:	*Changes in water flow regime*	Operational	Negative	Moderate	3	3	3	4	4	**52**	**N3**	2	2	3	4	2	**22**	**N2**
				Significance	**N3 - Moderate**							**N2 - Low**						
Impact 2:	*Changes in sediment entering and exiting the system*	Operational	Negative	Moderate	3	2	3	3	3	**33**	**N3**	2	2	3	3	2	**20**	**N2**
				Significance	**N3 - Moderate**							**N2 - Low**						
Impact 3:	*Introduction and spread of alien vegetation*	Operational	Negative	Moderate	3	2	3	3	3	**33**	**N3**	2	2	3	3	2	**20**	**N2**
				Significance	**N3 - Moderate**							**N2 - Low**						
Impact 4:	*Loss and disturbance of watercourse habitat and fringe vegetation*	Operational	Negative	Moderate	3	2	5	4	4	**56**	**N3**	2	2	3	3	3	**30**	**N2**
				Significance	**N3 - Moderate**							**N2 - Low**						
Impact 5:	*Changes in water quality due to pollution*	Operational	Negative	Moderate	3	2	3	3	3	**33**	**N3**	2	2	3	3	2	**20**	**N2**
				Significance	**N3 - Moderate**							**N2 - Low**						
Impact 6:	*Loss of aquatic biota*	Operational	Negative	Moderate	3	2	3	5	3	**39**	**N3**	2	2	3	4	2	**22**	**N2**
				Significance	**N3 - Moderate**							**N2 - Low**						

6.3. Potential Impacts during the Decommissioning Phase

The proposed WEF will have a lifespan of approximately twenty years. During the decommissioning phase it is envisaged that all infrastructure will be removed and will be returned to agricultural land use. Should the mitigation measure of the removal of the WEF layout from wetlands be followed, the impact will also be less during decommissioning. The major mitigation measure for the operational phase will still be related to remove the WEF layout from any wetlands or buffer areas. The impacts expected in the decommissioning phase are expected to be similar to the construction phase.

The impacts are limited to:

a) Alteration in flow regime;
b) Changes in sediment regimes;
c) Introduction and spread of alien vegetation;
d) Loss and disturbance of riparian/watercourse habitat and vegetation;
e) Alteration in water quality due to pollution; and
f) Loss of aquatic biota.

A description of these have been provide in section 6.1.

The impact assessment was conducted using the impact assessment methodology provided by the WSP as described in Appendix D.

Decommissioning Phase

Impact number	Aspect	Description Stage	Character	Ease of Mitigation	Pre-Mitigation							Post-Mitigation						
					(M +	E +	R +	D) x	P =	S	Rating	(M +	E +	R +	D) x	P =	S	Rating
Impact 1:	*Changes in water flow regime*	Decommissioning	Negative	Moderate	3	3	3	4	4	**52**	**N3**	2	2	3	4	2	**22**	**N2**
				Significance	**N3 - Moderate**							**N2 - Low**						
Impact 2:	*Changes in sediment entering and exiting the system*	Decommissioning	Negative	Moderate	3	2	3	3	3	**33**	**N3**	2	2	3	3	2	**20**	**N2**
				Significance	**N3 - Moderate**							**N2 - Low**						
Impact 3:	*Introduction and spread of alien vegetation*	Decommissioning	Negative	Moderate	3	2	3	3	3	**33**	**N3**	2	2	3	3	2	**20**	**N2**
				Significance	**N3 - Moderate**							**N2 - Low**						
Impact 4:	*Loss and disturbance of watercourse habitat and fringe vegetation*	Decommissioning	Negative	Moderate	3	2	5	4	4	**56**	**N3**	2	2	3	3	3	**30**	**N2**
				Significance	**N3 - Moderate**							**N2 - Low**						
Impact 5:	*Changes in water quality due to pollution*	Decommissioning	Negative	Moderate	3	2	3	3	3	**33**	**N3**	2	2	3	3	2	**20**	**N2**
				Significance	**N3 - Moderate**							**N2 - Low**						
Impact 6:	*Loss of aquatic biota*	Decommissioning	Negative	Moderate	3	2	3	5	3	**39**	**N3**	2	2	3	4	2	**22**	**N2**
				Significance	**N3 - Moderate**							**N2 - Low**						

6.4. Cumulative Impacts

In terms of drainage the Boesmanpruit, Leeuspruit and Grootspruit watercourses, their tributaries which surround the WEF all ultimately drain into the Vaal River which is a very important and strategic water source of South Africa and all care should be taken to protect the Vaal River from further pollution and other impacts.

Cumulative impacts are assessed by adding anticipated impacts from this proposed development to existing and proposed developments with similar impacts in a 55 km radius. The existing and proposed developments (Figure 19) that were taken into consideration for cumulative impacts include:

- The authorised Tutuka 65.9 MW Solar Photovoltaic (PV) Energy Facility and its associated infrastructure (Ref: 14/12/16/3/3/2/754) located 23km southeast of the site;
- The authorised Forzando North Coal Mine Solar PV Facility, 9.5MW, (Ref: 14/12/16/3/3/1/452) is located 55km northeast of the site; and
- The proposed Impumelelo WEF to be located approximately 25km west of the site.
- The proposed Vhuvhili Solar Energy Facility (NEAS No. MPP/EIA/0001063/2022) located approximately 10km east of the site.

Apart from the two projects listed above, ENERTRAG also intends to develop the proposed Vhuvhili SEF amd Impemolelo WEF which is in close proximity to the proposed Mukondeleli WEF site. This project will be subject to a separate application that will still be submitted, as well as a separate EIA process which must still commence. However, in terms of best practice, the proposed Vhuvhili SEF (Figure 20) is included in the list of projects to be assessed in terms of cumulative impacts. Figure 20 also includes the proposed grid infrastructure of the proposed Vhuvhili SEF and the Mukondeleli WEF which will be confirmed during the separate applications which will be undertaken for these projects.

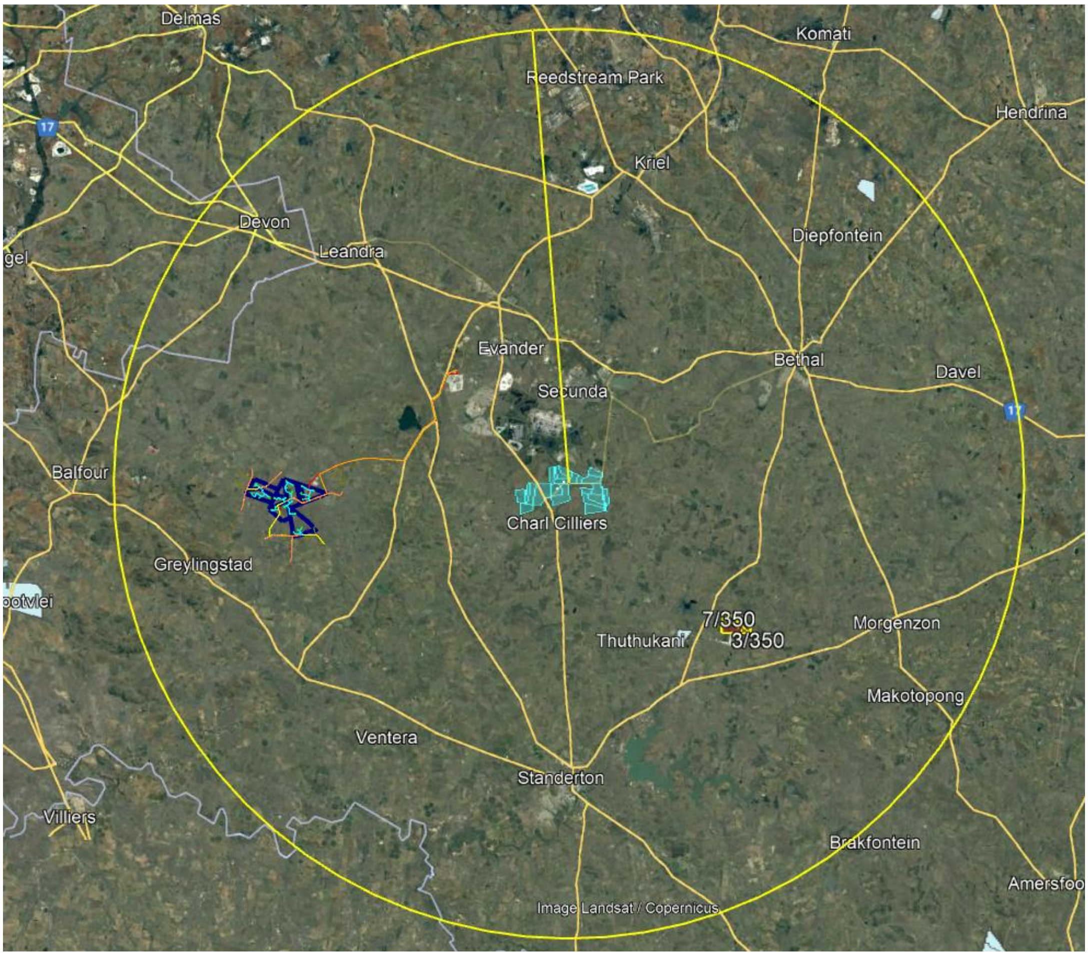


Figure 19: Projects considered within a 55 km radius of the proposed Mukondeleli WEF site for the assessment of cumulative impacts

The grid solutions for the Vhuvhili SEF and proposed Mukondeleli WEF is in design phase but will likely be shared. Research on SEF's environmental impact especially cumulative impacts are still limited (Rudman *et al.,* 2017).

On a landscape level the following are within the 10 km radius of the planned SEF:
Existing

- Agricultural activities;
- Roads;
- Sasol Secunda;
- Town of Secunda

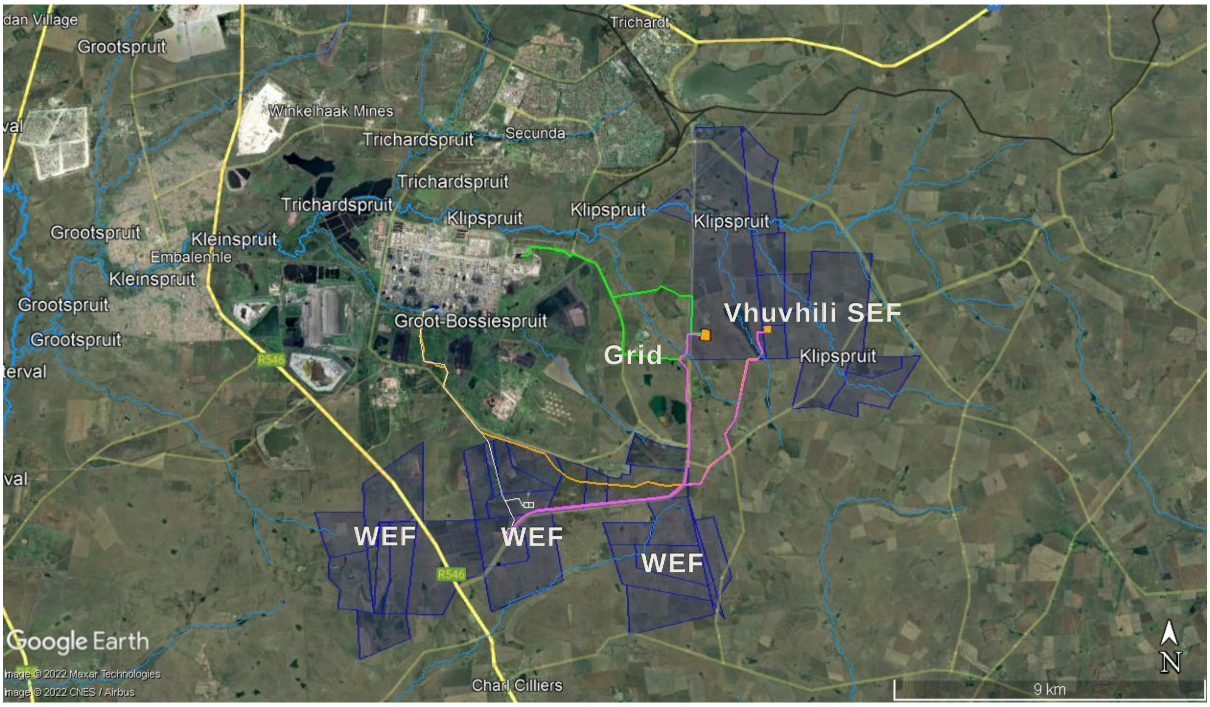


Figure 20: Location of the proposed Vhuvhili SEF, Mukondeleli WEF and proposed grid solutions in relation to the rivers and streams in the area as well as existing impacts

Although the footprint area of the proposed Mukondeleli WEF is known, the grid solutions have not been finalised, it gives an indication of the expected position of the proposed infrastructure within the landscape setting. At a landscape level it is imperative that the WEF design is kept out of the wetlands as well as associated buffer area, as this will ensure that there is a degree of connectivity at a landscape level as the watercourses and tributaries of the Boesmanspruit River and Grootbossiespruit also provide corridors for movement for fauna and insects.

During the construction phase it is likely that vegetative cover as well as disturbance of soil will increase the prevalence of erosion and subsequently the amount of sediment present in the catchment. It is also foreseen that during the construction phase the disturbance caused can increase the spread of alien invasive plant species. It is expected that during the operational phase the impact on hydrological regime will be higher due to the cumulative impacts of the WEF, SEF, grid solutions and supporting infrastructure.

In terms of aquatic biodiversity, the major cumulative impact is thought to be an increase in concentrated flows due to increase in runoff.

6.5. Mitigation Measures

The following mitigation measures as well as best practice measures and other specialist measures should e implemented to reduce potential risk.

Impact 1: Changes in water flow regime

Description	Changes to hydrological function at a landscape level which can arise from changes to flood regimes (e.g. suppression of floods, loss of flood attenuation capacity, unseasonal flooding or destruction of floodplain processes). The extent of the modification in relation to the overall aquatic ecosystem (i.e. at the source, upstream or downstream portion, in the temporary, seasonal, permanent zone of a wetland, in the riparian zone or within the channel of a watercourse, etc.). Changes to base flows (e.g. too little/too much water in terms of characteristics and requirements of system). Fragmentation (e.g. road or pipeline crossing a wetland) and loss of ecological connectivity (lateral and longitudinal).
Mitigation Construction Phase:	• The Wind Energy Structure currently located either within a wetland or within the buffer of a wetland should be moved into nearby impacted areas like agricultural fields • A temporary fence or demarcation must be erected around No-Go Areas outside the proposed works area prior to any construction taking place as part of the contractor planning phase when compiling work method statements to prevent access to the adjacent portions of the watercourse. • Where development activities are located upslope from wetlands, effective stormwater management should be a priority during both construction and operational phase. This should be monitored as part of the EMP. • Where development activities are located upslope from wetlands, high energy stormwater input into the watercourses should be prevented at all cost. • Ideally access roads should be avoided if possible
Mitigation Operational Phase	• The Wind Energy Structure currently located either within a wetland or within the buffer of a wetland should be moved into nearby impacted areas like agricultural fields • Where development activities are located upslope from wetlands, effective stormwater management should be a priority during both construction and operational phase. This should be monitored as part of the EMP. • Effective culverts should be incorporated into the design of access roads.
Mitigation Decommissioning Phase	• Where structures are removed from nearby watercourses care should be taken not to disturb a larger footprint than needed. • Do not increase hardened surfaces and compaction of the soils after the removal of the solar panels and related infrastructure. • Rehabilitation of exposed soil surfaces should commence as soon as practical after completion of removal of removal of the solar panels and related infrastructure. • Culverts must remain in place and must not be removed if the given road is not removed during the decommissioning phase. • Vehicle movement should be restricted to designated decommissioning areas to prevent the increase in hardened surfaces and subsequent increase in runoff.

Impact 2: Changes in sediment entering and exiting the system

Description	Changes in sediment regimes of the aquatic ecosystem and its sub -catchment by for example sand movement, meandering river mouth /estuary, changing flooding or sedimentation patterns
Mitigation Construction Phase:	• The Wind Energy Structure currently located either within a wetland or within the buffer of a wetland should be moved into nearby impacted areas like agricultural fields • Where development is located upslope from wetlands, a temporary fence or demarcation must be erected around No-Go Areas outside the proposed works area prior to any construction taking place as part of the contractor planning phase

	when compiling work method statements to prevent access to the adjacent portions of the watercourse. • Where development is located upslope from wetlands, effective stormwater management including sediment barriers should be a priority during both construction and operational phase. This should be monitored as part of the EMP. • Retain vegetation and soil in position for as long as possible, removing it immediately ahead of construction/earthworks in that area. • Protect all areas susceptible to erosion and ensure that there is no undue soil erosion resultant from activities within and adjacent to the construction camp and work areas. • Monitoring should be done to ensure that sediment pollution is timeously dressed.
Mitigation Operational Phase:	• The Wind Energy Structure currently located either within a wetland or within the buffer of a wetland should be moved into nearby impacted areas like agricultural fields • Where development is located upslope from wetlands, effective stormwater management including sediment barriers should be a priority during both construction and operational phase. This should be monitored as part of the EMP. • Monitoring should be done to ensure that sediment pollution is timeously dressed. •
Mitigation Decommissioning Phase	• Where structures are removed from nearby watercourses care should be taken not to disturb a larger footprint than needed. • Vehicle movement should be restricted to the minimum that is required for decommissioning. Unnecessary movement of vehicles will increase the degradation of paths and dirt roads leading to increased erosion risk. • Progressive rehabilitation must occur. Rehabilitation has to be take place as soon as decommissioning commences to prevent soil erosion. • Monitoring should be done to ensure that sediment pollution is timeously dressed.

Impact 3: Introduction and spread of alien vegetation

Description	The moving of soil and vegetation resulting in opportunistic invasions after disturbance and the introduction of seed in building materials and on vehicles. Invasions of alien plants can impact on hydrology, by reducing the quantity of water entering a watercourse, and outcompete natural vegetation, decreasing the natural biodiversity. Once in a system alien invasive plants can spread through the catchment. If allowed to seed before control measures are implemented alien plans can easily colonise and impact on downstream users
Mitigation Construction Phase:	• The Wind Energy Structure currently located either within a wetland or within the buffer of a wetland should be moved into nearby impacted areas like agricultural fields • Monitor the establishment of alien invasive species within the areas affected by the construction and maintenance and take immediate corrective action where invasive species are observed to establish. • Undertake an Alien Plant Control Plan which specifies actions and measurable targets • Retain vegetation and soil in position for as long as possible, removing it immediately ahead of construction/earthworks in that area and returning it where possible afterwards. • Long-term monitoring for the establishment of alien invasive species within the areas affected by the construction and maintenance and take immediate corrective action where invasive species are observed to establish, as specified in the Alien Vegetation Management Plan. • Rehabilitate or revegetate disturbed areas.
Mitigation Operational Phase:	• Monitor the establishment of alien invasive species within the areas affected by the construction and maintenance and take immediate corrective action where invasive species are observed to establish. • Undertake an Alien Plant Control Plan which specifies actions and measurable targets

	• Retain vegetation and soil in position for as long as possible, removing it immediately ahead of construction/earthworks in that area and returning it where possible afterwards. • Long-term monitoring for the establishment of alien invasive species within the areas affected by the construction and maintenance and take immediate corrective action where invasive species are observed to establish, as specified in the Alien Vegetation Management Plan.
Mitigation Decommissioning Phase	• Monitor the establishment of alien invasive species within the areas affected by the decommissioning and take immediate corrective action where invasive species are observed to establish. • Undertake an Alien Plant Control Plan which specifies actions and measurable targets • Retain vegetation and soil in position for as long as possible, removing it immediately ahead of decommissioning /earthworks in that area and returning it where possible afterwards. • Rehabilitation must occur concurrently with decommissioning. • The mixture of vegetation seed must be used during rehabilitation. The mix must include: Annual and perennial species, pioneer species, species which are indigenous to the area to ensure there is no ecological imbalance in the area. • Long-term monitoring for the establishment of alien invasive species within the areas affected by the construction and maintenance and take immediate corrective action where invasive species are observed to establish, as specified in the Alien Vegetation Management Plan.

Impact 4: Loss and disturbance of watercourse habitat and fringe vegetation

Description	Loss and disturbance of watercourse habitat and fringe vegetation due to direct development on the watercourse as well as changes in management, fire regime and habitat fragmentation.
Mitigation Construction Phase:	• The Wind Energy Structure currently located either within a wetland or within the buffer of a wetland should be moved into nearby impacted areas like agricultural fields • Monitor the establishment of alien invasive species within the areas affected by the construction and take immediate corrective action where invasive species are observed to establish. • Monitor rehabilitation and the occurrence of erosion twice during the rainy season for at least two years and take immediate corrective action where needed. • Operational activities should not take place within watercourses or buffer zones, nor should edge effects impact on these areas. • Operational activities should not impact on rehabilitated or naturally vegetated areas.
Mitigation Operational Phase:	• Amend WEF designs to exclude wetlands as well as buffer areas. • Monitor the establishment of alien invasive species within the areas affected by the construction and take immediate corrective action where invasive species are observed to establish. • Monitor rehabilitation and the occurrence of erosion twice during the rainy season for at least two years and take immediate corrective action where needed. • Operational activities should not take place within watercourses or buffer zones, nor should edge effects impact on these areas. • Operational activities should not impact on rehabilitated or naturally vegetated areas.
Mitigation Decommissioning Phase	• Where structures are removed from nearby watercourses care should be taken not to disturb a larger footprint than needed. • Vehicle movement should eb restricted to the minimum that is required for decommissioning. • Rehabilitation of decommissioned areas must commence concurrently with decommissioning. • Monitor the establishment of alien invasive species within the areas affected by the decommissioning and take immediate corrective action where invasive species are observed to establish.

	• Monitor rehabilitation and the occurrence of erosion twice during the rainy season for at least two years and take immediate corrective action where needed. • Decommissioning activities should not impact on rehabilitated or naturally vegetated areas.

Impact 5: Changes in water quality due to pollution

Description	Changes in water quality due to input of foreign materials e.g. due to increased sediment load, contamination by chemical and /or organic effluent, and /or eutrophication. Construction and operational activities may result in the discharge of solvents and other industrial chemicals, leakage of fuel/oil from vehicles and the disposal of sewage resulting in the loss of sensitive biota in the watercourses and a reduction in watercourse function
Mitigation Construction Phase:	• Provision of adequate sanitation facilities located outside of the watercourse or its associated buffer zone. • Implementation of appropriate stormwater management around the excavation to prevent the ingress of run-off into the excavation and to prevent contaminated runoff into the watercourse. • The development footprint must be fenced off from the watercourses and no related impacts may be allowed into the watercourse i.e. water runoff from cleaning of equipment, vehicle access etc. • Maintenance of construction vehicles/equipment should not take place within the watercourse or watercourse buffer. • Ensure that no operational activities impact on the watercourse or buffer area. This includes edge effects. • Control of waste discharges and do not allow dirty water from operational activities to enter the watercourse. • Regular independent water quality monitoring should form part of operational procedures in order to identify pollution. • Treatment of pollution identified should be prioritized according to best practice guidelines. • Develop norms and standards for the treatment of spills such as oil or hydraulic fluid. Ensure that the required equipment is available on hand to contain any spills. • Appoint a reliable contractor for the removal of refuse during the construction phase.
Mitigation Operational Phase:	• Amend WEF designs to exclude wetlands as well as buffer areas. • Provision of adequate sanitation facilities located outside of the watercourse or its associated buffer zone. • Maintenance of construction vehicles/equipment should not take place within the watercourse or watercourse buffer. • Ensure that no operational activities impact on the watercourse or buffer area. This includes edge effects. • Control of waste discharges and do not allow dirty water from operational activities to enter the watercourse. • Regular independent water quality monitoring should form part of operational procedures in order to identify pollution. • Treatment of pollution identified should be prioritized according to best practice guidelines. • Develop norms and practices for the treatment of spills such as oil or hydraulic fluid. Ensure that the required equipment is available on hand to contain any spills. • Appoint a reliable contractor for the removal of refuse during the operational phase.
Mitigation Decommissioning Phase	• Where structures are removed from nearby watercourses care should be taken not to disturb a larger footprint than needed. • Provision of adequate sanitation facilities located outside of the watercourse or its associated buffer zone. • Maintenance of construction vehicles/equipment should not take place within the watercourse or watercourse buffer. • Ensure that no decommissioning activities impact on the watercourse or buffer area. This includes edge effects.

	• Control of waste discharges and do not allow dirty water from decommissioning activities to enter the watercourse. • Regular independent water quality monitoring should form part of decommissioning procedures in order to identify pollution. • Treatment of pollution identified should be prioritized according to best practice guidelines. • Develop norms and practices for the treatment of spills such as oil or hydraulic fluid. Ensure that the required equipment is available on hand to contain any spills. • Appoint a reliable contractor for the removal of refuse during the operational phase

Impact 6: Loss of aquatic biota

Description	Loss and disturbance of watercourse habitat and fringe vegetation due to direct development on the watercourse as well as changes in management, fire regime and habitat fragmentation.
Mitigation Construction Phase:	• This impact is not easily mitigated. Further loss in diversity can be minimised by following the mitigation measures mentioned above • The Wind Energy Structure currently located either within a wetland or within the buffer of a wetland should be moved into nearby impacted areas like agricultural fields
Mitigation Operational Phase: Mitigation Decommissioning Phase	• This impact is not easily mitigated. Further loss in diversity can be minimised by following the mitigation measures mentioned above

Impact 7: Cumulative Impacts - Changes in water flow regime

Description	Cumulative impacts are assessed by adding anticipated impacts from this proposed development to existing and proposed developments with similar impacts in a 50 km radius. The existing and proposed developments that were taken into consideration for cumulative impacts include: Project 1: Forzando Solar PV project (In process): 9.5 MW Project 2: Tutuka Solar PV project (Approved): 66 MW
Mitigation Construction Phase:	• As described in section 6 • Environmental specialist should be consulted in the planning phase to ensure footprint layout excludes sensitive or no-go areas. • The proposed Vhuvhilli SEF, Mukondeleli WEF and the associated grid solutions should avoid or limit the footprint within watercourses as well as associated buffer areas. • Access roads should be planned to use existing tracks or roads to limit stream crossings, • Monitoring of the aquatic biodiversity as well as watercourses should be conducted on a catchment level to address the cumulative impacts of the SEF, WEF and grid solution. • Ensure that connectivity in the landscape remains.
Mitigation Operational Phase:	• As described in section 6 • The proposed Vhuvhilli SEF, Mukondeleli WEF and the associated grid solutions should avoid or limit the footprint within watercourses as well as associated buffer areas. • Monitoring of the aquatic biodiversity as well as watercourses should be conducted on a catchment level to address the cumulative impacts of the proposed Vhuvhilli SEF, Mukondeleli WEF and the associated grid solution

8. Impact Assessment Summary

Based on the impacts rated in section 7 above it is summarised that the overall impact of the proposed Mukondeleli WEF post mitigation will be low in both the construction as well as operational phases. Should all mitigation measures be adhered to it is also envisaged that the cumulative impacts in both the construction as well as operational phases are considered low (Table 24).

Table 24: Overall Impact Significance (Post Mitigation).

Phase	**Overall Impact Significance**
Construction	Low
Operational	Low
Decommissioning	Low
Nature of Impact	**Overall Impact Significance**
Cumulative - Construction	Low
Cumulative - Operational	Low

9. Legislative and Permit Requirements

It should also be noted that several plant species of conservation concern are known to occur in the area or have been recorded in the study site. These include: *Kniphofia typhoides, Boophone disticha, Hypoxis hemerocallidea, Crinum bulbispermum* and *Eucomis autumnalis.* Prior to the construction phase it is recommended that a botanist check the final Mukondeleli WEF layout footprint and determine if any of the plants will need to be relocated prior to construction. A permit will need to be obtained from the provincial authority prior to the removal or relocation of any of these species.

It is recommended that the terrestrial biodiversity report is also consulted to determine if any additional permits are required. In addition, should any of the alien vegetation, as listed as category 2 under The National Environmental Management: Biodiversity Act (NEMBA), 2004 (Act No. 10 of 2004): Alien and Invasive Species (AIS) Regulations, 2014 (as amended), not be removed a permit will be required for these to remain on site.

10. Conclusion

The desktop assessment indicated that the study site is situated in an area which has conservation significance in both national as well as provincial level.

A large number of wetlands were recorded on the study site. The wetlands were divided into several types including:

- Seepage wetlands;
- Valley Bottom Wetlands; and
- Depressional Pan wetlands.

The wetlands fall into three distinct catchment areas, with wetland 1-8, all located in catchment C12E and all draining into Boesmanspruit System. Furthermore, wetland 7 forms the headwaters of the Boesmanspruit System. Wetland 9 and 10 are located in the catchment C11K and drains into the Leeuspruit System. Lastly the remaining wetlands (Wetland 11-19) all drain into the Grootspruit System. Wetland 20 and 21 are also located in catchment C12E but are hydrologically isolated as pan wetlands that drain inward and does not flow into any neaby wetland system.

Buffer zones were calculated for the wetlands following Macfarlane *et al.,* (2015):

22. Combination of Seepage and Valley Bottom Wetlands – 61 m
23. Unchannelled Valley Bottom – 35 m
24. Seepage – 35m
25. Combination of Seepage and Valley Bottom Wetlands – 79m
26. Seepage – 35m
27. Seepage – 35m
28. Combination of Seepage and Valley Bottom Wetlands – 79m
29. Valley Bottom – 15m
30. Seepage – 35m
31. Seepage - 35m
32. Seepage – 15 m
33. Combination of Seepage and Valley Bottom Wetlands – 61 m
34. Seepage – 15 m
35. Combination of Seepage and Valley Bottom Wetlands – 61 m
36. Combination of Seepage and Valley Bottom Wetlands – 61 m
37. Seepage – 35m
38. Valley Bottom – 61m
39. Seepage – 15 m
40. Seepage – 15 m
41. Depressional Pan - 15m
42. Depressional Pan - 15m

The desktop assessment conducted by DWS indicated that the sub quaternary reaches surrounding the study site are largely natural (B) to moderately modified (C). The site verification indicated that the wetlands are moderately (C) to seriously modified (E) whilst the aquatic macroinvertebrates indicated that the aquatic ecosystems are mostly seriously/critically (E/F) modified with only one tributary of the Grootbossiespruit being largely natural (B). Therefore, the wetland and aquatic ecosystems surrounding the study site are more impacted than expected.

Only one Wind Energy Turbines was found to be recorded within a wetland buffer: MK – 37. The remainder of the structures are well enough buffered to have minimal impacts on the wetlands and although the majority still remain within the DWS regulated area of 500 m, some (MK – 03 , MK – 07, MK – 08 , MK – 09, MK – 25) are located distances of 500 m or more from a wetland and thus has very little chance of impacting on any watercourse.

Prior to the proposed mitigation measures most impacts rated moderate and post mitigation they ranked low in both the construction and operational phase. Cumulative impacts include the impacts of the proposed Mukondeleli WEF in combination with the other projects within a 50 km radius as indicated in Section 6.3 and as illustrated in Figure 19 and Figure 20. Similarly, if the wetlands and buffer zones are excluded, where possible from the proposed Mukondeleli WEF and grid routings (subject to separate applications) as well, the impacts should be reduced significantly.

11. Professional Opinion

If the proposed mitigation measures are adhered to and the design layout of the six Wind Energy Structures that is currently located in wetlands or wetland buffer is moved into degraded areas such as agricultural lands to avoid encroachment on the wetland and wetland buffer zones the proposed development is supported by the specialist.

12. Recommendations

Alternative layouts should be considered where the current footprints encroach into wetlands or wetland buffer zones. It is recommended that monitoring in terms of wetland PES as well as biomonitoring be conducted to consider the cumulative impacts of the proposed Vhuvhili SEF, Mukondeleli WEF as well as the gridline solution (subject to separate applications). Monitoring should be conducted in both the construction and operational phases of the project. It is imperative that an AIS plant management plan be developed for the proposed Mukondeleli WEF prior to the construction phase. Clearing and/treatment of these species occurs prior to any construction activities which will curb the spread of AIS plants due to the disturbance events caused by construction.

13. References

Dallas, H.F. 2007. River Health Programme: South African Scoring System (SASS) data interpretation guidelines. *Report prepared for Institute of Natural Resources and Department of Water Affairs and Forestry.*

De la Rey, P.A., Taylor, J.C., Laas, A., Van Rensburg, L. & Vosloo, A. 2004. Determining the possible application value of diatoms as indicators of general water quality: A comparison with SASS 5. Water SA 30: 325-332.

Department of Water Affairs 2008. Updated Manual for the Identification and Delineation of Wetlands and Riparian areas.

Department of Water Affairs 2010. National Water Act, 1998 (Act No 36 of 1998) S21(c) & (i) Water Uses. Version: February 2010. Training Manual.

Department of Water Affairs and Forestry 1999. Resource Directed Measures for Protection of Water Resources. Volume 4. Wetland Ecosystems Version 1.0. Pretoria

Department of Water Affairs and Forestry 2008. Updated Manual for the identification and delineation of wetlands and riparian areas. Department of Water affairs and Forestry. Pretoria. South Africa Second Edition. September 2008.

Department of Water and Sanitation. 2014. A Desktop Assessment of the Present Ecological State, Ecological Importance and Ecological Sensitivity per Sub Quaternary Reaches for Secondary Catchments in South Africa. Secondary: C2 Compiled by RQIS-RDM: https://www.dwa.gov.za/iwqs/rhp/eco/peseismodel.aspx accessed on [6 January 2021].

Department of Water Affairs and Sanitation 2016 Risk-based Water Use Authorisation Approach and Delegation Protocol for Section 21(c) and (i), Edition 02

Dickens, C.W.S. & Graham, P.M., 2002. The South African Scoring System (SASS) Version 5 Rapid Bioassessment Method for Rivers. African Journal of Aquatic Science 27: 1-10.

Digby Wells. 2015. Wetland Management and Offset Plan Vanchem Vanadium Products. Project Number VVP2685

Ewart-Smith J., Ollis D., Day J. and Malan H. 2006. National Wetland Inventory: Development of a Wetland Classification System for South Africa. Water Research Council project number K8/652

Kleynhans, C.J. 1999. A procedure for the determination of the determination of the ecological reserve for the purpose of the national water balance model for South African Rivers. Institute for Water Quality Studies Department of Water Affairs and Forestry, Pretoria.

Kleynhans, C. J. 2007. Module D: Fish Response Assessment Index (FRAI) in River Ecoclassification: Manual for Ecostatus Determination (Version 2). Joint Water Research Commission and Department of Water Affairs and Forestry report. WRC report nr: TT330/08.

Kleynhans, C.J. & Louw, M.D.,2007. Module A: EcoClassification and EcoStatus determination in River EcoClassification: Manual for EcoStatus Determination (version 2). Joint Water Research Commission and Department of Water Affairs and Forestry report. TT330/08. Water Research Commission. Pretoria.

Kleynhans, C.J. Mackenzie, J. & Louw, M.D., 2007. Riparian Vegetation Response Index in River EcoClassification: Manual for EcoStatus Determination (Version 2). Joint Water Research Commission and Department of Water Affairs and Forestry report. WRC report nr: TT333/08. Water Research Commission. Pretoria.

Kotze D C, 1999. A system for supporting wetland management decisions. Ph.D. thesis. School of Applied Environmental Sciences, University of Natal, Pietermaritzburg.

Kotze, D., Macfarlane, D. & Edwards, R. 2020. WET-EcoServices (Version 2): A technique for rapidly assessing ecosystem services supplied by wetlands and riparian areas. Final Report. WRC Project K5/2737.

Le Maitre, D.C., Seyler, H., Holland, M., Smith-Adao, L.B., Nel, J.L., Maherry, A. & Witthüser, K., 2018. Identification, Delineation and Importance of the Strategic Water Source Areas of South Africa, Lesotho and Swaziland for Surface Water and Groundwater, WRC Report No TT 754/1/18, Water Research Commission, Pretoria, South Africa.

Lötter, M.C., Cadman, M.J. & Lechmere-Oertel, R.G. 2014. Mpumalanga biodiversity sector plan handbook. Mpumalanga Tourism and Parks Agency, Mbombela (Nelspruit).

Macfarlane D.M., Kotze D.C., Ellery W.N., Walters D, Koopman V, Goodman P & Goge C. 2008. WET-Health: A technique for rapidly assessing wetland health. Water Research Commission, Pretoria. WRC Rport TT340/08 February 2008

Macfarlane, D.M., Ollis, D.J. & Kotze, D.C. 2020. WET-Health (Version 2.0): A Refined suite of tools for assessing the present ecological state of wetland ecosystems – Technical Guide. WRC Report No. TT 820/20.

Macfarlane D.M., Teixeira-Leite A., Goodman P., Bate G and Colvin C. 2015 Report on the Development of a Method and Model for Buffer Zone Determination. Water Research Commission project K5/1789. The Institute of Natural Resources and its Associates

Mcmilan, P.H., 1998. An Integrated Habitat Assessment System (IHAS v2) for the Rapid Biological Assessment of Rivers and Streams. A CSIR research project. Number ENV-P-I 98132 for the water resources management programme. CSIR.

Mucina L., & Rutherford M. C. 2006. Vegetation Map of South Africa, Lesotho and Swaziland, 1:1 000 000 scale sheet maps. South African National Biodiversity Institute., Pretoria.

Nel, J.L., Murray, K.M., Maherry, A.M., Petersen, C.P., Roux, D.J., Driver, A., Hill, L., Van Deventer, H., Funke, N., Swartz, E.R., Smith-Adao, L.B., Mbona, N., Downsborough, L. & Nienaber, S. 2011. Technical Report for the Freshwater Ecosystem Priority Areas Project. WRC Report No. 1801/2/11. Water Research Commission, Pretoria.

Ollis, D., Snaddon, K., Job. N. & Mbona. N. 2013. Classification System for Wetland and Other Aquatic Ecosystems in South Africa. User Manual: Inland Systems. Pretoria, South Africa: SANBI.

River Health Programme (RHP). 2005. State-of-Rivers Report: Monitoring and Managing the Ecological State of Rivers in the Crocodile (West) and Marico Water Management Area. Department of Water Affairs and Forestry, Pretoria, South Africa.

RSA (Republic of South Africa). 2011. National Environmental Management: Biodiversity Act (10/2004): National list of ecosystems that are threatened and in need of Protection. Government Gazette, South Africa 1002 (34809).

Rudman, J., Gauche, P. & Esler, K.J. 2017. Direct environmental impacts of solar power in two arid biomes: An initial investigation. South African Journal of Science, 113: 1-13.

Seaman M.T., Avenant M.F., Watson M., King J., Armour J., Barker C.H., Dollar E., du Preez P.J., Hughes D., Rossouw L., & van Tonder G. 2010. Developing a Method for Determining the Environmental water Requirements for Ephemeral Systems. Water Research Commission, Pretoria, Report No. TT459/10.

Schultze R.E. 1997. South African Atlas of Agrohydrology and Climatology. Water Research Commission, Pretoria, Report TT82/96

Skowno, A.L., Poole, C.J., Raimondo, D.C., Sink, K.J., Van Deventer, H., Van Niekerk, L., Harris, L.R., Smith-Adao, L.B., Tolley, K.A., Zengeya, T.A., Foden, W.B., Midgley, G.F. & Driver, A., 2019. National Biodiversity Assessment 2018: The status of South Africa's ecosystems and biodiversity. Synthesis Report. South African National Biodiversity Institute, an entity of the Department of Environment, Forestry and Fisheries, Pretoria.pp. 1–214.

Taylor, J.C., 2004. The Application of Diatom-Based Pollution Indices in the Vaal Catchment. Unpublished M.Sc. thesis, North-West University, Potchefstroom Campus, Potchefstroom.

Thirion, C., 2007. Module E: Macroinvertebrate Response Assessment Index in River EcoClassification: Manual for EcoStatus Determination (version 2). Joint Water Research Commission and Department of Water Affairs and Forestry report. WRC Report. Water Research Commission. Pretoria.

Van Deventer, H., Smith-Adao, L., Mbona, N., Petersen, C., Skowno, A., Collins, N.B., Grenfell, M., Job, N., Lötter, M., Ollis, D., Scherman, P., Sieben, E. & Snaddon, K., 2019. South African National Biodiversity Assessment. 2018. Technical Report. Volume 2a: South African Inventory of Inland Aquatic Ecosystems (SAIIAE). Version 3, final released on 3 October 2019. Council for Scientific and Industrial Research (CSIR) and South African National Biodiversity Institute (SANBI): Pretoria, South Africa. Report Number: CSIR report number CSIR/NRE/ECOS/IR/2018/0001/A; SANBI report number http://hdl.handle.net/20.500.12143/5847.

Wet-Earth 2020. Wetland Management Plan for Sasol Secunda Industrial Complex and Surroundings. Vendor No.40736. FINAL.

Appendices

LORAINMARI DEN BOOGERT

Contact: +27 722 006244
Email: lorain@iggdrasilscientific.com
Languages: English, Afrikaans, Dutch

Career Highlights

DIRECTOR, ECOLOGIST
Iggdrasil Scientific Services **Jan 2012 – Present**
A medium sized enterprise specialising in ecological assessments, covering fauna, flora, wetland and aquatic ecosystems.

PLANT ECOLOGIST
GEM – Science, South Africa **Oct 2010 – Jan 2012**
A medium sized enterprise providing comprehensive geological and environmental consulting service for the mining industry.

JUNIOR ENVIRONMENTAL CONSULTANT
Bokamoso Environmental Consultants, SA **Jan 2010 – Oct 2010**

PROJECT RESEARCH ASSISTANT
Abiotic Research Group, Alterra, Wageningen, The Netherlands **Jan 2009 – Jun 2009**

BOTANY DEMONSTRATOR
University of Pretoria, Plant Sciences, SA **Jul 2008 – Nov 2008**

FIELD ASSISTANT
University of Pretoria, Zoology, SA **Nov 2007 – Feb 2007**

PROJECT RESEARCH ASSISTANT
University of Pretoria, Zoology, SA **Jan 2006 – Aug 2006**

Education and Training

Degrees

- **Master of Science in Geohydrology** **2022**
  University of the Free State, Bloemfontein, SA
- **Master of Science Plant Science** **2010**
  Wageningen University, The Netherlands and University of Pretoria, SA
- **Bachelor of Science (Honours) Plant Science (Cum Laude)** **2008**
  University of Pretoria, SA
- **Bachelor of Science Ecology** **2007**
  University of Pretoria, SA

Certificates and Accreditations

- **SASS5 Accreditation (freshwater Aquatic Zoology)** **2017, 2014, 2011**
  Department of Water Affairs, SA

Additional Courses

- Asteraceae ID course, by Paul Herman from SANBI's National Herbarium at the University of Pretoria, Department of Plant and Soil Sciences. 2018
- MIRAI (Macro invertebrate Response Assessment Index), Department of Water and Sanitation 2016
- Invasive Species and Herbicide Training, South African Green Industries Council (SAGIC) 2016
- A rapid method for water quality assessment, Nepid Consultants, Sabie 2011
- EIA water use authorisation and waste management activity licences, CBSS, Pretoria 2011
- Tools for wetland assessment, Rhodes University, Grahamstown 2011
- Inventory and survey methods for invasive plants, Online Course, Department of land resource of environmental Sciences, Montana State University, Bozeman, Montana. 2009

Conference Presentations

- **Course Presenter: Riparian Vegetation Assessment Methods for DWS** **2017**
  Department of Water and Sanitation, DWS, Roodeplaat
- **Conservation Planning in Urban Open Spaces** **2016**
  Botanical Society, Pretoria
- **The Vegetation ecology of Seringveld Conservancy, Cullinan South Africa** **2010**
  South African Association of Botanist's Annual Conference, Potchefstroom
- **A comparison between Ellenberg and Wamelink Biological indicator values** **2009**
  Wageninen Abiotic Research Group, Alterra Annual Conference, Wageningen, The Netherlands
- **The effect of the higher energy flow in the Ash River System, Bethlehem, SA** **2003**
  Stockholm International Youth Science Seminar, Sweden
- **The youth of South Africa would like to see underground water pollution addresses in light of the international summit for sustainable development** **2003**
  Water institute of South Africa, Annual Conference, Durban

Achievements

- Selected for the J.P. Morgan, Groundswell, Business Accelerator programme for an 18 month business mentorship
- Board member of the South African Botanical Society Pretoria Branch
- Selected for an exchange program to the University of Wageningen as part of my MSc studies.
- Overall Winner and gold medallist of the Eskom Expo for Young Scientist, representing south Africa in the Stockholm Sweden at the Stockholm international youth seminar
- Winner of the South Africa youth water prize of the department of water affairs and represented South Africa at the international youth water prize during world water week in Stockholm Sweden.

Membership & Associations

- South African Council of Natural Scientific Professions - Registered Professional Scientist (Pr.Sci.Nat: 400003/13),
- South African Association for Botanists,
- South African Botanical Society,
- South African Society for Aquatic Scientist,
- **Full project list and references available on request**

ANTOINETTE BOOTSMA nee van Wyk

ID Number 7604250013088

Name of Firm: Limosella Consulting

SACNASP Status: Professional Natural Scientist # 400222-09 Botany and Ecology

---

EDUCATIONAL QUALIFICATIONS

- MSc Ecology, University of South Africa (2017) Awarded with distinction. Project Title: Natural mechanisms of erosion prevention and stabilization in a Marakele peatland; implications for conservation management
- Short course in wetland soils, Terrasoil Science (2009)
- Short course in wetland delineation, legislation and rehabilitation, University of Pretoria (2007)
- B. Sc (Hons) Botany, University of Pretoria (2003-2005). Project Title: A phytosociological Assessment of the Wetland Pans of Lake Chrissie
- B. Sc (Botany & Zoology), University of South Africa (1997 - 2001)

PUBLICATIONS

- A.A. Boostma, S. Elshehawi, A.P. Grootjans, P.L Grundling, S. Khosa. *In Press.* Ecohydrological analysis of the Matlabas Mountain mire, South Africa. Mires and Peat
- P.L. Grundling, A Lindstrom., M.L. Pretorius, A. Bootsma, N. Job, L. Delport, S. Elshahawi, A.P Grootjans, A. Grundling, S. Mitchell. 2015. Investigation of Peatland Characteristics and Processes as well as Understanding of their Contribution to the South African Wetland Ecological Infrastructure Water Research Comission KSA 2: K5/2346
- A.P. Grootjans, A.J.M Jansen , A, Snijdewind, P.C. de Hullu, H. Joosten, A. Bootsma and P.L. Grundling. (2014). In search of spring mires in Namibia: the Waterberg area revisited. Mires and Peat. Volume 15, Article 10, 1–11, http://www.mires-and-peat.net/, ISSN 1819-754X © 2015 International Mire Conservation Group and International Peat Society
- Haagner, A.S.H., van Wyk, A.A. & Wassenaar, T.D. 2006. *The biodiversity of herpetofauna of the Richards Bay Minerals leases.* CERU Technical Report 32. University of Pretoria.
- van Wyk, A.A., Wassenaar, T.D. 2006. *The biodiversity of epiphytic plants of the Richards Bay Minerals leases.* CERU Technical Report 33. University of Pretoria.
- Wassenaar, T.D., van Wyk, A.A., Haagner, A.S.H, & van Aarde, R.J.H. 2006. *Report on an Ecological Baseline Survey of Zulti South Lease for Richards Bay Minerals*. CERU Technical Report 29. University of Pretoria

KEY EXPERIENCE

The following projects provide an example of the application of wetland ecology on strategic as well as fine scale as well as its implementation into policies and guidelines. (This is not a complete list of projects completed, rather an extract to illustrate diversity);

- More than 90 external peer reviews as part of mentorship programs for companies including Gibb, Galago Environmental Consultants, Lidwala Consulting Engineers, Bokamoso Environmental Consultants, 2009 ongoing
- More than 300 fine scale wetland and ecological assessments in Gauteng, Mpumalanga, KwaZulu Natal, Limpopo and the Western Cape 2007, ongoing
- Strategic wetland specialist input into the Open Space Management Framework for Kyalami and Ruimsig, City of Johannesburg, 2016
- Fine scale wetland specialist input into the ESKOM Bravo Integration Project 3, 4, 5 and Kyalami – Midrand Strengthening.
- Wetland/Riparian delineation and functional assessment for the proposed maintenance work of the rand water pipelines and valve chambers exposed due to erosion in Casteel A, B and C in Bushbuckridge Mpumalanga Province
- Wetland/Riparian delineation and functional assessment for the Proposed Citrus Orchard Establishment, South of Burgersfort (Limpopo Province) and North of Lydenburg (Mpumalanga Province).
- Scoping level assessment to inform a proposed railway line between Swaziland and Richards Bay. April 2013.
- Environmental Control Officer. Management of onsite audit of compliance during the construction of a pedestrian bridge in Zola Park, Soweto, Phase 1 and Phase 2. Commenced in 2010, ongoing.
- Fine scale wetland delineation and functional assessments in Lesotho and Kenya. 2008 and 2009;
- Analysis of wetland/riparian conditions potentially affected by 14 powerline rebuilds in Midrand, Gauteng, as well submission of a General Rehabilitation and Monitoring Plan. May 2013.
- Wetland specialist input into the Environmental Management Plan for the upgrade of the Firgrove Substation, Western Cape. April 2013
- An audit of the wetlands in the City of Johannesburg. Specialist studies as well as project management and integration of independent datasets into a final report. Commenced in August 2007
- Input into the wetland component of the Green Star SA rating system. April 2009;
- A strategic assessment of wetlands in Gauteng to inform the GDACE Regional Environmental Management Framework. June 2008.
- As assessment of wetlands in southern Mozambique. This involved a detailed analysis of the vegetation composition and sensitivity associated with wetlands and swamp forest in order to inform the development layout of a proposed resort. May 2008.
- An assessment of three wetlands in the Highlands of Lesotho. This involved a detailed assessment of the value of the study sites in terms of functionality and rehabilitation opportunities. Integration of the specialist reports socio economic, aquatic, terrestrial and wetland ecology studies into a final synthesis. May 2007.

- Ecological studies on a strategic scale to inform an Environmental Management Framework for the Emakazeni Municipality and an Integrated Environmental Management Program for the Emalahleni Municipality. May and June 2007

RUDI BEZUIDENHOUDT

880831 5038 081
Limosella Consulting
Wetland Specialist
Pr.Sci.Nat (008867)
South African
Single
Afrikaans (mother tongue), English

EDUCATIONAL QUALIFICATIONS

- B.Sc. (Botany & Zoology), University of South Africa (2008 - 2012)
- B.Sc. (Hons) Botany, University of South Africa (2013 – 2015)
- M.sc Aquatic Ecology, University of Johannesburg (2017-)
- Introduction to wetlands, Gauteng Wetland Forum (2010)
- Biomimicry and Constructed Wetlands. Golder Associates and Water Research Commission (2011)
- Wetland Rehabilitation Principles, University of the Free State (2012)
- Tools for Wetland Assessment, Rhodes University (2011)
- Wetland Legislation, University of Free-State (2013)
- Understanding Environmental Impact Assessment, WESSA (2011)
- SASS 5, Groundtruth (2012)
- Wetland Operations and Diversity Management Master Class, Secolo Consulting Training Services (2015)
- Tree Identification, Braam van Wyk – University of Pretoria (2015)
- Wetland Buffer Legislation – Eco-Pulse & Water Research Commission (2015)
- Wetland Seminar, ARC-ISCW & IMCG (2011)
- Invasive Species Training, SAGIC (2016)

KEY EXPERIENCE

WETLAND SPECIALIST

This entails all aspects of scientific investigation associated with a consultancy that focuses on wetland specialist investigations. This includes the following:

- Approximately 200+ specialist investigations into wetland and riparian conditions on strategic, as well as fine scale levels in Gauteng, Limpopo, North-West Province Mpumalanga KwaZulu Natal, North-West Province, Western Cape, Eastern Cape & Northern Cape
- Ensuring the scientific integrity of wetland reports including peer review and publications.

Major Projects Involve:

- Numerous Eskom Powerline Projects some spanning more than one Province.
- Proposed New Kruger National Camp and Infrastructure (2016)
- Numerous Mining Projects
- Numerous Water infrastructure upgrades
- Numerous Residential and Housing Developments

BIODIVERSITY ACTION PLAN
This entails the gathering of data and compiling of a Biodiversity action plan.

WETLAND REHABILITATION
This entailed the management of wetland vegetation and rehabilitation related projects in terms of developing proposals, project management, technical investigation and quality control.

COURSES PRESENTED
- Riparian Vegetation Response Assessment Index (VEGRAI) Training presented to DWA (2017)
- Numerous Wetland Talks

WETLAND ECOLOGY
Experience in the delineation and functional assessment of wetlands and riparian areas in order to advise proposed development layouts, project management, report writing and quality control.

ENVIRONMENTAL CONTROL OFFICER:
Routine inspection of construction sites to ensure compliance with the City's environmental ordinances, the Environmental Management Program and other laws and by-laws associated with development at or near wetland or riparian areas.
- Soweto Zola Park 2011-2013
- Orange Farm Pipeline 2010-2011

WETLAND AUDIT:
Audit of Eskom Kusile power station to comply with the Kusile Section 21G Water Use Licence (Department of Water Affairs, Licence No. 04/B20F/BCFGIJ/41, 2011), the amended Water Use Licence (Department of water affairs and forestry, Ref. 27/2/2/B620/101/8, 2009) and the WUL checklist provided by Eskom.
- Kusile Powerstation 2012-2013.

INVASIVE SPECIES CONTROL PLAN

Libradene Filling Station, Boksburg, Gauteng

PUBLICATIONS
Bezuidenhoudt. R., De Klerk. A. R., Oberholster. P.J. (2017). Assessing the ecosystem processes of ecological infrastructure on post-coal mined land. COALTECH RESEARCH ASSOCIATION NPC. University of South Africa. Council for Scientific Industrial Research.

Employee Experience:
GIS Specialist – AfriGIS
January 2008 – August 2010
Tasks include:
- GIS Spatial layering
- Google Earth Street View Mapping
- Data Input

Wetland Specialist - Limosella Consulting
September 2010 – Ongoing
Tasks include:
- Wetland and Riparian delineation studies, opinions and functional assessments including data collection and analysis.
- Rehabilitation Reports
- Invasive species surveys and control plans
- Correspondence with stakeholders, clients, authorities and specialists.
- Presentations to stakeholders, clients and specialists.
- Project management.
- Planning and executing of fieldwork.
- Analysis of data.
- GIS spatial representation.

- Submission of technical reports containing management recommendations.
- General management of the research station and herbarium.
- Regular site visits.
- Attendance of monthly meetings
- Submission of monthly reports.

MEMBERSHIPS IN SOCIETIES

- Botanical Society of South African
- SAWS (South African Wetland Society) Founding member
- SACNASP (Reg. No. 500024/13)

ANDRÉ STRYDOM

Aquatic Ecologist

Specialisation

Aquatic biomonitoring, aquatic specialist biodiversity assessments, design of surface water monitoring programs, toxicity testing and nature reserve management.

Total years of environmental experience

13 years

Employment History

- 2019 - Present: Environmental and Aquatic Specialist (Enviro Elements)
- 2011 - 2018: Environmental Consultant and Laboratory manager
- 2016 – 2018: Aquatic Ecologist and Project Manager (Clean Stream Biological Services)
- 2013 - 2016: Fieldwork Manager (Clean Stream Biological Services) and
- 2013 - 2015: LaboratoryManager (Biotox Laboratory Services)
- 2011 - 2012: Junior Environmental Scientist (Clean Stream Biological services)
- 2007 - 2010: Assistant Reserve Manager (Doornkop Fish and Wildlife Reserve)

Professional Experience

- Conducting of aquatic and biodiversity specialist assessments.
- Acute and Chronic Toxicity testing of water and soil samples

Academic history

- 2014: B. Tech. Nature Conservation, University of South Africa
- 2006: National Diploma in Nature Conservation, Tshwane University of Technology2002: Matriculate, Nelspruit High School

General

- SASS5 Accredited
- Skippers licence, category R vessel (Power driven <9m)

Most relevant experience

- Aquatic baseline assessments for proposed new hydro power stations in Zambia.
- Aquatic biomonitoring on Orange River for Kakamas Hydro Power Station, South Africa.
- Aquatic Impact Assessment for proposed new alluvial diamond mine in Schmidtsdrif
- Aquatic Biomonitoring for one of a graphite mine in Northern Mozambique
- Aquatic Biomonitoring for Grootvlei Power Station
- Biomonitoring of the Leragane and Elands Rivers
- Biomonitoring of the Modder River
- Biomonitoring of the Seeikoei River
- Freshwater fish specialist study. In Environmental Impact Assessment: Mining Right application.

- Alluvial Diamond Mining at Rooipoort Private Nature Reserve
- Biomonitoring of the Hex River catchment in the vicinity of Anglo Platinum
- Biomonitoring of the Modderfonteinspruit in the area of Kelvin Power Station
- Biomonitoring of the Crocodile River in the Thabazimbi area
- Biomonitoring of receiving water bodies in the Rasimone Platinum mining area (Elands River catchment)
- Biomonitoring of the Bierspruit and Crocodile River in the vicinity of Northam.
- Biomonitoring of the Greensidespruit / Naauwpoortspruit catchments
- Biomonitoring of the Vaal River catchment (Vaal River & West Wits operations)
- Biomonitoring of the Luvuvhu and Mutale Rivers in the vicinity of Tsikondeni Mine
- Biodiversity assessment programme, Xstrata Eastern mines
- Biomonitoring of the Hex River catchment in the vicinity of Xstata Kroondal
- Biomonitoring of Selected Rivers (Receiving Water Bodies) in the Komati catchment
- Biomonitoring of the Olifants catchment, Mpumulanga
- Biomonitoring of the Bierspruit and Crocodile River in the vicinity of Thabazimbi
- Biomonitoring of the Klein-Olifants catchment, Mpumulanga
- Aquatic biomonitoring of Olifants River and Witbank Dam in the vicinity of Duvha Power

Prior to commencing with the specialist assessment in accordance with Appendix 6 of the National Environmental Management Act (Act 107 of 1998, as amended) (NEMA) Environmental Impact Assessment (EIA) Regulations of 2014, a site sensitivity verification was undertaken in order to confirm the current land use and environmental sensitivity of the proposed project area as identified by the National Web-Based Environmental Screening Tool (Screening Tool).

The details of the site sensitivity verification are noted below:

Date of Site Visit	1st to 4th of February 2022
Specialist Name	Rudi Bezuidenhout
Professional Registration Number	Pr.Sci.Nat (008867)
Specialist Affiliation / Company	Limosella Consulting

- Provide a description on how the site sensitivity verification was undertaken using the following means:

  (a) Desktop analysis, using satellite imagery as well as databases listed in Table 5 and Table 6 ;
  (b) National Web Based Screening Tool Results for aquatic ecosystems;
  (c) In field site inspection; and
  (d) Previous specialist reports wetland and aquatic on monitoring of wetlands and aquatic ecosystems for Sasol, Secunda.

It is important to note that a full assessment was conducted and not the site verification only as the aquatic ecosystems surrounding the proposed WEF based on the screening tool had a high sensitivity. The methods described in Appendix F were used during the site inspection. The outcome of the site verification indicated that wetlands were moderately to seriously modified and aquatics. The results of the site inspection are included in section 4.2 of this report.

The desktop assessment conducted by DWS indicated that the sub quaternary reaches surrounding the study site are largely natural (B) to moderately modified (C). The site verification indicated that the wetlands are moderately (C) to seriously modified (E) whilst the aquatic macroinvertebrates indicated that the aquatic ecosystems are mostly seriously/critically (E/F) modified with only one tributary of the Grootbossiespruit being largely natural (B). Therefore, the wetland and aquatic ecosystems surrounding the study site are more impacted than expected.

Although the wetland and aquatic ecosystems are impacted, they still fulfil important ecosystem services and also form part of national and provincial conservation targets and therefore are still considered as sensitive
Although the wetland and aquatic ecosystems are impacted, they still fulfil important ecosystem services and also form part of national and provincial conservation targets and therefore are still considered as sensitive. The significance rating of high as assigned by the Screening Tool for Aquatic Biodiversity (Figure 18) is therefore supported by the specialist.

<u>Impact Assessment Methodology</u>

The Impact Assessment Methodology was supplied to the specialsit by WSP.

<u>High-Level Screening of Impacts and Mitigation</u>

Appendix 2 of GNR 982, as amended, requires the identification of the significance of potential impacts during scoping. To this end, an impact screening tool has been used in the scoping phase. The screening tool is based on two criteria, namely probability; and, consequence (Table 25**,** Table 26**,** Table 27), where the latter is based on general consideration to the intensity, extent, and duration.

The scales and descriptors used for scoring probability and consequence are detailed in Table 25 and Table 26 respectively.

Table 25: Probability Scores and Descriptors

Score	Descriptor
4	Definite: The impact will occur regardless of any prevention measures
3	Highly Probable: It is most likely that the impact will occur
2	Probable: There is a good possibility that the impact will occur
1	Improbable: The possibility of the impact occurring is very low

Table 26: Consequence Score Descriptions

Score	Negative	Positive
4	Very severe: An irreversible and permanent change to the affected system(s) or party(ies) which cannot be mitigated.	Very beneficial: A permanent and very substantial benefit to the affected system(s) or party(ies), with no real alternative to achieving this benefit.
3	Severe: A long term impacts on the affected system(s) or party(ies) that could be mitigated. However, this mitigation would be difficult, expensive or time consuming or some combination of these.	Beneficial: A long term impact and substantial benefit to the affected system(s) or party(ies). Alternative ways of achieving this benefit would be difficult, expensive or time consuming, or some combination of these.
2	Moderately severe: A medium to long term impacts on the affected system(s) or party (ies) that could be mitigated.	Moderately beneficial: A medium to long term impact of real benefit to the affected system(s) or party(ies). Other ways of optimising the beneficial effects are equally difficult, expensive and time consuming (or some combination of these), as achieving them in this way.
1	Negligible: A short to medium term impacts on the affected system(s) or party(ies). Mitigation is very easy, cheap, less time consuming or not necessary.	Negligible: A short to medium term impact and negligible benefit to the affected system(s) or party(ies). Other ways of optimising the beneficial effects are easier, cheaper and quicker, or some combination of these.

Table 27: Significance Screening Tool

	Consequence Scale				
Probability Scale		1	2	3	4
	1	Very Low	Very Low	Low	Medium
	2	Very Low	Low	Medium	Medium
	3	Low	Medium	Medium	High
	4	Medium	Medium	High	High

The nature of the impact must be characterised as to whether the impact is deemed to be positive (+ve) (i.e. beneficial) or negative (-ve) (i.e. harmful) to the receiving environment/receptor. For ease of reference, a colour reference system (Table 28) has been applied according to the nature and significance of the identified impacts.

Table 28: Impact Significance Colour Reference System to Indicate the Nature of the Impact

Negative Impacts (-ve)	Positive Impacts (+ve)
Negligible	Negligible
Very Low	Very Low
Low	Low
Medium	Medium
High	High

Assessment of Impacts and Mitigation

The assessment of impacts and mitigation evaluates the likely extent and significance of the potential impacts on identified receptors and resources against defined assessment criteria, to develop and describe measures that will be taken to avoid, minimise or compensate for any adverse environmental impacts, to enhance positive impacts, and to report the significance of residual impacts that occur following mitigation.

The key objectives of the risk assessment methodology are to identify any additional potential environmental issues and associated impacts likely to arise from the proposed project, and to propose a significance ranking. Issues / aspects will be reviewed and ranked against a series of significance criteria to identify and record interactions between activities and aspects, and resources and receptors to provide a detailed discussion of impacts. The assessment considers direct1, indirect2, secondary3 as well as cumulative4 impacts.

A standard risk assessment methodology is used for the ranking of the identified environmental impacts pre-and post-mitigation (i.e. residual impact). The significance of environmental aspects is determined and ranked by considering the criteria5 presented in Table 29

Impact Significance Colour Reference System to Indicate the Nature of the Impact

Table 29: Impact Assessment Criteria and Scoring System

CRITERIA	SCORE 1	SCORE 2	SCORE 3	SCORE 4	SCORE 5
Impact Magnitude (M) The degree of alteration of the affected environmental receptor	Very low: No impact on processes	Low: Slight impact on processes	Medium: Processes continue but in a modified way	High: Processes temporarily cease	Very High: Permanent cessation of processes
Impact Extent (E) The geographical extent of the impact on a given environmental receptor	Site: Site only	Local: Inside activity area	Regional: Outside activity area	National: National scope or level	International: Across borders or boundaries

[1] Impacts that arise directly from activities that form an integral part of the Project.
[2] Impacts that arise indirectly from activities not explicitly forming part of the Project.
[3] Secondary or induced impacts caused by a change in the Project environment.
[4] Impacts are those impacts arising from the combination of multiple impacts from existing projects, the Project and/or future projects.
[5] The definitions given are for guidance only, and not all the definitions will apply to all the environmental receptors and resources being assessed. Impact significance was assessed with and without mitigation measures in place.

Impact Reversibility (R) The ability of the environmental receptor to rehabilitate or restore after the activity has caused environmental change	Reversible: Recovery without rehabilitation		Recoverable: Recovery with rehabilitation		Irreversible: Not possible despite action
Impact Duration (D) The length of permanence of the impact on the environmental receptor	Immediate: On impact	Short term: 0-5 years	Medium term: 5-15 years	Long term: Project life	Permanent: Indefinite
Probability of Occurrence (P) The likelihood of an impact occurring in the absence of pertinent environmental management measures or mitigation	Improbable	Low Probability	Probable	Highly Probability	Definite
Significance (S) is determined by combining the above criteria in the following formula:	$[S = (E + D + R + M) \times P]$ $Significance = (Extent + Duration + Reversibility + Magnitude) \times Probability$				
IMPACT SIGNIFICANCE RATING					
Total Score	4 to 15	16 to 30	31 to 60	61 to 80	81 to 100
Environmental Significance Rating (Negative (-))	Very low	Low	Moderate	High	Very High
Environmental Significance Rating (Positive (+))	Very low	Low	Moderate	High	Very High

Impact Mitigation

The impact significance without mitigation measures will be assessed with the design controls in place. Impacts without mitigation measures in place are not representative of the proposed development's actual extent of impact and are included to facilitate understanding of how and why mitigation measures were identified. The residual impact is what remains following the application of mitigation and management measures and is thus the final level of impact associated with the development. Residual impacts also serve as the focus of management and monitoring activities during Project implementation to verify that actual impacts are the same as those predicted in this report.

The mitigation measures chosen are based on the mitigation sequence/hierarchy which allows for consideration of five (5) different levels, which include avoid/prevent, minimise, rehabilitate/restore, offset and no-go in that order. The idea is that when project impacts are considered, the first option should be to avoid or prevent the impacts from occurring in the first place if possible, however, this is not always feasible. If this is not attainable, the impacts can be allowed, however they must be minimised as far as possible by considering reducing the footprint of the development for example so that little damage is encountered. If impacts are unavoidable, the next goal is to rehabilitate or restore the areas impacted back to their original form after project completion. Offsets are then considered if all the other measures described above fail to remedy high/significant residual negative impacts. If no offsets can be achieved on a potential impact, which results in full destruction of any ecosystem for example, the no-go option is considered so that another activity or location is considered in place of the original plan.
The mitigation sequence/hierarchy is shown in Figure 21 below.

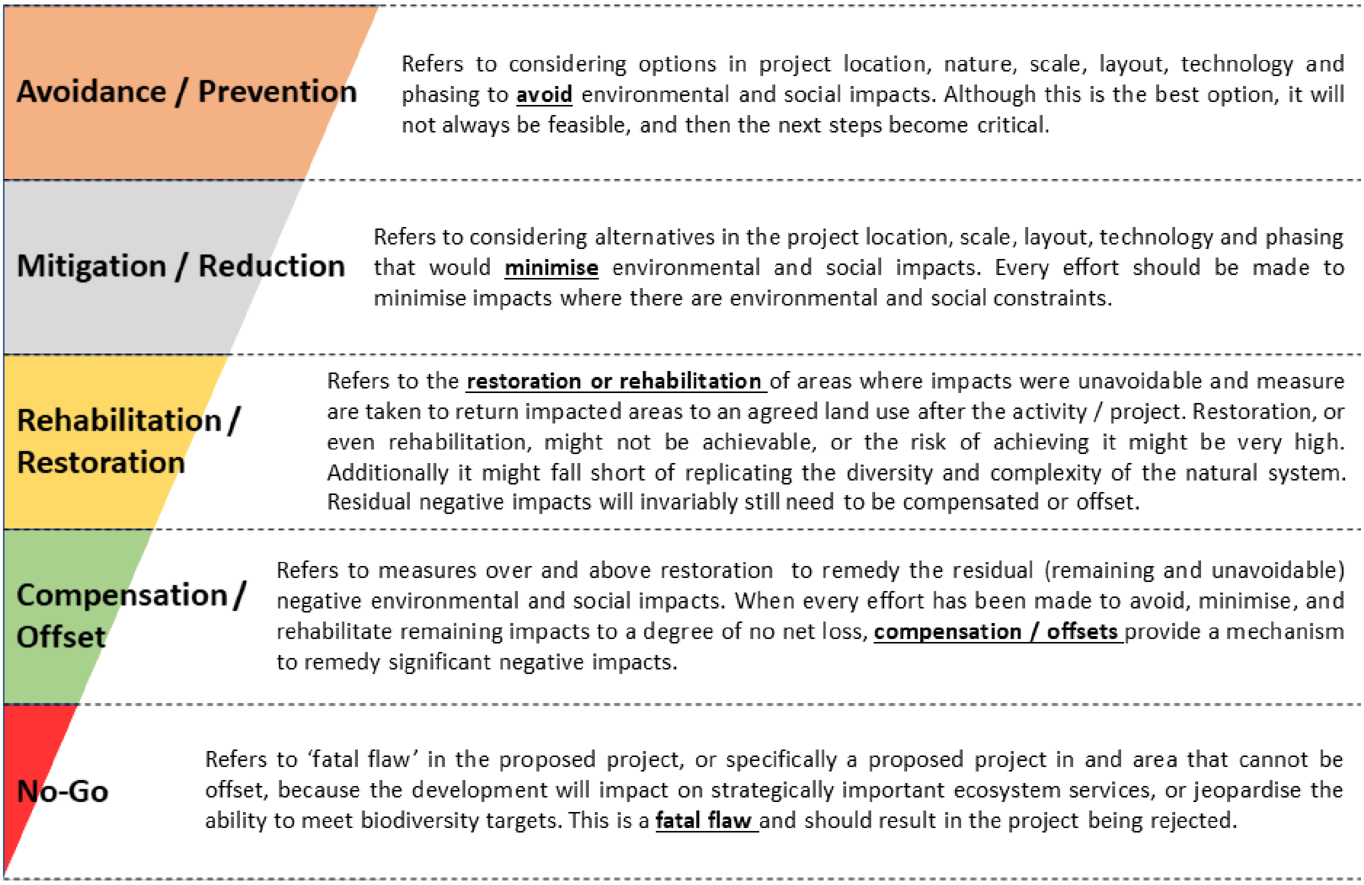


Figure 21: Mitigation Sequence/Hierarchy

Appendix E – Aquatic Assessment Detailed Methodology

Wetland and Riparian Delineation

Wetlands are delineated based on scientifically sound methods and utilizes a tool from the Department of Water and Sanitation 'A practical field procedure for identification and delineation of wetlands and riparian areas' (DWAF, 2005) as well as the "Updated manual for identification and delineation of wetlands and riparian areas" (DWAF, 2008). The delineation of the watercourses presented in this report is based on both desktop delineation and groundtruthing.

Desktop Delineation

A desktop assessment was conducted with wetland and riparian units potentially affected by the proposed activities identified using a range of tools, including:

- 1: 50 000 topographical maps;
- S A Water Resources;
- Recent, relevant aerial and satellite imagery, including Google Earth.

All areas suspected of being wetland and riparian habitat based on the visual signatures on the digital base maps were mapped using google earth.

Ground Truthing

Wetlands were identified based on one or more of the following characteristic attributes (DWAF, 2005) Figure 22& Figure 23):

- The Terrain Unit Indicator helps to identify those parts of the landscape where wetlands are more likely to occur;
- The presence of plants adapted to or tolerant of saturated soils (hydrophytes);
- Wetland (hydromorphic) soils that display characteristics resulting from prolonged saturation; and
- A high water table that results in saturation at or near the surface, leading to anaerobic conditions developing within 50 cm of the soil surface.

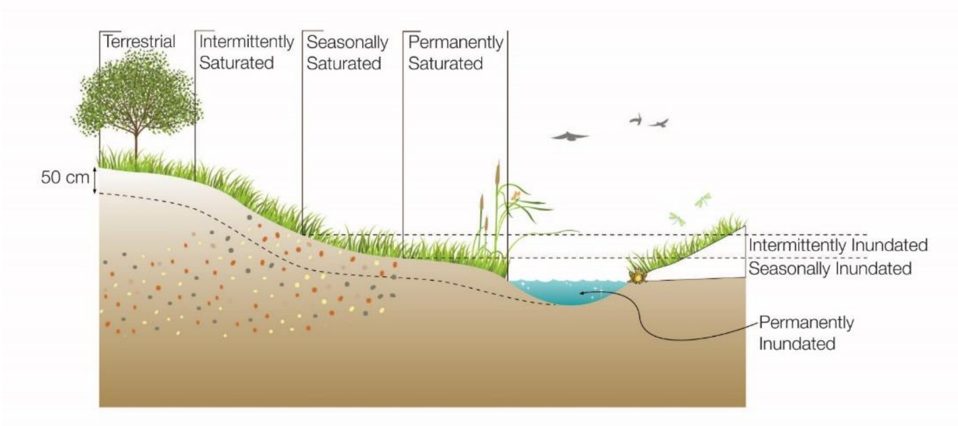


Figure 22: Typical cross section of a wetland (Ollis, 2013)

The Terrain Unit Indicator

The terrain unit indicator (Figure 23) is an important guide for identifying the parts of the landscape where wetlands might possibly occur. Some wetlands occur on slopes higher up in the catchment where groundwater discharge is taking place through seeps. An area with soil wetness and/or vegetation indicators, but not displaying any of the topographical indicators should therefore not be excluded from being classified as a wetland. The type of wetland which occurs on a specific topographical area in the landscape is described using the Hydrogeomorphic classification which separates wetlands into 'HGM' units. The classification of Ollis, *et al*. (2013) is used, where wetlands are classified on Level 4 as either Rivers, Floodplain wetlands, Valley-bottom wetlands, Depressions, Seeps, or Flats (Figure 24).

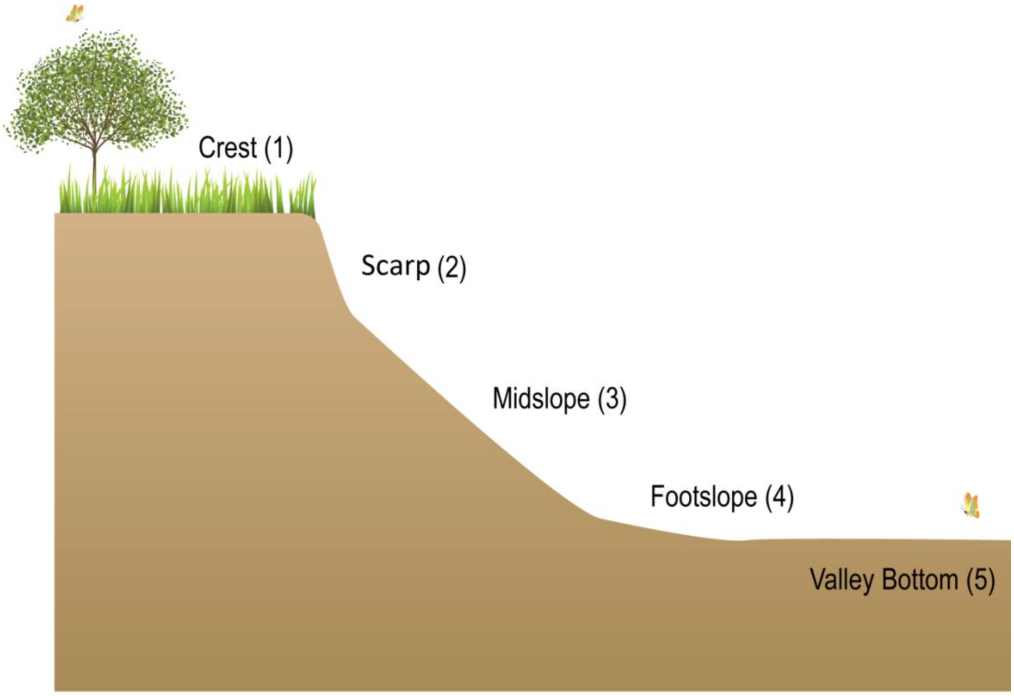


Figure 23: Terrain units (DWAF, 2005).

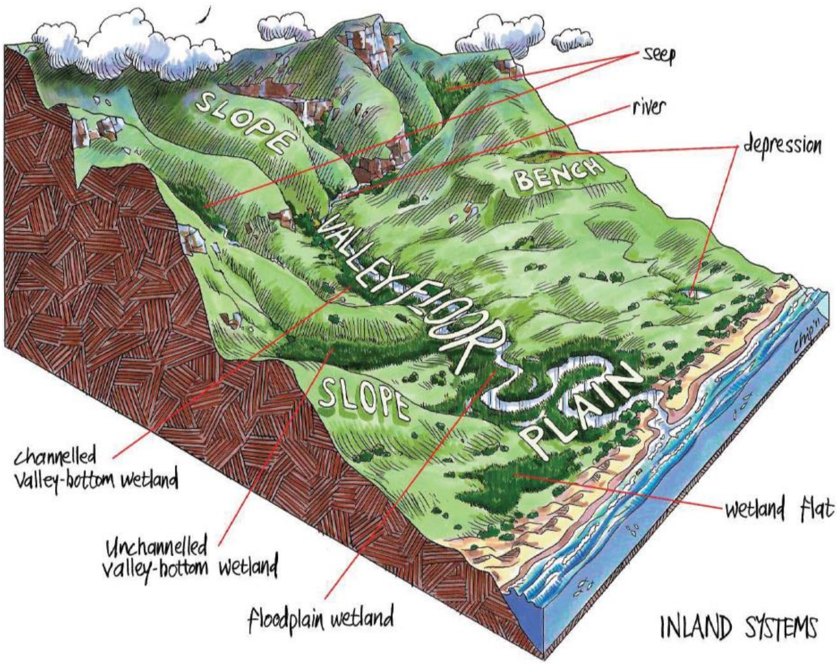


Figure 24: Wetland Units based on hydrogeomorphic types (Ollis *et al.* 2013)

Riparian Indicators
Riparian habitat is classified primarily by identifying riparian vegetation along the edge of the macro stream channel. The macro stream channel is defined as the outer bank of a compound channel and should not be confused with the active river bank. The macro channel bank often represents a dramatic change in the energy with which water passes through the system. Rich alluvial soils deposit nutrients making the riparian area a highly productive zone. This causes a very distinct change in vegetation structure and composition along the edges of the riparian area (DWAF, 2008). The marginal zone includes the area from the water level at low flow, to those features that are hydrologically activated for the greater part of the Year (WRC Report No TT 333/08 April, 2008). The non-marginal zone is the combination of the upper and lower zones (Figure 25).

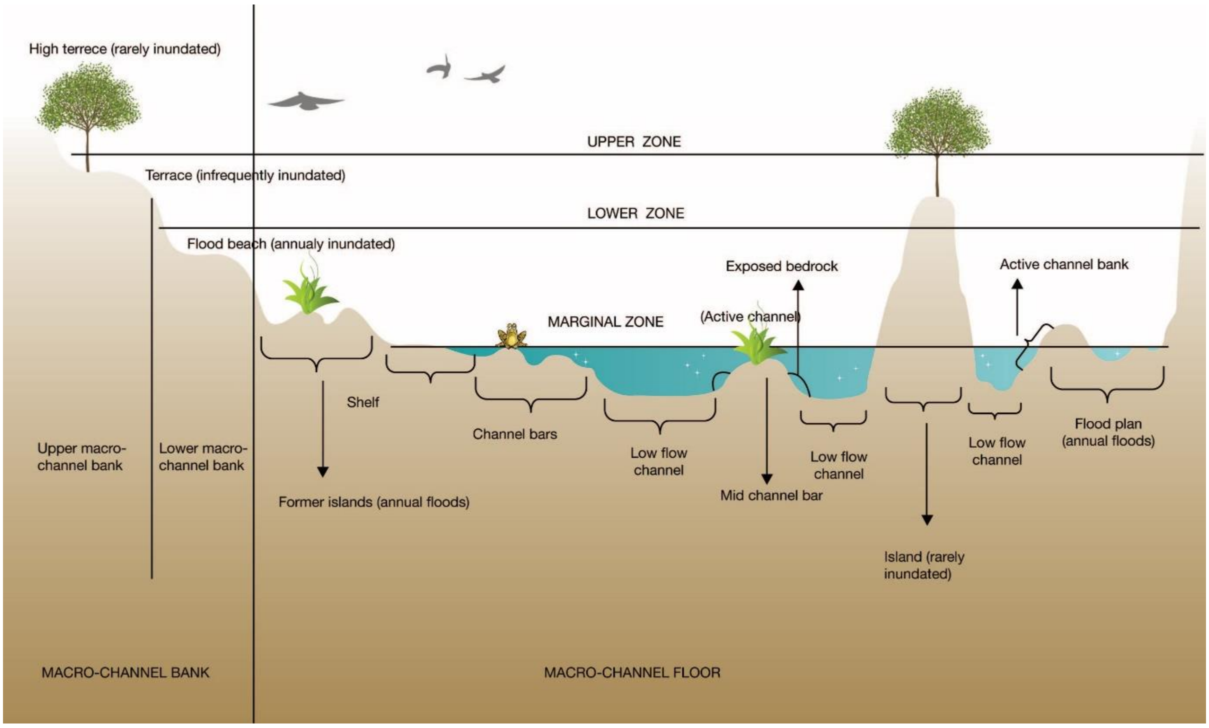


Figure 25: Schematic diagram illustrating an example of where the 3 zones would be placed relative to geomorphic diversity (Kleynhans *et al*, 2007)

Riparian Area:
A riparian area can be defined as a linear fluvial, eroded landform which carries channelized flow on a permanent, seasonal or ephemeral/episodic basis. The river channel flows within a confined valley (gorge) or within an incised macro-channel. The “river” includes both the active channel (the portion which carries the water) as well as the riparian zone (Figure 26) (Kotze, 1999).

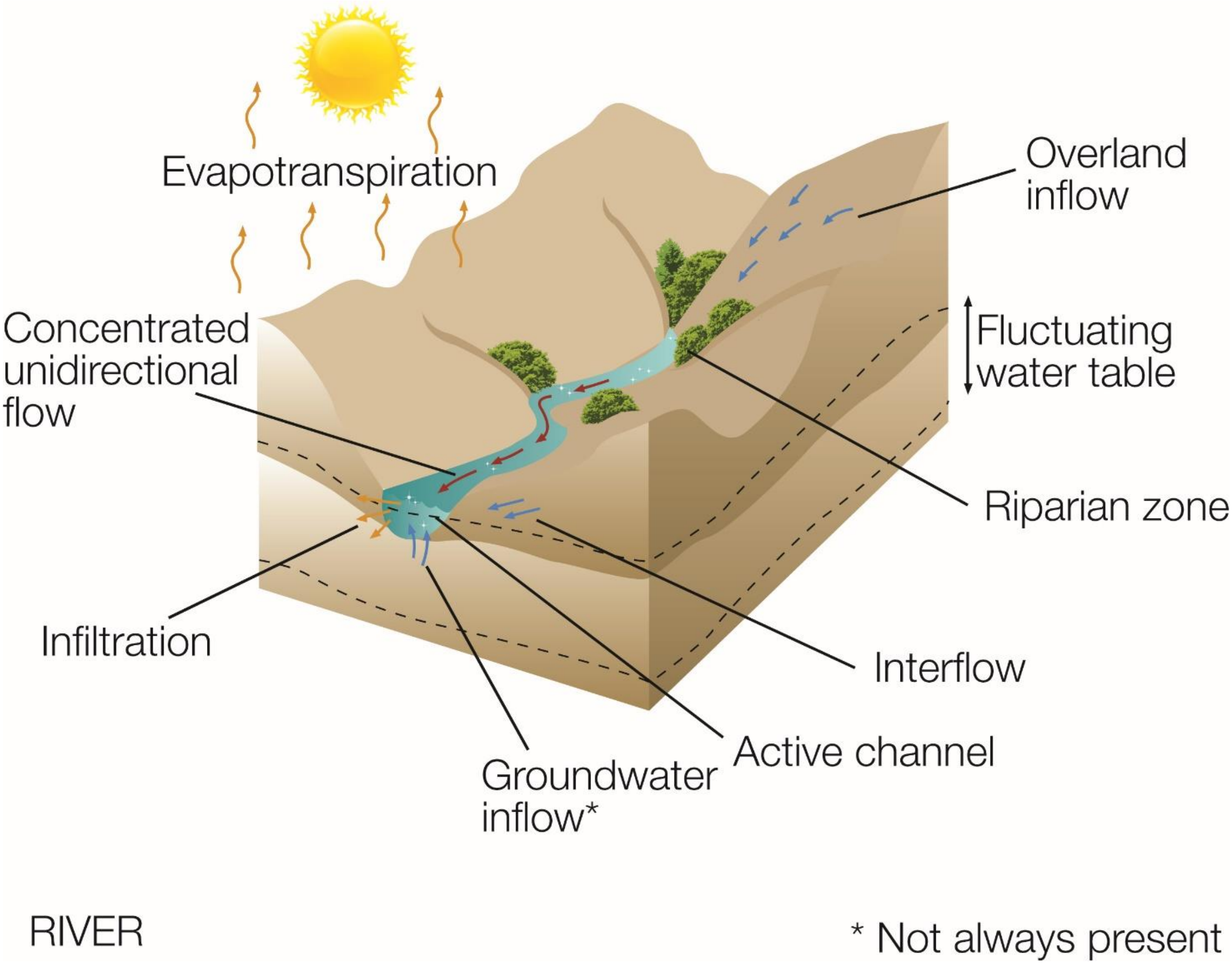


Figure 26: A schematic representation of the processes characteristic of a river area (Ollis *et al*, 2013).

Riparian areas can be grouped into different categories based on their inundation period per year. Perennial rivers are rivers with continuous surface water flow, intermittent rivers are rivers where surface flow disappears but some surface flow remains, temporary rivers are rivers where surface flow disappears for most of the channel (Figure 27). Two types of temporary rivers are recognized, namely "ephemeral" rivers that flow for less time than they are dry and support a series of pools in parts of the channel, and "episodic" rivers that only flow in response to extreme rainfall events, usually high in their catchments (Seaman *et al.*, 2010).

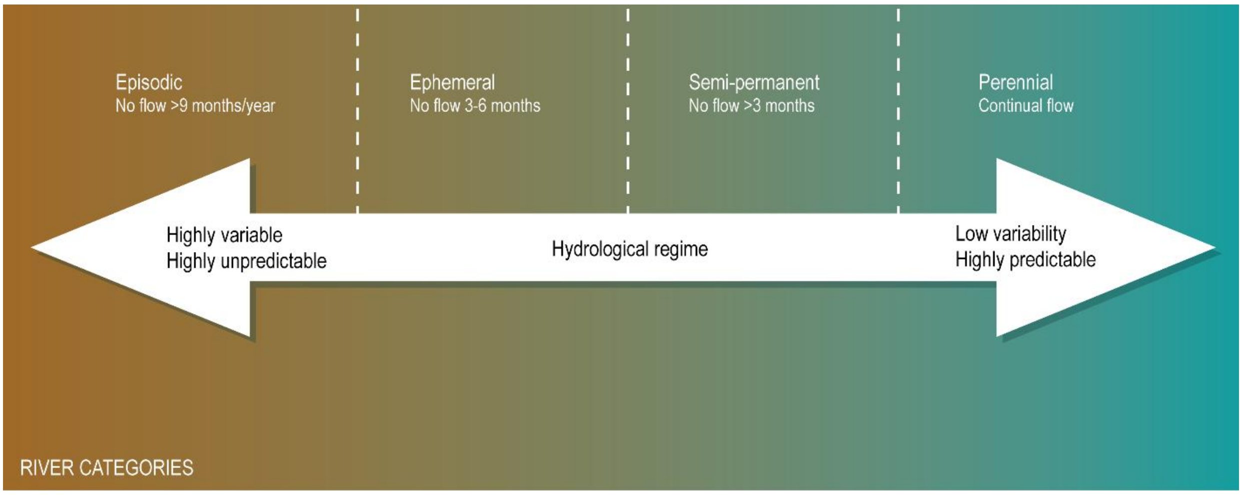


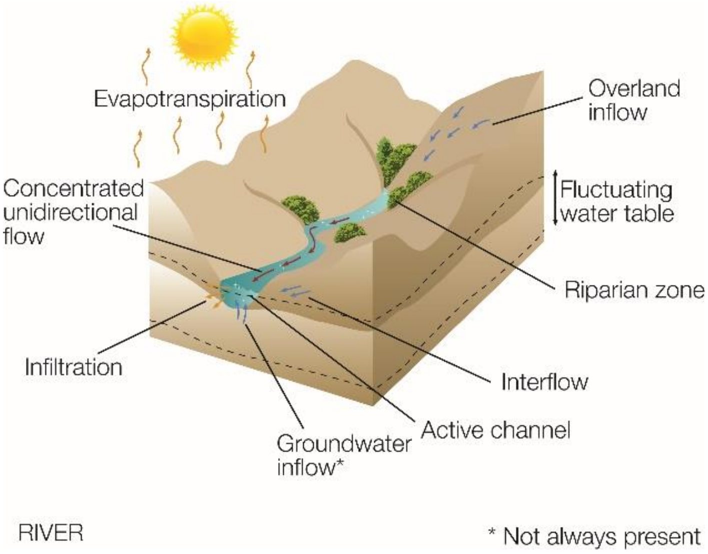
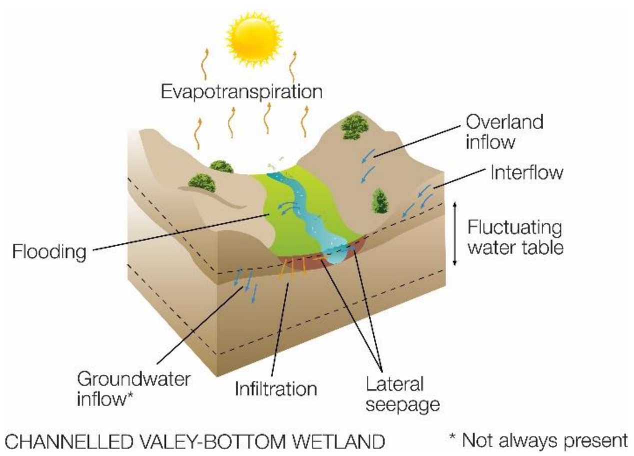
Figure 27: The four categories associated with rivers and the hydrological continuum. Dashed lines indicate that boundaries are not fixed (Seaman *et al*, 2010).

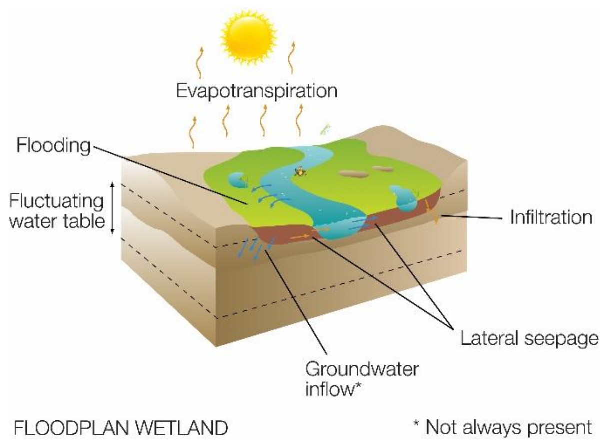
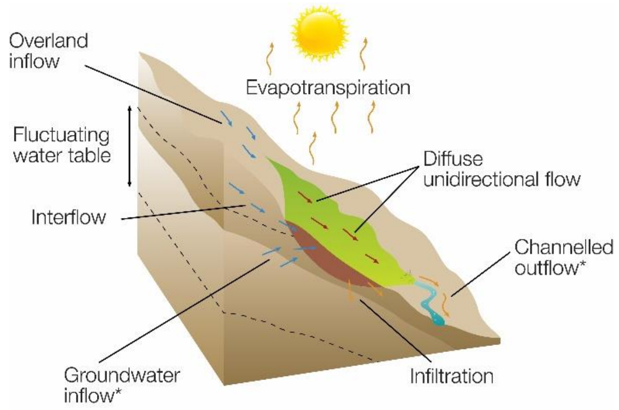
Watercourse Classification and Delineation
The classification system developed for the National Wetlands Inventory is based on the principles of the hydro-geomorphic (HGM) approach to wetland classification (SANBI, 2013). The current wetland study follows the same approach by classifying wetlands in terms of a functional unit in line with a level three category recognised in the classification system proposed in SANBI (2013). HGM units take into consideration factors that determine the nature of water movement into, through and out of the wetland system. In general, HGM units encompass three key elements (Kotze *et al.*, 2005):

- Geomorphic setting - This refers to the landform, its position in the landscape and how it evolved (e.g. through the deposition of river borne sediment);
- Water source - There are usually several sources, although their relative contributions will vary amongst wetlands, including precipitation, groundwater flow, stream flow, etc.; and
- Hydrodynamics - This refers to how water moves through the wetland.

The classification of wetland areas found within the study site and/or within 500 m of the study site (adapted from Brinson, 1993; Kotze, 1999, Marneweck and Batchelor, 2002 and DWAF, 2005) are as follows (Table 30):

Table 30: Wetland Types and descriptions

Wetland Type:	Description:
Valley bottom without a channel 	Linear fluvial, eroded landforms which carry channelized flow on a permanent, seasonal or ephemeral/episodic basis. The river channel flows within a confined valley (gorge) or within an incised macro-channel. The "river" includes both the active channel (the portion which carries the water) as well as the riparian zone.
Valley bottom with a channel 	Linear fluvial, net depositional valley bottom surfaces which have a straight channel with flow on a permanent or seasonal basis. Episodic flow is thought to be unlikely in this wetland setting. The straight channel tends to flow parallel with the direction of the valley (i.e. there is no meandering), and no ox-bows or cut-off meanders are present in these wetland systems. The valley floor is, however, a depositional environment such that the channel flows through fluvially-deposited sediment. These systems tend to be found in the upper catchment areas.

<table>
<tr><td>Wetland Type:</td><td>Description:</td></tr>
<tr><td>Meandering Floodplain

</td><td>Linear fluvial, net depositional valley bottom surfaces which have a meandering channel which develop upstream of a local (e.g. resistant dyke) base level, or close to the mouth of the river (upstream of the ultimate base level, the sea) . The meandering channel flows within an unconfined depositional valley, and ox-bows or cut-off meanders evidence of meandering – are usually visible at the 1:10 000 scale (i.e. observable from 1:10 000 orthomaps).
The floodplain surface usually slopes away from the channel margins due to preferential sediment deposition along the channel edges and areas closest to the channel. This can result in the formation of backwater swamps at the edges of the floodplain margins.</td></tr>
<tr><td>Seepage Wetlands

</td><td>Seepage wetlands are the most common type of wetland (in number), but probably also the most overlooked. These wetlands can be located on the mid- and footslopes of hillsides; either as isolated systems or connected to downslope valley bottom weltands. They may also occur fringing depressional pans. Seepages occur where springs are decanting into the soil profile near the surface, causing hydric conditions to develop; or where through flow in the soil profile is forced close to the surface due to impervious layers (such as plinthite layers; or where large outcrops of impervious rock force subsurface water to the surface).</td></tr>
</table>

Buffer Zones and Regulated Areas

A buffer zone is defined as a strip of land surrounding a wetland or riparian area in which activities are controlled or restricted (DWAF, 2005). A development has several impacts on the surrounding environment and on a watercourse. The development changes habitats, the ecological environment, infiltration rate, amount of runoff and runoff intensity of the site, and therefore the water regime of the entire site. An increased volume of stormwater runoff, peak discharges, and frequency and severity of flooding is, therefore, often characteristic of transformed catchments. The buffer zone identified in this report serves to highlight an ecologically sensitive area in which activities should be conducted with this sensitivity in mind.

Buffer zones have been shown to perform a wide range of functions and have therefore been widely proposed as a standard measure to protect water resources and their associated biodiversity. These include (i) maintaining basic hydrological processes; (ii) reducing impacts on water resources from upstream activities and adjoining landuses; (iii) providing habitat for various aspects of biodiversity. Buffer zones are therefore proposed as a standard mitigation measure to reduce impacts of land uses / activities planned adjacent to water resources. Although buffer zones can be effective in addressing diffuse source pollution in storm water run-off, they should typically be seen as part of a treatment train designed to address storm water impacts (MacFarlane & Brendin, 2017).

Generic buffer zones are specified in regional and local policies including GDARD (2014). These include 30m for wetlands and 50m for rivers inside the urban edge within which development is not supported.

Authorisation from the DWS requires calculation of a site-specific buffer zone (General Notice 267 of 24 March 2017), following Macfarlane *et al* 2015. This Excel-based tool calculates the best suited buffer for each wetland or section of a wetland based on numerous on-site observations. The resulting buffer zone can thus have large differences depending on the current state of the wetland as well as the nature of the proposed development. Developments with a high-risk factor such as mining are likely to have a larger buffer area compared to a residential development with a lower risk factor.

Figure 28 images represent the buffer zone setback for the watercourse types discussed in this report.

It should be noted that the buffer calculation tool does not take into account the effects of climate change or cumulative impacts to floodflows resulting from transformed catchments. Therefore, a conservative approach to the application of buffer zones is encouraged.

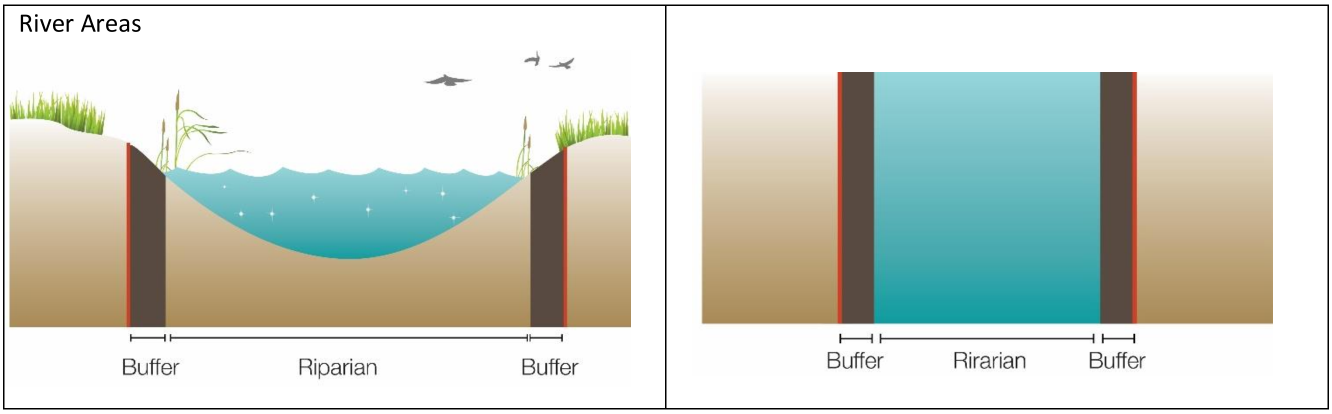


Figure 28: A represent the buffer zone setback for the wetland discussed in this report

Regulated areas are zones within which authorisation is required. The DWS specify a 500m regulated area around all wetlands and 100m around all riparian zones within which development must be authorised from their department. Development within 32m of the edge of the watercourse triggers the requirement for authorisation under the National Environmental Management Act (NEMA): Environmental Impact Assessment (EIA) Regulations of 2014 (GNR 326) as amended.

DWS (2016) Impact Ratings

Risk-based management has value in providing an indication of the potential for delegating certain categories of water use "risks" to DHWS regional offices (RO) or Catchment Management Agencies (CMA). Risk categories obtained through this assessment serve as a guideline to establish the appropriate channel of 125uthorization of these water uses.
The DHWS has therefore developed a risk assessment matrix to assist in quantifying expected impacts. The scores obtained in this assessment are useful in evaluating how the proposed activities should be 125uthorizat.
The formula used to derive a risk score is as follows:
RISK = CONSEQUENCE x LIKELIHOOD
CONSEQUENCE = SEVERITY + SPATIAL SCALE + DURATION
LIKELIHOOD = FREQUENCY OF THE ACTIVITY + FREQUENCY OF THE IMPACT +LEGAL ISSUES + DETECTION

Table 31 below provides a description of the classes into which scores are sorted, and their implication for 125 authorization.

Table 31: An extract from DWS (2016) indicating the risk scores and classes as well as the implication for the appropriate authorization process

RATING	CLASS	MANAGEMENT DESCRIPTION
1 – 55	(L) Low Risk	Acceptable as is or consider requirement for mitigation. Impact to watercourses and resource quality small and easily mitigated.
56 – 169	M) Moderate Risk	Risk and impact on watercourses are notably and require mitigation measures on a higher level, which costs more and require specialist input. Licence required.
170 – 300	(H) High Risk	Watercourse(s) impacts by the activity are such that they impose a long-term threat on a large scale and lowering of the Reserve. Licence required.

Wetland Functionality, Status and Sensitivity

The functional assessment methodologies presented below take into consideration subjective recorded impacts to determine the scores attributed to each functional Hydrogeomorphic (HGM) unit. Following the calculation of PES and EC scores, a Recommended Ecological Category can be obtained. This score reflects an auditable management or rehabilitation target to be achieved by the proposed project. The sections below provide a brief description of each method employed in the 2021 assessment.

Wetland functionality is defined as a measure of the deviation of wetland structure and function from its natural reference condition. The natural reference condition is based on a theoretical undisturbed state extrapolated from an understanding of undisturbed regional vegetation and hydrological conditions. In the current assessment the hydrological, water quality, geomorphological and vegetation integrity was assessed for the wetland unit associated with the study site, to provide a Present Ecological Status (PES) score (Macfarlane *et al.*, 2020) and an Environmental Importance and Sensitivity category (EIS) (Kotze *et al.*, 2020). These impacts are based on evidence observed during the field survey and land use changes visible on aerial imagery including historical images.

The allocations of scores in the functional and integrity assessment are subjective and are thus vulnerable to the interpretation of the specialist. Collection of empirical data is precluded at this level of investigation due to project constraints including time and budget. Water quality values, species richness and abundance indices, surface and groundwater volumes, amongst others, should ideally be used rather than a subjective scoring system such as is presented here.

The functional assessment methodologies presented below take into consideration subjective recorded impacts to determine the scores attributed to each functional Hydrogeomorphic (HGM) wetland unit. The aspect of wetland functionality and integrity that are predominantly addressed include hydrological and geomorphological function (subjective observations) and the integrity of the biodiversity component (mainly based on the theoretical intactness of natural vegetation) as directed by the assessment methodology.

Present Ecological Status (PES) – WET-Health

A summary of the four components of the WET-Health (2.0) namely Hydrological; Geomorphological, water quality and Vegetation Health assessment for the wetlands found on site is described in Table 18. For this assessment, WET-Health Version 2.0 was used. This method builds on the WET-Health Version 1.0 (Macfarlane *et al*. 2008) and Wetland-IHI (DWAF 2007) Tool, offering a refined and more robust suite of tools (Macfarlane *et al*. 2020). The WET-Health Version 2 considers four (4) components to assess the PES of wetland ecosystems. Geology, climate and topographic position determines the ecological setting of a wetland. Three (3) core interrelated drivers broadly influence all wetlands, namely Hydrology, Geomorphology and Water Quality (i.e. physico-chemical attributes). Wetland biology, and more specifically vegetation, responds to the changes in these drivers and to the surrounding environment. A combination of level 1B and Level 2 assessment was used for the wetlands recorded on the study site (Table 32).

Table 32: The three levels of assessment to cater for application of the WET-Health Version 2 Tool across different spatial scales and for different purposes (Adapted from Macfarlane *et al*., 2020).

Level of Assessment	Spatial Scale	Description
Level 1A	Desktop-based, low resolution	Entirely desktop-based and only uses pre-existing landcover data. Landcover types within a buffer / "pseudo catchment" around a wetland is used to determine the impacts on the wetland arising from the upslope catchment. Impacts arising from within individual wetlands are inferred from landcover types occurring within desktop-delineated wetlands.
Level 1B	Desktop-based, high resolution	Largely desktop-based using pre-existing landcover data but makes a few finer distinctions than Level 1A in terms of landcover types and usually requires "heads-up" interpretation of the best available aerial imagery in order to do so. Upslope catchment of each wetland can be individually delineated at this level, and landcover in this area is used as a proxy of the impacts on a wetland arising from its upslope catchment. Impacts arising from within individual wetlands are inferred from landcover types occurring within desktop-delineated wetlands. In terms of water quality PES, the option is provided to factor in point-source pollution inputs in a Level 1B assessment.
Level 2	Rapid field-based assessment	Strongly informed by desktop landcover mapping; refined by assessing a range of catchment and wetland-related indicators known to affect wetland condition. Impacts arising from the upslope catchment of a wetland are inferred from landcover mapping but are refined based on additional information. Landcover types occurring within the wetland are used as the starting point for assessing human impacts arising from within the wetland but are refined through the assessment of additional indicators as part of a rapid field-based assessment. This involves sub-dividing the wetland into relatively homogenous "disturbance units" and assessing a suite of site-based wetland questions that provide a more direct assessment of change. Determination of water quality PES in a Level 2 assessment requires the identification and characterisation of point-source pollution inputs.

A summary of the change class, description and symbols used to evaluate wetland health are summarised in Table 33. The trajectory of change is summarised in Table 34.

Table 33: Health categories used by WET-Health for describing the integrity of wetlands (Macfarlane *et al*, 2020)

Ecological Category	Description	Impact Score	PES Score (%)
A	Unmodified, natural	0 to 0.9	90-00
B	Largely Natural with few modifications. A slight change in ecosystem processes is discernible and a small loss of natural habitats and biota may have taken place.	1.0 to 1.9	80-89
C	Moderately Modified. A moderate change in ecosystem processes and loss of natural habitats has taken place, but the natural habitat remains predominantly intact.	2.0 to 3.9	60-79
D	Largely Modified. A large change in ecosystem processes and loss of natural habitat and biota has occurred.	4.0 to 5.9	40-59
E	Seriously Modified. The change in ecosystem processes and loss of natural habitat and biota is great, but some remaining natural habitat features are still recognizable.	6.0 to 7.9	20-39
F	Critical Modification. The modifications have reached a critical level and the ecosystem processes have been modified completely with an almost complete loss of natural habitat and biota.	8.0 to 10	0-19

Table 34: Trajectory class, change scores and symbols used to evaluate Trajectory of Change to wetland health (Macfarlane et al., 2007)

Change Class	Description		Symbol
Improve	Condition is likely to improve over the over the next 5 years		(↑)
Remain stable	Condition is likely to remain stable over the next 5 years		(→)
Slowly deteriorate	Condition is likely to deteriorate slightly over the next 5 years		(↓)
Rapidly deteriorate	Substantial deterioration of condition is expected over the next 5 years		(↓↓)

Ecological Importance and Sensitivity (EIS)

The Ecological Importance and Sensitivity (EIS) score forms part of a larger assessment called the Wetland Importance and Sensitivity scoring system which also addresses hydrological importance and direct human benefits relevant to a HGM unit. Both PES and EIS form part of a larger reserve determination process documented by the Department of Water and Sanitation.

Ecological importance is an expression of a wetland's importance to the maintenance of ecological diversity and functioning on local and wider spatial scales. Ecological sensitivity refers to the system's ability to tolerate disturbance and its capacity to recover from disturbance once it has occurred (DWAF, 1999). This classification of water resources allows for an appropriate management class to be allocated to the water resource and includes the following:

- Ecological Importance in terms of ecosystems and biodiversity such as species diversity and abundance;
- Ecological functions including groundwater recharge, provision of specialised habitat and dispersal corridors;
- Basic human needs including subsistence farming and water use.

The Ecological Importance and Sensitivity of the wetlands is represented are described in the results section. Explanations of the scores are given in Table 35.

Table 35: Environmental Importance and Sensitivity rating scale used for the estimation of EIS scores (DWAF, 1999)

Ecological Importance and Sensitivity Categories	Rating
Very High Wetlands that are considered ecologically important and sensitive on a national or even international level. The biodiversity of these wetlands is usually very sensitive to flow and habitat modifications. They play a major role in moderating the quantity and quality of water in major rivers.	>3 and <=4
High Wetlands that are considered to be ecologically important and sensitive. The biodiversity of these wetlands may be sensitive to flow and habitat modifications. They play a role in moderating the quantity and quality of water of major rivers.	>2 and <=3
Moderate Wetlands that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these wetlands is not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water in major rivers.	>1 and <=2
Low/Marginal Wetlands that are not ecologically important and sensitive at any scale. The biodiversity of these wetlands is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water in major rivers.	>0 and <=1

Ecosystem Services (ES)

The DWS authorisations related to wetlands are regulated by Government Notice 267 published in the Government Gazette 40713 of 24 March 2017. Page 196 of this notice provides a detailed “terms of reference” for wetland assessment reports and includes the requirement that the ecological integrity and function of wetlands be addressed. This requirement is addressed through the WetEcoServices toolkit (Kotze *et al.*, 2020). This wetland assessment method is an Excel based tool which is based on the integral function of wetlands in terms of their hydrogeomorphic setting. Each of seven benefits are assessed based on a list of characteristics (e.g. slope of the wetland) that are relevant to the particular benefit. Scores are subjectively awarded to characteristics of the wetland and its catchment relative to the proposed activity. Scores are ranked as Very High, High, Moderately-High, Moderate, Moderately-Low, Low and Very Low (Table 36 and Table 37).

Table 36: Integrating the scores for ecosystem supply and demand into an overall importance score

Integrating scores for supply & demand to obtain an overall importance score						
		Supply				
		Very Low	Low	Moderate	High	Very High
Demand		0	1	2	3	4
Very Low	0	0.0	0.0	0.5	1.5	2.5
Low	1	0.0	0.0	1.0	2.0	3.0
Moderate	2	0.0	0.5	1.5	2.5	3.5
High	3	0.0	1.0	2.0	3.0	4.0
Very High	4	0.5	1.5	2.5	3.5	4.0

Table 37: Categories used for reporting the overall importance of ecosystem services

Importance Category		Description
Very Low	0-0.79	The importance of services supplied is very low relative to that supplied by other wetlands.
Low	0.8 – 1.29	The importance of services supplied is low relative to that supplied by other wetlands.
Moderately-Low	1.3 – 1.69	The importance of services supplied is moderately-low relative to that supplied by other wetlands.
Moderate	1.7 – 2.29	The importance of services supplied is moderate relative to that supplied by other wetlands.
Moderately-High	2.3 – 2.69	The importance of services supplied is moderately-high relative to that supplied by other wetlands.
High	2.7 – 3.19	The importance of services supplied is high relative to that supplied by other wetlands.
Very High	3.2 - 4.0	The importance of services supplied is very high relative to that supplied by other wetlands.

Ecological Importance and Sensitivity (EIS)

The Ecological Importance and Sensitivity (EIS) score forms part of a larger assessment called the Wetland Importance and Sensitivity scoring system which also addresses hydrological importance and direct human benefits relevant to a HGM unit. Both EC and EIS form part of a larger reserve determination process documented by the Department of Water and Sanitation.
Ecological importance is an expression of a wetland's importance to the maintenance of ecological diversity and functioning on local and wider spatial scales. Ecological sensitivity refers to the system's ability to tolerate disturbance and its capacity to recover from disturbance once it has occurred (DWAF, 1999). This classification of water resources allows for an appropriate management class to be allocated to the water resource and includes the following:

- Ecological Importance in terms of ecosystems and biodiversity such as species diversity and abundance.

- Ecological functions including groundwater recharge, provision of specialised habitat and dispersal corridors.
- Basic human needs including subsistence farming and water use.

The Ecological Importance and Sensitivity of the riparian units is represented in the results section. Explanations of the scores are given in Table 38 below.

Table 38: Environmental Importance and Sensitivity rating scale used for the estimation of EIS scores (DWAF, 1999)

Ecological Importance and Sensitivity Categories	Rating
Very High Wetlands that are considered ecologically important and sensitive on a national or even international level. The biodiversity of these wetlands is usually very sensitive to flow and habitat modifications. They play a major role in moderating the quantity and quality of water in major rivers	>3 and <=4
High Wetlands that are considered to be ecologically important and sensitive. The biodiversity of these wetlands may be sensitive to flow and habitat modifications. They play a role in moderating the quantity and quality of water of major rivers	>2 and <=3
Moderate Wetlands that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these wetlands is not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water in major rivers	>1 and <=2
Low/Marginal Wetlands that are not ecologically important and sensitive at any scale. The biodiversity of these wetlands is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water in major rivers	>0 and <=1

Use of WET-EcoServices for assessing the Ecological Importance and Sensitivity (EIS) of wetlands

The term Ecological Importance and Sensitivity (EIS) is well entrenched in water resource management in South Africa. Ecological Importance (EI) is the expression of the importance of wetlands and rivers in terms of the maintenance of biological diversity and ecological functioning at a local and landscape level. Ecological Sensitivity (S) refers to ecosystem fragility or the ability to resist or recover from disturbance (Rountree and Kotze 2013). The purpose of assessing ecological importance and sensitivity of water resources like wetlands, and rivers is to be able to identify those systems that provide valuable biodiversity support functions, regulating ecosystem services, or are especially sensitive to impacts. Knowing what ecosystems are valuable enables the appropriate setting of management objectives (i.e. recommended ecological category - REC) and the prioritization of management actions and interventions to promote effective water resource management.

The tool currently used for assessing wetland EIS (Rountree and Kotze 2013) is somewhat outdated but is typically informed by a WET-EcoServices assessment. The implication is that practitioners involved in wetland assessments typically have to complete both a WET-EcoServices assessment and a stand-alone EIS assessment to inform decision-making processes. Recommendations to refine the wetland EIS tool have been documented (Macfarlane *et al.* 2019) and includes the need to revise and update the wetland EIS assessment framework to simply integrate the key outputs of the WET-EcoServices tool to produce an overall ecological importance (EI) score.

Specific recommendations for integrating the WET-EcoServices outputs into the wetland EIS assessment have also been documented. These include grouping of ecosystem service scores into broad categories which would then be integrated into an overall ecological importance (EI) score:

• ***Biodiversity maintenance importance***: This is the importance score derived from the biodiversity maintenance component of WET-EcoServices.
• ***Regulating services importance***: This would be calculated as the maximum score of all the importance scores for regulating services considered in WET-EcoServices.
• ***Provisioning and cultural services importance***: This would be calculated as the maximum score of all the importance scores for provisioning and cultural services considered in WET-EcoServices.

The EI would be simply derived based on the maximum of these scores and could then be integrated with the ecological sensitivity (ES) score to produce an overall EIS score. A simple schematic of the proposed Wetland EIS framework is shown in Figure 29 below.

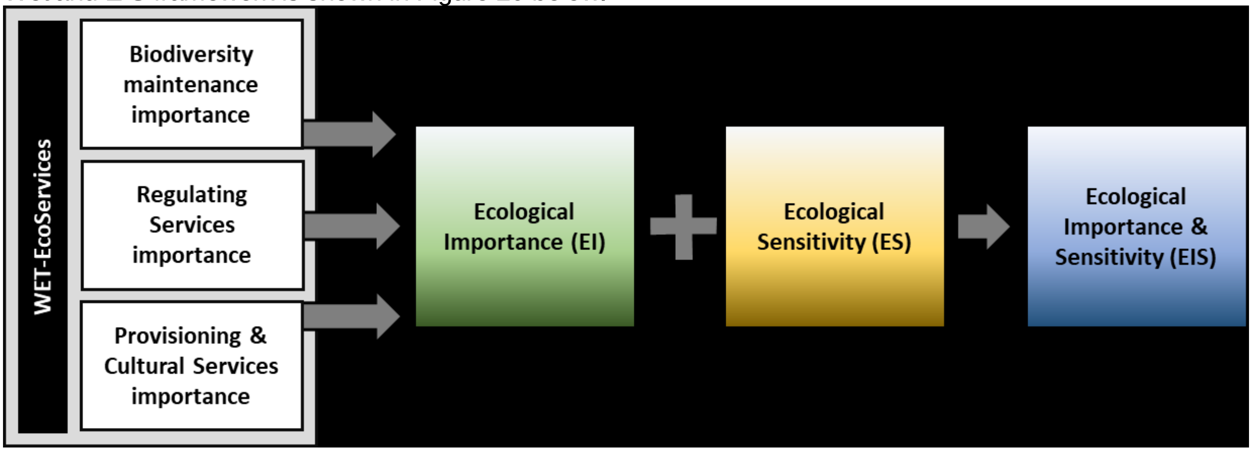


Figure 29: Schematic of the recommended Wetland EIS framework.

Recommended Ecological Category (REC)

"Upon completion of the EC and EIS assessments for the wetland, a Recommended Ecological Category for the Recommended Ecological Category (REC) of the water resource must be determined according to the methods set out in Roundtree *et al.* (2013).

The REC is determined by the Present Ecological State of the water resource and the importance and/or sensitivity of the water resource. Water resources which have Ecological Categories in an E or F class are deemed unsustainable by the DWS. In such cases the REC must automatically be increased to a D.

Where the PES is in the A, B, C, D or E the EIS components must be checked to determine if any of the aspects of importance and sensitivity (Ecological Importance; Hydrological Functions and Direct Human Benefits) are high or very high. If this is the case, the feasibility of increasing the EC (particularly if the EC is in a low C or D category) should be evaluated. This is recommended to enable important and/or sensitive wetland water resources to maintain their functionality and continue to provide the goods and services for the environment and society.
If (Table 39):

- EC is in an E or F category:
  The REC should be set at at least a D, since E and F EC's are considered unsustainable.
    - The EC category is in a A, B, C or D category, AND the EIS criteria are low or moderate OR the EIS criteria are high or even very high, but it is not feasible or practicable for the EC to be improved:
- The REC is set at the current PES.
    - The EC category is in a B, C or D category, AND the EIS criteria are high or very high AND it is feasible or practicable for the EC to be improved:
- The REC is set at least one Ecological Category higher than the current EC." (Rountree *et al,* 2013)

Table 39: Generic Matrix for the determination of REC and RMO for water resources

			EIS			
			Very high	High	Moderate	Low
PES	A	Pristine/Natural	A Maintain	A Maintain	A Maintain	A Maintain
	B	Largely Natural	A Improve	A/B Improve	B Maintain	B Maintain
	C	Good - Fair	B Improve	B/C Improve	C Maintain	C Maintain
	D	Poor	C Improve	C/D Improve	D Maintain	D Maintain
	E/F	Very Poor	D Improve	E/F Improve	E/F Maintain	E/F Maintain

Site Ecological Importance

Based on the Species Environmental Assessment Guideline (SANBI, 2020) wetlands and specialised habitats should be assessed based on their Site Ecological Importance (SEI). The SEI is based on several factors Figure 30

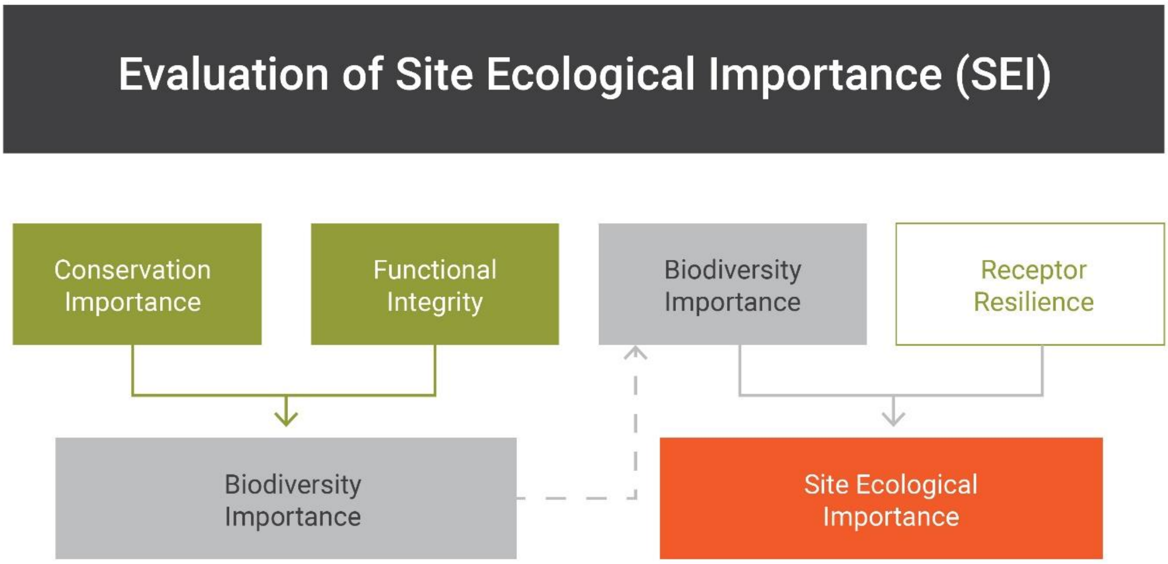


Figure 30: Evaluation of Site Ecological Importance based on CI, FI, BI, RR and SEI (SANBI, 2020)

Conservation Importance (CI) (Table 40) and Functional Integrity (FI) (Table 41) = Biodiversity Importance (Table 42).

Biodiversity Importance (BI) and Receptor Resilience (RR) (Table 43) = Site Ecological Importance (Table 44).

Table 40: Conservation Importance (SANBI, 2020).

Conservation importance	Fulfilling criteria
Very High	Confirmed or highly likely occurrence of CR, EN, VU or Extremely Rare23 or Critically Rare24 species that have a global EOO of < 10 km2. Any area of natural habitat25 of a CR ecosystem type or large area (> 0.1% of the total ecosystem type extent26) of natural habitat of EN ecosystem type. Globally significant populations of congregatory species (> 10% of global population).
High	Confirmed or highly likely occurrence of CR, EN, VU species that have a global EOO of > 10 km2 . IUCN threatened species (CR, EN, VU) must be listed under any criterion other than A. If listed as threatened only under Criterion A, include if there are less than 10 locations or < 10 000 mature individuals remaining. Small area (> 0.01% but < 0.1% of the total ecosystem type extent) of natural habitat of EN ecosystem type or large area (> 0.1%) of natural habitat of VU ecosystem type. Presence of Rare species. Globally significant populations of congregatory species (> 1% but < 10% of global population).
Medium	Confirmed or highly likely occurrence of populations of NT species, threatened species (CR, EN, VU) listed under Criterion A only and which have more than 10 locations or more than 10 000 mature individuals. Any area of natural habitat of threatened

	ecosystem type with status of VU. Presence of range-restricted species. > 50% of receptor contains natural habitat with potential to support SCC
Low	No confirmed or highly likely populations of SCC. No confirmed or highly likely populations of range-restricted species. < 50% of receptor contains natural habitat with limited potential to support SCC
Very low	No confirmed and highly unlikely populations of SCC. No confirmed and highly unlikely populations of range-restricted species. No natural habitat remaining.

Table 41: Functional Integrity (SANBI, 2020)

Functional Integrity	Fulfilling criteria
Very High	Very large (>100 ha) intact area for any conservation status of ecosystem type or >5 ha for CR ecosystem types Very High High habitat connectivity serving as functional ecological corridors, limited road network between intact habitat patches No or minimal current negative ecological impacts with no signs of major past disturbance (e.g. ploughing)
High	Large (>20 ha but <100 ha) intact area for any conservation status of ecosystem type or >10 ha for EN ecosystem types Good habitat connectivity with potentially functional ecological corridors and a regularly used road network between intact habitat patches Only minor current negative ecological impacts (e.g. few livestock utilising area) with no signs of major past disturbance (e.g. ploughing) and good rehabilitation potential
Medium	Medium (>5 ha but <20 ha) semi-intact area for any conservation status of ecosystem type or > 20 ha for VU ecosystem types Only narrow corridors of good habitat connectivity or larger areas of poor habitat connectivity and a busy used road network between intact habitat patches Mostly minor current negative ecological impacts with some major impacts (e.g. established population of alien and invasive flora) and a few signs of minor past disturbance; moderate rehabilitation potential
Low	Small (>1 ha but <5 ha) area Almost no habitat connectivity but migrations still possible across some transformed or degraded natural habitat and a very busy used road network surrounds the area. Low rehabilitation potential Several minor and major current negative ecological impacts
Very low	Very small (<1 ha) area No habitat connectivity except for flying species or flora with wind-dispersed seeds. Several major current negative ecological impacts

Table 42: Biodiversity Importance (SANBI, 2020)

Biodiversity Importance		Conservation Importance				
		Very High	High	Medium	Low	Very Low
Functional Integrity	Very High	Very High	Very High	High	Medium	Low
	High	Very High	High	Medium	Medium	Low
	Medium	High	Medium	Medium	Low	Very Low
	Low	Medium	Medium	Low	Low	Very Low
	Very Low	Medium	Low	Very Low	Very Low	Very Low

Table 43: Receptor Resilience (SANBI, 2020)

Resilience	Fulfilling criteria
Very High	Habitat that can recover rapidly (~ less than 5 years) to restore > 70 % of the original species composition and functionality of the receptor functionality, or species that have a very high likelihood of remaining at a site even when a disturbance or impact is occurring, or species that have a very high likelihood of returning to a site once the disturbance or impact has been removed
High	Habitat that can recover relatively quickly (~ 5-10 years) to restore > 70 % of the original species composition and functionality of the receptor functionality, or species that have a high likelihood of remaining at a site even when a disturbance or impact is occurring, or species that have a high likelihood of returning to a site once the disturbance or impact has been removed
Medium	Will recover slowly (~more than 10 years) to restore > 70 % of the original species composition and functionality of the receptor functionality, or species that have a

Resilience	Fulfilling criteria
	moderate likelihood of remaining at a site even when a disturbance or impact is occurring, or species that have a moderate likelihood of returning to a site once the disturbance or impact has been removed
Low	Habitat that is unlikely to be able to recover fully after a relatively long period: > 15 years required to restore ~less than 50 % of the original species composition and functionality of the receptor functionality, or species that have a low likelihood of remaining at a site even when a disturbance or impact is occurring, or species that have a low likelihood of returning to a site once the disturbance or impact has been removed
Very low	Habitat that is unable to recover from major impacts, or species that are unlikely to remain at a site even when a disturbance or impact is occurring, or species that are unlikely to return to a site once the disturbance or impact has been removed

Table 44: Site Ecological Importance (SANBI, 2020)

Site Ecological Importance		Biodiversity Importance				
		Very High	High	Medium	Low	Very Low
Receptor Resilience	Very Low	Very High	Very High	High	Medium	Low
	Low	Very High	Very High	High	Medium	Very Low
	Medium	Very High	High	Medium	Low	Very Low
	High	High	Medium	Low	Very Low	Very Low
	Very High	Medium	Low	Very Low	Very Low	Very Low

Aquatic Assessment

Physical Habitat Assessment: The IHAS Method

The quality of the instream and riparian habitat has a direct influence on the aquatic community. Evaluating the structure and functioning of an aquatic ecosystem must therefore take into account the physical habitat to assess the ecological integrity. The IHAS sampling protocol, of which version 2 is currently used, was developed by McMillan in 1998 for use in conjunction with the SASS5 protocol to determine which habitats are present for aquatic macroinvertebrates.

IHAS consists of a scoring sheet that assists to determine the extent of each of the instream habitats, together with the physical parameter of the stream. For example, the proportion of stones in current and stones out of current will be compared with the presence of instream vegetation. This sampling protocol assists with the interpretation of the SASS5 data.

Data recorded during the site visit concerning sampling habitat and stream condition is uploaded into an excel spreadsheet. The results are then interpreted according to the categories supplied by McMillan:

IHAS score	Interpretation
<65%	Insufficient for supporting a diverse aquatic macro invertebrate community
65%-75%	Acceptable for supporting a diverse aquatic macroinvertebrate community
75%	Highly suitable for supporting a diverse aquatic macroinvertebrate community

Chemical Habitat Assessment: In Situ Water Quality

Water quality has a direct influence on in stream biota, and can fluctuate, depending on site-specific conditions. The biological monitoring of especially macroinvertebrates and fish thus need to be augmented with the *in situ* measurement of basic water quality indicator parameters (DWAF 1996), namely:

Temperature, which plays an important role in water by affecting the rates of chemical reactions and therefore the metabolic rates of organisms. Temperature is one of the major factors controlling the distribution of aquatic organisms. The temperatures of inland waters in South Africa generally range from 5 – 30°C. Natural variations in water temperature occur in response to seasonal and diel cycles and organisms use these changes as cues for activities such as migration, emergence and spawning.

Artificially-induced changes in water temperature can thus impact on individual organisms and on entire aquatic communities.

pH, which gives an indication of the level of hydrogen ions in water, as calculated by the expression: pH = $-\log_{10}[H^+]$, where $[H^+]$ is the hydrogen ion concentration. The pH of pure distilled water (that is, water containing no other soluble chemicals) at a temperature of 24°C is 7.0, implying that the number of H^+ and OH^- ions are equal and the water is therefore electrochemically neutral. As the concentration of hydrogen ions increases, pH decreases and the solution becomes more acidic. As $[H^+]$ decreases, pH increases and the solution becomes more alkaline. For natural surface water systems, pH values typically range between 4 and 11, and depends on the availability of carbonate and bicarbonate, which influences the buffer capacity of the water, and which are determined by geological and atmospheric circumstances.

Electrical Conductivity ("EC") is the measurement of the ease with which water conducts electricity (in milli-Siemens/meter – mS/m) and can also be used to estimate the total dissolved salts ("TDS"): EC in mS/mx 7 ≈ TDS in mg/ℓ. Changes in the EC values provide useful and rapid estimates of changes in the TDS concentration, which indicates the quantity of all compounds dissolved in the water that carry an electrical charge. Natural waters contain varying concentrations of TDS as a consequence of the dissolution of minerals in rocks, soils and decomposing plant material. TDS thus depends on the characteristics of the geological formations which the water has been in contact with, and on physical processes such as rainfall and evaporation. Plants and animals possess a wide range of physiological mechanisms and adaptations to maintain the necessary balance of water and dissolved ions in cells and tissues. Changes in EC can affect microbial and ecological processes such as rates of metabolism and nutrient cycling. The effect on aquatic organisms depend more on the rate of change than absolute changes in concentrations of salts.

Dissolved Oxygen (DO) is the measurement of the percentage saturation of water with gaseous oxygen, which is generated by aquatic plants during photosynthesis, or which dissolved into the water from the atmosphere. Gaseous oxygen is moderately soluble in water, and the saturation solubility varies non-linearly with temperature, salinity, atmospheric pressure (and thus altitude), and other site-specific chemical and physical factors. In unpolluted surface waters, dissolved oxygen concentrations are usually close to 100% saturation. Concentrations of less than 100% saturation indicate that DO has been depleted from the theoretical equilibrium concentration. Results in excess of 100% saturation (super-saturation of oxygen) usually indicate eutrophication in a water body. Typical oxygen saturation concentrations at sea level, and at TDS values below 3,000 mg/ℓ, are at around 13 mg/ℓ (@5 °C); 10 mg/ℓ (@15 °C); and 9 mg/ℓ (@20 °C). High water temperatures combined with low dissolved oxygen levels can compound stress effects on aquatic organisms. There is a natural diel (24-hour cycle) variation in DO, associated with the 24-hour cycle of photosynthesis and respiration by aquatic biota. Concentrations decline through the night to a minimum near dawn, then rise to a maximum by mid-afternoon. Seasonal variations arise from changes in temperature and biological productivity. The maintenance of adequate DO saturation levels in water is critical for the survival and functioning of aquatic biota, because it is required for the respiration of all aerobic organisms. Therefore, the DO saturation levels provide a useful measure of the health of an aquatic ecosystem (DWAF 1996). Measuring DO is measuring a dissolved gas, and is thus best measured in situ, to prevent de-oxygenation or oxygenation during transportation.

It should be noted that the *in situ* measurement of these water quality parameters does not represent the general water quality at the sampling points or the streams. It is not a laboratory analysis of water quality, and does not measure macro anions and cations, metals or organic contaminants, nutrients or pesticides. The *in situ* measurements of these parameters provide a snapshot of the water quality at the survey site **at the time the biological samples were taken**, and thus can provide valuable insight into the characteristics at a survey site that could have an influence on the aquatic biota at that site, and at the time of conducting the sampling for biomonitoring.

In situ measurements of pH, temperature (in °C), and EC (in µS/cm) were taken by means of a calibrated hand-held instrument (Hanna - HI 991300) in the main flow of the river or stream sampled, both prior to conducting the sampling for biomonitoring as well as after the completion of conducting the sampling for biomonitoring.

The EC measurements in µS/cm were converted to mS/m (10 µS/cm = 1 mS/m) by dividing with a factor of 10.

Receiving water quality objectives ("RWQOs") based on the water quality requirements for different users, are contained in a set of documents first published by DWAF in 1993, and revised in 1996 (DWAF, 1996). These documents are collectively known as the "South African Water Quality Guidelines" ("SAWQGs") and contain guidelines for specific types of water users, namely:
SAWQG Volume 1: Domestic Water Use
SAWQG Volume 2: Recreational Water Use
SAWQG Volume 3: Industrial Water Use
SAWQG Volume 4: Agricultural Water Use: Irrigation
SAWQG Volume 5: Agricultural Water Use: Livestock Watering
SAWQG Volume 6: Agricultural Water Use: Aquaculture
SAWQG Volume 7: Aquatic Ecosystems

These guidelines provide useful information on the effects of various chemical substances on water resource quality and establish objectives for the management of the water resource based on the requirements of the different users of the water resource. The water quality requirements for protecting and maintaining the health of aquatic ecosystems differ from those of other water uses. It is difficult to determine the effects of changes in water quality on aquatic ecosystems, as the cause-effect relationships are not well understood. Therefore, water quality guidelines have to be derived indirectly through extrapolation of the known effects of water quality on a very limited number of aquatic organisms. Certain quality ranges are required to protect and maintain aquatic ecosystem health. For each constituent, guideline ranges are specified, including the No Effect Range (Target Water Quality Range or "TWQR"), Minimum Allowable Values, Acceptable Range, and, for some parameters, Intolerable levels.

The SAWQGs for aquatic ecosystems that are applicable to the *in situ* measurements of water quality, are summarised below (DWAF 1996):

Parameter	Unit	Target Water Quality Range	Minimum Allowable Values
Temperature	°C	should not vary from the background average daily water temperature considered to be normal for that specific site and time of day, by > 2 °C, **or** by > 10 %, whichever estimate is the more conservative	
EC	mS/m	Should not be changed by > 15 % from the normal cycles of the water body	
pH	pH units	Variation from background pH limited to <0.5 of a pH unit, or < 5%, whichever is the more conservative estimate	
DO	% saturation	80 – 120	> 60 (sub lethal) > 40 (lethal)

Data collected during the *in situ* measurements were compared against these SAWQGs for aquatic ecosystems.

Species Response: Aquatic Invertebrates & the SASS5 Method

SASS5 is a rapid bioassessment method used to identify changes in species composition of aquatic invertebrates to indicate relative water quality (Dickens and Graham 2002). SASS5 requires the identification of invertebrates to a family level in the field.

SASS5 is based on the principle that some invertebrate taxa are more sensitive than others to pollutants. In particular, macroinvertebrate assemblages are good indicators of localized conditions in rivers. Many macroinvertebrates have limited migration patterns or are not free-moving, which makes them well-suited for assessing site specific impacts with upstream/downstream studies. Benthic macroinvertebrates are abundant in most streams. Even small streams (1st and 2nd order) which may have a limited fish population will support a diverse macroinvertebrate fauna. These groups of species constitute a broad range of trophic levels and pollution tolerances. Thus, SASS5 is a useful method for interpreting the cumulative effects of impacts on aquatic environments.

Using a 'kick net', the SASS5 sampling method entails prescribed time-periods and spatial areas for the kicking of in-current and out-current stones and bedrock; sweeping of in-current and out-current marginal and aquatic vegetation, as well as of gravel, stones and mud ("GSM"); followed by visual observations and hand-picking. The results of each biotope are kept separate, until all observations are noted. The entire sample is then returned to the river, retained alive, or preserved for further identification.

In SASS5 analysis, species abundance is recorded on an SASS5 data sheet which weighs the different taxa common to South African rivers from 1 (pollutant tolerant) to 15 (pollution sensitive). The SASS5 score will be high at a particular site if the taxa are pollution sensitive and low if they are mostly pollution tolerant.

The SASS5 Score, the number of taxa observed, and the average score per taxon ("ASPT") are calculated for all of the biotopes combined. Dallas (2007) used available SASS5 Score and ASPT values for each eco-region in South Africa to generate biological bands on standardised graphs that are used as a guideline for interpreting any data obtained during the study. The meaning of each *SASS5 Ecological Category* is as follows (Dallas 2007).

EC	Ecological category	Description
A	Natural	Unmodified natural
B	Good	Largely natural with few modifications
C	Fair	Moderately modified
D	Poor	Largely modified
E	Seriously modified	Seriously modified
F	Critically modified	Critically or extremely modified

Appendix F – Results of the Aquatic Baseline Assessment

Results – In situ Water Quality

The chemical characteristics were determined by the *in situ* measurement of temperature, pH, electrical conductivity, and dissolved oxygen at each sampling point, and the results are summarised below.

Comparison of *in situ* water quality results for the 2022 baseline aquatic assessment

Sampling point	**MUB1**	**MUB2**	**MUB3**	**MUB4**	**MUB5**	**MUB6**	**MUB7**	**MUB8**	**GRB1**
IHAS Score	**No access** 2022/01/06 2022/02/04 2022/02/22	43%	48%	Water quality taken in downstream dam	56	21%	No flow	39%	46%
IHAS Class description		Insufficient	Insufficient		Acceptable	Insufficient		Insufficient	Insufficient
Visual appearance of water prior to sampling		Discoloured	Discoloured		Murky	Murky		Discoloured	Discoloured
Date		2022/02/04	2022/02/04	2022/02/04	2022/02/04	2022/02/04	2022/02/22	2022/01/06	2/24/2022
Time (hh:mm)		14:30	15:10	13:00	16:00	17:00	10:50	8:30	12:28
Temperature (°C)		24,6	24,3	22,4	25,3	24,4	24,5	25,1	24.7
pH		8,39	7,87	6,93	8,2	8,5	7,84	7,8	7.92
EC (mS/m)		109.6	95.4	60.5	40.3	41.8	31.1	115.8	47.5
DO (%)		82,6	90,8	68,3	97	82,1	70,1	66,4	82.8

Habitat observations, biotope suitability scores and IHAS results

Monitoring site	MUB1	MUB2	MUB3	MUB4	MUB5	MUB6	MUB7	MUB8	GRB1
Visual Observations									
Turbidity	No access	Discoloured	Slightly Discoloured	No sass, water quality conducted in downstream dam	Murky	Murky	Murky	Discoloured	Discoloured
Flow		Trickle	Low				No flow	Moderate	Moderate
Site Biotope Suitability Scores									
SIC		0	0		3	0		0	0
SOOC		3	1		2	1		0	0
BR		2	1		3	1		0	0
AV		1	1		0	1		0	2

Monitoring site	MUB1	MUB2	MUB3	MUB4	MUB5	MUB6	MUB7	MUB8	GRB1
MVIC		0	1		2	0		0	0
MVOOC		2	3		2	3		3	3
Gravel		1	1		2	0		0	0
Sand		0	0		0	1		0	0
Mud		3	3		2	3		1	3
IHAS									
Total length of white water rapids (ie: bubbling water) (in meters)		0	0		1	0		0	0
Total length of submerged stones in current (run) (in meters)		0	0		2	0		0	0

Monitoring site	MUB1	MUB2	MUB3	MUB4	MUB5	MUB6	MUB7	MUB8	GRB1
Number of separate SIC area's kicked		0	0		2	0		0	0
Average stone sizes kicked (in cm's)		0	0		3	0		0	0
Amount of stone surface clear (in %)		0	0		2	0		0	0
Protocol: time spent actually kicking SIC's (in mins)		0	0		3	0		0	0
Vegetation									
Length of fringing vegetation sampled (banks) (in meters)		1	4		4	4		4	4
Amount of aquatic vegetation/algae sampled (in square meters)		1	1		1	1		1	2

Monitoring site	MUB1	MUB2	MUB3	MUB4	MUB5	MUB6	MUB7	MUB8	GRB1
Fringing vegetation sampled in		3	3		5	3		3	3
Type of veg. (percent leafy as apposed to stems/shoots)		2	3		3	3		2	3
Other Habitat									
Stones Out Of Current (SOOC) sampled (in square meters)		4	1		1	2		0	0
Sand sampled (in minutes)		0	0		0	1		0	0
Mud sampled (in minutes)		3	3		2	3		2	3
Gravel sampled (in minutes)		1	0		1	0		0	0

Monitoring site	MUB1	MUB2	MUB3	MUB4	MUB5	MUB6	MUB7	MUB8	GRB1
Bedrock sampled (all = no SIC, sand, gravel)		1	1		1	1		0	0
Algal presence (m2)		4	4		5	5		4	4
Tray identification		3	3		3	3		3	3
Physical									
River make up		0	2		5	0		0	0
Average width of stream (in meters)		5	5		5	5		4	5
Average depth of stream (in meters)		2	2		5	3		3	3

Monitoring site	MUB1	MUB2	MUB3	MUB4	MUB5	MUB6	MUB7	MUB8	GRB1
Approximate velocity of stream		0	3		5	3		0	1
Water colour		3	3		0	0		3	3
Recent disturbances		5	5		5	5		5	5
Bank/Riparian vegetation		2	2		2	2		2	2
Surrounding impacts		1	1		1	1		1	3
Left bank cover (rocks and vegetation) (in %)		1	1		1	1		1	1
Right bank cover (rocks and vegetation) (in %)		1	1		1	1		1	1

SASS5 Results

SASS5 Monitoring site	MUB2			MUB3			MUB5			MUB6			MUB8			GRB1		
	S	VEG	GSM	S	VEG	GSM	S	VEG	GSM	S	VEG	GSM	S	VEG	GSM	S	VEG	GSM
PORIFERA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
COELENTERATA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TURBELLARIA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oligochaeta	-	-	A	1	-	A	-	-	1	-	-	-	-	-	-	-	-	1
Leeches	-	-	-	-	-	-	A	-	-	-	-	1	-	-	-	-	-	-
Amphipoda	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Potamonautidae*	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Atyidae	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
Palaemonidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HYDRACARINA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A
Notonemouridae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Perlidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Baetidae 1 sp.	-	-	-	-	-	-	A	A	-	-	1	-	-	A	1	1	-	-
2 spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 2 spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Caenidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ephemeridae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Heptageniidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Leptophlebiidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oligoneuridae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polymitarcyidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Prosopistomatidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Teloganodidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tricorythidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calopterygidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chlorocyphidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chlorolestidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

SASS5 Monitoring site	MUB2			MUB3			MUB5			MUB6			MUB8			GRB1		
	S	VEG	GSM	S	VEG	GSM	S	VEG	GSM	S	VEG	GSM	S	VEG	GSM	S	VEG	GSM
Coenagrionidae	-	-	-	-	A	-	-	-	-	-	-	-	-	1	-	2	-	-
Lestidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Platycnemidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Protoneuridae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zygoptera juvs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aeshnidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Corduliidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gomphidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Libelludae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pyralidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Belostomatidae*	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
Corixidae*	A	A	-	A	A	1	-	A	-	A	B	A	-	A	A	A	-	B
Gerridae*	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-
Hydrometridae*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Naucoridae*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nepidae*	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
Notonectidae*	-	1	-	-	-	-	-	1	A	1	A	-	-	1	1	-	-	-
Pleidae*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Veliidae*	-	A	-	-	A	-	-	A	-	-	-	-	-	-	-	-	-	-
Corydalidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sialidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dipseudopsidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ecnomidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydropsychidae 1sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2 spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 2 spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Philopotamidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Psychomydae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polycentropodidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Barbarochthonidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calamoceratidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

SASS5 Monitoring site	MUB2			MUB3			MUB5			MUB6			MUB8			GRB1		
	S	VEG	GSM	S	VEG	GSM	S	VEG	GSM	S	VEG	GSM	S	VEG	GSM	S	VEG	GSM
Glossosomatidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydroptilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydrosalpingidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lepidostomatidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Leptoceridae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Petrothrincidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pisuliidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sericostomatidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dytiscidae (adults*)	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	A	-	-
Elmidae / Dryopidae*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gyrinidae (adults*)	-	1	-	1	-	-	-	-	-	-	A	-	-	-	-	-	-	-
Haliplidae (adults*)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Helodidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydraenidae (adults*)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydrophilidae (adults*)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Limnichidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Psephenidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Athericidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Blepharoceridae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ceratopogonidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Chironomidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Culicidae*	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	1	-	-
Dixidae*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Empididae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ephydridae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Muscidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Psychodidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Simuliidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-
Syrphidae*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tabanidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tipulidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

SASS5 Monitoring site	MUB2			MUB3			MUB5			MUB6			MUB8			GRB1		
	S	VEG	GSM	S	VEG	GSM	S	VEG	GSM	S	VEG	GSM	S	VEG	GSM	S	VEG	GSM
Ancylidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bulininea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydrobidae*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lymnaeidae*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Physidae*	-	-	-	-	-	-	1	1	-	-	A	-	-	1	-	-	-	-
Planorbinae*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thiaridae*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Viviparidae*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Corbiculidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sphaeridae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unionidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Key to table

S= Stones

Veg= Vegetation

GSM = Gravel Sand and Mud

* Air breathers

Determination of SASS5 Ecological Category

For the purposes of the 2022 baseline aquatic assessment survey, it was possible to determine the SASS5 Ecological Category (EC) at all sampling points MUB2, MUB3, MUB5, MUB6, MUB8 and GRB1. MUB1 had no access whilst MUB4 and MUB7 had no flow present during the survey.

The SASS5 EC of the MUB2, MUB3, MUB5, MUB6 and GRB1 was E/F indicating a seriously to critically mofified system for both the Grootbossiespruit and the Boesmanspruit and their respective tributaries. The only sampling point which was had a largely natural condition was MUB8 situated in a perennial tributary of the Grootbossiespruit, downstream of the planned WEF (Figure 31)

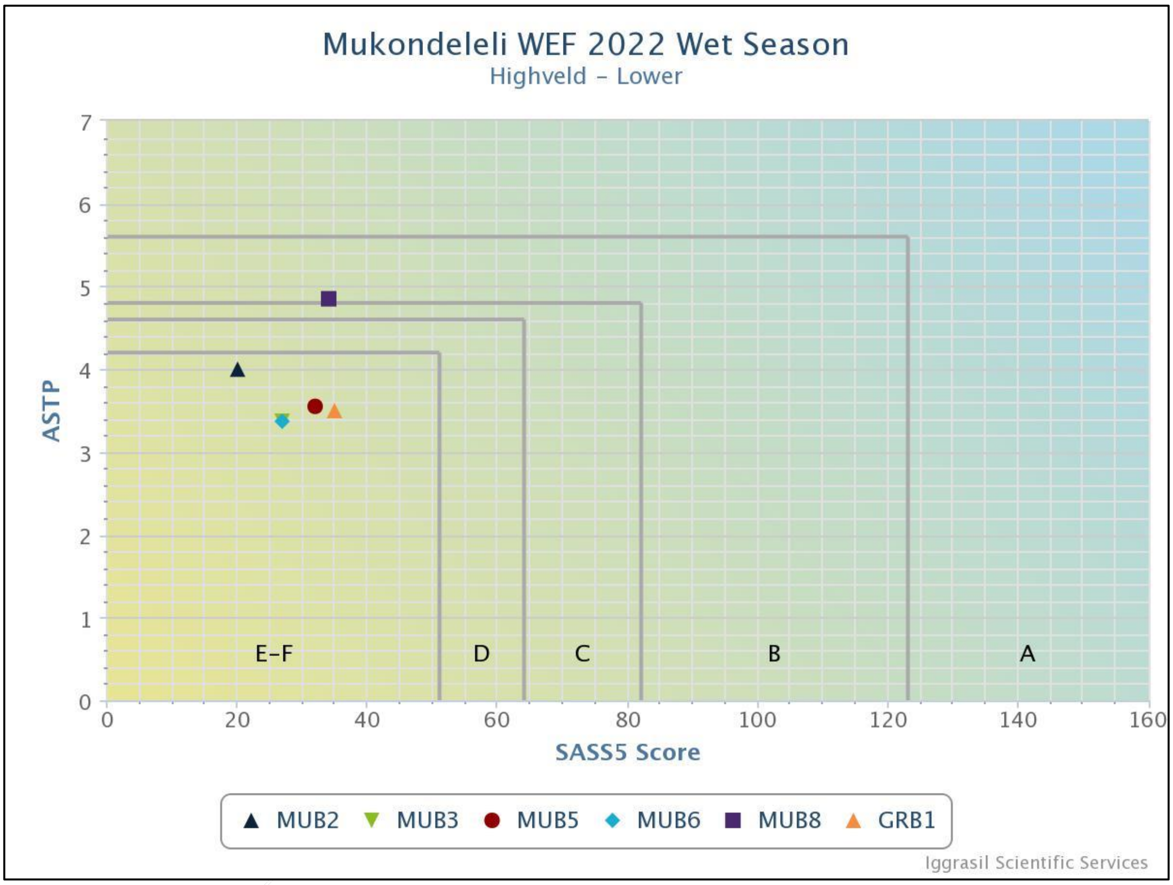


Figure 31: SASS5 Score and ASPT Plot for sampling points

The SASS5 Score and ASPT for the 2022 baseline aquatic assessment survey for the planned Mukondeleli WEF to the biological bands for the Highveld Ecoregion (Lower zone) (Dallas, 2007)