Aquatic Baseline & Impact Assessment for the Proposed FE Kudu Wind Energy Facility and Associated Infrastructure

Aberdeen, Eastern Cape Province

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CLIENT

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Executive Summary

The Biodiversity Company was appointed by Savannah Environmental (Pty) Ltd to conduct an Aquatic Baseline and Impact (risk) Assessment for the proposed FE Kudu Wind Energy Facility (WEF). The proposed project is located between Beaufort West to the north-west and Aberdeen to the south-east, in the Eastern Cape Province of South Africa. A single dry season survey was conducted on the 23rd to the 25th of May 2023 by a qualified freshwater ecologist.

The purpose of the specialist study is to provide relevant input into the environmental authorisation process and provide a report for the proposed activities associated with the project. This report, after taking into consideration the findings and recommendations provided by the specialists herein, should inform and guide the Environmental Assessment Practitioner, enabling informed decision making as to the ecological viability of the proposed project and to provide an opinion on the whether any Environmental Authorisation (EA) process or licensing is required for the project.

The baseline assessment investigated the watercourses present within the Project Area of Influence (PAOI). Numerous drainage features are present comprising of an extensive braided watercourse network, presenting ephemeral conditions with scattered vernal pools present. Several watercourses presented surface water at the time of the survey, however not all of them were suitable for the assessment of aquatic biota. The sampled watercourses were tributaries of the Tulpleegte and Kariega rivers. The results of the Present Ecological Status (PES) assessment derived a moderately modified (class C) status for the Tulpleegte. The anthropogenic activities within the catchment have resulted in large modifications to the riparian and instream habitat integrity of the watercourse. These activities have contributed to alteration of hydrology and some erosion of the river banks, with evidence of flow and channel modification, cumulatively reducing the biotic integrity of the sampled watercourses. The biotic integrity must be interpreted with caution due to the ephemeral nature of the watercourses and limited availability of surface water to support a diverse aquatic ecosystem.

Despite modification, the instream water quality in the sampled systems was suitable for aquatic biota, which was supporting a low diversity of aquatic macroinvertebrates. This low diversity is a common feature of arid region communities due to surface water limitations. Sampling for fish was conducted, however despite adequate habitat suitability for fish, no fish were collected. The absence of fish is likely due to the ephemeral nature of the watercourses that may not be conducive to support fish year-round. It is likely that the absence of sufficient rainfall leading up to the survey may have limited the presence of fish at the time of the survey. Despite this, fish are likely present within the Kariega River immediately downstream of the PAOI, highlighting the need to limit water quality and habitat impacts during the execution of the project to conserve fish and aquatic life within the downstream watercourse and those potentially occurring within the sampled watercourses. Additionally, vernal biota namely clam shrimp (Conchostraca) were sampled in the upper reaches of the Tulpleegte River. The specialist recommends that the moderately modified (class C) status be set as the Management Class for the watercourses traversed by the project infrastructure.

Due to the sensitivity of the catchment and soils to erosion, together with the flat topography and braided alluvial fan nature of the watercourses within the PAOI, an increase in anthropogenic activities poses a risk to the ecological integrity of the watercourses notably from a hydrological perspective. The presence of aquatic macroinvertebrates and vernal biota highlights the sensitivity of the watercourses. Any proposed activities in proximity to the

watercourses should not further contribute to the deterioration of the instream and riparian zones as this will compromise the ecological integrity of the reach and Management Class may not be achieved.

The aquatic features presented in this report require a buffer of 32 m and are to be treated as a no-go zone and avoided as far as is feasible. The optimized layout has implemented the avoidance strategy and positioned majority of the turbine platforms and road networks outside the buffer areas. There are however some watercourse crossings proposed and these are deemed acceptable and appropriately placed. There are however several artificial and natural vernal pools located in close proximity to the proposed road between turbines N23 and N24, and turbines S37 and S38, respectively. It is suggested that this infrastructure be relocated slightly and meander to avoid these aquatic features while catering for natural surface runoff (box culverts) to continue to feed into these aquatic features to sustain the functioning of these systems and their likely vernal biota. Ensuring that aquatic features and buffers are intact increases the resilience of a watercourse to future disturbances. These buffers would ensure adequate ecological integrity maintenance from the adjacent proposed wind energy facilities.

Impact Assessment

An impact statement is required as per the NEMA regulations with regards to the proposed development. As a result of the ephemeral and braided nature of the watercourses and susceptibility to erosion and the flat topography likely to be seasonally flooded, the construction and operation phase activities would influence the hydrology, water quality and soil movement within the affected watercourses and vernal pools, notably where the proposed infrastructure traverse these aquatic features and their associated 32 m buffer. This 32 m buffer would also apply to the vernal pools. The optimized layout has largely avoided the ESAs and associated aquatic features with some watercourse crossings proposed and these are deemed acceptable and appropriately placed. There is however the exception of portions of the roads that come in close proximity to the vernal pools and fall within their buffers. These need to be avoided. Provided the mitigation and recommendations are implemented responsibly the project will present low rated residual impacts to the watercourses.

Specialist Opinion

Based on the survey findings, the specialist agrees with the “Very High” aquatic theme sensitivity as per the National Web based Environmental Screening Tool. The project infrastructure does pose risk to the watercourses and it is the specialist’s opinion that following the implementation of avoidance mitigation, recommendations and remedial measures, the risks can be lowered. Therefore, authorisation of the proposed development can be carefully considered by the authorities.

Document Guide

The table below provides the minimum requirements for aquatic specialist assessments, and the relevant sections in the reports where these requirements are addressed. These are as per the "Protocol for the Specialist Assessment and Minimum Report Content Requirements for Environmental Impacts on Aquatic Biodiversity" gazetted 20 March 2020, published in Government Notice No. 320.

Item	Section	Comment
The assessment must be prepared by a specialist registered with the South African Council for Natural Scientific Professionals (SACNASP) with expertise in the field of aquatic sciences.	Section 1.6	
Contact details of the specialist, their SACNASP registration number, their field of expertise and a curriculum vitae.	Section 1.6	CV attached as Appendix C
A signed statement of independence by the specialist(s).	Appendix A	
The assessment must be undertaken on the preferred site and within the proposed development footprint.	Section 1.2	
A baseline description of the aquatic biodiversity and ecosystems on the site, including: (a) aquatic ecosystem types; (b) presence of aquatic species, and composition of aquatic species communities, their habitat, distribution and movement patterns.	Sections 2 & 4	
The threat status of the ecosystem and species as identified by the screening tool;	Section 2.9	
An indication of the national and provincial priority status of the aquatic ecosystem, including a description of the criteria for the given status (i.e. if the site includes a wetland or a river freshwater ecosystem priority area (NFEPA) or sub catchment, a strategic water source area (SWSA), a priority estuary, whether or not they are free -flowing rivers, wetland clusters, a critical biodiversity or ecologically sensitivity area);	Section 2.7	
A description of the ecological importance and sensitivity of the aquatic ecosystem including: (a) the description (spatially, if possible) of the ecosystem processes that operate in relation to the aquatic ecosystems on and immediately adjacent to the site (e.g. movement of surface and subsurface water, recharge, discharge, sediment transport, etc.); and (b) the historic ecological condition (reference) as well as present ecological state of rivers (in-stream, riparian and floodplain habitat), wetlands and/or estuaries in terms of possible changes to the channel and flow regime (surface and groundwater).	Sections 2 & 4	
A statement on the duration, date and season of the site inspection and the relevance of the season to the outcome of the assessment.	Section 3.1	
A description of the methodology used to undertake the site verification and impact assessment and site inspection, including equipment and modelling used, where relevant.	Section 3.1	
A description of the assumptions made and any uncertainties or gaps in knowledge or data.	Section 1.4	
The assessment must identify any alternative development footprints within the preferred site which would be of a "low" sensitivity as identified by the screening tool and verified through the site sensitivity verification.	Section 6.2.1	Recommendation have been included to avoid sensitive areas
Related to impacts, a detailed assessment of the potential impacts of the proposed development on the following aspects must be undertaken to answer the following questions: Is the proposed development consistent with maintaining the priority aquatic ecosystem in its current state and according to the stated goal? Is the proposed development consistent with maintaining the resource quality objectives for the aquatic ecosystems present? How will the proposed development impact on fixed and dynamic ecological processes that operate within or across the site? This must include: (a) impacts on hydrological functioning at a landscape level and across the site 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); (b) will the proposed development change the sediment regime of the aquatic ecosystem and its sub -catchment (e.g. sand movement, meandering river mouth or estuary, flooding or sedimentation patterns);	Section 6	

Item	Section	Comment
(c) what will the extent of the modification in relation to the overall aquatic ecosystem be (e.g. at the source, upstream or downstream portion, in the temporary I seasonal I permanent zone of a wetland, in the riparian zone or within the channel of a watercourse, etc.); and (d) to what extent will the risks associated with water uses and related activities change.		
How will the proposed development impact on the functioning of the aquatic feature? This must include: (a) base flows (e.g. too little or too much water in terms of characteristics and requirements of the system); (b) quantity of water including change in the hydrological regime or hydroperiod of the aquatic ecosystem (e.g. seasonal to temporary or permanent; impact of over -abstraction or instream or off stream impoundment of a wetland or river); (c) change in the hydrogeomorphic typing of the aquatic ecosystem (e.g. change from an unchannelled valley- bottom wetland to a channelled valley -bottom wetland); (d) quality of water (e.g. due to increased sediment load, contamination by chemical and/or organic effluent, and/or eutrophication); (e) fragmentation (e.g. road or pipeline crossing a wetland) and loss of ecological connectivity (lateral and longitudinal); and (f) the loss or degradation of all or part of any unique or important features associated with or within the aquatic ecosystem (e.g. waterfalls, springs, oxbow lakes, meandering or braided channels, peat soils, etc.);	Section 6	
How will the proposed development impact community composition (numbers and density of species) and integrity (condition, viability, predator - prey ratios, dispersal rates, etc.) of the faunal and vegetation communities inhabiting the site?	Section 6	
A location of the areas not suitable for development, which are to be avoided during construction and operation (where relevant).	Section 6	
Additional environmental impacts expected from the proposed development.	Section 6	
Any direct, indirect and cumulative impacts of the proposed development.	Section 6	
The degree to which impacts and risks can be mitigated.	Section 6	
The degree to which the impacts and risks can be reversed.	Section 6	
The degree to which the impacts and risks can cause loss of irreplaceable resources.	Section 6	
A suitable construction and operational buffer for the aquatic ecosystem, using the accepted methodologies.	Section 5	
Proposed impact management actions and impact management outcomes proposed by the specialist for inclusion in the Environmental Management Programme (EMPr).	Section 7	
A motivation must be provided if there were development footprints identified as per above that were identified as having a “low” aquatic biodiversity sensitivity and that were not considered appropriate.	-	N/A
A substantiated statement, based on the findings of the specialist assessment, regarding the acceptability, or not, of the proposed development, if it should receive approval or not;	Section 9	
Any conditions to which this above statement is subjected	Section 9	

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Acronyms and Abbreviations

Abbreviation	Definition
ASPT	Average Score Per Recorded Taxon
BESS	Battery Energy Storage System
BPEO	Best Practicable Environmental Option
CBA	Critical Biodiversity Area
CR	Critically Endangered
DEA	The then Department of Environmental Affairs (now DFFE)
DO	Dissolved Oxygen
DWA	The then Department of Water Affairs (now DWS)
DFFE	Department of Forestry; Fisheries and the Environment
DWAF	The then Department of Water Affairs and Forestry (now DWS)
DWS	Department of Water and Sanitation
EA	Environmental Authorisation
ECO	Environmental Control Officer
EI	Ecological Importance
EIA	Environmental Impact Assessment
EIS	Ecological Importance and Sensitivity
EMP	Environmental Management Programme
EN	Endangered
ESA	Ecological Support Area
ETS	Ecosystem threat status
FRAI	Fish Response Assessment Index
GIS	Geographic Information System
GPS	Global Positioning System
IHIA	Intermediate Habitat Integrity Assessment
IUCN	International Union for Conservation of Nature
LC	Least Concerned
MASL	Meters Above Sea Level
MIRAI	Macroinvertebrate Response Assessment Index
MTS	Main Transmission Substation
NEMA	The National Environmental Management Act 107 of 1998
NFEPA (FEPA)	National Freshwater Ecosystem Priority Areas
NT	Near threatened
NWA	National Water Act 36 of 1998
NWBEST	National Web Based Environmental Screening Tool
PAOI	Project Area Of Influence
PES	Present Ecological State
SACNASP	the South African Council for Natural Scientific Professionals
SAIIAE	South African Inventory of Inland Aquatic Ecosystems
SANBI	South African National Biodiversity Institute
SASS5	South African Scoring System version 5
SCC	Species of Conservation Concern
SQR	Sub Quaternary Reach
SWSA	Strategic Water Source Area
TBC	The Biodiversity Company

Abbreviation	Definition
TWQR	Target Water Quality Range
VU	Vulnerable
WEF	Wind Energy Facility
WULA	Water Use License Application
WMA	Water Management Area

1 Introduction

1.1 Background

The modification of land use within a river catchment has the potential to degrade local water resources (Wepener *et al*., 2005). Altered land use associated with renewable energy developments thus has the potential to negatively impact on local water resources and ecosystem services. In order to effectively manage the potential impacts to watercourses, the establishment of the baseline condition of a watercourse is required.

The Biodiversity Company was appointed by Savannah Environmental (Pty) Ltd (Savannah) to conduct an aquatic baseline and impact (risk) assessment for the proposed FE Kudu Wind Energy Facility (WEF) and associated infrastructure. The applicant, FE Kudu (Pty) Ltd, is proposing the development of a wind energy facility and associated infrastructure between Beaufort West to the north-west and Aberdeen to the south-east, in the Eastern Cape Province of South Africa.

This assessment was conducted in accordance with the Environmental Impact Assessment Regulations, 2014 (Government Notice (GN) 326, 7 April 2017) (EIA Regulations) of the National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA). The approach has taken cognisance of the Assessment Protocol. The Department of Forestry; Fisheries and the Environment (DFFE) National Web based Environmental Screening Tool has characterised the aquatic biodiversity sensitivity theme for the Project Area of Influence (PAOI) as “*Very High*” and therefore specialist assessments were completed for the project. A single dry season survey was conducted on the 23rd to the 25th of May 2023 by a qualified freshwater ecologist.

This report, after taking into consideration the findings and recommendations provided by the specialists herein, should inform and guide the Environmental Assessment Practitioner, enabling informed decision making as to the ecological viability of the proposed project and to provide an opinion on the whether any Environmental Authorisation (EA) process or licensing is required for the project.

1.2 Project Area and Description

The project is located approximately 40 km west of Aberdeen in the Eastern Cape Province (Figure 1-1). The project is located within the Dr Beyers Naude Local Municipality and the greater Sarah Baartman District Municipality. The project site comprises a single affected property, Portion 2 of Farm Oorlogspoort 85. The project is known as the FE Kudu Wind Energy Facility. The project is planned as part of a cluster of renewable energy projects, which includes a second facility, FE Tango Wind Energy Facility, located approximately 20 km to the east of the site.

The entire extent of the site falls within the Beaufort West Renewable Energy Development Zones (i.e. REDZ Focus Area 11). The undertaking of a basic assessment process for the project is in-line with the requirements stated in GNR 114 of 16 February 2018.

The Kudu Wind Energy Facility will have a contracted capacity of up to 600 MW and comprise wind turbines with a capacity of up to 7.5 MW each. The project has a preferred project site of approximately ~9 170ha. Access to the site will be via an existing road off of the nearby R61.

The FE Kudu Wind Energy Facility project site is proposed to accommodate the following infrastructure:

- Up to 60 wind turbines, turbine foundations and turbine hardstands.
- An on-site substation hub incorporating:
  - A132 kV on-site facility substation (OSS);
  - Switchyard with collector infrastructure;
  - Battery Energy Storage System (BESS); and
  - Operation and Maintenance buildings.
- A balance of plant area incorporating:
  - Temporary laydown areas; and
  - A construction camp laydown and temporary concrete batching plant.
- Power lines internal to the wind farm, trenched and located adjacent to internal access roads, where feasible. The intention is for internal project cabling to follow the internal roads.
- Access roads (gravel) to the site and between project components with a width up to 8 m for primary access routes.

A technically viable development footprint was proposed by the developer and assessed as part of the studies.

The details of the project is as follows:

Project Name	**FE Kudu Wind Energy Facility**
Location	Portion 2 of Farm Oorlogspoort 85
Applicant	FE Kudu (Pty) Ltd
Contracted capacity	Up to 600 MW (turbines up to 7.5 MW in capacity)
Number of turbines	Up to 80 turbines[1]
Turbine hub height	Up to 164 m
Turbine top tip height	Up to 250 m
Rotor swept area	up to 21 m^2
Capacity of on-site substation	132 kV
Area occupied by the on-site substation	~ 2 ha in extent
Underground cabling	Underground cabling, with a capacity of 33 kV, will be installed to connect the turbines to the on-site facility substation.
Battery Energy Storage System (BESS)	Solid state battery technology (e.g. Lithium-ion technology) as a preferred technology. BESS will be housed in containers approximately 20 m long, 3 m wide, and 5 m high with an approximate footprint of up to 5 ha.
Operation and maintenance (O&M) buildings	~ 1ha in extent
Balance of plant area	Temporary laydown areas with an extent up to 6 ha. Temporary warehouse of 1 ha Temporary site camp establishment and concrete batching plants of 1 ha.

[1] 42 north turbines, and 41 south turbines

Project Name	FE Kudu Wind Energy Facility
Access and internal roads – Main road	Main access road to the site and between project components with a width up to 8 m and a servitude of 13.5 m.
Access and internal roads – internal network	Road network between project components with a width up to 8 m
Turbine hardstand footprint	~up to 7500 m^2 per turbine
Turbine foundation footprint	~ 1000 m^2 per turbine

The project is intended to provide electricity to the national grid through the Department of Mineral Resource and Energy's (DMRE) Renewable Energy Independent Power Producer Procurement (REIPPP) Programme or other public or private off-taker programmes.

The proposed project will require clearing of natural vegetation for the construction of the WEF, and the associated infrastructure which includes access roads, turbines and grid connections (substation, BESS and cabling), as well as any construction areas and laydown areas. These project aspects could potentially have negative impacts to the freshwater ecosystems and associated biota.

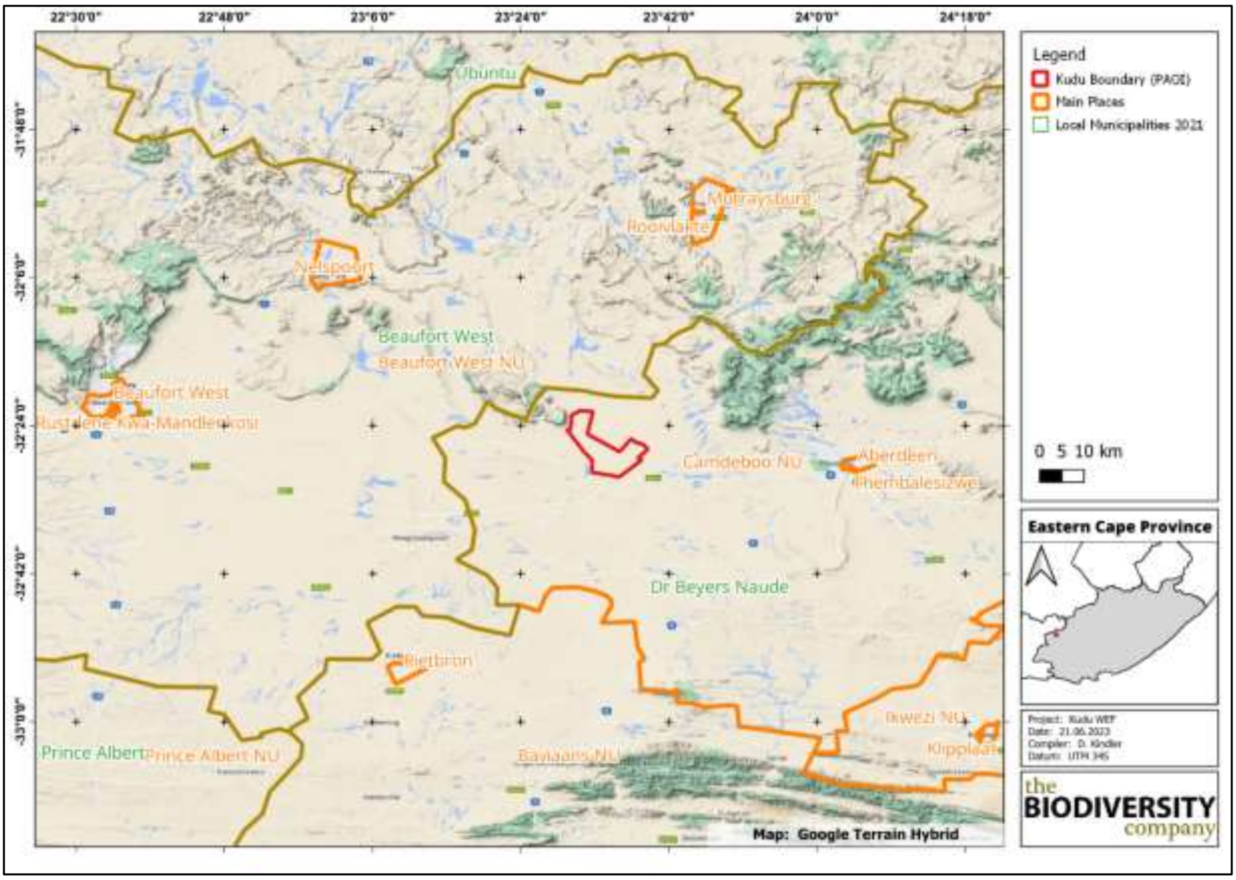


Figure 1-1 Locality of the project area

The farm boundary was used as the Project Area of Influence (PAOI) to incorporate the proposed development footprint and represents the total project area of assessment. A map illustrating the proposed project infrastructure and PAOI is presented on the next page in Figure 1-2. The proposed project infrastructure presents the optimized layout (August 2023) which planned to avoid sensitive aquatic and terrestrial features following specialist feedback following the respective studies May 2023 site investigations.

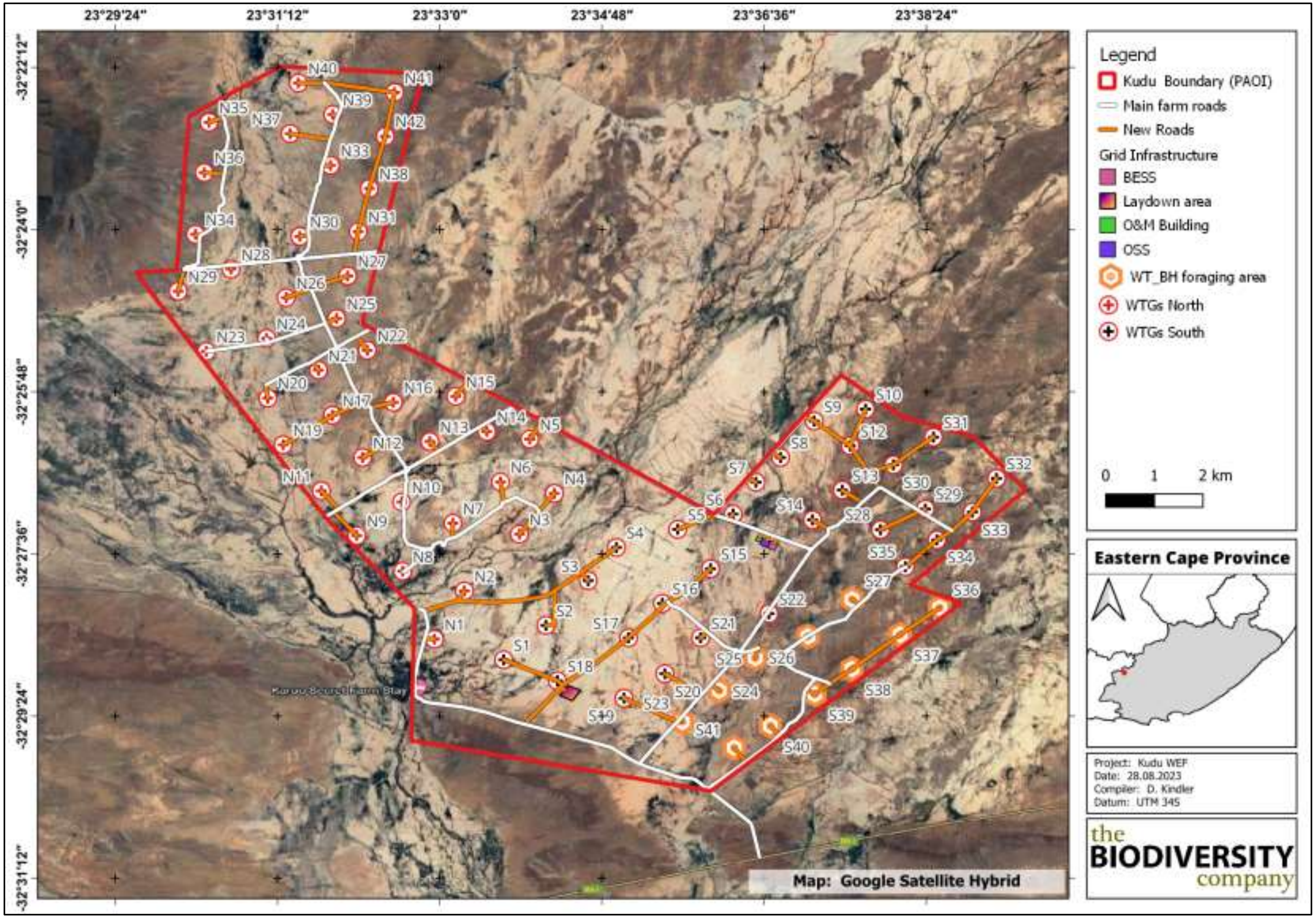


Figure 1-2 Spatial layout of the proposed project infrastructure (Optimized facility layout)

1.3 Scope of Work

The following tasks were completed in fulfilment of the terms of reference for this project:

- Desktop assessment to identify the relevant ecologically important geographical features within the PAOI;
- Desktop assessment to compile an expected species list and possible threatened aquatic biota that occur within the PAOI;
- Field survey to ascertain the species composition, Present Ecological Status (PES): instream and riparian condition (receiving environment) of the associated freshwater ecosystems within the PAOI – using appropriate survey methods;
- The delineation and identification of sensitive watercourse areas;
- Identify the manner that the proposed activity(s) impacts the freshwater ecosystems and evaluate the level of risk of these potential impacts;
- Provide mitigation and rehabilitation measures and recommendations to prevent or reduce the possible impacts; and
- Report compilation detailing the baseline findings.

1.4 Assumptions, Limitations and Gaps in Knowledge

The following assumptions and limitations are applicable for this project:

- Results for the study are based on a single site visit (low flow/ winter survey) and therefore no ecological trends are included in this report, however the data is sufficient to derive meaningful baseline conditions;
- Due to an unforeseen error, numerous site photographs were corrupted and subsequently following the site visit. This limited the visual representation of the project area and sampling efforts conducted;
- 20 meter contours were used to assist in the delineation of the watercourse features and may cause some discrepancies in areas between sites;
- Due to the time of sampling (winter) some of the ephemeral systems were dry, and could not be sampled due to absence of surface waters. These sites remain critical to ecosystem services and are regarded as highly sensitive;
- A portion of the site photographs were lost due to an unexpected error with the camera after the survey;
- Due to the rapid nature of the assessment and the survey methods applied (industry standard, aquatic biota diversity and abundance was likely to be underestimated; and
- This risk assessment is desktop based following a brief site inspection. The risks may not be conclusive and would require further investigation as the need may arise.

1.5 Key Legislative Requirements

The legislation, policies and guidelines listed below in Table 1-1 are applicable to the current project. The list below, although extensive, may not be complete and other legislation, policies and guidelines may apply in addition to those listed below.

Table 1-1 A list of key legislative requirements relevant to biodiversity and conservation in the Eastern Cape Province

Region	Legislation / Guideline	Comment
National	The National Environmental Management Act (NEMA) (Act No. 107 of 1998)	Environmental Impact Assessment Regulations. 2014 (GNR 326, 7 April 2017), Appendix 6 requirements.
	The National Environmental Management: Biodiversity Act (Act No. 10 of 2004), Threatened or Protected Species Regulations	The protection of species and ecosystems that warrant protection.
	Procedures for the Assessment and Minimum Criteria for Reporting on Identified Environmental Themes in terms of Sections 24(5)(a) and (h) and 44 of the National Environmental Management Act, 1998, GNR 320 of Government Gazette 43310 (March 2020)	The minimum criteria for reporting.
	Procedures for the Assessment and Minimum Criteria for Reporting on Identified Environmental Themes in terms of Sections 24(5)(a) and (h) and 44 of the National Environmental Management Act, 1998, GNR 1150 of Government Gazette 43855 (October 2020)	Protocol for the specialist assessment and minimum report content requirements.
	The National Environmental Management: Waste Act, 2008 (Act 59 of 2008);	The regulation of waste management to protect the environment.
	National Water Act (NWA) (Act No. 36 of 1998)	The regulation of water uses.
	Alien and Invasive Species Regulations and, Alien and Invasive Species List 20142020, published under NEMBA	The regulation and management of alien invasive species.
	Conservation of Agricultural Resources Act, 1983 (Act 43 of 1983) (CARA)	To provide for control over the utilization of the natural agricultural resources including the vegetation and the combating of weeds and invader plants.
Provincial	Eastern Cape Biodiversity Conservation Plan (ECBCP, Ver 2, 2019)	To inform land use planning, environmental assessments, land and water use authorisations, as well as natural resource management,

1.5.1 National Environmental Management Act (NEMA, 1998)

The NEMA and the associated EIA Regulations require that prior to certain listed activities taking place, an EA process needs to be followed. This could follow either the Basic Assessment (BA) process or the Scoping and EIA process, depending on the scale of the impact. A BA process is being undertaken for the project.

The Assessment Protocol has replaced the requirements of Appendix 6 of the EIA Regulations in respect of certain specialist reports. These Assessment Protocol provide the criteria and minimum requirements for specialist's assessments, to consider the impacts on freshwater biodiversity for activities which require EA.

1.5.2 National Water Act (NWA, 1998)

The Department Water and Sanitation (DWS) is the custodian of South Africa's water resources and therefore assumes public trusteeship of water resources, which includes watercourses, surface water, estuaries, or aquifers. The NWA allows for the protection of water resources, which includes the:

- Maintenance of the quality of the water resource to the extent that the water resources may be used in an ecologically sustainable way;
- Prevention of the degradation of the water resource; and
- Rehabilitation of the water resource.

A watercourse is defined in the NWA as:

- A river or spring;
- A natural channel in which water flows regularly or intermittently;
- A wetland, lake or dam into which, or from which, water flows; and
- Any collection of water which the Minister may, by notice in the Gazette, declare to be a watercourse, and a reference to a watercourse includes, where relevant, its bed and banks.

The NWA recognises that the entire ecosystem and not just the water in isolation, and any given water resource constitutes the resource and as such needs to be conserved. No activity may therefore take place within a watercourse unless it is authorised by the DWS. Any area within a wetland or riparian zone is therefore excluded from development unless authorisation is obtained from the DWS in terms of Section 21 (c) – impeding or diverting the flow of water within a watercourse, and (i) – altering the bed, banks, course or characteristics of a watercourse, of the NWA.

1.6 Specialist Details

Report Name	**Aquatic Baseline & Impact Assessment for the Proposed FE Kudu Wind Energy Facility and Associated Infrastructure**
Submitted to	savannah environmental
Survey Date	23-25 May 2023
Fieldwork Surveyor & Report Writer	**Dale Kindler** dale@thebiodiversitycompany.com
	Dale Kindler (MSc Aquatic Health) is a registered Professional Natural Scientist (Pr. Sci. Nat. 114743). He has 10 years' experience in conducting Aquatic Specialist Assessments and is SASS 5 Accredited with the Department of Water and Sanitation (DWS). Dale has completed numerous specialist studies locally and internationally, ranging from Basic Assessments (BA) to Environmental Impact Assessments (EIAs), following IFC standards.
Reviewer	**Prasheen Singh** prasheen@thebiodiversitycompany.com
	Prasheen Singh (MSc in Aquatic Health) is a registered Professional Scientist in the field of Aquatic Science (Pr. Sci. Nat. 116822) and he is a accredited SASS5 Practitioner. He is an Aquatic Ecologist whose 10 years' experience comprises numerous Aquatic Scientific Studies, Peer Reviews, Research, and having served as a SANAS accredited Technical Signatory at an Ecotoxicology Laboratory. Over and above his qiualification he has completed training courses for wetlands, river eco-status monitoring, hydropedology, and ecosystem restoration.
Declaration	The Biodiversity Company and its associates operate as independent consultants under the auspice of the South African Council for Natural Scientific Professions. We declare that we have no affiliation with or vested financial interests in the proponent, other than for work performed under the EIA Regulations, 2014 (as amended). We have no conflicting interests in the undertaking of this activity and have no interests in secondary developments resulting from the authorisation of this project. We have no vested interest in the project, other than to provide a professional service within the constraints of the project (timing, time and budget) based on the principles of science.

2 Desktop Baseline Assessment (Receiving Catchment)

2.1 Ecologically Important Landscape Features

The following spatial features describes the general area and associated freshwater resources (ecologically important landscape features). This assessment is based on spatial data that are provided by various sources such as the provincial environmental authority and the South African National Biodiversity Institute (SANBI). The desktop analysis and their relevance to this project are listed in Table 2-1.

Table 2-1 Summary of the proposed project to ecologically important landscape features

Desktop Information Considered	Features	Section
Powerline Corridor	**Relevant** – The PAOI falls within the Eastern corridor	2.2
Renewable Energy Development Zones (REDZ)	**Relevant** – The PAOI falls within the Beaufort West REDZ.	2.3
Strategic Water Source Areas (SWSA)	**Irrelevant** – PAOI is not located within the surface water or groundwater SWSAs	2.6
NFEPA Rivers	**Relevant** – NFEPA features located in PAOI	2.7

Desktop Information Considered	Features	Section
Conservation Plan	**Relevant** – Overlaps with Ecological Support Areas and Other Natural Areas	0
Ecosystem Threat Status	**Relevant** – Overlaps with the *Least Threatened* non-perennial river ecosystems	2.9
Ecosystem Protection Level	**Relevant** – Overlaps with poorly protected non-perennial river ecosystems	2.10
Protected Areas	**Relevant** – The PAOI does not occur or influence any protected areas.	

2.2 Strategic Transmission Corridors (EGI)

On the 16 February 2018 minister Edna Molewa published Government Notice No. 113 in Government Gazette No. 41445 which identified five (5) strategic transmission corridors/ Electricity Grid Infrastructure (EGI) important for the planning of electricity transmission and distribution infrastructure as well as procedure to be followed when applying for environmental authorisation for electricity transmission and distribution expansion when occurring in these corridors. A map illustrating the five Gazetted EGI Corridors is presented in Figure 2-1.

On the 29th of April 2021, Minister Barbara Dallas Creecy published Government Notice No. 383 in Government Gazette No. 44504, which expanded the eastern and western transmission corridors and gave notice of the applicability of the application procedures identified in Government Notice No. 113, to these expanded corridors. More information on this can be obtained from https://egis.environment.gov.za/egi.

Figure 2-2 indicates that the project overlaps with the Eastern EGI corridor.

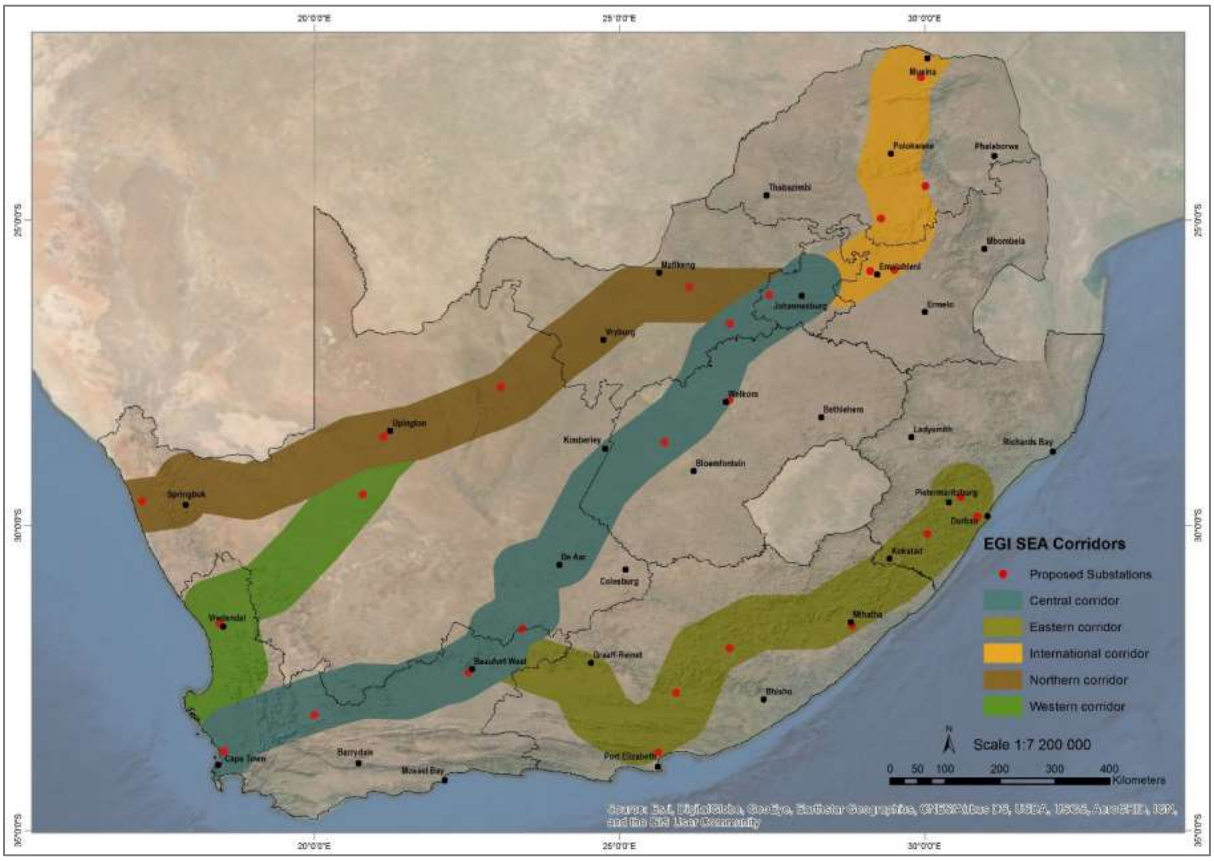


Figure 2-1 The five strategic transmission corridors (DEFF, 2019)

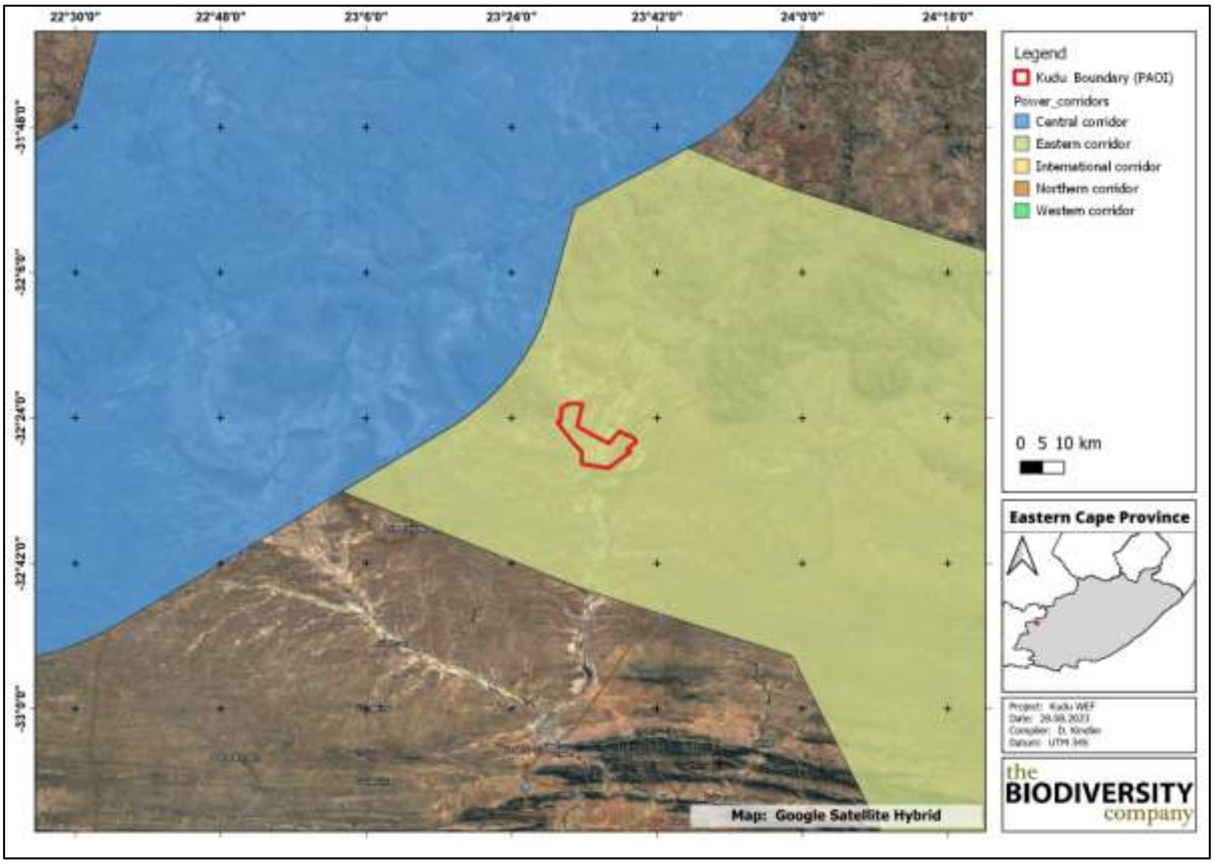


Figure 2-2 The project area in relation to the strategic transmission corridors

2.3 Renewable Energy Development Zones (REDZ)

On 16 February 2018, Minister Edna Molewa published Government Notice No. 114 in Government Gazette No. 41445 which identified eight (8) Renewable Energy Development Zones (REDZ) important for the development of large scale wind and solar photovoltaic facilities. The Government Notice included procedure to be followed when applying for environmental authorisation for large scale wind and solar photovoltaic energy facilities when occurring in these REDZs.

On 26 February 2021, Minister Barbara Dallas Creecy, published Government Notice No. 142, 144 and 145 in Government Gazette No. 44191 which identified three (3) additional REDZs for implementation as well as the procedures to be followed when applying for environmental authorisation for electricity transmission or distribution infrastructure or large scale wind and solar photovoltaic energy facilities in these REDZs.

The REDZs were identified through the undertaking of 2 Strategic Environmental Assessments, the first being finalised in 2015 and the second being finalised in 2019. More information on this can be obtained from https://egis.environment.gov.za/redz.

Figure 2-3 indicates that the PAOI falls within the Beaufort West REDZ.

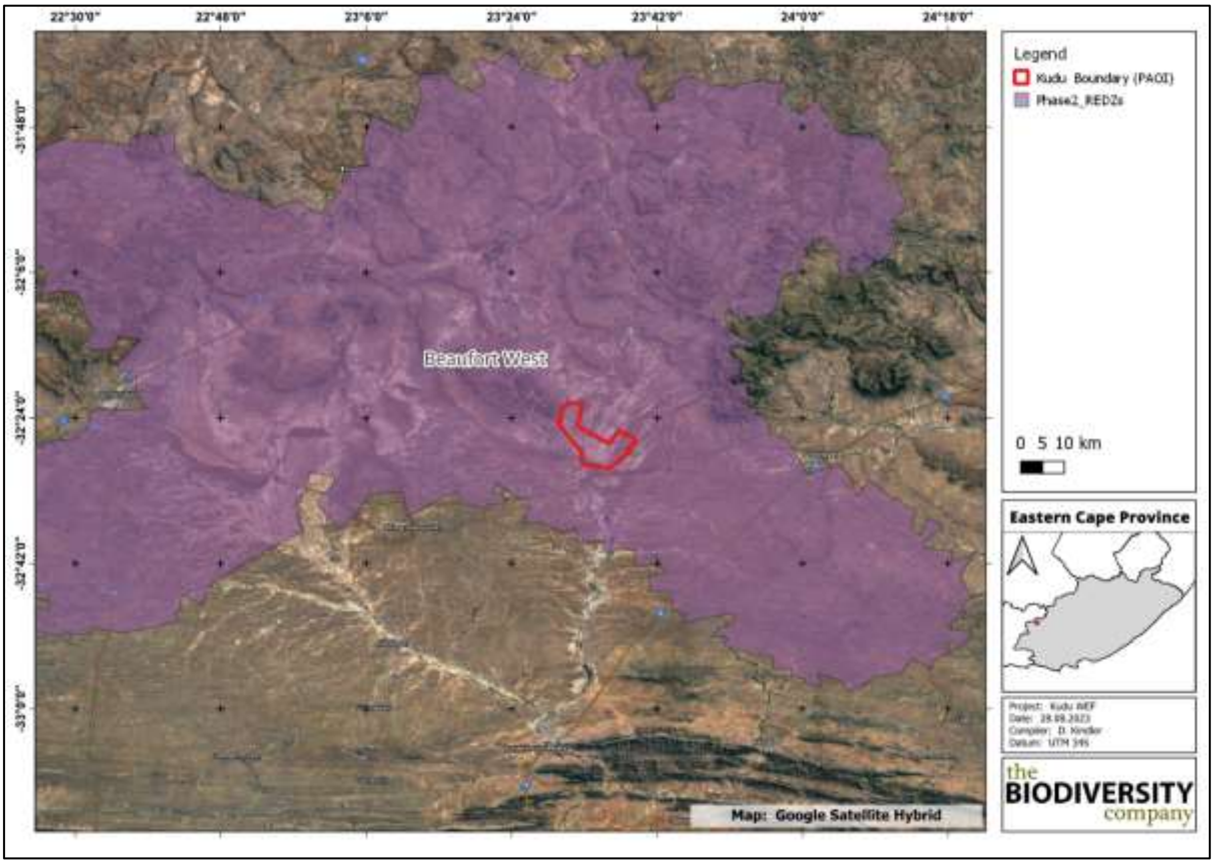


Figure 2-3 The project area in relation to the Renewable Energy Development Zones

2.4 Hydrological Setting

As presented in Figure 2-4, the project area is drained by several ephemeral and non-perennial watercourses, which falls within the L22C, L22D, L23A and L23B quaternary catchments (sub-catchments), and the larger Mzimvubu-Tsitsikama Water Management Area (WMA 7 - NWA, 2016). The non-perennial and ephemeral systems that drain the PAOI are largely unnamed and form tributaries of the Ouplaas River in the eastern portion of the PAOI, the 3 unnamed rivers in the middle portion of the PAOI, the Tulpleegte River in the western portion, and the Kariega River in the southern portion of the PAOI. The river systems draining the PAOI flows in a southerly direction into the Kariega River at the quaternary catchment boundary south of the project area. The Kariega River falls within the upper reaches of the Gamtoos drainage basin, which drains into the Indian Ocean.

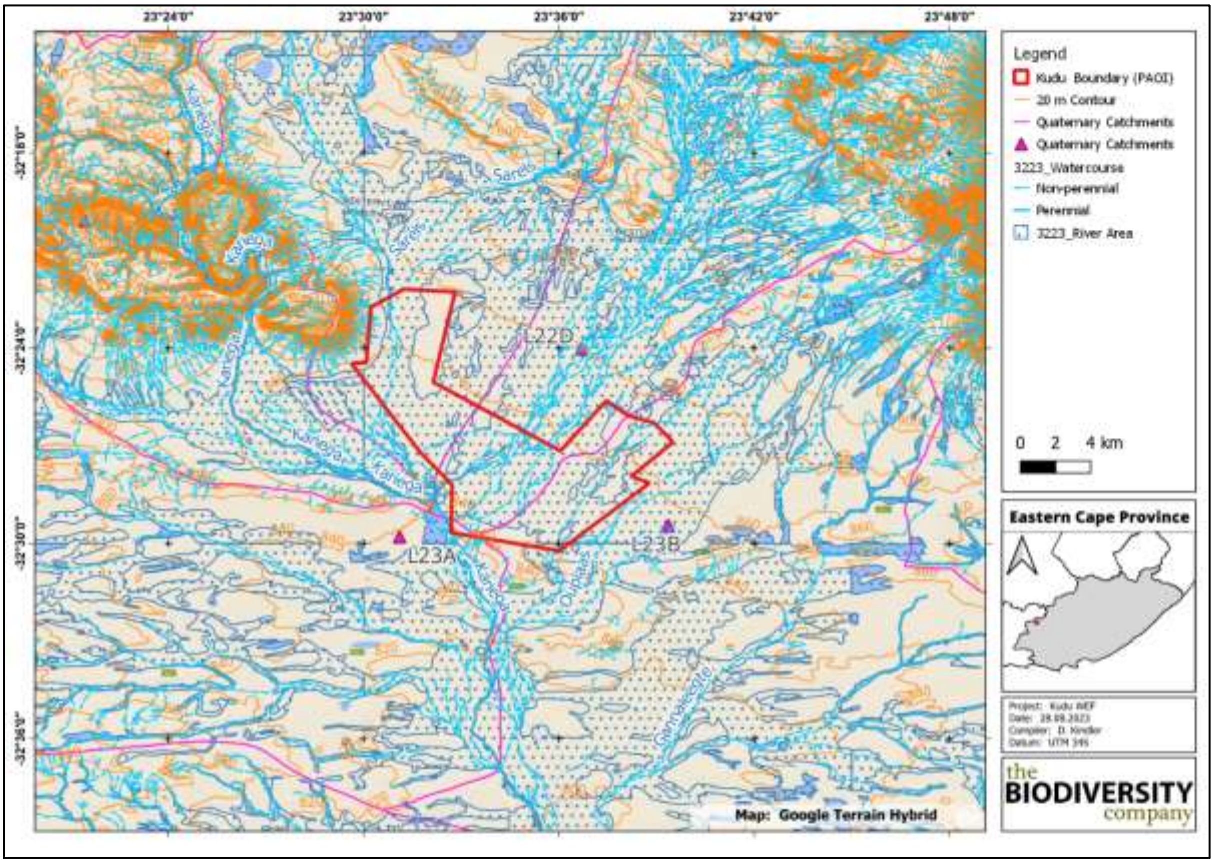


Figure 2-4 Hydrological setting associated with the project area

2.5 Freshwater Ecological Setting

The study area is located across a single Freshwater Ecoregion, the Karoo (Ecoregion ID: 573 - Figure 2-5), with the rivers draining either directly into the Indian Ocean (e.g. Gamtoos River) The succulent Karoo is separated from the Nama Karoo by the Bokkeveldberg Mountains. The aquatic fauna of the Karoo Freshwater Ecoregion, in comparison to northern African river systems is depauperate with a southern temperate (Cape) ichthyofauna (Abel *et al.,* 2008). Dry for most of the year (Barnes, 1998b), riverbeds in the Nama Karoo descend sharply from escarpments to meander across the flat plains of the Central Plateau. Lined by belts of riverine *Vachellia karroo* thicket, the riverbeds create a network of riparian habitats that extends across the landscape (Barnes, 1998b). Other riparian species include *Tamarix usneoides* and *Euclea, Ozoroa*, and *Acacia shrubs* (Barnes & Anderson, 1998). Notable aquatic ecology in these basins include the several endemic Cyprinid species. According to the expected fish species list, a total of 3 indigenous species are expected within the Kariega River system, with fewer species expected within the associated tributaries based on species habitat requirements. The species assemblage expected within the study area are typically widely distributed over a large geographic range.

The study area falls within the Great Karoo Level 1 aquatic ecoregion [Kleynhans, Thirion and Moolman (2005)]. The arid ecoregion is characterised by plains with moderate to low relief.

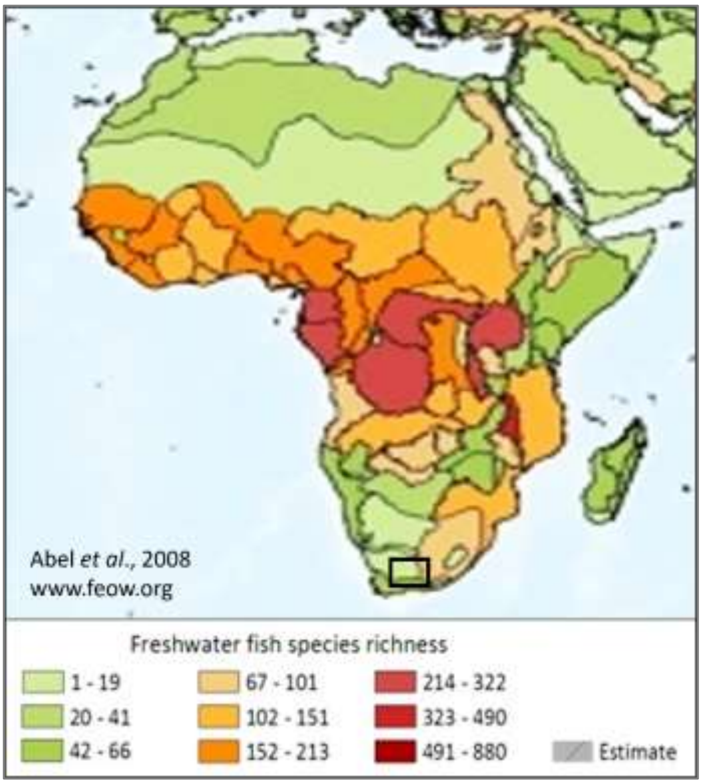


Figure 2-5 Freshwater Ecoregions of the World (Abell et al., 2008)

2.6 Strategic Water Source Areas

Strategic Water Source Areas (SWSAs) are areas that supply a disproportionate amount of mean annual runoff to a geographical region of interest. The areas supplying ≥ 50% of South Africa's water supply (which were represented by areas with a mean annual runoff of ≥ 135 mm/ year) represent national Strategic Water Source Areas (SANBI, 2013). According to Le Maitre (2018), ''SWSAs are defined as areas of land that either: (a) supply a disproportionate (i.e. relatively large) quantity of mean annual surface water runoff in relation to their size and so are considered nationally important; or (b) have high groundwater recharge and where the groundwater forms a nationally important resource; or (c) areas that meet both criteria (a) and (b). They include transboundary Water Source Areas that extend into Lesotho and Swaziland. According to Lötter and Le Maitre (2021), the 2018 SWSAs data set for surface water was identified based on a generalised 1.7 x 1.7 km resolution Mean Annual Runoff dataset, while the 2021 data set was delineated at a finer resolution of 90 x 90 m. The purpose of the update was to refine the spatial resolution such that SWSAs can be reliably integrated into a range of catchment- and local-level planning, management and regulatory processes.

According to the SWSAs of South Africa, Lesotho and Swaziland, the project area is not located within the surface water or groundwater SWSAs (Figure 2-6). Therefore, the proposed WEF is unlikely to have any significant impact to downstream water resources.

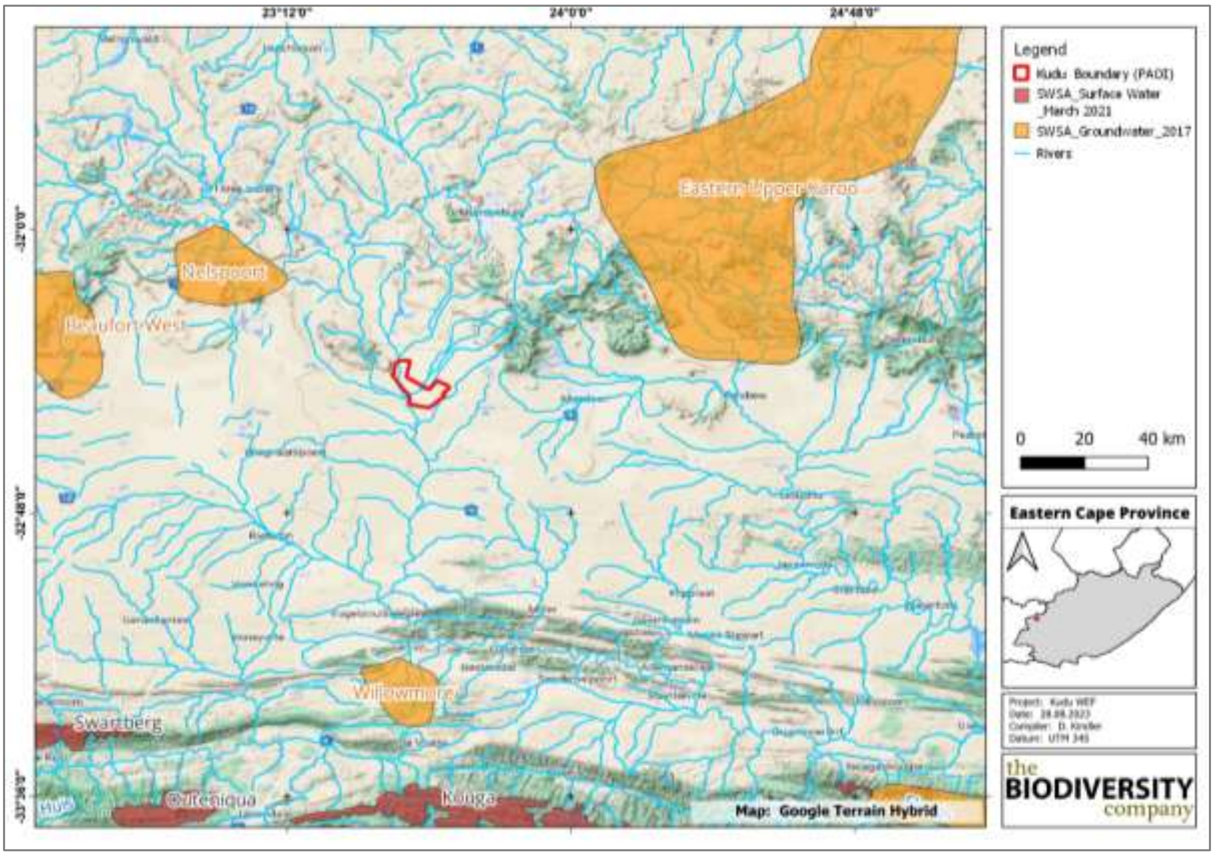


Figure 2-6 The project area in relation to the SWSA's

2.7 National Freshwater Ecosystem Priority Areas (NFEPA)

The National Freshwater Ecosystem Priority Areas (NFEPA) database forms part of a comprehensive approach to the sustainable and equitable development of South Africa's scarce water resources. This database provides guidance on how many rivers, wetlands and estuaries, and which ones, should remain in a natural or near-natural condition to support the water resource protection goals of the National Water Act (Act 36 of 1998). This directly applies to the National Water Act, which feeds into Catchment Management Strategies, water resource classification, reserve determination, and the setting and monitoring of resource quality objectives (Nel *et al.,* 2011). The NFEPAs are intended to be conservation support tools and envisioned to guide the effective implementation of measures to achieve the National Environment Management Biodiversity Act's biodiversity goals (NEM:BA) (Act 10 of 2004), informing both the listing of threatened freshwater ecosystems and the process of bioregional planning provided for by this Act (Nel *et al*., 2011). In an attempt to better conserve aquatic ecosystems, South Africa has categorised its river systems according to set ecological criteria (i.e. ecosystem representation, water yield, connectivity, unique features, and threatened taxa) to identify Freshwater Ecosystem Priority Areas (FEPAs) (Driver *et al*., 2011). The FEPAs are intended to be conservation support tools and envisioned to guide the effective implementation of measures to achieve the National Environment Management Biodiversity Act's (NEM:BA) biodiversity goals (Nel *et al.,* 2011).

The project area is located across six Sub-Quaternary Reaches (SQRs) that have NFEPA status assigned to these catchments (Table 2-2). The Ouplaas River SQR L23B-7249 in the eastern portion of the PAOI, the 3 unnamed SQRs L22D-7392, L22D-7471 and L22D-7545 in the middle portion of the PAOI, and the Tulpleegte SQR L22C-7367 in the western portion of the PAOI all form an *upstream management areas.* The Kariega River SQR L22D-7550 in the southern portion of the PAOI forms a *Fish Corridor catchment*. The Kariega, Tulpleegte Ouplaas rivers and the unnamed rivers are NFEPA rivers, which flow into the downstream Kariega River, a listed NFEPA River serving as a *Fish Sanctuary Area* (Figure 2-7). Several wetland FEPA's are present in the PAOI (Table 2-2 and Figure 2-8).

Conserving the water quality, riverine and wetland habitat and associated ecological functioning within the project area and associated catchments, will aid in the protection of riverine habitat supporting fish species occurring within the entire catchment and water quality for the aquatic and terrestrial biota downstream of the project area (lower reaches of the associated watercourses and the Kariega River). The Kariega River serves as a *Fish Sanctuary Area* for threatened fish species such as Smallscale Redfin (*Pseudobarbus asper*). *Pseudobarbus asper* are listed as **Vulnerable**, showing population declines from anthropogenic activities within the watercourses and associated catchment areas, which includes predation impacts from invasive fish species (Jordaan and Chakona, 2018). The catchments in which human activities occur need to be managed to maintain water quality and prevent further degradation of local and downstream water resources in order to contribute to national biodiversity goals and support sustainable use of water resources.

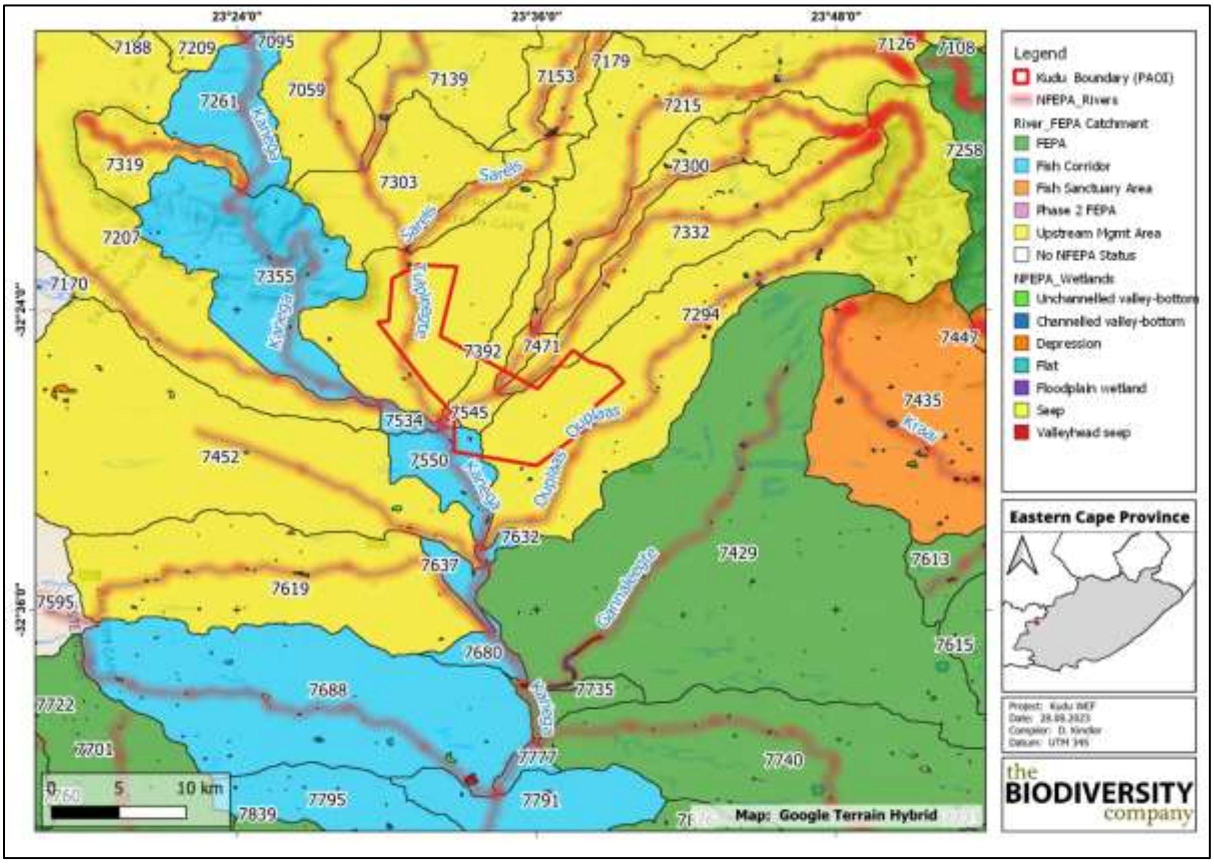


Figure 2-7 Aquatic FEPAs associated with the project area (Nel et al., 2011)

Table 2-2 NFEPAs listed for the project area

Type of FEPA map category	Biodiversity features
Tulpleegte SQR L22C-7367	
No listed features	
Unnamed SQR L22D-7392	
No listed features	
Ouplaas SQR L23B-7249	
No listed features	
Unnamed SQR L22D-7471	
No listed features	
Unnamed SQR L22D-7332	
FEPA: Wetland ecosystem type	Lower Nama Karoo_Channelled valley-bottom wetland
FEPA: Wetland ecosystem type	Lower Nama Karoo_Unchannelled valley-bottom wetland
Kariega SQR L22D-7550	
Fish Support Area: Fish sp	*Enteromius anoplus*
Fish Support Area: Fish sp	*Pseudobarbus asper*
Gannaleegte SQR L23B-7429	
FEPA: River ecosystem type	Ephemeral - Great Karoo - Lower foothill
FEPA: River ecosystem type	Ephemeral - Great Karoo - Lowland river
FEPA: River ecosystem type	Ephemeral - Great Karoo - Upper foothill
FEPA: Wetland ecosystem type	Lower Nama Karoo_Flat
FEPA: Wetland ecosystem type	Lower Nama Karoo_Floodplain wetland
FEPA: Wetland ecosystem type	Lower Nama Karoo_Unchannelled valley-bottom wetland
FEPA: Wetland ecosystem type	Lower Nama Karoo_Valleyhead seep

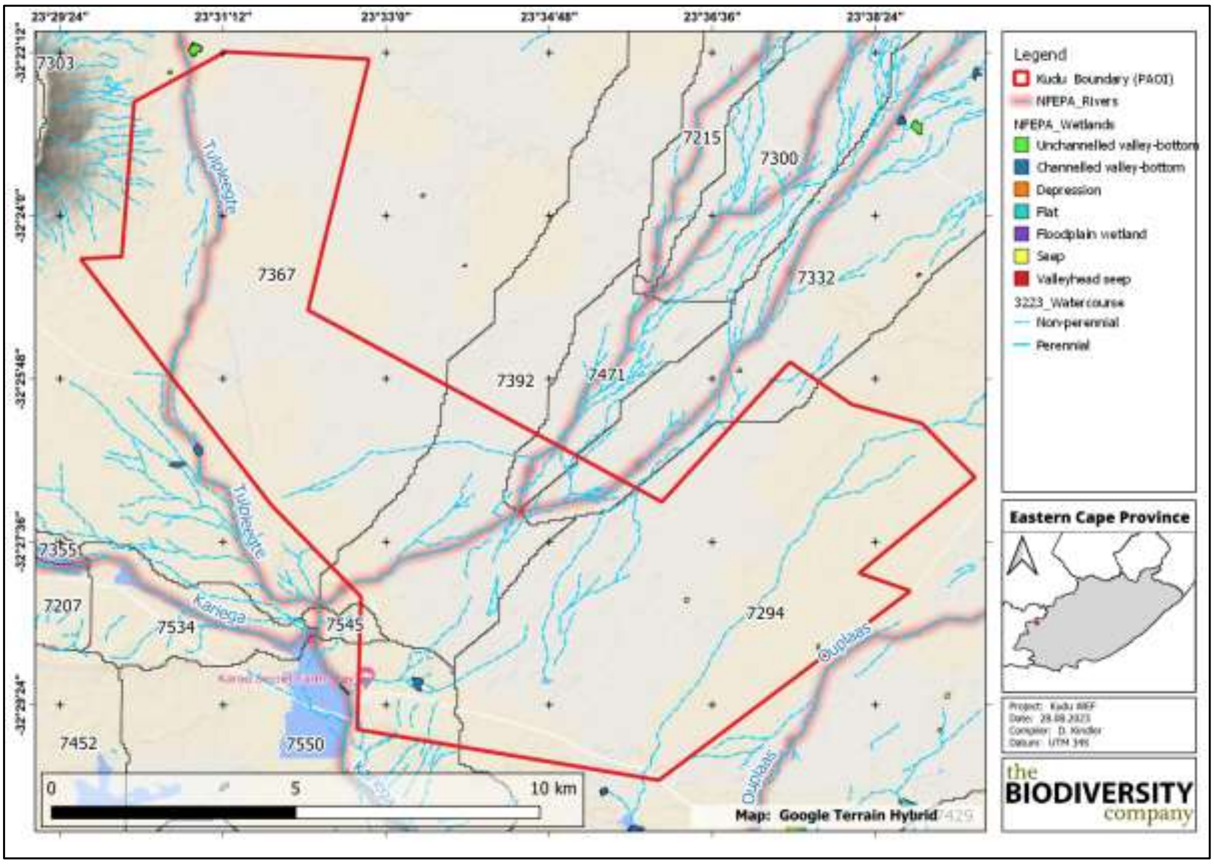


Figure 2-8 Wetland FEPAs associated with the project area (Nel et al., 2011)

2.8 Freshwater Critical Biodiversity Area and Ecological Support Areas

Critical Biodiversity Areas (CBAs) are terrestrial and aquatic areas of the landscape that need to be maintained in a natural or near-natural state to ensure the continued existence and functioning of species and ecosystems and the delivery of ecosystem services. CBAs are areas of high biodiversity value and need to be kept in a natural state, with no further loss of habitat or species (MTPA, 2014). Thus, if these areas are not maintained in a natural or near natural state then biodiversity targets cannot be met. Maintaining an area in a natural state can include a variety of biodiversity compatible land uses and resource uses (SANBI, 2017). Ecological Support Areas (ESA) are the areas of land that are adjacent to and can envelope CBAs. These areas are not essential for achieving biodiversity targets, but they play a vital role in supporting the ecological functioning of adjacent CBAs and/or in delivering ecosystem services. Other natural Areas (ONA) are all remaining natural areas not included in the above CBA or ESA categories. No desired state or management objective is provided for ONA's.

Figure 2-9 shows the project area superimposed on the freshwater CBA map. The project overlaps with an ESA1 which is associated with the watercourses, while portions of the PAOI overlap with ONA's. The infrastructure does not overlap with CBAs.

For areas classified as ESA1, the following ECBCP (2019) objectives apply:

- These areas are not required to meet biodiversity targets, but they still perform essential roles in terms of connectivity, ecosystem service delivery and climate change resilience.
- These systems may vary in condition and maintaining function is the main objective, therefore:

- Ecosystems still in natural, near natural state should be maintained.
- Ecosystems that are moderately disturbed/degraded should be restored.

The nature of the development, i.e., a WEF development comprising wind turbines and associated servitude infrastructure (roads and powerlines), will lead to modification of the ESAs and consequently, the footprint area will no longer be congruent with ESAs. The ECBCP (2019) states that road land uses are not consistent with the land management objectives of CBAs and ESAs. In cases where technical options are limited, these activities may only take place in CBAs and ESAs under specific conditions of authorisation and contingent on biodiversity offsets. Therefore, the transportation network must avoid impacts (direct or indirect) on ESAs, especially connectivity of the landscape and local corridors. Considering that turbines are a greater risk to birds and bats, than aquatic biota, expert studies for terrestrial biodiversity will be required where these are earmarked within ESAs. To maintain ecosystem functioning, the proposed turbine footprints must avoid ESA's notably where they intersect aquatic features. The Optimised Layout has largely avoided the ESAs and associated aquatic features and the turbines, roads and associated infrastructure are deemed acceptable and appropriately placed, with limited influence on ESAs.

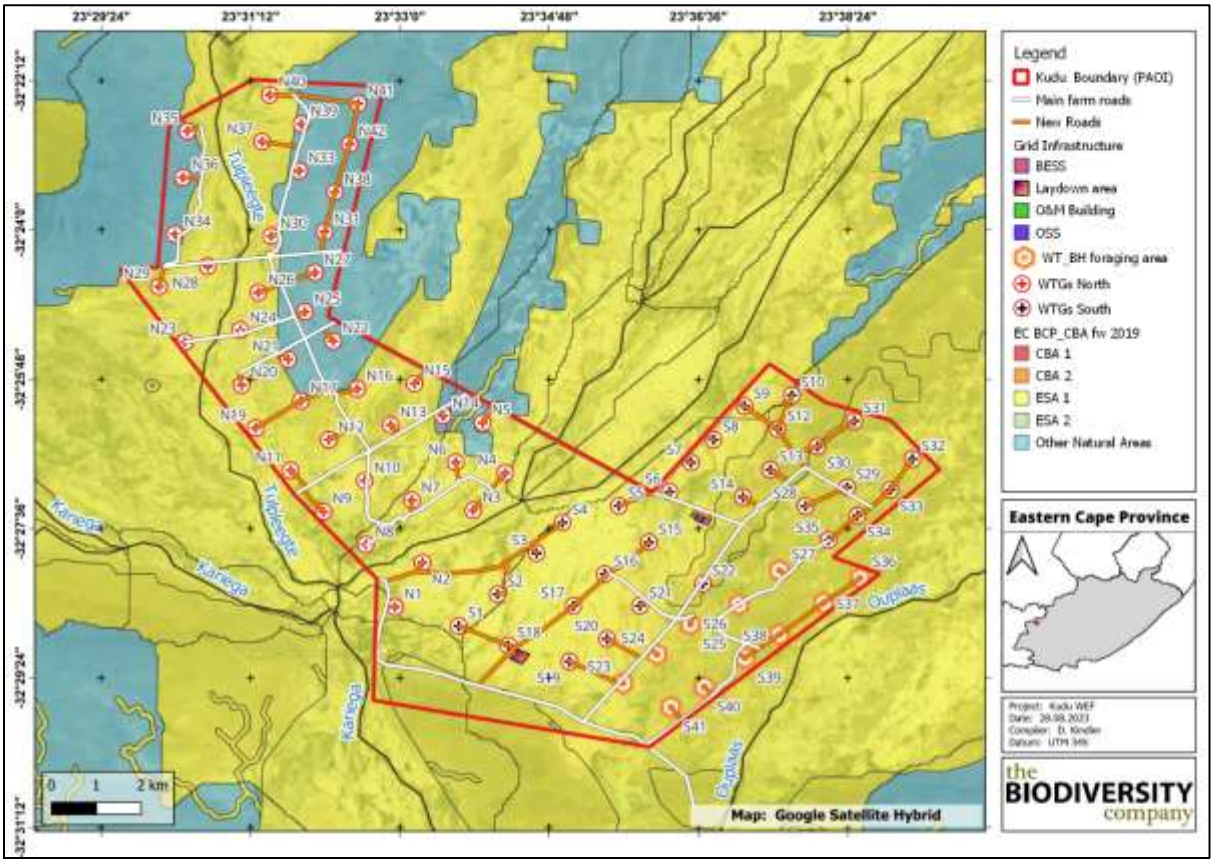


Figure 2-9 Illustration of the Critical Biodiversity Areas within the project area

2.9 Aquatic Ecosystem Threat Status

The South African Inventory of Inland Aquatic Ecosystems (SAIIAE) was released with the National Biodiversity Assessment (NBA) (Van Deventer *et al.,* 2018). The Ecosystem threat status of river and wetland ecosystem outlines the degree to which the ecosystems are still intact or alternatively losing vital aspects of their structure, function and composition, on which their ability to provide ecosystem services ultimately depends (Van Deventer et al., 2019).

Ecosystem types are categorised as Critically Endangered (CR), Endangered (EN), Vulnerable (VU) or Least Threatened (LT), based on the proportion of each ecosystem type that remains in good ecological condition (Van Deventer *et al*., 2019). The Ecosystem Threat Status (ETS) of each river assessed was based on the extent to which the system had been modified from its natural condition (SANBI, 2022). According to the SAIIAE dataset, the project area is drained by the interconnected *Least Threatened* Ouplaas, Tulpleegte and Kariega rivers and unnamed tributaries (Figure 2-10 and Figure 2-4).

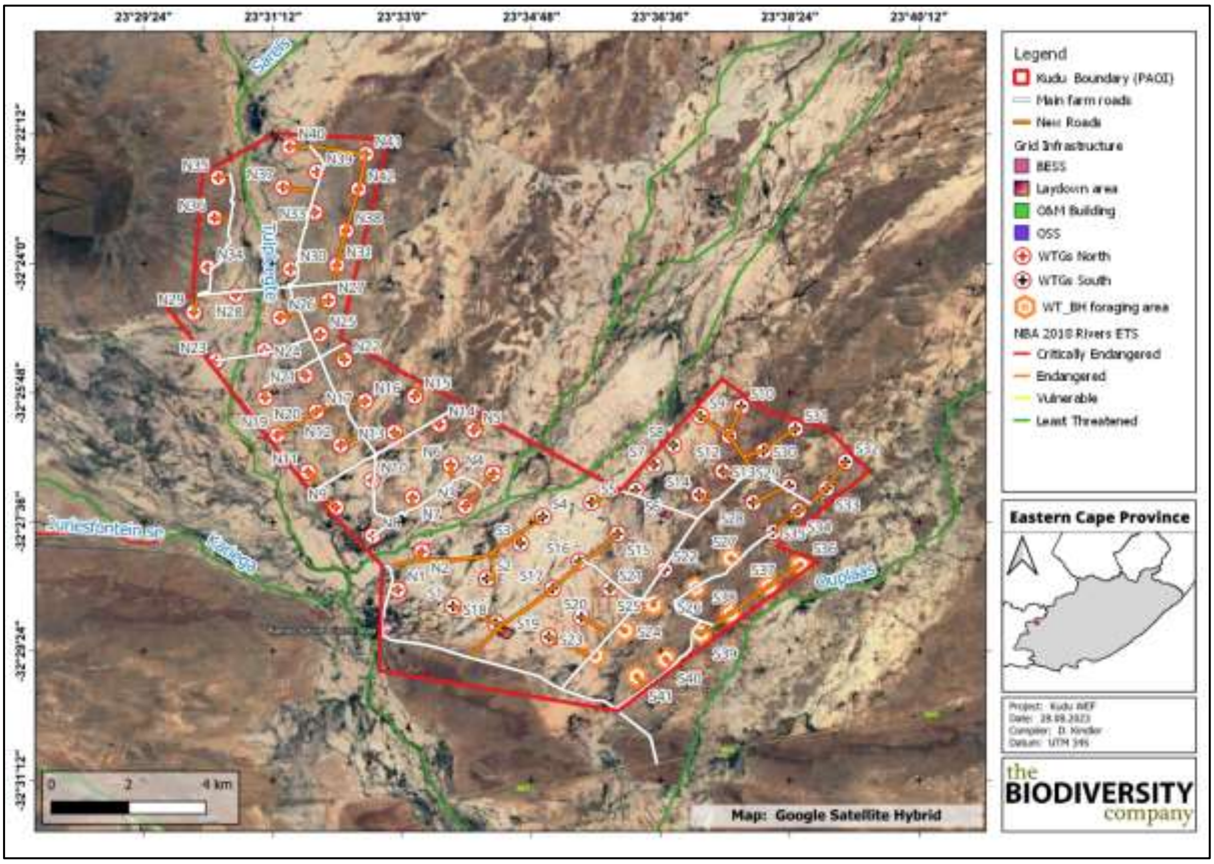


Figure 2-10 Illustration of the Ecosystem Threat Status of the project area (NBA, 2018)

2.10 Aquatic Ecosystem Protection Level

Ecosystem protection level indicates whether ecosystems are adequately protected or under-protected. Ecosystem types are categorised as not protected, poorly protected, moderately protected or well protected, based on the proportion of each ecosystem type that occurs within a protected area recognised in the Protected Areas Act (Van Deventer *et al.,* 2018). The Ecosystem Protection Level (EPL) of each river assessed was based on the extent (expressed as a percentage) to which the system has their biodiversity target located within protected areas and are in a natural or near-natural ecological condition. Rivers in protected areas need to be in good condition (A or B ecological category) to be considered as protected. Well protected rivers have 100% of their biodiversity target located within protected areas, while moderately protected and poorly protected river ecosystem types have at least 50% and 5% of their biodiversity target in protected areas, respectively. Not protected rivers form less than 5% (SANBI, 2022). The project area was superimposed on the ecosystem protection level map to assess the protection status of aquatic ecosystems associated with the project (Figure 2-11). This indicates that the aquatic ecosystems associated with the project area are all rated as *Poorly Protected*. This highlights the need to limit project related impacts to the watercourses and associated ephemeral drainage network through the implementation of avoidance strategies together with ongoing and adaptive mitigation.

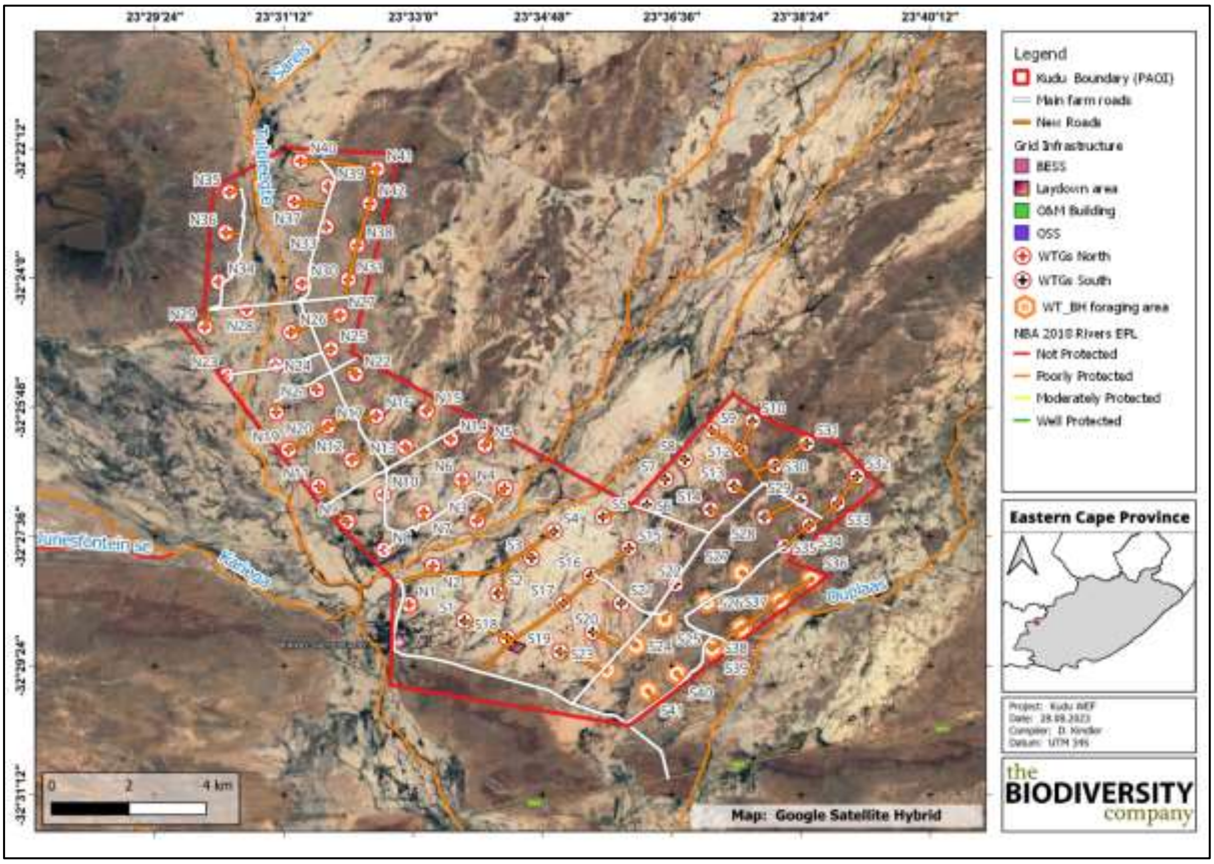


Figure 2-11 Illustration of the Ecosystem Protection Level of the project area (NBA, 2018)

2.11 National Wetland Map 5

The National Wetland Map 5 (NWM5) spatial data was published in October 2019 (Van Deventer *et al*. 2019), in collaboration with the SANBI, with the specific aim of spatially representing the location, type and extent of wetlands in South Africa. The data represents a synthesis of a wide number of official watercourse data, including rivers, inland wetlands and estuaries. This database does recognise the presence of freshwater features within the extent of the project area, however these features are rivers as presented in Figure 2-12 and are associated with the Kariega and Tulpleegte rivers.

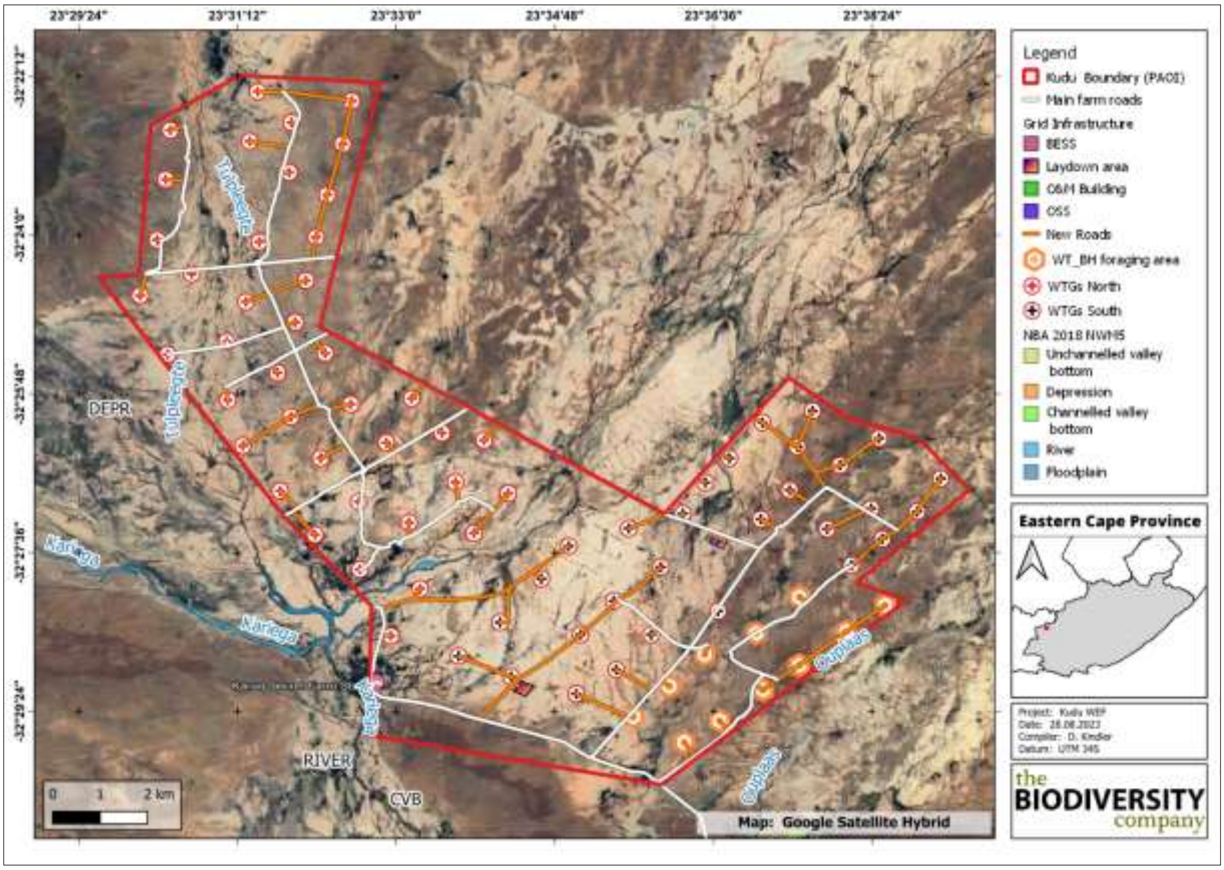


Figure 2-12 Map illustrating the NWM5 for the project area

2.12 Environmental Screening Tool

This approach has also taken cognisance of the recently published Minimum Criteria for Reporting on Identified Environmental Themes (DWS, 2020). The aquatic biodiversity theme sensitivity as indicated in the screening tool report indicates "Very High" sensitivity areas as presented in Figure 2-13, which are associated with the listed features as verified in Table 2-3.

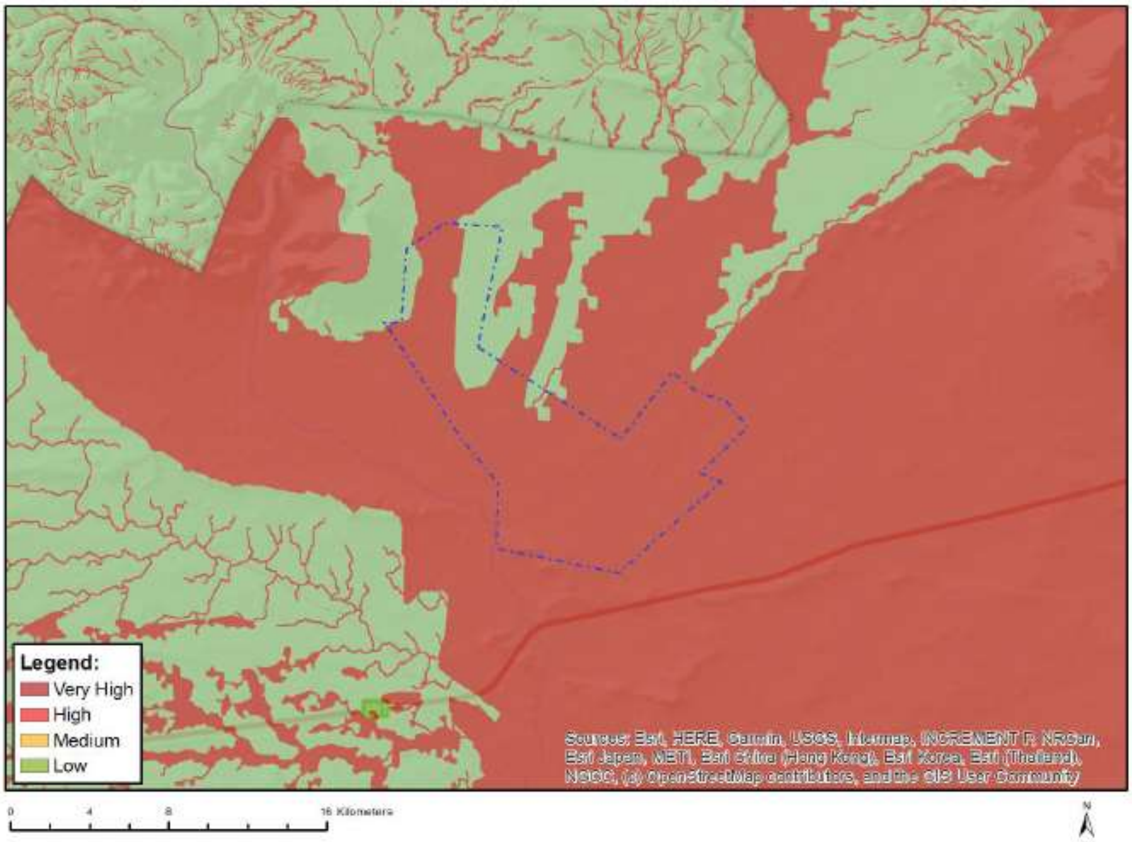
Table 2-3 Sensitivity features associated with Aquatic Biodiversity Combined Sensitivity (National Web based Environmental Screening Tool)

Sensitivity	Features	Specialist Verification
Low	Low sensitivity	**Yes Low sensitivity areas present**, portions of the property are not sensitive
Very High	ESA1	**Yes ESA1 present**, overlaps with an ESA1 which is associated with the watercourses.
Very High	Rivers_C*	**Yes**, the riverine ecosystems present in catchment have been modified and would largely conform to the '*Moderately Modified condition (River_C)*'. The modification stems largely from surface flow alterations with some agricultural influence.
Very High	Rivers_Z*	**Yes**, the tributary ecosystems present in catchment have been modified by historical modification which includes agriculture and surface flow alterations, and their condition conforms with desktop model of being 'not intact according to natural land cover'. However, this is limited to some sections being modified with large portions remaining intact.
Very High	Wetlands_(River)	**Yes**, the Kariega and Tulpleegte river ecosystems are present in catchment as per NWM5 dataset.

*Screening tool uses metadata from 2018 NBA

The freshwater ecology of the immediate project area and further downstream areas are considered sensitive to disturbance from a hydrological and biological perspective, however due to the ephemeral nature of the watercourses, this sensitivity applies more to the watercourses' physical characteristics that influence the hydrological and biological aspects in times of surface water presence/ inundation. This will include all watercourses within the project area which are considered sensitive due to their relatively small spatial scale when compared to adjacent terrestrial habitat with a large demand for the ecosystem services which they provide. Construction and operation activities must take cognisance of this and avoid any unnecessary disturbance of the watercourses and adjacent habitat (Figure 2-14).

MAP OF RELATIVE AQUATIC BIODIVERSITY THEME SENSITIVITY



Very High sensitivity	High sensitivity	Medium sensitivity	Low sensitivity
X			

Sensitivity Features:

Sensitivity	Feature(s)
Low	Low sensitivity
Very High	ESA 1
Very High	Rivers_C
Very High	Rivers_Z
Very High	Wetlands_(River)

Figure 2-13 Aquatic Biodiversity Combined Sensitivity (National Web based Environmental Screening Tool)

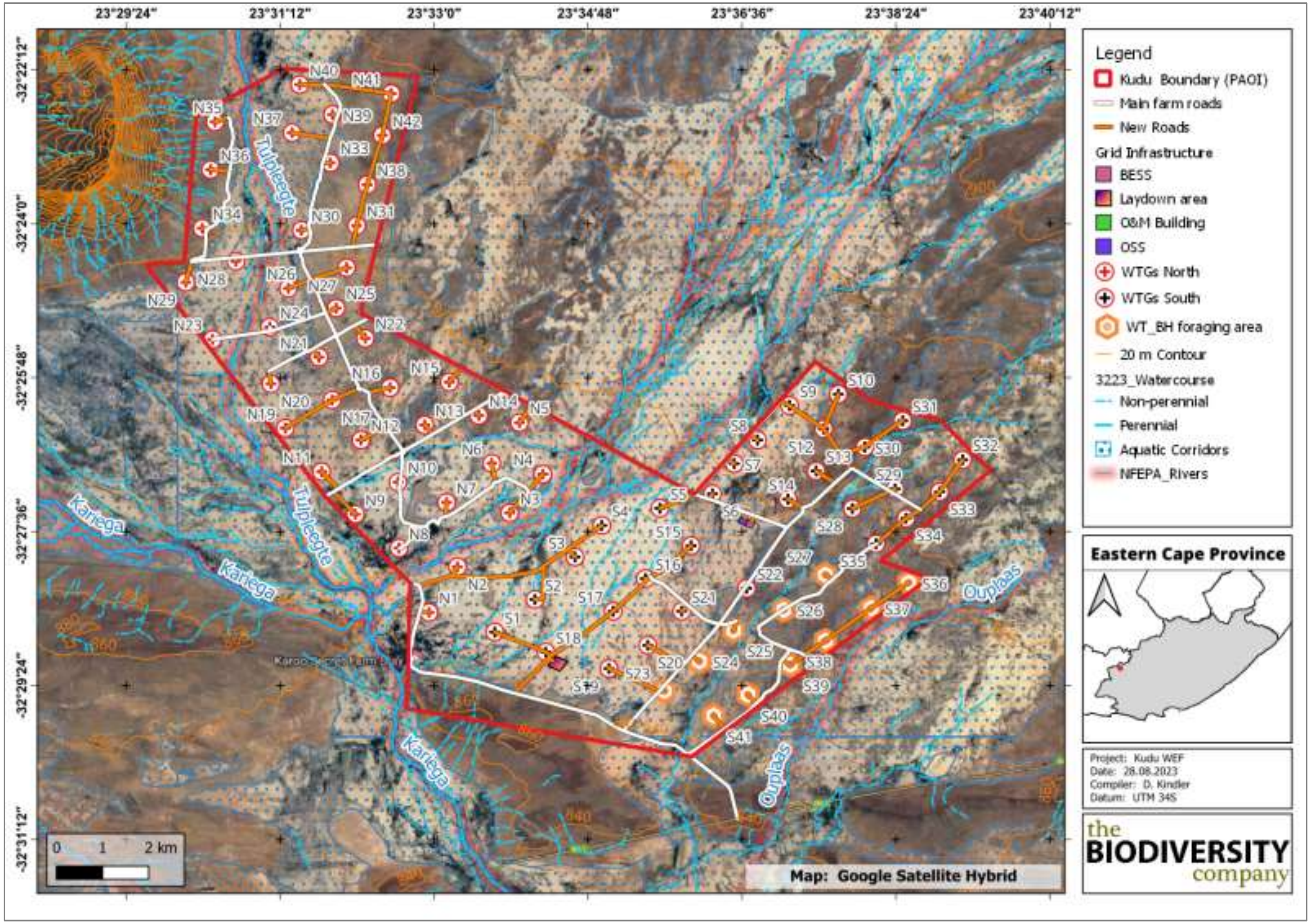


Figure 2-14 Proposed infrastructure in relation to aquatic features

2.13 Status of Watercourses

The desktop DWS (2014) listed Present Ecological Status (PES) of the watercourses' catchments in relation to the project area are illustrated in Figure 2-15. The watercourses have been assigned desktop PES. The watercourses are all ecologically interlinked and are currently affected by various land use activities such as agriculture and need to be managed to prevent degradation of the catchment condition, water quality and ecological integrity of the downslope watercourses. Catchment mismanagement within a SQR is well documented to degrade its catchment and associated watercourses due to damaged ecological drivers. A summary of the PES, stream orders, and Ecological Importance (EI) and Ecological Sensitivity (ES) for the relevant SQRs are presented in Table 2-4.

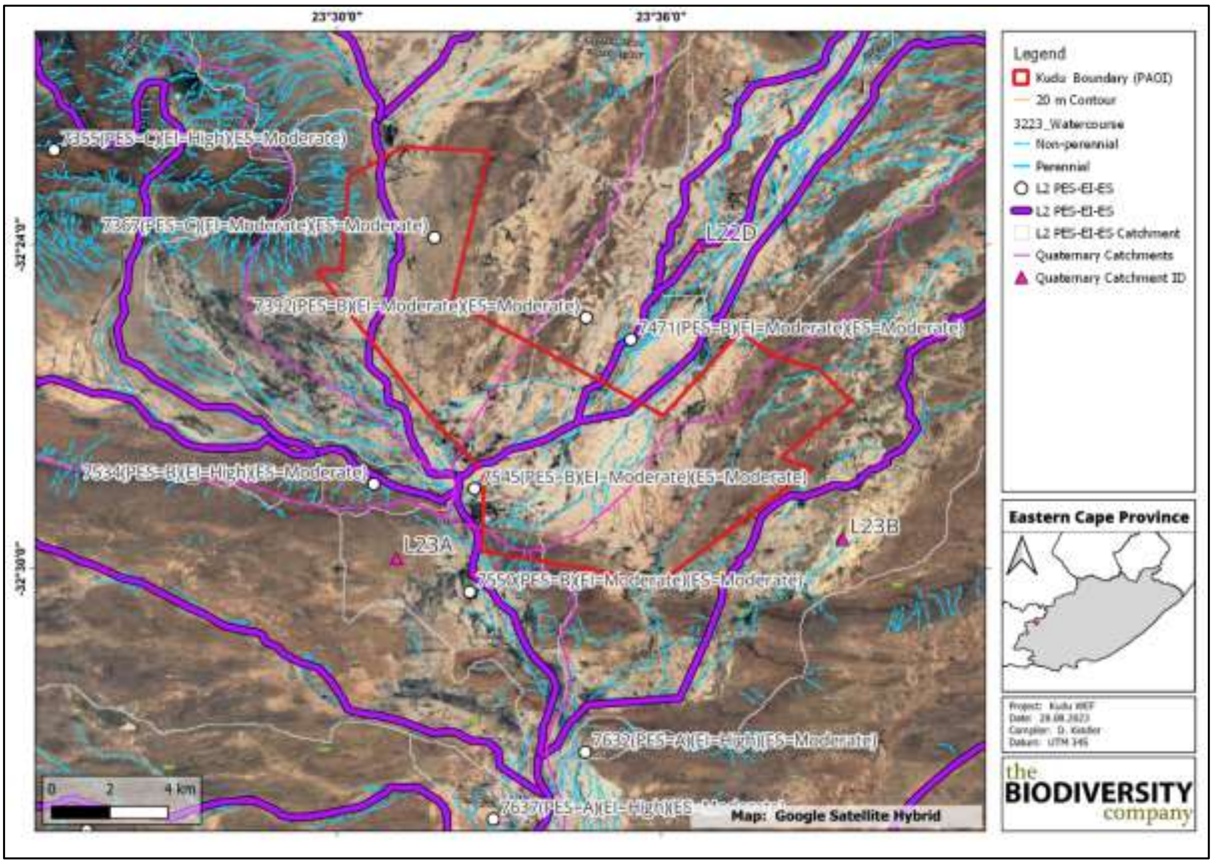


Figure 2-15 Illustration of the Present Ecological State within the relevant catchments (DWS, 2014)

Table 2-4 Desktop Ecological summary for the relevant quaternary catchments

SQR	Stream order	Length (km)	PES (DWS, 2014)	ES	EI	Default Ecological Category
Ouplaas Catchment (This SQR drains the eastern border of the PAOI)						
L23B-7249	1	53.47	B (Largely Natural)	High	Moderate	B (Largely Natural)
PES-EIS Justification	Habitat & continuity (fish): Upper catchment stream; numerous anti-erosion berms in flat lower catchment. General, habitat (invertebrates) & flow: Upper catchment well vegetated; little development; extensive erosion in lower catchment. Riparian/wetland zone & continuity: Alluvial system + floodplain agric. Physico-chemical: little activity in upper section other than crossings + a weir/berm; area is well vegetated; off-channel dams + patches of cult; lower section barren with little veg cover; non-perennial system.					
Unnamed Catchment (This SQR drains the middle of the PAOI)						
L22D-7392	2	4.09	B (Largely Natural)	Moderate	Moderate	C (Moderately Modified)
PES-EIS Justification	Habitat & continuity (fish): Upstream impacts. Riparian/wetland zone & continuity: Sq that is dominated by alluvial structures + mostly natural. Physico-chemical: Off-channel + instream dam; low-level crossing; non-perennial; little veg in area.					
Unnamed Catchment (This SQR drains the middle of the PAOI)						
L22D-7471	2	5.23	B (Largely Natural)	Moderate	Moderate	C (Moderately Modified)
PES-EIS Justification	Habitat & continuity (fish): Upstream impacts. General, habitat (invertebrates) & flow: Cross-channel erosion berms. Riparian/wetland zone & continuity: Alluvial system + floodplain agric. Physico-chemical: Short reach; non-perennial; few berms; area v bare.					
Tulpleegte Catchment (This SQR drains the middle of the PAOI)						
L22D-7545	3	0.59	B (Largely Natural)	Moderate	Moderate	C (Moderately Modified)
PES-EIS Justification	Habitat & continuity (fish): 0.6km reach; upstream impacts. Riparian/wetland zone & continuity: Small sq + natural + berms. Physico-chemical: V small reach; non-perennial.					
Tulpleegte Catchment (This SQR drains the western of the PAOI)						
L22C-7367	3	14.06	B (Largely Natural)	Moderate	Moderate	C (Moderately Modified)
PES-EIS Justification	Habitat & continuity (fish): Upstream impacts; erosion. General, habitat (invertebrates) & flow: Catchment disturbed due to exposed land surface + erosion. Riparian/wetland zone & continuity: Large sq that is dominated by alluvial structures + mostly natural. Physico-chemical: Long reach; berms; crossings; possibly an A/B ito wq.					
Kariega Catchment (This SQR drains the western of the PAOI)						
L22A-7550	4	10.12	B (Largely Natural)	Moderate	Moderate	C (Moderately Modified)
PES-EIS Justification	Habitat & continuity (fish): Upstream impacts; diversion weir in lower reach. General, habitat (invertebrates) & flow: Disturbed landscape + river channel; due to erosion + erosion treatment. Riparian/wetland zone & continuity: Alluvial floodplain systems + natural other then R61 crossing. Physico-chemical: Low level crossing; R61 crossing; non-perennial; barren area.					

2.14 Expected Fish Species and Conservation Status

An expected species list was generated from DWS (2014), and Skelton (2001) for the PAOI watercourses and the associated downstream Kariega River SQR. A total of 3 fish species are expected to occur within the watercourses potentially influenced (cumulatively) by the project and these are presented in Table 2-5.

The expected species are generated on a reach basis, and the occurrence of all species in the system is unlikely as different species are specialists of different habitats which are present along a reach. The local watercourses within the PAOI presented largely dry conditions during the May 2023 survey, with only the Tulpleegte River and several smaller unnamed watercourses presenting surface water (standing and not flowing). Due to the non-perennial and episodic nature of the watercourses the presence of fish within the project area is unlikely.

The downstream Kariega River is however likely to support fish. The conservational status (Figure 2-16) of the fish species was assessed against the latest International Union for Conservation of Nature (IUCN) red list of threatened species database to identify Species of Conservation Concern (SCC) (IUCN, 2023).

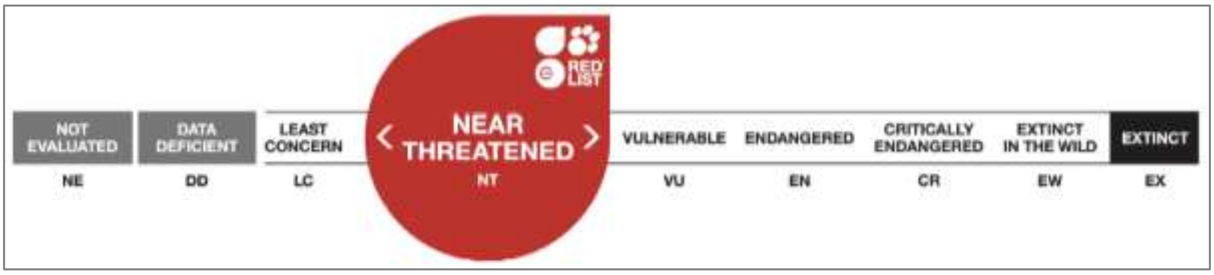


Figure 2-16 IUCN red list categories illustrating the conservational status of the floral and faunal species (IUCN, 2023)

The small barb species previously known as *Enteromius anoplus* (Chubbyhead barb) is expected within the downstream systems, and was thought to be widely distributed across southern Africa with an IUCN listed status of Least Concern (LC) due to an extensive distribution range. However, according to a recent genetic study conducted by Kambikambi *et al.* (2021), *Enteromius anoplus* was reclassified into four distinct genetic lineages separated by selected major river systems, indicating distinct species endemic to different drainage basins. These results render the current IUCN Red List assessment of *E. anoplus* obsolete. Kambikambi *et al.* (2021), suggest that there is thus the need for generating baseline information, including knowledge of ecological requirements, habitat utilization, distribution, life history and feeding ecology to support conservation and protection of these endemic fish. In absence of a threatened status these fish should be conserved through the precautionary principle and be treated as highly threatened for proposed developments until otherwise proven to be less threatened. The Gamtoos drainage basin was not included in the aforementioned study, therefore the expected *E. anoplus* should be treated as a highly threatened Gamtoos endemic species that remains undescribed.

An additional indigenous species of conservational concern is expected within the downstream Kariega River (*Fish Sanctuary Area*) namely *Pseudobarbus asper* (Smallscale Redfin) which is listed as Vulnerable (VU) requiring management of water quality, habitat and predation impacts from invasive fish species (Jordaan and Chakona, 2018).

Both *Enteromius anoplus* and *Pseudobarbus asper* are SCC taxa potentially influenced from the proposed project on a cumulative scale with water quality impacts of key concern to their survival.

Table 2-5 Expected fish species for the SQRs potentially influenced by the project

Species	Common Name	IUCN (2023)*	Ouplaas and Gannaleegte	Downstream Kariega River
Enteromius anoplus	Chubbyhead barb	Unknown	Yes	Yes
Labeo umbratus	Moggel	LC		Yes
Pseudobarbus asper	Smallscale Redfin	VU		Yes
Total expected species	**3**		**1**	**3**
*LC – Least Concern; VU – Vulnerable				

3 Methods Employed During the Study

3.1 Approach and Field Assessment

In line with the minimum requirements for aquatic biodiversity surveys a single aquatic sampling survey was conducted on the 23rd to the 25th of May 2023. The survey constituted a dry season/ low flow/ winter assessment.

Standard methods were implemented to establish the baseline conditions of the considered river reaches. Details pertaining to the specific methodologies applied are provided in the relevant sections below.

3.1.1 Investigation Sites

Every effort was made to visit every watercourse within the PAOI, with access roads, farm fences and wet muddy clay soil conditions limiting extensive coverage. The larger dominant watercourses were visited. It should be noted that the majority of the assessed watercourses were dry at the time of the survey and not suitable for biological sampling due to the absence of surface waters. Therefore, a total of 2 sampling sites were assessed during the study, with emphasis placed on the systems within the PAOI that had surface water present 2 additional sites were not sampled however these presented surface water. Figure 3-1 illustrates the sampling sites for the study, and Table 3-1 presents site photographs, Global Positioning System (GPS) coordinates and comments for each site.

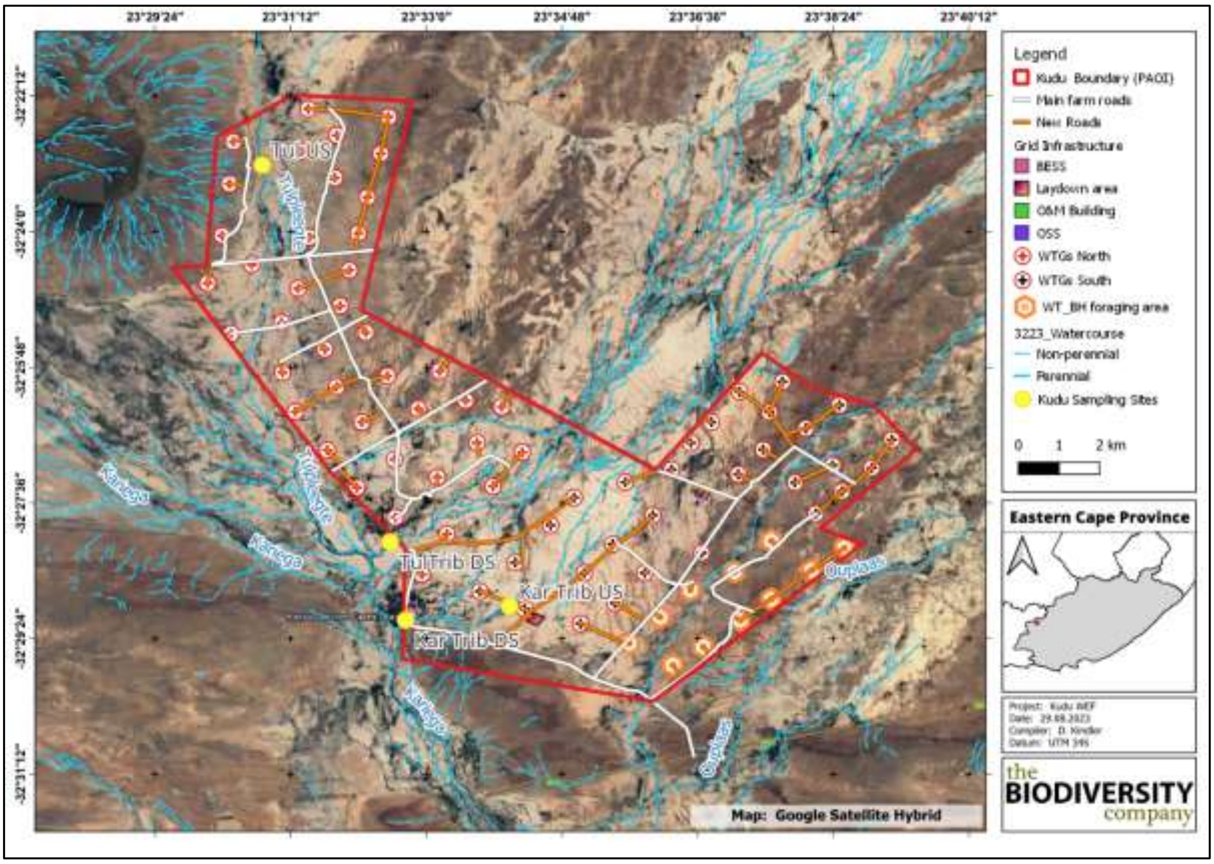


Figure 3-1 Study sampling points

Table 3-1 Investigation site photographs and coordinates (May 2023)

Site	Upstream	Downstream
Tul US		
Comments	Site Tul US is located in the upper reaches of the Tulpleegte River, a non-perennial river in the North-western portion of the project area. The site was located at an instream weir that had inundated the upstream areas and was holding water at the time of the survey. The watercourse was not flowing. The channel has been subjected to catchment erosion and sedimentation.	
GPS-coordinates	32°23'7.06"S; 23°30'49.30"E	
Tul Trib DS		
Comments	Site Tul Trib DS is located in the lower reaches of an unnamed ephemeral tributary of the Tulpleegte River to the centre of the project area. The watercourse was not flowing. The channel was largely intact and traversed by the existing main farm road.	
GPS-coordinates	32°28'7.20"S; 23°32'31.16"E	
Kar Trib US		
Comments	Site Kar Trib US is in the upper reaches of an unnamed ephemeral tributary of the Kariega River in the middle to western portion of the project area. The site was located at an instream earthen impoundment that had inundated the upstream areas and was holding water at the time of the survey. The watercourse was not flowing. The channel has been subjected to some catchment erosion and sedimentation.	
GPS-coordinates	32°28'58.32"S; 23°34'6.25"E	
Kar Trib DS	Photos corrupted	
Comments	Site Kar Trib DS is located downstream of site Kar Trib US is in the lower reaches of the unnamed Kariega River tributary. The channel was largely intact and traversed by the existing main farm road near the Karoo Secret Farm Stay Building.	
GPS-coordinates	32°29'9.32"S; 23°32'43.57"E	

3.1.2 Water Quality

Water quality was measured *in situ* using a handheld calibrated multi-parameter water quality meter. The constituents considered that were measured included: pH, electrical conductivity (µS/cm), temperature (°C) and Dissolved Oxygen (DO) in mg/l. Water quality analysis is typically conducted at each sampling site along the watercourses in the project area which contain water.

3.1.3 Aquatic Habitat Integrity

The Intermediate Habitat Integrity Assessment (IHIA) as described in the Procedure for Rapid Determination of Resource Directed Measures for River Ecosystems (Section D), 1999 were used to define the ecological status of the river reach. The IHIA makes use of data obtained at each site to compile a reach-based PES. The method is based on Kleynhans (1996).

The IHIA model will be used to assess the integrity of the habitats from a riparian and in-stream perspective. The habitat integrity of a river refers to the maintenance of a balanced composition of physico-chemical and habitat characteristics on a temporal and spatial scale which are comparable to the characteristics of natural habitats of the region (Kleynhans, 1996). This model compares current conditions with reference conditions that are expected to have been present. Specification of the reference condition follows an impact based approach where the intensity and extent of anthropogenic changes are used to interpret the impact on the habitat integrity of the system. To accomplish this, information on abiotic changes that can potentially influence river habitat integrity are obtained from surveys or available data sources. These changes are all related and interpreted in terms of modification of the drivers of the system, namely hydrology, geomorphology and physico-chemical conditions and how these changes would impact on the natural riverine habitats. The criteria and ratings utilised in the assessment of habitat integrity in the current study are presented in Table 3-2 and Table 3-3 respectively.

Table 3-2 Criteria used in the assessment of habitat integrity (Kleynhans, 1996)

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

Criterion	Relevance
Exotic aquatic fauna	The disturbance of the stream bottom during feeding may influence the water quality and increase turbidity. Dependent upon the species involved and their abundance.
Solid waste disposal	A direct anthropogenic impact which may alter habitat structurally. Also, a general indication of the misuse and mismanagement of the river.
Indigenous vegetation removal	Impairment of the buffer the vegetation forms to the movement of sediment and other catchment runoff products into the river. Refers to physical removal for farming, firewood and overgrazing.
Exotic vegetation encroachment	Excludes natural vegetation due to vigorous growth, causing bank instability and decreasing the buffering function of the riparian zone. Allochtonous organic matter input will also be changed. Riparian zone habitat diversity is also reduced.
Bank erosion	Decrease in bank stability will cause sedimentation and possible collapse of the riverbank resulting in a loss or modification of both instream and riparian habitats. Increased erosion can be the result of natural vegetation removal, overgrazing or exotic vegetation encroachment.

Table 3-3 Descriptions used for the ratings of the various habitat criteria

Impact Category	Description	Impact Score
None	No discernible impact or the modification is located in such a way that it has no impact on habitat quality, diversity, size and variability.	0
Small	The modification is limited to very few localities and the impact on habitat quality, diversity, size and variability are also very small.	1-5
Moderate	The modifications are present at a small number of localities and the impact on habitat quality, diversity, size and variability are also limited.	6-10
Large	The modification is generally present with a clearly detrimental impact on habitat quality, diversity, size and variability. Large areas are, however, not influenced.	11-15
Serious	The modification is frequently present and the habitat quality, diversity, size and variability in almost the whole of the defined area are affected. Only small areas are not influenced.	16-20
Critical	The modification is present overall with a high intensity. The habitat quality, diversity, size and variability in almost the whole of the defined section are influenced detrimentally.	21-25

3.1.4 Aquatic Macroinvertebrate Assessment

Macroinvertebrate assemblages are good indicators of localised conditions because many benthic macroinvertebrates have limited migration patterns or a sessile mode of life. They are particularly well-suited for assessing site-specific impacts (upstream and downstream studies) (Barbour *et al.,* 1999). Benthic macroinvertebrate assemblages are made up of species that constitute a broad range of trophic levels and pollution tolerances, thus providing strong information for interpreting cumulative effects (Barbour *et al.,* 1999). The assessment and monitoring of benthic macroinvertebrate communities forms an integral part of monitoring the health of an aquatic ecosystem.

3.1.4.1 Macroinvertebrate Habitat

The invertebrate habitat at the site was assessed using the South African Scoring System version 5 (SASS5) biotope rating assessment. A rating system of 0 to 5 was applied, 0 being not available or absent, while 5 was abundant and diverse. The weightings for lower foothill rivers (slope class E) were used to categorize biotope ratings (Rowntree *et al.,* 2000; Rowntree & Ziervogel, 1999).

3.1.4.2 South African Scoring System

The South African Scoring System version 5 (SASS5) is the current index being used to assess the status of riverine macroinvertebrates in South Africa. According to Dickens and Graham (2002), the index is based on the presence of aquatic invertebrate families and the perceived sensitivity to water quality changes of these families. Different families exhibit different sensitivities to pollution, these sensitivities range from highly tolerant families (e.g. Chironomidae) to highly sensitive families (e.g. Perlidae). SASS results are expressed both as an index score (SASS score) and the Average Score Per recorded Taxon (ASPT value).

Sampled invertebrates are identified using the "Aquatic Invertebrates of South African Rivers" Illustrations book, by Gerber and Gabriel (2002). Identification of organisms is made to family level (Fry, 2022; Thirion *et al.,* 1995; Dickens and Graham, 2002; Gerber and Gabriel, 2002).

All SASS5 and ASPT scores are compared with the SASS5 Data Interpretation Guidelines (Dallas, 2007) for the Great Karoo Ecoregion. This method seeks to develop biological bands depicting the various ecological states and is derived from data contained within the Rivers Database and supplemented with other data not yet in the database. Due to insufficient data to formulate biological bands for the Great Karoo Ecoregion, no biological bands could be directly compared for the survey. The specialist has used the adjacent arid regions biological bands for the Nama Karoo Ecoregion as a substitute (Figure 3-2). The resultant ecological categories must be used with caution.

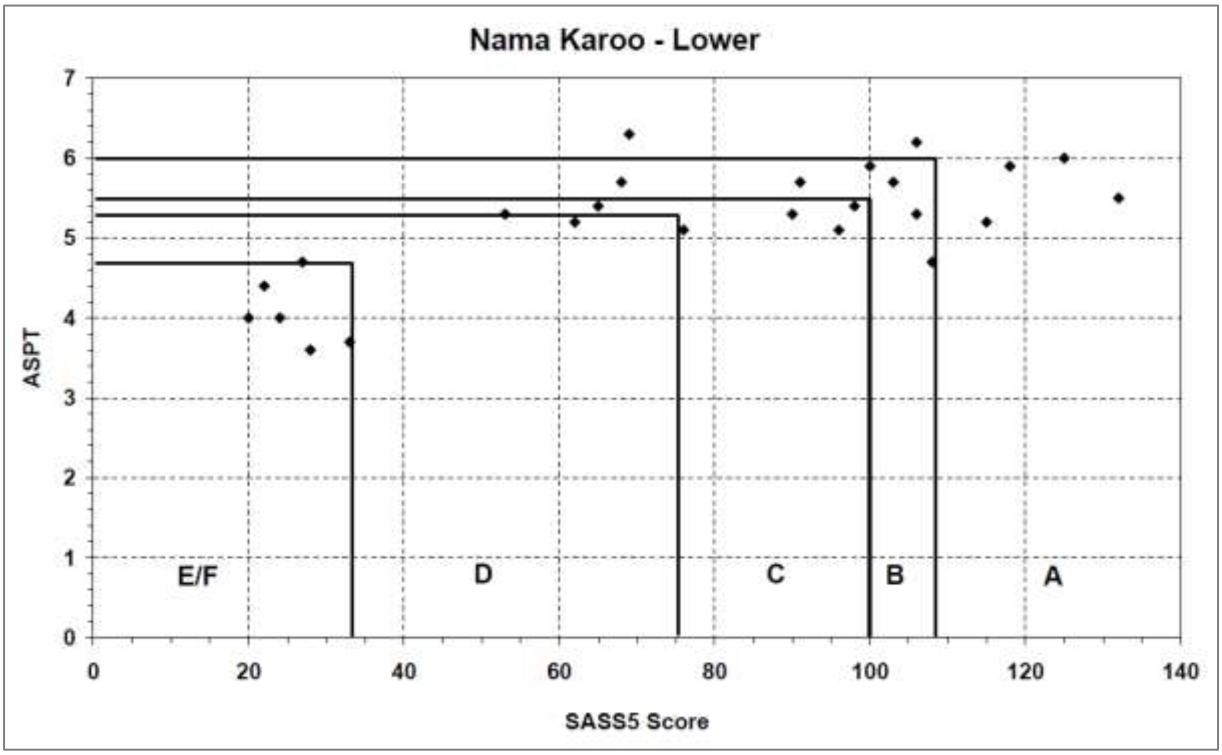


Figure 3-2 Biological Bands for the Nama Karoo Lower - Ecoregion, calculated using percentiles

3.1.5 Macroinvertebrate Response Assessment Index

The Macroinvertebrate Response Assessment Index (MIRAI) was used to provide a habitat-based cause-and-effect foundation to interpret the deviation of the aquatic invertebrate community from the calculated reference conditions for the SQR. This does not preclude the calculation of SASS5 scores if required (Thirion, 2007). The four major components of a stream system that determine productivity for aquatic macroinvertebrates are as follows:

- Flow regime;
- Physical habitat structure;
- Water quality; and
- Energy inputs from the watershed Riparian vegetation assessment.

The results of the MIRAI will provide an indication of the current ecological category and therefore assist in the determination of the PES.

3.1.6 Fish Presence

Fish sampling was conducted using electroshocking techniques and visual observation (Figure 3-3). All fish captured are identified in the field and released at the point of capture, in order not to cross fish populations between sites and watercourses. Fish species are identified using the guide Freshwater Fishes of Southern Africa (Skelton, 2001). The identified fish species are compared to those expected to be present for the quaternary catchment. The expected fish species list for the project area was developed from a literature survey to compare to the sampled species at site. Different fish species represent different sensitivities to water chemistry, habitat and flow which considered as part of the Fish Response Assessment Index (FRAI) (Kleynhans *et al*., 2007 and Skelton 2001).

Figure 3-3 Example of electroshocking used to catch fish (Mpumalanga, 2019)

3.1.7 Present Ecology Status Classification

Ecological classification refers to the determination and categorisation of the integrity of the various selected biophysical attributes of ecosystems compared to the natural or close to natural reference conditions (Kleynhans and Louw, 2007). For the purpose of this study, ecological classifications have been determined for biophysical attributes for the associated watercourses. This was completed using the river ecoclassification manual by Kleynhans and

Louw (2007). The areas considered in the PES assessment are outlined in the description of the project area section.

3.2 Determining Buffer Requirements

Macfarlane *et al.* (2014) was consulted to determine the appropriate watercourse buffer zone for the proposed activity.

4 Results

4.1 *In situ* Water Quality

In situ water quality analysis is typically conducted at each sampling site along the watercourses in the project area which contained water. Although sites Tul US and Kar Trib DS contained water, these sites were excluded as water quality was taken elsewhere in the catchment and deemed not critical for the study. These results are important to assist in the interpretation of biological results due to the direct influence water quality has on aquatic life forms. Results have been compared to limits stipulated in the Target Water Quality Range (TWQR) for aquatic ecosystems (DWAF, 1996). The results of the May 2023 assessment are presented in Table 4-1.

Table 4-1 In situ surface water quality results (May 2023)

Site	River system	pH	Conductivity (µS/cm)	DO (mg/l)	Temperature (°C)
TWQR*		6.5-9.0	700	>5.0 mg/l	5-30
Tul Trib DS	Tulpleegte Trib	8.0	414	7.56	12.4
Kar Trib US	Kariega Trib	7.6	247	7.1	18.4
The remainder of the watercourses			Dry		

*TWQR – Target Water Quality Range (DWAF, 2006); Levels exceeding guideline levels are indicated in red

Water quality results in the assessed Tulpleegte and Kariega River tributaries indicated pH levels, concentrations of dissolved solids as measured by electrical conductivity, and dissolved oxygen levels within the catchment were within the guideline values to support aquatic biota. Water temperatures fell within expected ranges for the ecoregion during the winter survey period. The water quality was deemed suitable of supporting aquatic biota at the time of the survey.

Impacts from the alteration of land use within a catchment which includes contaminated runoff from the construction phase of WEF developments can contribute to water quality impacts in the downslope watercourses (the receptor). The project must take cognisance of this.

4.2 Habitat Integrity Assessment

The on-site assessment of the watercourses presented largely dry conditions in the smaller tributaries, with surface water presence in the larger tributaries and main river systems. Cumulatively these non-perennial systems displayed ephemeral characteristics which is typical for watercourses in an arid region (Figure 4-1). Channel habitat modification has taken place through land use activities as discussed below, however the ecosystems and adjacent terrestrial habitat is considered open and largely intact, although modified. Portions of the watercourses are braided within the site, creating an extensive alluvial fan landscape surrounding the watercourses which intersect terrestrial habitat, highlighting their interdependence. Despite their current level of modification and ephemeral nature, the watercourses are sensitive to further modification as these systems do provide drinking opportunities (following rainfall) and habitat for foraging, nesting and refugia for terrestrial biota and avifauna (see associated terrestrial ecology report and avifauna report for the project). Therefore, the watercourses in the project area are regarded as sensitive environments in relation to changes in habitat integrity, flow and water quality (ecological drivers) requiring avoidance from the project related disturbance activities and maintenance of baseline conditions.

Figure 4-1 Illustration of some of the ephemeral watercourses scattered across the project area (May 2023)

The condition of the watercourses and associated aquatic biodiversity is largely dependent on the condition and degree of modification of the surrounding catchment. The more intact and natural the catchment is, the greater the watercourse condition and ecosystem functioning, and services will be with an associated high aquatic and terrestrial biodiversity presence. An altered catchment compromises the watercourse condition, ecosystem functioning, and services offered with deleterious effects depending on the degree and type of catchment modification. The more modified catchment will ultimately have a low ecological value watercourse offering limited services with an absence of key services such as phytoremediation (cleaning of water by vegetation) with the cumulative loss of its original biodiversity with only the most tolerant biota remaining in the most negatively modified catchments. The IHIA was completed for the Tulpeegte River as described in the IHIA methodology component of this study to determine the condition of this watercourse. The smaller systems had intermittent presence of water due to the presence of unnatural dams built intermittently along their flow paths, disrupting the riverine characteristics of these systems making it difficult to accurately assess using IHIA models. The spatial framework of which constitutes a 10 km river reach was used to complete the IHIA of the assessed watercourses and is represented in Table 4-2.

Table 4-2 Results for the Tulpleegte catchment habitat integrity assessment

Criterion	Impact Score	Justification
		Instream
Water abstraction	4	Limited areas are cultivated with no center pivots present along watercourse. The river is largely used for free-range drinking by livestock (sheep).
Flow modification	18	Numerous instream weirs and several off channel impoundments and a few instream crossing structures & bridges present in catchment.
Bed modification	16	Moderate instream sedimentation from bank and catchment erosion with low to moderate levels of trampling by livestock. A high number of crossing structures with moderate influence on substrate movement. The erosion and sedimentation levels have smothered some instream areas.
Channel modification	20	Low to moderate levels of trampling of vegetation by livestock with subsequent bank erosion & instream sedimentation. The highly erodible nature of the soils has lead to moderate levels of erosion of the watercourse banks during periods of flow, which are typically episodic events that may present as flash floods. The high level of impoundments and surface flow alterations has negatively altered the channel characteristics.
Water quality	5	Active livestock (nutrients) in catchment with some roads (hydrocarbons & miscellaneous spillages) intersecting the Tulpleegte River and its tributaries. A low number of informal river crossings where farm vehicles drive through the watercourse washing hydrocarbons from vehicle (in times of flow). Limited farmsteads present serving as points of pollution. No sewage works present, therefore likely French drains used by farmsteads.
Inundation	10	A high number of weirs/ impoundments & a few instream crossing structures. Low to moderate impact due to ephemeral nature of system.
Exotic macrophytes	0	No surface water present to support these long term.
Exotic aquatic fauna	0	No surface water present to support these long term.
Solid waste disposal	3	Present yet limited, indicating adequate management of the catchment and associated watercourses.
Total Instream	**62.2**	
Category	**C (Moderately Modified)**	
		Riparian
Indigenous vegetation removal	6	Minimal areas denuded for cultivation which are largely outside of riparian zones, with low to moderate levels of grazing and trampling by livestock & erosion. Low levels of invasion and competition from alien vegetation throughout catchment.
Exotic vegetation encroachment	3	Limited areas of the riparian zone invaded by alien & invasive vegetation. The level of invasion can decrease the buffering function of the riparian zone.
Bank erosion	12	Moderate due to the high erodibility of the catchment exacerbated by ephemeral nature, livestock trampling & presence of instream structures.
Channel modification	12	Moderate due to livestock trampling & instream structures, road network and largely non-cultivated watercourse buffer areas with minor impacts from encroachment of alien vegetation
Water abstraction	9	Limited areas are cultivated with no center pivots present. Numerous instream impoundments lead to great water losses through increased surface areas for evaporation. The river is further used for free-range drinking by livestock.

Criterion	Impact Score	Justification
Inundation	8	A high number of weirs/ impoundments & a few instream crossing structures, with lower impact to the riparian areas than the instream areas
Flow modification	20	A high number of impoundments and a few instream crossing structures and bridges present in catchment. These structures concentrate or dissipate flows resulting in bank erosion while altering the sediment regime of the catchment.
Water quality	6	Active livestock (nutrients) in catchment with some roads (hydrocarbons & miscellaneous spillages) intersecting the Tulpleegte River and its tributaries. A low number of informal river crossings where farm vehicles drive through the watercourse washing hydrocarbons from vehicle (in times of flow). Limited farmsteads present serving as points of pollution. No sewage works present, therefore likely French drains used by farmsteads.
Total Riparian	**62.0**	
Category	**C (Moderately Modified)**	

The results of the instream and riparian habitat assessment for the Tulpleegte River indicated *class C or moderately modified* habitat condition. This class indicated that a loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged. The relatively low intensity of active anthropogenic activities (farmsteads and livestock land uses - Figure 4-2) and historic activities associated with catchment flow alterations (high intensity of impoundments - Figure 4-3) within the catchment contributes to moderate modifications to the riparian and instream habitat integrity as described in the results table.

Figure 4-2 Illustration of limited agricultural activities (livestock) within Tulpleegte River catchment (Google Earth, 1/2023)

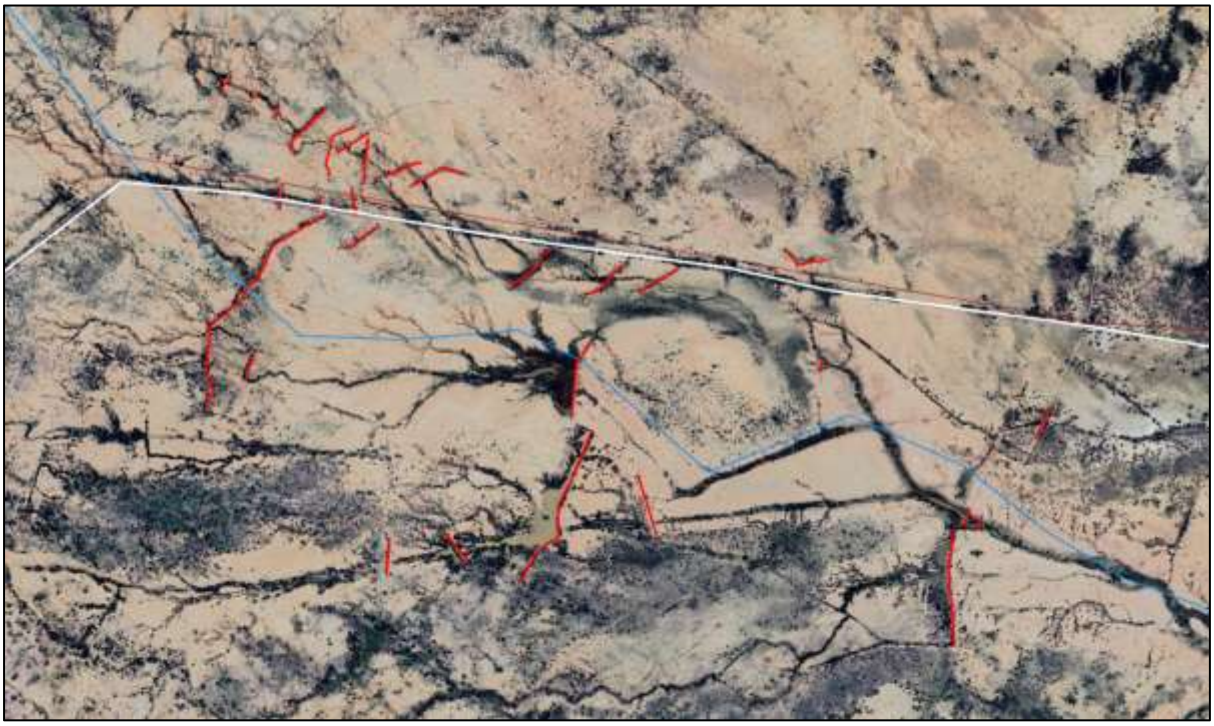


Figure 4-3 Illustration of flow alterations (impoundments – red lines, and roads – white line) within Tulpleegte River catchment (Google Earth, 1/2023)

4.3 Aquatic Macroinvertebrate Assessment

4.3.1 Macroinvertebrate Habitat

Biological SASS5 assessments were completed at representative sites in the considered river reaches. A biotope rating of available habitat was conducted at each sampled site to determine the suitability of habitat to macroinvertebrate communities. The Tulpleegte River has been classed as an Lower foothills (slope geoclass E) system and was assigned different weightings for the various biotopes according to importance value. The unnamed watercourse was by default placed in this geoclass. A rating system of 0 to 5 was applied, whereby 0 represents a biotope as not available (absent) and 5 as abundant and diverse for sampling. The biotope diversity per site was assigned a category according to the diversity which considered the abundance and diversity across the depth-flow classes. The results of the biotope assessment are provided in Table 4-3.

Table 4-3 Biotope availability at the sites during the survey (Rating 0-5)

Biotope, Weighting & Sites		Kar Trib US	Tul Trib DS
Stones in current (SIC)	18*	0	0
Stones out of current (SOOC)	12	0	1
Bedrock	3	0	0
Aquatic vegetation	1	0	0
Marginal vegetation in current	2	0	0
Marginal vegetation out of current	2	1	2
Gravel	4	0	1
Sand	2	0	1
Mud	1	2	3
Total Score (X / 45)		**3**	**8**

Biotope, Weighting & Sites	Kar Trib US	Tul Trib DS
Weighted Biotope Score (%)	2	11
Biotope Diversity	Low	Low

*Weighting value for Upper foothills geoclass; Diversity rating: High (61-100); Moderate (41 - 60); and Low (<40)

Both sampled watercourses had a low biotope diversity deemed not suitable to support a diverse aquatic macroinvertebrate assemblage. Both sites had substrates dominated by sand and mud with and absence or limited presence of course substrates such as stones and gravel. The watercourses were low in hydraulic habitat variations due to the absence of flow, limited to standing water held behind artificial dam walls. The sites were largely devoid of marginal and aquatic vegetation, due to their ephemeral characteristics and partly eroded channels. The watercourses typically had a narrow, sparsely to well vegetated channel of 1 to 2 meters wide, comprising largely terrestrial grasses and Acacia thicket along its margins.

4.3.2 South African Scoring System

The SASS5 score and SASS5 ecological classes obtained for the sampled systems during the survey are presented in Table 4-4. An illustration of selected macroinvertebrates are presented in Figure 4-4, while the full list of macroinvertebrates collected during the survey is presented in Table 4-5.

Table 4-4 Macroinvertebrate assessment results (May 2023)

Site	Kar Trib US	Tul Trib DS
SASS5 Score	21	36
No. of Taxa	5	8
ASPT*	4.2	4.5
Category (Dallas, 2007)	Seriously Modified (class E/F)	Largely Modified (class D)
Biotope Score % & Comment	2	11
	Low diversity of substrates, dominated by sand and mud with low diversity of flow classes and limited marginal vegetation	Low diversity of substrates, dominated by sand and mud with low diversity of flow classes and limited marginal vegetation

*ASPT: Average score per taxon; **Nama Karoo Ecoregion as a substitute – Interpret with caution

The results of the SASS5 assessment indicated that the sampled communities had a total sensitivity score (SASS5 Score) ranging from 21 to 36, a low diversity ranging from 5 to 8 taxa and an ASPT value (average sensitivity score) ranging from of 4.2 to 4.6. ASPT values of 4.2 and 4.6 indicates that the sampled communities were dominated by tolerant taxa. Based on the recorded taxa and sensitivities the sites were placed in a *class E/F (Seriously Modified)* and *class D (Largely Modified)* ecological category for the substituted Nama Karoo ecoregion indicating that the biotic integrity was likely critically to largely impaired. These low diversities and modified ecological categories are expected for these non-perennial systems that presented ephemeral characteristics. The sampled communities reflected this, as a large portion of the sampled community where adults that are known to fly between waterbodies, which is a common feature of arid region communities. The presence of some taxa in juvenile life stages (Chironomidae) and sessile snails (Bulininae) indicated that both the sampled watercourses have had some resident water allowing recruitment of these taxa. According to personal communication with landowners, the resident water can be attributed to the two rainfall events that occurred two weeks before the survey. The presence of resident water can be attributed to larger/ deeper pools due to the presence of impoundments present within the catchment and PAOI. The resultant ecological categories must be used with caution, and the sampled communities are not considered to be seriously and largely modified, but rather largely intact for ephemeral watercourses. Therefore, the specialist recommends a *class B (Largely Natural)* ecological category.

Based on the *in situ* water quality section and sampled habitat, the systems currently support aquatic biota, albeit a low diversity with a low portion of moderately sensitive taxa present. Should additional sites be intensively sampled, additional taxa are likely to be recorded due to differences in available habitat distributed across a watercourse reach, highlighting the need to avoid the watercourses for the project.

Figure 4-4 Examples of sampled macroinvertebrates juvenile Chironomidae (left), adult Corixidae (Centre) and adult Hydrophilidae & Bulininae (right)

Table 4-5 Macroinvertebrate families collected during the survey (May 2023)

Taxon	Sensitivity Score	Kar Trib US	Tul Trib DS
Hemiptera (Bugs)			
Corixidae* (Water boatmen)	3	B	B
Gerridae* (Pond skaters/Water striders)	5	1	A
Notonectidae* (Backswimmers)	3		A
Veliidae/ Mesoveliidae * (Ripple bugs)	5		A
Coleoptera (Beetles)			
Dytiscidae/ Noteridae* (Diving beetles)	5	1	B
Hydraenidae* (Minute moss beetles)	8		A
Hydrophilidae* (Water scavenger beetles)	5	B	B
Diptera (Flies)			
Chironomidae (Midges)	2		A
Gastropoda (Snails)			
Bulininae (Bubble snails)	3	1	
Total Taxa	**9**	**5**	**8**
Sensitivity scores: **1 – 5**: Highly tolerant to pollution **6 -10**: Moderately tolerant to pollution **11 – 15**: Very low tolerance to pollution *Airbreathing taxa	**Abundance estimates:** **1:** A single individual **A:** 2 - 10 individuals **B:** 11 - 100 individuals		

4.4 Macroinvertebrate Response Assessment Index

The MIRAI methodology is conducted according to Thirion (2007). Data collected from the SASS5 method is usually applied to the MIRAI model. The MIRAI model provides a habitat-based cause-and-effect foundation to interpret the deviation of the aquatic macroinvertebrate community (assemblage) from the reference condition (unmodified river). The MIRAI results provide a more robust interpretation of the macroinvertebrate community structure compared to the SASS5 biological bands.

Due to the ephemeral nature of the sampled watercourses, large portions of the macroinvertebrate community were not expected, notably the flow dependant families and as a result many of these flow dependant families form the bulk of the taxa that fall within the intolerant taxa group (Sensitivity scores 11-15). Subsequently, the MIRAI score would be highly skewed, indicating a modified macroinvertebrate community reducing the confidence of the MIRAI scores, which is not a true reflection of the sampled community. Therefore, no MIRAI score was calculated for the project.

4.5 Fish Communities

Sampling for fish was conducted both systems, however despite adequate habitat suitability for fish, no fish were collected. The absence of fish is likely due to the ephemeral nature of the watercourses that may not be conducive to support fish year-round. It is likely that the absence of sufficient rainfall leading up to the survey may have limited the presence of fish at the time of the survey. Despite this, fish are likely present within the Kariega River immediately downstream of the PAOI, highlighting the need to limit water quality and habitat impacts during the execution of the project to conserve fish and aquatic life within the downstream watercourse and those potentially occurring within the sampled watercourses.

4.6 Vernal Aquatic Biota

Ephemeral watercourses in arid environments may present aquatic biota not typically found in temperate watercourses. These ephemeral watercourses often present as vernal pools that intermittently hold water for short periods (from a few days to months) following sufficient rainfall, where by the standing surface water may support vernal biota. Vernal pool plants and animals are very sensitive to the duration and timing of ponding. Vernal pools as described by Los Huertos (2020) are “seasonal wetlands that form in shallow basins and alternate on an annual basis between a stage of standing water and extreme drying conditions”. An example of a vernal system although modified from natural conditions due to altered catchment hydrology was sampled in the upper reaches of the Tulpleegte River at site Tul US which presented as an impoundment. This pool held a number of clam shrimp (Conchostraca) which were sampled and photographed. Photographs of the clam shrimp are presented in Figure 4-6. It is expected that more of the impoundments as well as the natural vernal pools in the form of pans present across the project area will support vernal biota, which may include Anostraca (fairy shrimp), Notostraca (tadpole shrimps such as *Triops* and *Lepidurus* species). The Tulpleegte River would be subjected to period flooding, although a rare event in the arid climate, the clam shrimp and likely other vernal biota (and their egg bank) would historically been dispersed across the project areas watercourse network, with potential occurrence in many of the non-sampled waterholding depressions and impoundments.

Clam shrimp are members of the crustacean order Conchostraca (subclass Branchiopoda) and are non-selective algal and detritus feeders. According to Day *et al*., (1999), some species (e.g. *Cycleslheria hislopi*) may occasionally occur in the littoral zone of lakes and in river systems and some species have extremely local distributions. Temperature is a significant factor controlling the occurrence of conchostracans. Breeding occurs continuously throughout the adult stage where the female produces egg cysts (resting eggs) which are dispersed by wind, waterfowl, and by humans. Cysts can survive extremely unfavourable circumstances.

Hatching time is often variable and is triggered by specific environmental conditions, with some eggs not hatching after the first inundation of habitat following rains. This results in the formation of an egg bank, to serve as a survival strategy against subsequent episodes of drought-related reproductive failure (Day *et al*., 1999).

Figure 4-5 Vernal pool sampled at site Tul US (May 2023)

Figure 4-6 Examples of sampled clam shrimp at site Tul US (May 2023)

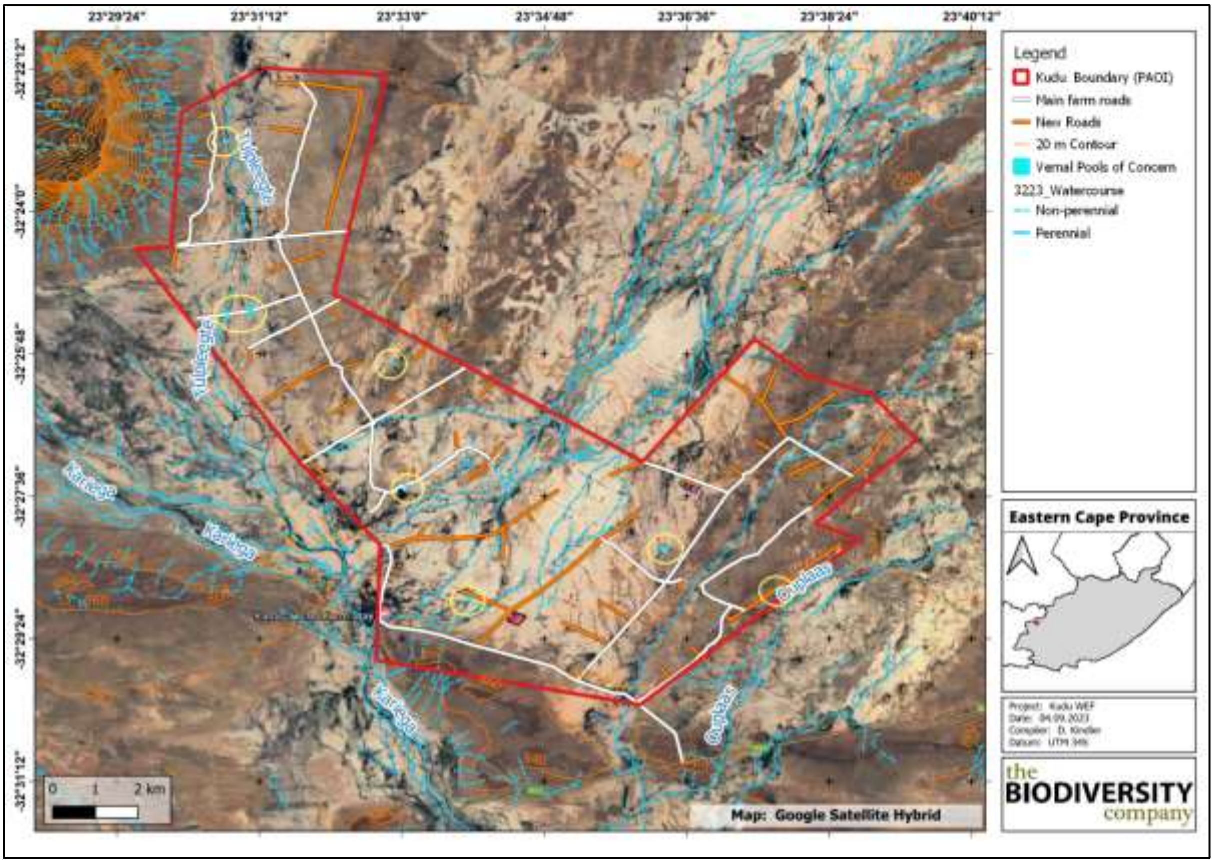


Figure 4-7 Vernal pools (circle in yellow) identified in the project area

The conservation status of species of this order was assessed against the latest IUCN database for threatened species (IUCN, 2023), and where not available the Day *et al*. (1999) status was considered. No conservation statuses were found for the South African species, while as a comparative example the Serbian species are rated as 'Vulnerable'. Relative to its area, southern Africa has one of the richest anostracan faunas in the world, of which 80% are endemic, highlighting that conchostracans may be similarly endemic. The presence of these temporary lifeforms and lack of conservation status highlights the importance and sensitivity of these watercourses and the project should treat these biota as highly threatened using the *Precautionary Principle* approach.

It is therefore recommended that all the watercourses and off channel depressions (pans and wetlands - Figure 4-7) and associated buffer areas be avoided by any activities relating to the project using the Best Practicable Environmental Option (BPEO).

4.7 Present Ecological Status

The PES assessment for the sampled watercourses is based on the collective data collected during the May 2023 survey and the results are provided in Table 4-6. The Kariega River tributary was not suitable for a full PES assessment, therefore only the Tulpleegte was PES status was derived.

Table 4-6 Present Ecological Status of the watercourse (May 2023)

Aspect Assessed	Tulpleegte
Instream Ecological Category (IHIA)	C

Aspect Assessed	Tulpleegte
Riparian Ecological Category (IHIA)	C
Aquatic Invertebrate Ecological Category	Not Applicable = SASS5 used (class B)
Fish Community	-
Ecostatus	**C**
PES (DWS, 2014)	**B (Largely Natural)**
Management Class	**C**

The results of the PES assessment derived a *moderately modified (class C)* status for the Tulpleegte River which includes its major tributaries within the PAOI. The anthropogenic activities within the catchment have resulted in large modifications to the riparian and instream habitat integrity of the watercourse. These activities have contributed to alteration of hydrology and some erosion of the river banks, with evidence of flow and channel modification, cumulatively reducing the biotic integrity of the sampled watercourses. The biotic integrity must be interpreted with caution due to the ephemeral nature of the watercourses and limited availability of surface water to support a diverse aquatic ecosystem.

The Tulpleegte River and its tributary fell short of the DWS (2014) PES. However, the PES data is outdated and the status was derived from a large reach of the watercourse (Table 2-4). Despite this, the specialist recommends that the *moderately modified (class C)* status be set as the Management Class for the project areas watercourses.

Due to the sensitivity of the catchment and soils to erosion, together with the flat topography and braided alluvial fan nature of the watercourses within the PAOI, an increase in anthropogenic activities poses a risk to the ecological integrity of the watercourses notably from a hydrological perspective. The presence of aquatic macroinvertebrates and vernal biota highlights the sensitivity of the watercourses. Any proposed activities in proximity to the watercourses should not further contribute to the deterioration of the instream and riparian zones as this will compromise the ecological integrity of the reach and Management Class may not be achieved.

5 Sensitivity and Buffer Assessment

As noted in the geomorphological description of the project area, the watercourses considered in this assessment represented ephemeral system characteristics that have naturally been subjected to instream erosion and sedimentation compounded by intensive surface flow alterations. As can be observed in Figure 4-1 in the IHIA section, riparian areas were not well defined for all watercourses across the project area and comprised of a mix of herbaceous species with sparse woody species present. The larger systems presented a typical riverine *Vachellia karroo* thicket along the riparian zones (Figure 5-1), with the thickness of these zones becoming sparser and more non-existent as the size of the watercourse decreased. Despite alteration, these areas were considered to be largely intact with impacts to their integrity presented in the IHIA section (Table 4-2).

Figure 5-1 Typical arid zone watercourse and associated instream and riparian areas in the project area

The ecological sensitivity of the watercourses draining the PAOI was determined to be largely uniform across the project area. The watercourses presented evidence of reliance/ dependence on these systems by terrestrial biota and frogs for drinking (in times of surface water presence after rainfall), foraging, nesting and refugia, with animal tracks observed in the substrates in majority of the watercourses. Despite the absence of water and aquatic taxa in majority of the braided channels at the time of the survey, all of the watercourses in the project area are regarded as sensitive environments in relation to changes in habitat integrity, flow and water quality (ecological drivers).

Given the varied geomorphological features of the watercourses, flat topography and absence of a clear and consistent riparian zone, no riparian delineation could be assigned to the local watercourse networks. Despite this, the watercourse/ drainage extent was mapped with associated sensitivity assigned by identifying vegetation features on aerial imagery and confirmation through ground truthing during the survey. A diagrammatic example of the typical watercourse extent as well as where appropriate buffer areas are located is provided in Figure 5-2. The watercourse layouts and their respective delineated sensitive areas are depicted in Figure 5-3 and all infrastructure should avoid the high and medium sensitivity areas and apply a 32 m buffer from the edge of the watercourse as per the sensitivity maps. This 32 m buffer would also apply to the vernal pools. The High sensitivity areas (red areas) are to be treated as no-go areas, allowing only minimum critical watercourse crossing in these areas.

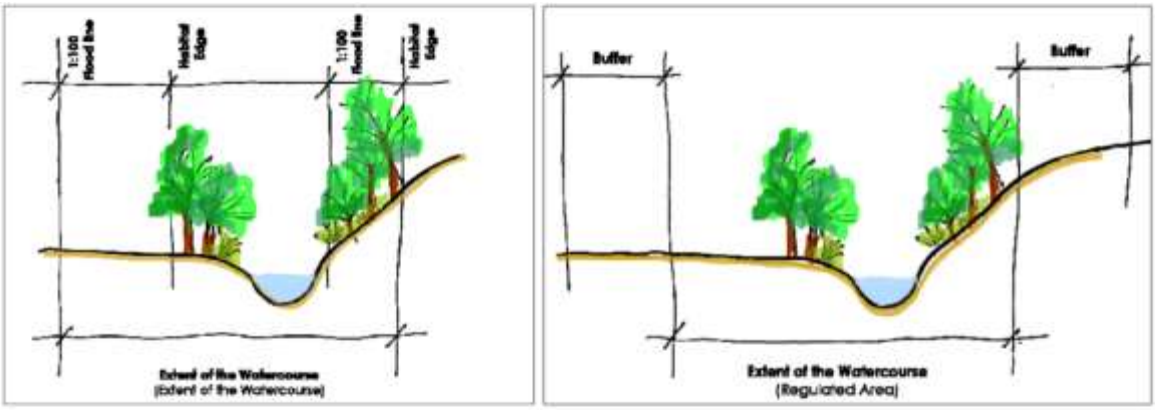


Figure 5-2 Illustration of the extent of a watercourse and the Regulated Area (DWA, 2012)

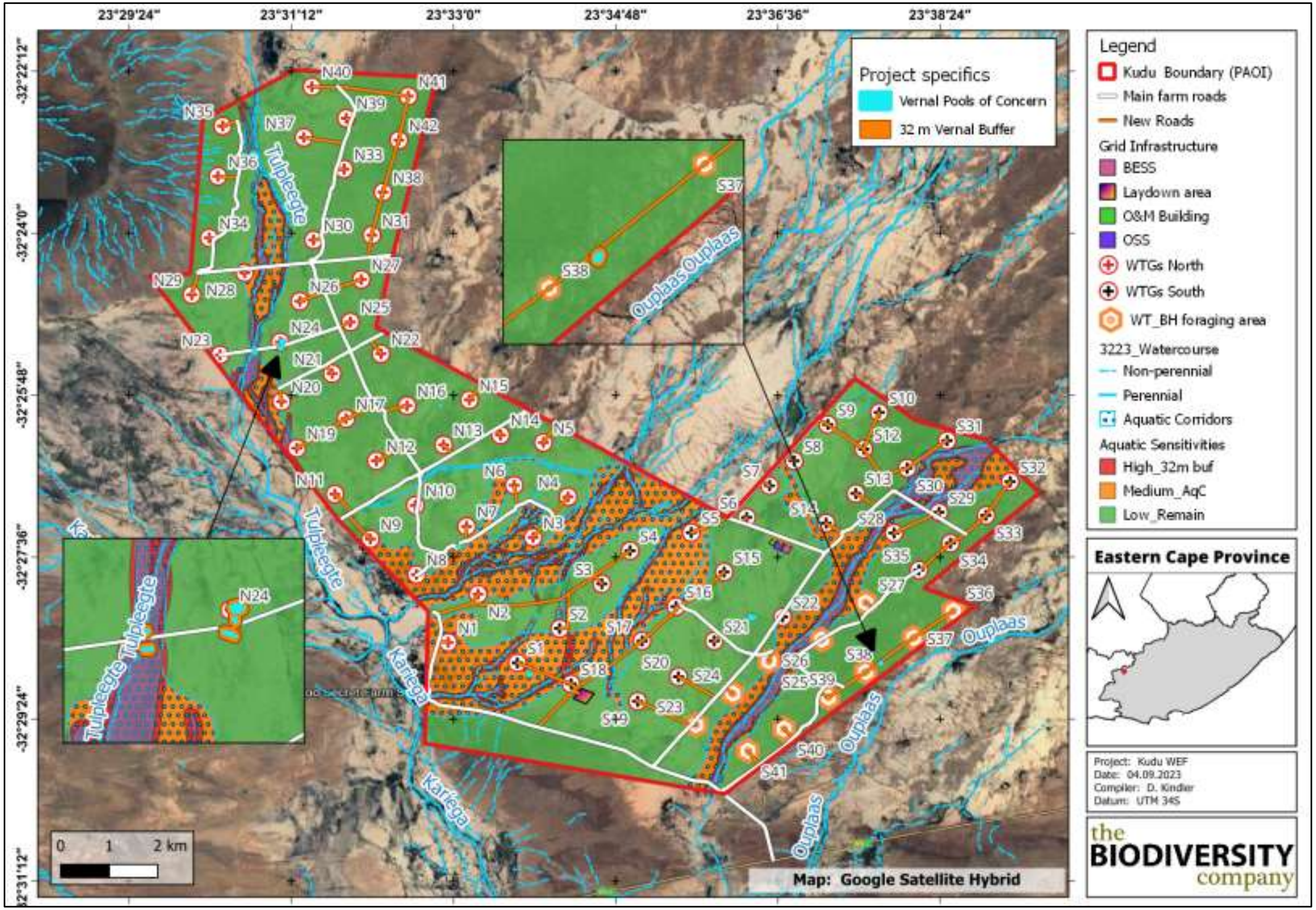


Figure 5-3 Project related infrastructure and associated sensitivity of freshwater resources

6 Impact Assessment

The section below and associated tables serve to indicate and summarise the significance of perceived impacts on the aquatic ecology of the project area. Potential impacts were evaluated against the data captured during the desktop and field assessment to identify relevance to the project area. The relevant impacts associated with the construction of the proposed development were then subjected to a prescribed impact assessment methodology which were provided by Savannah Environmental as is presented in Table 6-1.

Table 6-1 Impact assessment methodology

Extent of impact	Rating
Site specific	Very low (1)
Footprint & surrounding areas	Low (2)
Local area	Moderate (3)
Regional	High (4)
Entire habitat unit / Entire system	Very high (5)
Duration of impact	**Rating**
The lifetime of the impact will be of a very short duration (0–1 years)	Very short term (1)
The lifetime of the impact will be of a short duration (2-5 years)	Short term (2)
Medium term (5–15 years)	Moderate term (3)
Long term (> 15 years)	Long term (4)
Permanent	Permanent (5)
Consequence/Magnitude of impact	**Rating**
Small and will have no effect on the environment	None (0)
Minor and will not result in an impact on processes	Minor (2)
Low and will cause a slight impact on processes	Low (4)
Moderate and will result in processes continuing but in a modified way	Moderate (6)
High (processes are altered to the extent that they temporarily cease)	High (8)
Very high and results in complete destruction of patterns and permanent cessation of processes	Very high (10)
Probability of impact	**Rating**
Very improbable (probably will not happen)	Very improbable (1)
Improbable (some possibility, but low likelihood)	Improbable (2)
Probable (distinct possibility)	Probable (3)
Highly probable (most likely)	Highly probable (4)
Definite (impact will occur regardless of any prevention measures)	Definite (5)
Status	**Rating**
Positive	Positive
Negative	Negative
Neutral	Neutral
Reversibility	**Rating**
None	None
Low	Low
Moderate	Moderate
High	High
Irreplaceable loss of resources?	**Rating**

Yes	Yes
No	No
Can impacts be mitigated?	**Rating**
Yes	Yes
No	No
Significance	**Rating**
< 30 points	Low
30-60 points	Medium
> 60 points	High

6.1 Present Impacts to Aquatic Ecology

Considering the current anthropogenic activities and influences within the landscape, several negative impacts to aquatic biodiversity were observed within the PAOI, however limited in intensity unless otherwise stated. These include:

- Historic land modification from reference conditions;
- Farm roads and main roads (and associated altered surface hydrology and wash of hydrocarbons into watercourses. Both formal and informal river crossing structures have altered instream flow characteristics);
- Historical dryland agriculture (and associated altered surface hydrology);
- Grazing and trampling of natural vegetation by livestock in aquatic and riparian areas and adjacent alluvial fan areas;
- Minor encroachment of riparian areas by Alien and/or Invasive Plants (IAP);
- Erosion from steep slopes, river banks and roads (especially roads lacking anti-erosion measures);
- The ephemeral watercourses have numerous anti-erosion berms (instream weirs/ impoundments) across the flat topography, negatively influencing the flow and functioning of the watercourses and their immediate catchment;
- Low to moderate levels of instream sedimentation; and
- Fences and associated maintenance resulting in habitat fragmentation.

6.2 Aquatic Impact Assessment

Anthropogenic activities drive habitat modification and destruction causing displacement of aquatic and terrestrial fauna and flora, and possibly direct mortality. Land clearing for development infrastructure (all inclusive) destroys local wildlife habitat and can lead to the loss of local breeding grounds, nesting sites and wildlife movement corridors such as rivers, streams and drainage lines and their associated riparian area, or other locally important features such as off channel wetlands or vernal pools. The removal of natural vegetation from these areas and their respective buffers will reduce the habitat available for fauna and may reduce ecological integrity and species diversity within the area depending on the intensity and footprint of clearing and destruction caused.

6.2.1 Alternatives considered

This section of the report presents the assessment of the preliminary WEF layout (Figure 6-1), which informed alternative layouts for the proposed development. The alternative layout (proposed optimised facility layout) was derived following collaboration with the terrestrial ecologist, which resulted in the formation of the optimised WEF layout as presented in Figure 6-2. The optimised WEF layout relocated portions of internal access roads outside of watercourses and their associated aquatic corridors and 32 m buffers, with other portions of internal access roads aligned to existing roads. Furthermore, crossings over the delineated aquatic corridors were minimised and restricted to one crossing per watercourse, to limit hydrological functioning related impacts of the watercourses. Where it is not feasible to avoid watercourses for road crossings, the project should prioritise crossing watercourses where riverine thicket is absent, rather than removing riverine or riparian thicket vegetation.

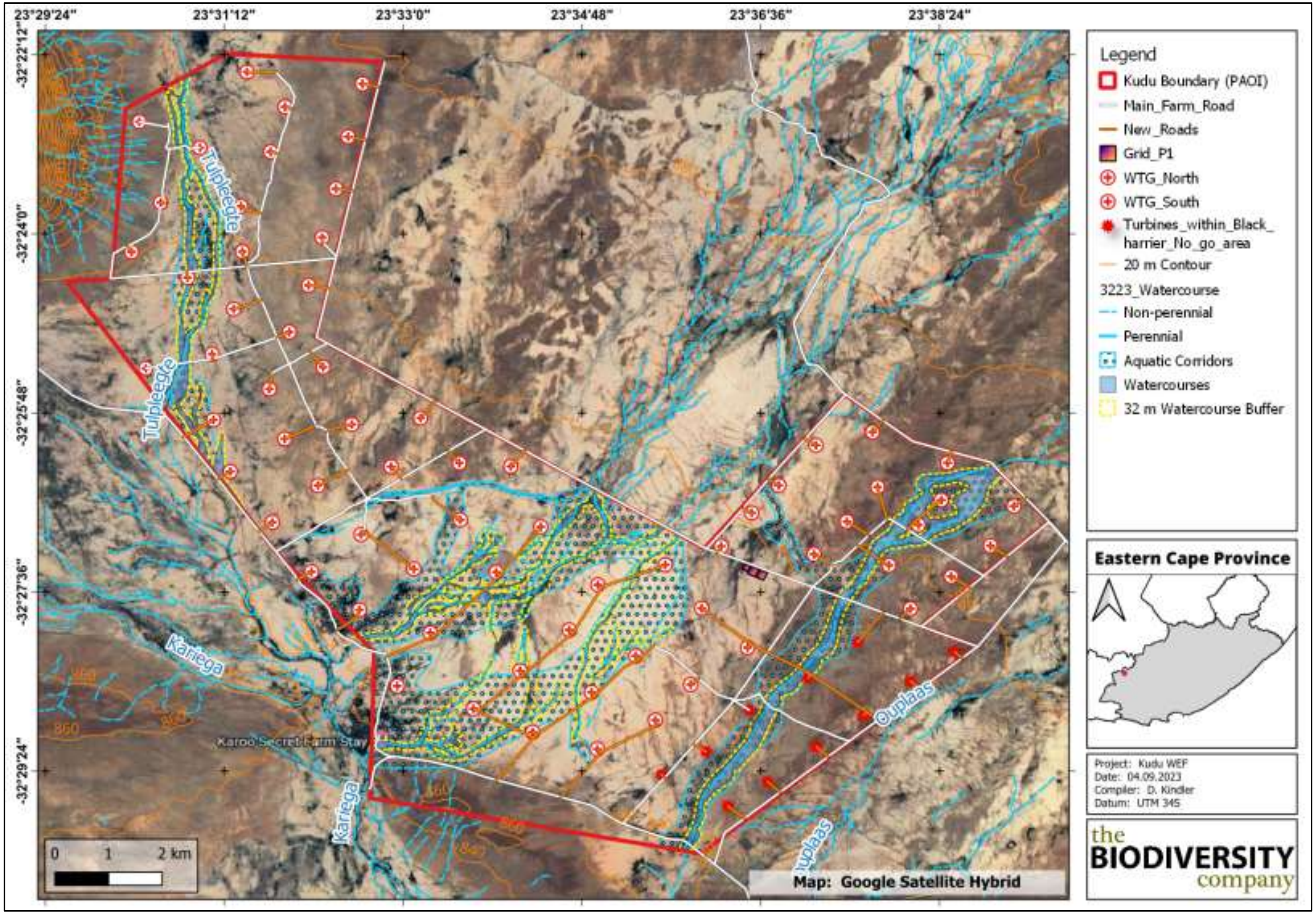


Figure 6-1 Preliminary WEF layout and associated sensitivity of freshwater resources

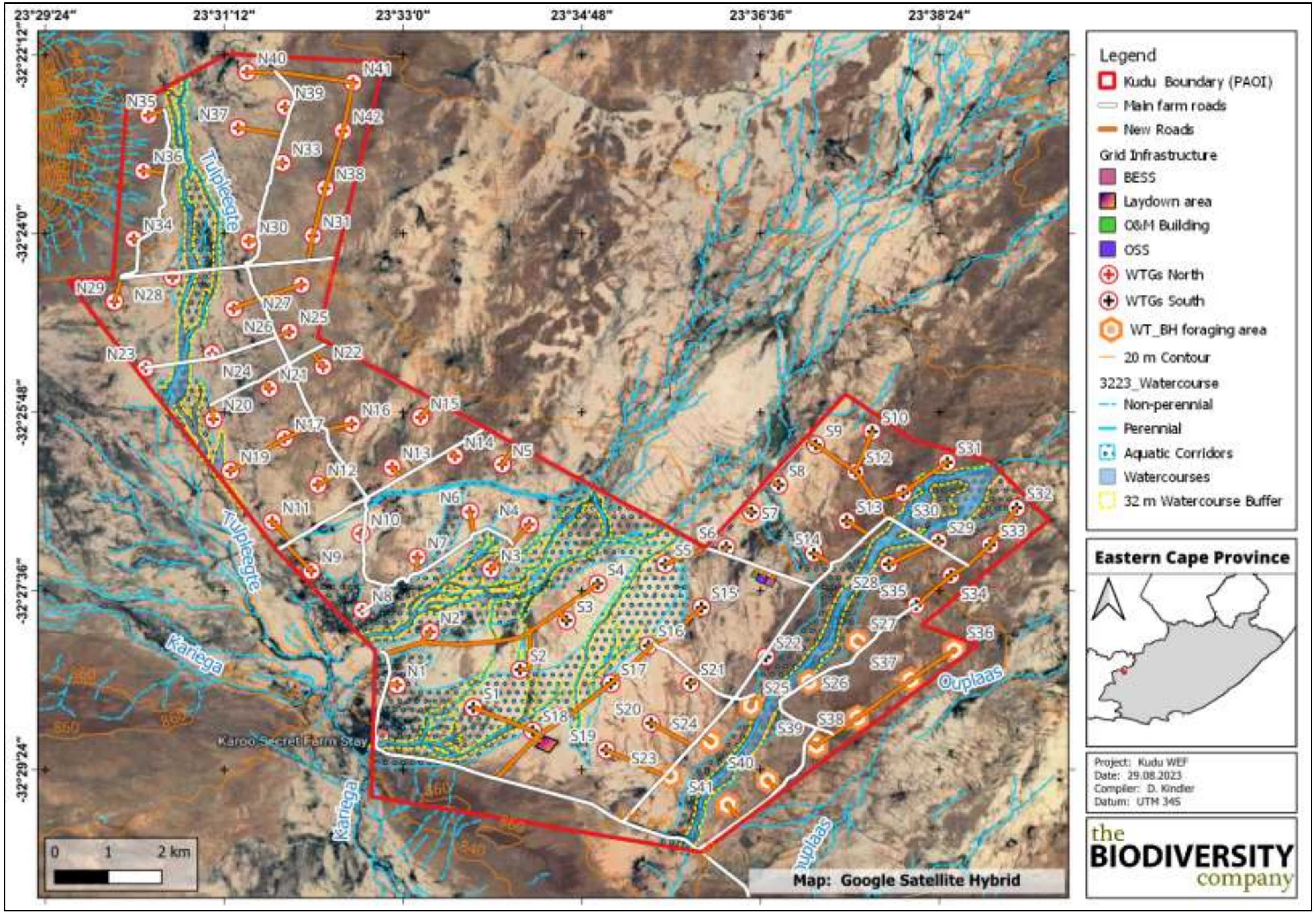


Figure 6-2 Optimised WEF layout and associated sensitivity of freshwater resources, , as assessed in this report

6.2.2 Loss of Irreplaceable Resources

The proposed project will require clearing of natural vegetation for the construction of the WEF, and the associated infrastructure which includes access roads, turbines, turbine platforms and grid connections (substation, BESS and cabling), as well as any construction areas and laydown areas. These project aspects overlap with an ESA1 which is associated with the watercourses and the adjacent terrestrial habitat. Following construction, the project footprint area will no longer be congruent with an ESA, notably due to the establishment of the road network and expected alterations to hydrology of the extensively braided watercourse and alluvial fan network. The Optimised Facility Layout development footprint has largely avoided the ESAs and associated aquatic features and the layout is deemed acceptable and appropriately placed, with some influence on ESAs. Only small portions of the ESAs will be altered (Figure 2-9).

The aquatic corridors were mapped to incorporate the well-defined watercourses. Numerous smaller drainage lines and channels have not been delineated, due to the large number present within the very flat alluvial landscape. In terms of the freshwater resources and processes within the PAOI, the minor watercourses and drainage lines are not a significant priority, and would be deemed an acceptable loss, provided measures are implemented to accommodate flows as mentioned above. This could include box (or other non-flow concentrating type) culverts under raised access roads to allow lateral movement of water and to minimise localised flooding and/or drying out along the road network.

6.2.3 Anticipated Impacts

The impacts anticipated for the proposed development activities are considered in order to predict and quantify these impacts and assess and evaluate the magnitude on the identified aquatic biodiversity (Table 6-2). As presented in Section 5, it is evident that the following project related activities may result in the loss or degradation of the watercourses, most of which are functional and provide ecological services, as the optimized road network is expected to traverse several ephemeral drainage features. Impacts would therefore be expected directly within the drainage network through damage to the watercourse habitat, notably where construction disturbance will take place, and indirectly along the minor drainage lines through altered hydrology. Impacts have the potential for downstream impacts if left unmitigated.

Impacts include changes to the hydrological regime such as alteration of surface run-off patterns, runoff velocities and or volumes associated with vegetation clearing, earthworks, levelling, soil stockpiling and the establishment of grid infrastructure (turbines, turbine platforms: typically 100 x 100 m, substation, BESS and cabling), and the associated road network (linear infrastructure). This would include watercourse crossing infrastructure for the roads (numerous crossings along new roads and with many existing along the main road). Earthworks will expose and mobilise earth materials which could result in sedimentation of the receiving systems. A number of machines, vehicles and equipment (cranes for turbine lifting) will be required, aided by chemicals and concrete mixes for the project, notably for permanent turbine platforms, substation, BESS and road network. Leaks, spillages or breakages from any of these could result in contamination of the receiving water resources. Contaminated water resources are likely to influence the associated biota in time of surface water presence. Only a limited amount of water is utilised during construction for the batching of cement for wind turbines and other construction activities. The raised road network may require larger water volumes for construction, requiring careful considerations to water handling activities and potential contamination related impacts.

The presence of a compacted road network, and in this case a raised road is proposed, increases hard surfaces within the catchment, resulting in an increase in and alteration of runoff volumes and flow paths during high precipitation events and may be significant if inadequately designed stormwater management infrastructure is implemented. The catchment alterations will have a direct impact on the sediment movement and drainage characteristics both locally within the influenced drainage network and associated downslope areas. Where turbine platforms and roads are constructed within the drainage features and associated marginal zones, a direct loss or disturbance of watercourse habitat with associated alteration of hydrology can be expected. As presented in this report, the soil and watercourse banks are highly erodible and susceptible to increased degradation from construction related disturbance. The same applies to watercourse crossing structures (box culverts) within drainage areas, as these are expected to be constructed in areas where no access roads exist. In turn, habitat disturbance may degrade habitat quality and produce watercourse and surrounding watercourse/ ecological corridor (Ecological Support Area) fragmentation. A negative shift in the biotic integrity of the watercourses within the PAOI would be expected based on the severity of baseline habitat alterations or losses. It should be taken into account that due to the arid nature of the region and limited rainfall, the Karoo may take decades to re-establish habitat cover, therefore rehabilitation may be challenging, highlighting the need to avoid disturbance of these areas. This concern has been addressed in the optimised facility layout for the WEF and therefore is no longer of major concern, yet must still be considered for the life of the project. The grid infrastructure is located away from key aquatic features, and the position of these structures is deemed acceptable. There is however an intact vernal pool located roughly 15 meters from the proposed road between turbines S37 and S38 (Figure 6-3).

Figure 6-3 Vernal Pool (Turquoise) in proximity to road between turbines S37 and S38 (Google Earth 9/2022)

There are several artificial vernal pools located roughly 20 meters from the proposed road between turbines N23 and N24 (Figure 6-4). It is suggested that this infrastructure be relocated slightly and meander to avoid these aquatic features while catering for natural surface runoff (box culverts) to continue to feed into these aquatic features to sustain the functioning of these systems and their likely vernal biota.

Figure 6-4 Vernal Pools (Turquoise) in proximity to road between turbines N23 and N24 (Google Earth 8/2023)

It is important to highlight that these arid climate systems receive majority of their rainfall during short rainfall events and only present surface flow for limited time periods. Some rainfall events can be considered as massive for the region with resultant flooding expected, notably from increased hardened surfaces in the form of project infrastructure (buildings, platforms and roads) and localised catchment hydrology alterations (landscaping). Therefore, careful consideration should be given to the hydrology of these systems with special attention given to stormwater and watercourse crossing designs and resultant discharge velocities from these structures. Risks will be lowered through avoidance mitigation of road network, with key consideration given to accommodating lateral flows (interconnectivity) of water and sediment between watercourses and alluvial areas where seasonal flooding occurs.

These disturbances will be the greatest during the construction phase as the related disturbances could result in direct loss and/or damage, while to a lesser degree in the operation phase (i.e. as and when maintenance occurs). The road network will increase surface runoff velocities and is of key concern for the maintenance of baseline watercourse conditions. These construction and operational phase disturbances could also result in the spread of alien vegetation which in turn would affect the functioning of the aquatic ecosystems.

Table 6-2 Anticipated impacts for the proposed WEF activities on aquatic habitat and biodiversity

Aspect	Project activities that can cause loss/ impacts to watercourse	Secondary impacts to watercourses
Destruction, fragmentation and degradation of habitats and ecosystems	1. Physical removal of vegetation, including riparian areas and buffer zones for project infrastructure. 2. Physical alteration of surface topography and cover for road network and servitudes. 3. Physical alteration of riparian and instream areas for river crossing infrastructure. 4. Soil management and soil wash from earth works, soil stock piles, crop lands and road network. 5. Soil dust precipitation. 6. Indiscriminate dumping of waste products. 7. Spread of alien plants.	• Disturbance/ displacement/ loss of riparian, marginal and instream riverine habitat (Habitat fragmentation). • Reduced dispersal/ migration of fauna (in times of flow). • Erosion in key areas (steep and/or exposed areas). • Increase in sediment inputs & turbidity and associated smothering and loss of instream habitat. • Input of toxicants from construction and operation vehicles (lateral movement into natural areas). • Degradation of watercourse flora and fauna through the spread of alien and invasive species. • Displacement/loss of flora & fauna (including SCC). • Reduction of ecological integrity • Loss of ecosystem services.
Water quality	1. Pollution of water resources due to dust effects, improper storage of chemicals and spills, construction materials (notably cement), fuel and machinery leaks. 2. Pollution of water resources from indiscriminate dumping of waste products.	• Physical changes such as increased turbidity levels. • Chemical changes (e.g. pH, salinity and toxicants). • Contamination of watercourse with toxicants and faunal mortality (direct and indirectly). • Disruption/alteration of ecological life cycles due to water quality perturbation. • Alteration/degradation of riparian and instream habitat integrity and lowered biodiversity potential. • Loss of SCCs • Groundwater pollution. • Loss of ecosystem services.
Flow dynamics	1. Physical removal of vegetation, including riparian areas. 2. Physical alteration of surface topography for road network.	• Alteration to flow patterns and velocities (flow dynamics) across catchment due to altered surface roughness, slope and road network. • Erosion in key areas (steep and/or exposed areas). • Ponding in where surface runoff has not been catered for (flat topography). • Erosion (notably headcut erosion) of exposed surfaces and bank collapse due to changes in the catchment's sediment balance. • Alteration/degradation of downstream aquatic habitat and biota through erosion and sedimentation.
Compiled by Dale Kindler (Pr. Sci. Nat. 114743)		

6.2.4 Unplanned Events

The planned activities will have anticipated impacts as discussed; however, unplanned events may occur on any project and may have potential impacts which will need mitigation, management and pre-allocated funding for emergency situations.

Table 6-3 is a summary of the findings of an unplanned event assessment from an aquatic ecology perspective. Note, not all potential unplanned events may be captured herein, and this must therefore be managed throughout all phases of the project according to recorded events.

Table 6-3 Summary of unplanned events for aquatic biodiversity and their management measures

Unplanned Event	Potential Impact	Mitigation
Flooding during construction	Significant habitat degradation of downstream areas.	A flood emergency response plan should be drafted, with adequate stormwater management required.
Spills into the surrounding environment and watercourses	Contamination of habitat as well as water resources associated with a spillage of hazardous construction materials.	A spill response kit must be available at all times. The incident must be reported on and if necessary, an experienced aquatic ecologist must investigate the extent of the impact and provide rehabilitation recommendations.
Uncontrolled erosion	Sedimentation of downslope watercourses	Erosion control measures must be put in place. Measures must include monthly inspections across the project footprint and should be adaptive based on site-conditions.
Fire	Uncontrolled/unmanaged fire that spreads to the surrounding natural habitat.	Appropriate/Adequate fire management plan need to be implemented to protect the veld from potential damage and livestock loss.

Before construction takes place, the project must develop emergency response procedures to be followed in the event of a hazardous material spill. This emergency protocol must: 1) Define responsibilities; 2) Specify notification requirements; 3) Identify response actions; 4) Itemise the necessary clean-up equipment; and 5) Define clean-up objectives.

6.2.5 Assessment of Impact Significance

The assessment of impact significance considers pre-mitigation as well as implemented post-mitigation scenarios. Mitigation measures must be implemented to negate potential impacts to water resources. The mitigation actions required to lower the risk of the impact are provided in Section 6.2.6 of this report.

6.2.5.1 Planning Phase

The planning phase activities are considered a low and insignificant risk as they typically involve desktop assessments and initial site inspections (light vehicle and foot traffic). This would include preparations and desktop work in support of environmental and social screening assessments, finalising placement of infrastructure sites and consultation with various contractors involved with a diversity of proposed project related activities going forward.

6.2.5.2 Construction Phase

The following potential main impacts on the watercourses and associated biodiversity dependent on these systems (based on the framework above) were considered for the construction phase of the proposed WEF. This phase refers to the period during construction when the proposed project infrastructure is constructed; and is considered to have a significant direct impact on aquatic habitat and associated ecosystem functioning. This phase typically involves the removal of indigenous vegetation for infrastructure (laydown yards, turbine platforms, grid connection infrastructure, underground cabling and road network - with watercourse crossings), landscaping to desired topography, establishment of infrastructure, and end of construction rehabilitation. This involves earthworks activities (digging and soil stockpiling) and the use of construction materials, chemicals and machinery, all of which influence watercourses and includes adjacent habitats such as riparian zones and buffers. The footprint of the turbine platforms and grid connection infrastructure has a small, localised impact, while the clearance and creation of access and service roads has a greater potential for environmental impact due to the extent and width of the roads (width 8 m and a servitude of 13.5 m) across the PAOI. The following construction phase related impacts to aquatic ecology were considered:

- Disturbance/ displacement/ loss of watercourse habitat (Habitat fragmentation) (Table 6-4),
- Contamination of watercourse and biotic community effects (Table 6-5); and
- Alteration of catchment hydrology and associated habitat ecology impacts (Table 6-6).

Table 6-4 Impacts to watercourse habitat and biotic community associated with the construction phase

Impact Nature: Disturbance/ displacement/ loss of watercourse habitat (Habitat fragmentation)		
Construction phase activities that result in the disturbance, destruction, loss and fragmentation of freshwater habitats, ecosystems and biotic community responses to the alteration of the catchment for development footprint (laydown yards, turbine platforms, grid infrastructure, cabling and road network - with associated watercourse crossings). This involves activities directly within watercourses (direct), and activities adjacent to watercourses (indirect).		
	Without mitigation (Impact Rating)	**With mitigation (Impact Rating)**
Extent	Local area (3)	Site specific (1)
Duration	Permanent (5)	The lifetime of the impact will be of a short duration (2-5 years) (2)
Magnitude	Moderate and will result in processes continuing but in a modified way (6)	Low and will cause a slight impact on processes (4)
Probability	Definite (5)	Probable (distinct possibility) (3)
Significance	**High (70)**	**Low (21)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	High
Irreplaceable loss of resources?	Yes	No
Can impacts be mitigated?	Yes, however not entirely. The optimized layout has lowered the number of interceptions with watercourses, vernal pools and associated buffers.	
Mitigation:		
See section 6.2.6 of this report.		
Residual Impacts:		
The loss of currently intact vegetation is an unavoidable consequence of the project and cannot be entirely mitigated. Avoidance mitigation for freshwater features, with minimal watercourse crossings. The residual impact would however be low for the construction phase with focus on limiting both erosion and inundation required.		

Table 6-5 Contamination of watercourse and biotic community effects associated with the construction phase

Impact Nature: Pollution of water resources from construction activities		
Pollution (cement and hydrocarbons) stemming from construction activities that enters the natural environment and downslope watercourses, with associated impacts to soils, habitat integrity and ecological function. In turn, these impacts reduce the aquatic and terrestrial biodiversity dependent on the affected freshwater ecosystems, notably in times of surface water availability.		
	Without mitigation (Impact Rating)	**With mitigation (Impact Rating)**
Extent	Local area (3)	Site specific (1)
Duration	Moderate term (5–15 years) (3)	Very short term (0–1 years) (1)
Magnitude	Moderate and will result in processes continuing but in a modified way (6)	Minor and will not result in an impact on processes (2)
Probability	Definite (5)	Probable (distinct possibility) (3)
Significance	**Medium (60)**	**Low (12)**
Status (positive or negative)	Negative	Negative
Reversibility	Moderate	High
Irreplaceable loss of resources?	No	No
Can impacts be mitigated?	Yes, although this impact cannot be well mitigated as some level of pollution is unavoidable.	
Mitigation:		
See section 6.2.6 of this report.		
Residual Impacts:		
Some level of pollution is inevitable due to the nature of the construction activities and cannot be entirely mitigated. The residual impact would however be low and of short duration for the construction phase provided mitigation is responsibly implemented.		

Table 6-6 Impacts to catchment hydrology associated with the proposed construction phase

Impact Nature: Alteration of catchment hydrology and associated habitat ecology impacts from construction activities		
Construction phase activities that result in the reshaping and change in vegetative cover density for infrastructure with associated alterations of slope, runoff quantities and velocities, infiltration capacity and sediment movement from baseline conditions. This is expected to occur across the catchment, with associated impacts to slope stability, habitat integrity and ecological function. This is especially of concern due to the complex and extensively braided watercourse network compounded by the flat topography between the well-defined drainage features prone to ponding. This is especially true as seen by the level of existing surface flow alterations and impoundments. If not carefully considered, the new road network could limit flows from reaching vernal pools, negatively impacting these systems.		
	Without mitigation (Impact Rating)	**With mitigation (Impact Rating)**
Extent	Local area (3)	Footprint & surrounding areas (2)
Duration	Permanent (5)	Moderate term (5–15 years) (3)
Magnitude	Moderate and will result in processes continuing but in a modified way (6)	Low and will cause a slight impact on processes (4)
Probability	Definite (5)	Probable (distinct possibility) (3)
Significance	**High (70)**	**Low (27)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Moderate
Irreplaceable loss of resources?	Yes	No
Can impacts be mitigated?	Yes, although this impact cannot be well mitigated as the hydrology alterations are unavoidable. However, the optimized layout has lowered the number of interceptions with watercourses and associated buffers	
Mitigation:		
See section 6.2.6 of this report.		

Impact Nature: Alteration of catchment hydrology and associated habitat ecology impacts from construction activities
Residual Impacts:
Alteration of the catchment hydrology is inevitable due to the nature of the construction activities and cannot be entirely mitigated. The residual impact would however be low and of moderate duration for the construction phase.

6.2.5.3 Operation Phase

During the operation phase, the wind turbines will operate continuously for more than 20 years, largely unattended. Maintenance levels are low in comparison to other renewable energy projects, with maintenance only taking place when required. The operational phase impacts are related to regular (daily/ weekly/ monthly) maintenance activities and associated increase in maintenance vehicles across the project footprint, which are anticipated to have minimal indirect impacts on aquatic ecosystems. The only potentially toxic or hazardous materials which would be present in relatively small amounts would be of lubricating oils and hydraulic and insulating fluids for maintenance. Therefore, contamination of surface or groundwater or soils is highly unlikely. Additionally, there is no water consumption impact associated with the operation of wind turbines.

The modification of the catchment drainage will alter watercourse habitats through altered drainage from baseline conditions with increased erosion and sedimentation of the downslope areas, especially in exposed/ denuded areas and increased hardened surfaces (notably from roads). A localised long-term impact (more than 20 years) of low intensity (depending on the distance between the turbines and the freshwater features) could be expected that would have a very low overall significance post-mitigation in terms of its impact on the identified aquatic ecosystems in the area. Stormwater management will therefore be crucial within the proposed operations footprint.

The following operational phase related impacts to aquatic ecosystems were considered:

- Continued fragmentation and degradation of habitats and ecosystems (Table 6-7);
- Contamination of watercourse and biotic community effects (Table 6-8);
- Alteration of catchment hydrology and associated habitat ecology impacts (Table 6-9).

Table 6-7 Impacts to watercourse habitat and biotic community associated with the operational phase

Impact Nature: Continued disturbance/ displacement/ loss of watercourse habitat		
Disturbance created during the construction phase will leave the project area and watercourses vulnerable to erosion (highly erodible catchment) and encroachment by alien vegetation. The operational phase activities will result in the continued destruction, loss and fragmentation of habitats, ecosystems and biotic community responses. This includes the operation of watercourse crossing structures.		
	Without mitigation (Impact Rating)	**With mitigation (Impact Rating)**
Extent	Low (2)	Site specific (1)
Duration	Long term (> 15 years) (4)	The lifetime of the impact will be of a short duration (2-5 years) (2)
Magnitude	Moderate and will result in processes continuing but in a modified way (6)	Low and will cause a slight impact on processes (4)
Probability	Definite (5)	Probable (distinct possibility) (3)
Significance	**Medium (60)**	**Low (21)**
Status (positive or negative)	Negative	Negative
Reversibility	Moderate	High

Impact Nature: Continued disturbance/ displacement/ loss of watercourse habitat		
Irreplaceable loss of resources?	Yes	No
Can impacts be mitigated?	Yes, with proper management and avoidance and appropriate structures implemented at construction, this impact can be mitigated to a low level.	
Mitigation:		
See section 6.2.6 of this report.		
Residual Impacts:		
The ESA areas will be degraded by the WEF and grid development activities, however the area is not pristine with historical modification present. However, the highest impacts stem from the construction phase, while operational impacts are of low intensity. Despite mitigation, erosion is expected across the project footprint, influencing downslope watercourses and habitat, especially where roads intercept with watercourses or lateral drainage. The residual impact following mitigation would however be low.		

Table 6-8 Contamination of watercourses and biotic community effects associated with the operation phase

Impact Nature: Pollution of water resources from operational activities		
The operation and maintenance of the proposed development will result in minimal pollution impacts from lubricating oils and hydraulic and insulating fluids for turbine maintenance, and hydrocarbons (fuels, oil, etc) from leaking maintenance vehicles which escape into the environment along the road network, entering downslope watercourses during rainfall events, with impacts to water quality and ecological functioning.		
	Without mitigation (Impact Rating)	**With mitigation (Impact Rating)**
Extent	Local area (3)	Site specific (1)
Duration	The lifetime of the impact will be of a short duration (2-5 years) (2)	Very short term (0–1 years) (1)
Magnitude	Moderate and will result in processes continuing but in a modified way (6)	Minor and will not result in an impact on processes (2)
Probability	Definite (5)	Probable (distinct possibility) (3)
Significance	**Medium (55)**	**Low (12)**
Status (positive or negative)	Negative	Negative
Reversibility	Moderate	High
Irreplaceable loss of resources?	No	No
Can impacts be mitigated?	Yes, although this impact cannot be well mitigated as some level of pollution is unavoidable, although minimal.	
Mitigation:		
See section 6.2.6 of this report.		
Residual Impacts:		
Some level of pollution is inevitable due to the nature of the operational activities and cannot be entirely mitigated. The residual impact would be low and of very short duration following the implementation of mitigation.		

Table 6-9 Impacts to catchment hydrology associated with the operation phase

Impact Nature: Alteration of catchment hydrology and associated habitat ecology impacts from operational activities		
As a result of the landscaping to new topography and change in vegetative cover type in the project footprint, together with increased hardened surfaces from grid infrastructure, turbine platforms and road network, new functioning regimes pertaining to surface runoff, infiltration and sediment movement patterns will influence the adjacent natural habitat characteristics. This in turn will influence habitat integrity and ecological functioning, notably from localised increases in return flows (surface runoff), erosion and instream sedimentation impacts. This would be applicable to habitat and watercourse features in proximity to the proposed infrastructure, notably the areas downslope of the road network.		
	Without mitigation (Impact Rating)	**With mitigation (Impact Rating)**
Extent	Local area (3)	Footprint & surrounding areas (2)
Duration	Long term (> 15 years) (4)	The lifetime of the impact will be of a short duration (2-5 years) (2)

Impact Nature: Alteration of catchment hydrology and associated habitat ecology impacts from operational activities		
Magnitude	High (processes are altered to the extent that they temporarily cease) (8)	Low and will cause a slight impact on processes (4)
Probability	Definite (5)	Probable (distinct possibility) (3)
Significance	**High (75)**	**Low (24)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	High
Irreplaceable loss of resources?	No	No
Can impacts be mitigated?	Yes, although this impact cannot be well mitigated as the hydrology alterations are unavoidable. However, the operational activities need to avoid direct impacts to watercourses and associated buffers, notably erosion.	
Mitigation:		
See section 6.2.6 of this report.		
Residual Impacts:		
Residual impacts following mitigation are largely related to altered surface runoff and erosion due to altered hydro-dynamics and erodibility of the associated catchment.		

6.2.5.4 Cumulative Impacts

Cumulative impacts are assessed in context of the extent of the proposed project area; other developments in the SQR and Quaternary catchment areas; and general habitat loss and transformation resulting from other activities in the area. The impacts of projects are often assessed by comparing the post-project condition to a pre-existing baseline condition. Where projects can be considered in isolation this provides a good method of assessing a project's impact. However, in areas where baselines have already been affected, or where future development will continue to add to the impacts in an area or region, it is appropriate to consider the cumulative effects of development. This is similar to the concept of shifting baselines, which describes how the environmental baseline, at a point in time, may represent a significant change from the original state of the system. This section describes the potential impacts of the project that are cumulative for freshwater fauna and flora.

Localised cumulative impacts include the cumulative effects from anthropogenic activities that are close enough (such as nearby farming activities within the area) to potentially cause additive effects on the environment or sensitive receivers. These include disruption of ecological corridors or habitat such as watercourses, impacts to groundwater and surface water quality, and transport of soils and instream habitat smothering impacts associated with catchment and road reserve erosion.

Long-term cumulative impacts due to the proposed electricity generation and transmission footprint, comprising the wind turbines and servitudes in the upper reaches of the Kariega River combined with the low density agricultural activities currently present in these upper reaches (Figure 6-5 and Figure 6-6), has the potential to degrade watercourse habitat across the catchment. The cumulative impact of the project was rated as medium should the project go ahead and involve the implementation of mitigation.

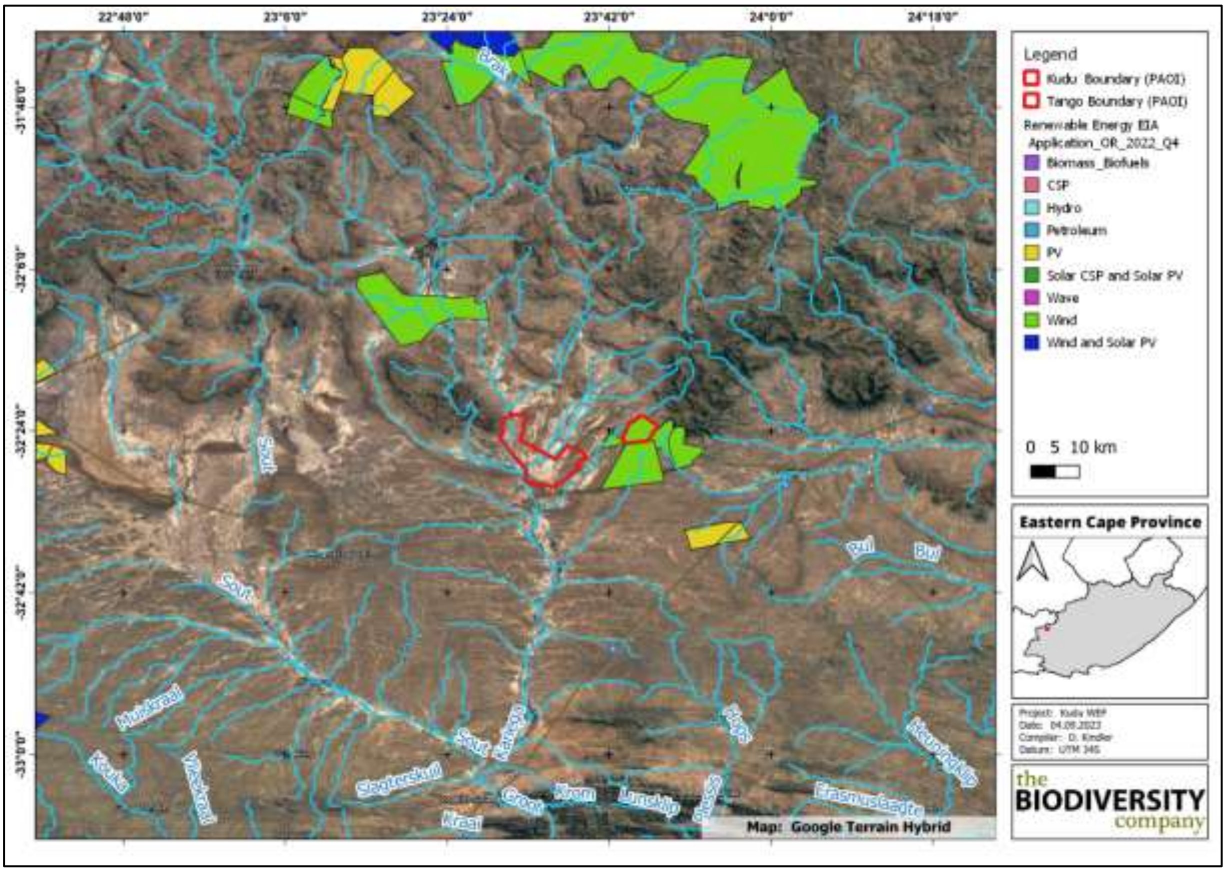


Figure 6-5 Cumulative renewable applications in region

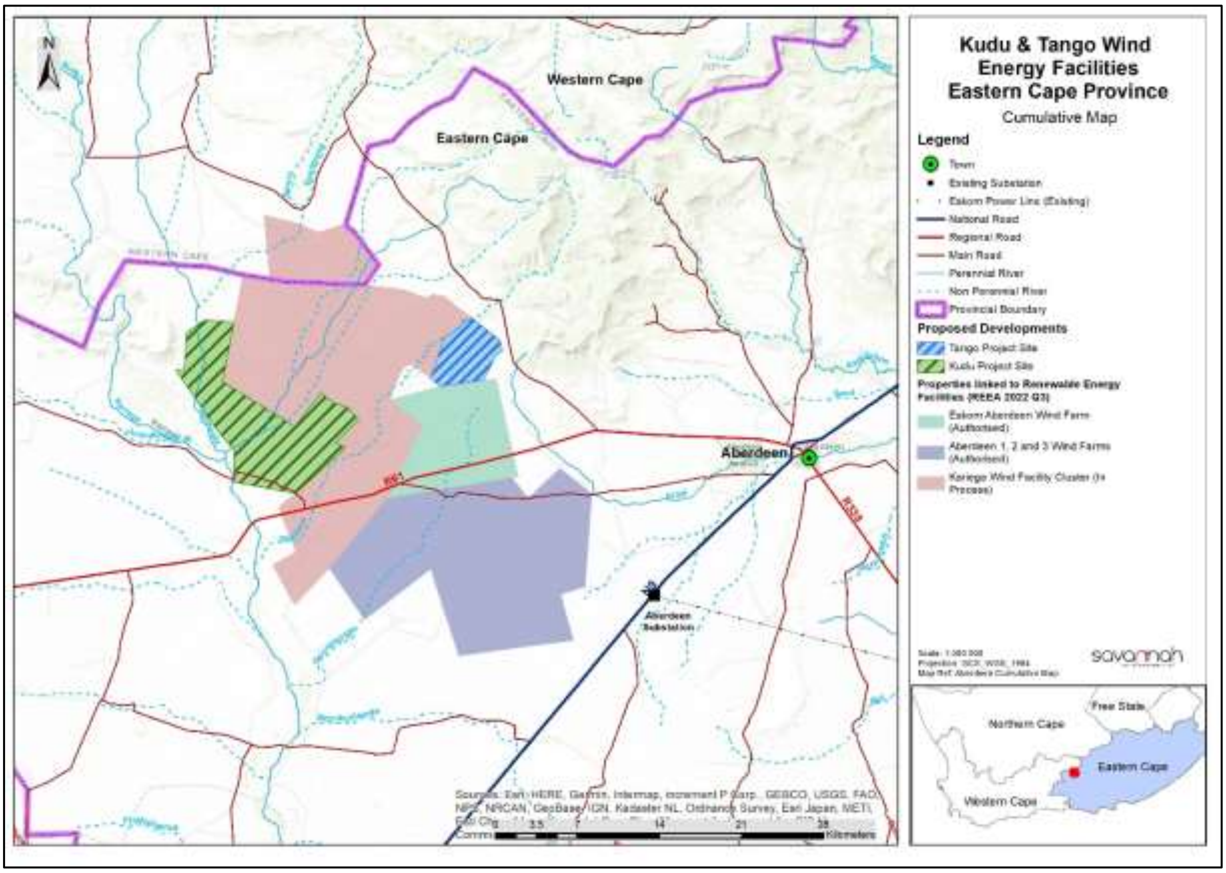


Figure 6-6 Cumulative renewable applications in region (Savannah, 2023)

Table 6-10 Cumulative impacts to aquatic ecology associated with the proposed project

Impact Nature: Cumulative loss/ disturbance of habitat and ecological functioning of watercourses in the region		
The development of the proposed infrastructure will contribute to cumulative habitat loss within the local ESAs, watercourses and adjacent habitat together with the potential for increased contaminants and sediment entering the watercourses. The loss/alteration of habitat lowers the buffering capacity of the catchment to water quality impacts, which will have negative impacts on the ecological processes of the associated watercourse in the PAOI, with no impacts of significance expected in the region.		
	Overall impact of the proposed project (with mitigation) considered in isolation	**Cumulative impact of the project together with the existing and proposed projects in the area**
Extent	Footprint & surrounding areas (2)	Local area (3)
Duration	Long term (> 15 years) (4)	Long term (> 15 years) (4)
Magnitude	Low and will cause a slight impact on processes (4)	Moderate and will result in processes continuing but in a modified way (6)
Probability	Probable (distinct possibility) (3)	Highly probable (4)
Significance	**Medium (30)**	**Medium (52)**
Status (positive or negative)	Negative	Negative
Reversibility	Moderate	Low
Irreplaceable loss of resources?	Yes	Yes
Can impacts be mitigated?	Yes, although this impact cannot be well mitigated as some level of hydrological and habitat modification is unavoidable. Avoidance of watercourse areas will be of highest importance to mitigate impacts. However some watercourse crossing are required.	
Mitigation:		
See section 6.2.6 of this report.		
Residual Impacts:		
Some level of modification is inevitable due to the nature of the construction and operational activities and cannot be entirely mitigated. The residual impact would be medium and of long term duration for the life of the project following the implementation of mitigation.		

6.2.5.5 Decommissioning Phase

During decommissioning, the potential freshwater impacts will be very similar to that of the Construction Phase, although the potential for water quality and flow related risks will be lower.

During decommissioning, disturbance to the freshwater ecosystems should be limited as far as possible. Disturbed areas may need to be rehabilitated and revegetated. Mitigation and follow up monitoring of residual impacts (alien vegetation growth and erosion) will be required.

6.2.6 Mitigation

In light of the expected impacts from proposed activities the following mitigation measures have been proposed to lower the intensity of the impacts on the ecological integrity of the catchment and its downslope watercourses.

6.2.6.1 Mitigation Measure Objectives

The focus of mitigation measures should be to reduce the significance of potential environmental impacts associated with the Project to thereby:

- Prevent the unnecessary destruction, and fragmentation of the watercourses (including the riparian areas and vernal pools where applicable) through avoidance strategies;

- Prevent the loss of the faunal community (aquatic, vernal and terrestrial) associated with the watercourse habitat; and
- Limiting the construction area to the defined project areas and only impacting those areas where it is unavoidable to do so otherwise, such as at the existing areas of disturbance along the existing road network.

6.2.6.2 Development specific mitigation measures

The following development-specific mitigation measures are provided:

- A buffer of 32 m is allocated to the watercourse delineations. Adherence to the buffer areas outside of the areas earmarked for the proposed project infrastructure. These should be visibly demarcated in areas where construction will verge the buffers to avoid encroachment into these areas;
- Buffer zones must be treated as no-go areas and maintained as conservation areas; and
- The project area is susceptible to surface ponding with a high water retention time expected, due to the flat topography comprising clay soils. To cater for this, the project will require a raised road.

6.2.6.3 Roads and Cabling (Linear infrastructure)

The PAOI already has an existing road network comprising several watercourse crossings. Despite the presence of this existing infrastructure, the project requires additional roads. These must be aligned with the existing road network as far as possible and must avoid the establishment of new watercourse crossing infrastructure in undisturbed areas (where feasible). The proposed road network construction is regarded as a low risk to the watercourses should construction occur outside of the delineated sensitive drainage features and implement the necessary mitigation. The minimisation of the optimized layout to limited watercourse crossings is deemed sufficient to maintain this low risk rating, provided all mitigation for the crossings points in responsibly implemented. Similarly, the cabling construction is regarded as a low risk to the watercourses should construction occur outside of the delineated sensitive drainage features and implement the necessary mitigation. Should road and cable placement be within the watercourse areas impacts would be expected.

The following powerline and road mitigation measures are provided:

- The recommended buffer zones must be strictly adhered to during the construction phase of the project, with exception of the activities and structures required to traverse the watercourse. Any supporting aspects and activities not required to be within the buffer area must adhere to the buffer zone;
- Areas where construction is to take place must be clearly demarcated. Any areas not demarcated must be completely avoided;
- Landscape and re-vegetate all cleared areas as soon as possible to limit flow path creation and erosion potential;
- It is strongly recommended that the project make use of existing road networks, before new areas are cleared for new access roads. The optimised road layouts are considered to be sufficient;

- The project must focus on responsible stormwater management during construction and operation (see Hydrological Management Measures);
- Install sedimentation/erosion protection measures prior to construction in the form of several rows of sand bags, silt traps and/ or fences, this is particularly important in the access roads leading to any drainage channel and around active working areas for culvert installations;
- Energy dissipation, such as stone berms or blocks must be strategically placed along the road margins for the entire road network as surface runoff leaves the roads and enters the surrounding environment with the potential for severe erosion and damage to road margins. The steeper the slope of the road, the more regular the berms should be spaced and can be as close as one meter apart where necessary. This is for the life of the project;

Figure 6-7 Example of road margin erosion prevention

- The road margins should be hydroseeded with vigorous growing indigenous grasses that are drought tolerant to lower erosion of these key areas;
- An inspection of the road and cabling network and surrounding influenced areas must be completed within 1 month following the end of construction activities and within a week after the first rainfall event that results in surface runoff. Thereafter, routine monitoring should take place for the life of the project. Should erosion be developing this must be immediately addressed through appropriate and adaptive measures.

6.2.6.4 Hydrological Management Measures (Watercourse Crossings)

Culverts and bridges are structures built into a road, to allow water to pass under roads to protect the roads from erosion and flooding. The construction and operational risks of these structures can be lowered following the correct implementation of mitigation actions. The following measures must be implemented to prevent alterations to the hydrological regime of catchments surface flow and downslope watercourses:

- Preparation of crossing points and installation of the crossing structures must be undertaken during the low flow period to avoid the need for river diversions and associated impacts;
- To minimise the impact on both surface water flow and interflow, portions of the road must include a coarse rock layer that has been specifically incorporated to increase the porosity and permeability of the sub-layers of the road. This is most applicable in

depressions and the supporting structures of drainage crossings, even if these drainage lines seem inferior;

- All crossings along the road route must allow for sufficient dispersion of water through the road to prevent the concentration of flow and the resultant scouring and incision of the discharge areas;
- Ensure that hydrological connectivity between areas upstream and downstream of construction activities are maintained throughout the construction phase;
- The maintenance of natural interflow in the watercourses must be maintained using several culverts that span the extent of the macro-channel, thus box type culverts are preferred over pipe culverts to avoid concentrating flows, scouring and erosion. This is applicable where crossings are required;
- The width of the culvert should be at least equal to the average stream bed width, otherwise multicell box culverts must be used;
- Box culverts that have a solid flat cement base (cube shaped) must be avoided as they result in a uniform depth and flow of water covering the full width of the culvert floor, resulting in an insufficient depth of water for the passage of aquatic biota during periods of flow;
- Alternatively, arch shaped box culverts with natural riverine bottoms allow for the natural stream depth and flow characteristics, with associated maintenance of a low flow channel that aquatic biota can utilise;
- The use of precast arch shaped (with an open base) box culverts, could result in substantial cost savings associated with lower difficulty and less time spent on site (speed of construction) in comparison to building bridges, which in turn will lower the environmental impact at the crossing sites;
- Inlets and outlets of each culvert must be positioned below the stream bed for the continuation of the streambed and natural movement of riverine substrates as discussed for Arch shaped box culverts;
- The gradient and horizontal alignment of the culverts must be the same as the existing watercourse bed;
- The culverts to be utilised must be able to accommodate at least a 1:50 year flood;
- Rocky material (aggregate) must be placed at the base of the culvert discharge point(s) to avoid the concentrated flow from eroding and scouring the receiving area. Ideally this layer should incorporate a double layer with the bottom layer partially sunken into the riverbed, with the second layer placed on top of the base layer. Due to the increased flow velocities created by smooth concrete and box culverts flow dynamics, the sediments in the discharge area are expected to be washed away. The double aggregate layer will limit this for most flow events;
- For best environmental practice implementation and least long term environmental impact, each watercourse crossing structure should incorporate larger box (single or multicell) culverts with natural riverine bottoms over the smaller culvert pipes; and

- Ensure that the beds and banks of the watercourses at the road crossing areas are restored to the natural base level to prevent erosion or upstream ponding post construction.

6.2.6.5 Wind Turbines

The biggest impact to watercourses associated with the wind turbines is the placement of the wind turbine platforms (cement platforms) and the associated hardened surface to accommodate the cranes to lift the turbines in place. Hydrology impacts relating to surface runoff from these structures is regarded to be of low significance.

The following wind turbine mitigation measures are provided:

- The wind turbine platforms and the associated hardened surface to accommodate the cranes must be constructed outside of the delineated drainage network and buffer where possible. This avoidance measure limits platforms from being built within or near drainage features; and
- During the construction phase, site management must be undertaken at the laydown area, batching plant and the individual turbine construction areas. This should specifically address on-site stormwater management and prevention of pollution measures from any potential pollution sources during the construction activities such as hydrocarbon spills. Any stormwater that does arise within the construction sites must be handled in a suitable manner to trap sediments and reduce flow velocities.

6.2.6.6 Erosion and Sedimentation of Catchment and Downstream Watercourses

The alteration of surface topography and hydrology and the increase in exposed soil surfaces along road networks and disturbed areas, will inevitably be accompanied by an increase in erosion and sedimentation as rainwater erodes and washes exposed soils into downslope watercourses. This is a key consideration for the project due to the high erodibility of the catchment soils.

- Loose soils are particularly prone to loss due to wind or water. It is therefore preferable that construction takes place during the dry season to reduce the erosion potential of the exposed surfaces;
- Practice good soil management across the PAOI;
- All removed soil and material must not be stockpiled within the watercourses. Stockpiling should take place outside of drainage systems. All stockpiles must be protected from erosion, stored on flat areas where run-off will be minimised, and be surrounded by bunds;
- Avoid the creation of concentrated flow paths wherever possible;
- Devise and implement a stormwater management plan for the project footprint;
- Install sandbags as a temporary measure around key areas of soil loss to prevent soils washing into the local watercourses;
- Signs of erosion must be addressed immediately to prevent further erosion of the area to prevent headcut erosion from forming;

- Temporary and permanent erosion control methods may include silt fences, flotation silt curtains, retention basins, detention ponds, interceptor ditches, seeding and sodding, riprap of exposed embankments, erosion mats, and mulching;
- Any exposed earth should be rehabilitated promptly by planting suitable drought tolerant vegetation (vigorous indigenous grasses) to protect the exposed soil;
- Relandscape to gentler gradients and re-vegetate all cleared areas as soon as possible to limit erosion potential. Sandbags and geotextiles should be used to assist until vegetation has established in these reworked areas;
- A 1:3 gradient is considered best practice to ensure vegetation establishment and limit erosion and topsoil loss.
- Stem any headcut/ erosion gulley as it occurs by bulldozing, filling, re-contouring to gentler gradients and re-vegetating; and
- The rehabilitation of watercourse banks should take place as an offset to altered land use with associated negative ecological impacts. Key areas where erosion has occurred should be rehabilitated through bank reprofiling to gentler gradients and the revegetation of the reworked banks.

6.2.6.7 Water Quality Management Measures

The use of various construction materials and equipment has the potential to be contaminate local soils and surface waters, with associated impacts on terrestrial and freshwater habitat and biota. The following mitigation measures are provided to lower the risk and intensity of these impacts:

- Restrict construction activities within the designated areas as indicated on the construction layout plan;
- Have action plans on site, and training for contactors and employees in the event of spills, leaks and other impacts to the drainage systems;
- The contractors used for the project should have spill kits available to ensure that any fuel or oil spills are clean-up and discarded correctly;
- All chemicals and toxicants to be used for the construction must be stored outside the watercourses and in a bunded area or their buffer zones;
- Appropriately contain any generator diesel storage tanks, machinery spills (e.g. accidental spills of hydrocarbons oils, diesel etc.) or construction materials on site (e.g. concrete) in such a way as to prevent them leaking and entering the environment;
- All machinery and equipment should be inspected regularly for faults and possible leaks, these should be serviced off-site;
- Servicing of vehicles and refuelling may not take place on site or in close proximity of any watercourse;
- No vehicle or machinery is allowed to be washed within a watercourse or its buffer area, and should preferably take place off site;
- Drip trays or any form of oil absorbent material must be placed underneath construction vehicles/machinery and equipment when not in use;

- Drip trays or other suitable secure weather-proof containers should be kept on site in the event of a vehicle leakage or spillages;
- Mixing of concrete must under no circumstances take place within the drainage systems. Scrape the area where mixing and storage of sand and concrete occurred to clean once finished;
- All contractors and employees should undergo induction which is to include a component of environmental awareness. The induction is to include aspects such as the need to avoid littering, the reporting and cleaning of spills and leaks and general good “housekeeping”;
- Adequate sanitary facilities and ablutions on the servitude must be provided for all personnel throughout the project area. These should not be placed near any watercourse or in buffer zones. Use of these facilities must be enforced (these facilities must be kept clean so that they are a desired alternative to the surrounding vegetation); and
- The contractor is responsible for cleaning up any spillages (e.g. concrete, oil, fuel), immediately and contaminated soil must be removed and disposed of appropriately.

6.2.6.8 Spread of Alien and Invasive Vegetation

Disturbance of soil and vegetation has the potential to be accompanied by the proliferation and spread of alien and invasive species. The following mitigation is recommended:

- Keep disturbances to within footprints and outside of buffer zones;
- Control new stands of alien species as they arise;
- Land users are required by law, to remove and / or control Category 1 alien and invasive vegetation according to the National Environmental Management: Biodiversity Act (NEMBA: Act 10 of 2004) (September 2020 List – GN1003). Additionally, unless authorised, in terms of the National Water Act, 1998 (Act No. 36 of 1998), no land user shall allow Category 2 plants to occur within 30 meters of the 1:50 year flood line of a river, stream, spring, natural channel in which water flows regularly or intermittently, lake, dam or wetland. Category 3 plants are also prohibited from occurring within proximity to a watercourse;
- It is recommended that Category 1 species are prioritised for control, with control of herbaceous weedy species (which would need to include follow-up control);
- Foliar herbicide spray must not be used within any of the sensitive riparian areas, rather opt for mechanical removal or direct dribbled application to stumps (use a dye); and
- Quarterly vegetation rehabilitation surveys need to be conducted of the vegetation within the project footprint to stay on top of the alien vegetation for the life of the project. This will improve the biotic integrity of the watercourses over the long term.

6.2.6.9 General Mitigation Measures

The following general mitigation measures are provided:

- Construction activities must take place during the low flow period (as much as possible). In addition to this, basic stormwater structures such as berms must be designed and implemented prior to and throughout the duration of the construction activities;

- A qualified Hydrologist with experience in arid areas must develop a suitable and adaptive Stormwater management plan to ensure no erosion takes place and that clean water reports back to the local watercourses;
- Stormwater runoff from the infrastructure should enter the drainage systems through diffuse channels fitted with flow attention / energy dissipation structures in the form of green infrastructure;
- The water resources outside of the specific project site area must be avoided;
- Prevent uncontrolled access of vehicles through the watercourse that can cause a significant adverse impact on the hydrology and alluvial soil structure of these areas;
- Laydown yards, camps and storage areas must be beyond the watercourse and associated buffer areas;
- The access road and associated road margins, and silt traps must be inspected on a monthly basis for signs of erosion. When erosion is observed, the area should be rehabilitated within 7 days. In addition, inspections following a >50 mm/ 24 hr rainfall event must occur within 7 days of the event;
- No dumping of construction material on-site may take place;
- All waste generated on-site during construction must be adequately managed. Separation and recycling of different waste materials should be supported; and
- Make sure all excess consumables and building materials / rubble are removed from site and deposited at an appropriate waste facility.

7 Monitoring and management programme

Based on the outcomes of this assessment, further actions are recommended:

- Annual auditing of the recommended mitigation actions for the project infrastructure must be conducted and amended to suit the needs of the local conditions;
- Alien invasive vegetation assessments must be conducted in accordance with the terrestrial component of this overall application;

It is noted that the mitigation actions provided in this assessment must make use of the proposed mitigation actions as an Environmental Management Programme (EMP). The outcome based management plan for freshwater resources is presented in Table 7-1.

Table 7-1 Outcome Based Management Plan

Outcome	Action	Timeframe
Limit watercourse habitat degradation	Implement buffer and no-go areas.	Project lifespan
	Implement stormwater management plan.	Project lifespan
	Revegetate disturbed areas.	Project lifespan
	Implement erosion control measures such as energy dissipation and vegetative cover.	Project lifespan

Outcome	Action	Timeframe
	Implement alien invasive plan removal and monitoring programme.	Project lifespan
Limit water quality degradation	Implement buffer and no-go areas.	Project lifespan
	Implement stormwater management plan.	Project lifespan
	Implement erosion control measures such as energy dissipation and vegetative cover.	Project lifespan
	Revegetate disturbed areas.	Project lifespan
	Implement alien invasive plan removal and monitoring programme.	Project lifespan
	Implement stockpile and waste management strategies whereby exposure to direct runoff can be reduced.	Project lifespan
Effective Water Resource Management	Implement water quality monitoring studies in times of flow.	Project lifespan
	Implement annual vernal biota monitoring studies	Project lifespan

The monitoring plan has been designed to be achievable and realistic for the nature of the project. The plan must provide details as to the frequency of the monitoring efforts, the location of these efforts and what should be monitored. The primary focus for the monitoring plan is to evaluate the success of the rehabilitation efforts.

Seasonal monitoring: The applicant must appoint an independent contractor to conduct seasonal (wet season) monitoring for a period of two years after the completion of the rehabilitation measures. The monitoring should be conducted during October/ November or shortly after the first summer rains, and then towards the end of the growing season. The monitoring should inspect the following:

- Recovery of the vegetation layer;
- Extent of alien vegetation establishment;
- Hydrology and inundation of the drainage systems;
- The formation of erosion gullies and sedimentation of the drainage systems; and
- The removal of solid waste from the watercourses and buffer areas.

Vernal biota monitoring: Due to the deficiency in data on vernal biota, species diversity and conservation status across South Africa, the applicant must appoint a freshwater ecologist to conduct seasonal (wet season) monitoring every two to three years for the life of the project. This will exclude years of drought where no rain has fallen, when the vernal biota are in their dormant desiccated egg stages. The monitoring should be conducted during October/ November or shortly after the first summer rains, within two weeks of the first rains. The monitoring should inspect the following:

- Presence/absence of vernal biota and impacts from road network on hydrology for these systems;
- Collection of vernal biota and/or sediment samples for hatching and species identification studies. This should be done for at least 2 surveys until no new species are recorded; and

- Thereafter, surveys should be repeated once every 5 years to monitor the state of the vernal systems and associated vernal biota.

8 Recommendations

The following recommendations are provided for the project:

- A competent Environmental Control Officer (ECO) must oversee the construction and associated rehabilitation phase of the project, with watercourse areas as a priority to limit the listed impacts on the watercourses. Two follow up ECO assessments/ audits must be carried out in the first and sixth months of operation. Ideally one of these audits should take place following a rainfall event. The ECO must be supplied with a copy of this report, and the associated terrestrial biodiversity report, to familiarise themselves with the mitigation and recommendations prior to construction;
- Several aquatic features or aquatic functional zones are present including an extensive braided watercourse network, which may provide some technical challenges due to seasonal flooding. Any footprint within these areas will likely require careful planning in order to minimise changes to flows which could alter species composition and affect ecological processes to both aquatic and terrestrial areas. Furthermore, in general the braided watercourse areas align with the ESA designations. As a minimum any roads traversing these alluvial areas must accommodate lateral flows (interconnectivity) of water and sediment between watercourses and alluvial area where seasonal flooding occurs. This challenge can be overcome through the use of raised access roads fitted with appropriate aggregate base layers and culverts to allow lateral movement of water and to minimise localised flooding and/or drying out;
- The optimized road alignments have been designed to largely avoid most watercourses and their 32 m buffer areas. Multiple crossings across the same watercourse section are not advised, and must be restricted to the minimum number feasible;
- Several artificial and natural vernal pools are located in close proximity to some of the roads. Road infrastructure (specifically the roads between turbines N23 and N24, and turbines S37 and S38) should be re-aligned to avoid the 32m vernal pool buffers while catering for natural surface runoff (box culverts) to continue to feed into these aquatic features to sustain the functioning of these systems and their likely vernal biota;
- A qualified freshwater ecologist conduct seasonal (wet season) monitoring of the vernal biota every two to three years to record species diversity and monitor that the project is not impacting on these populations;
- A qualified Hydrologist with experience in arid areas must develop a suitable and adaptive Stormwater management plan to ensure no erosion takes place and that clean water reports back to the local watercourses which includes the vernal pools;
- An adaptive rehabilitation plan needs to be implemented from the onset of the project. The key focus should be placed on stormwater and erosion prevention strategies for the development area. The plan should be adhered to for all stages of the project life;
- Therefore, an infrastructure monitoring and service plan must be compiled and implemented during the operational phase. This will include monitoring the road reserve route, all stormwater discharge points, energy dissipation structures, and

stability of watercourse habitat in the project footprint. This service plan should be adaptive based on on-site conditions;

- This report must consider the associated terrestrial biodiversity report and associated mitigation and recommendations; and
- A walkdown must be conducted on the final layout to confirm the larger watercourses are adequately avoided, and that the smaller drainage features (regardless of how insignificant they may appear) will have adequate flow catering structures in place. This must be conducted prior to final design sign off and construction.

9 Conclusion

9.1 Baseline Ecology

The baseline assessment investigated the watercourses present within the PAOI. Numerous drainage features are present comprising of an extensive braided watercourse network, presenting ephemeral conditions with scattered vernal pools present. Several watercourses presented surface water at the time of the survey, however not all of them were suitable for the assessment of aquatic biota. The sampled watercourses were tributaries of the Tulpleegte and Kariega rivers. The results of the PES assessment derived a moderately modified (class C) status for the Tulpleegte. The anthropogenic activities within the catchment have resulted in large modifications to the riparian and instream habitat integrity of the watercourse. These activities have contributed to alteration of hydrology and some erosion of the river banks, with evidence of flow and channel modification, cumulatively reducing the biotic integrity of the sampled watercourses. The biotic integrity must be interpreted with caution due to the ephemeral nature of the watercourses and limited availability of surface water to support a diverse aquatic ecosystem.

Despite modification, the instream water quality in the sampled systems was suitable for aquatic biota, which was supporting a low diversity of aquatic macroinvertebrates. This low diversity is a common feature of arid region communities due to surface water limitations. Sampling for fish was conducted, however despite adequate habitat suitability for fish, no fish were collected. The absence of fish is likely due to the ephemeral nature of the watercourses that may not be conducive to support fish year-round. It is likely that the absence of sufficient rainfall leading up to the survey may have limited the presence of fish at the time of the survey. Despite this, fish are likely present within the Kariega River immediately downstream of the PAOI, highlighting the need to limit water quality and habitat impacts during the execution of the project to conserve fish and aquatic life within the downstream watercourse and those potentially occurring within the sampled watercourses. Additionally, vernal biota namely clam shrimp (Conchostraca) were sampled in the upper reaches of the Tulpleegte River. The specialist recommends that the moderately modified (class C) status be set as the Management Class for the watercourses traversed by the project infrastructure.

Due to the sensitivity of the catchment and soils to erosion, together with the flat topography and braided alluvial fan nature of the watercourses within the PAOI, an increase in anthropogenic activities poses a risk to the ecological integrity of the watercourses notably from a hydrological perspective. The presence of aquatic macroinvertebrates and vernal biota highlights the sensitivity of the watercourses. Any proposed activities in proximity to the watercourses should not further contribute to the deterioration of the instream and riparian zones as this will compromise the ecological integrity of the reach and Management Class may not be achieved.

The aquatic features presented in this report require a buffer of 32 m and are to be treated as a no-go zone and avoided as far as is feasible. The optimised facility layout has implemented the avoidance strategy and positioned majority of the turbine platforms and road networks outside the buffer areas. There are however some watercourse crossings proposed and these are deemed acceptable and appropriately placed. Several artificial and natural vernal pools are located in close proximity to some of the roads. Road infrastructure (specifically the roads between turbines N23 and N24, and turbines S37 and S38) should be re-aligned to avoid the 32m vernal pool buffers while catering for natural surface runoff (box culverts) to continue to feed into these aquatic features to sustain the functioning of these systems and their likely vernal biota. Ensuring that aquatic features and buffers are intact increases the resilience of a watercourse to future disturbances. These buffers would ensure adequate ecological integrity maintenance from the adjacent proposed wind energy facilities.

9.2 Impact Assessment

An impact statement is required as per the NEMA regulations with regards to the proposed development. As a result of the ephemeral and braided nature of the watercourses and susceptibility to erosion and the flat topography likely to be seasonally flooded, the construction and operation phase activities would influence the hydrology, water quality and soil movement within the affected watercourses and vernal pools, notably where the proposed infrastructure traverse these aquatic features and their associated 32 m buffer. This 32 m buffer would also apply to the vernal pools. The optimised facility layout has largely avoided the ESAs and associated aquatic features with some watercourse crossings proposed and these are deemed acceptable and appropriately placed. There is however the exception of portions of the roads that come in close proximity to the vernal pools and fall within their buffers. These need to be avoided. Provided the mitigation and recommendations are implemented responsibly the project will present low rated residual impacts to the watercourses.

Specialist Opinion

Based on the survey findings, the specialist confirms the “Very High” aquatic theme sensitivity as per the National Web based Environmental Screening Tool. The project infrastructure does pose risk to the watercourses, and it is the specialist’s opinion that following the implementation of avoidance mitigation, recommendations and remedial measures, the risks can be lowered to acceptable levels. Therefore, authorisation of the proposed development can be carefully considered by the authorities.

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Appendix A Specialist Declaration

I, Dale Kindler declare that:

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

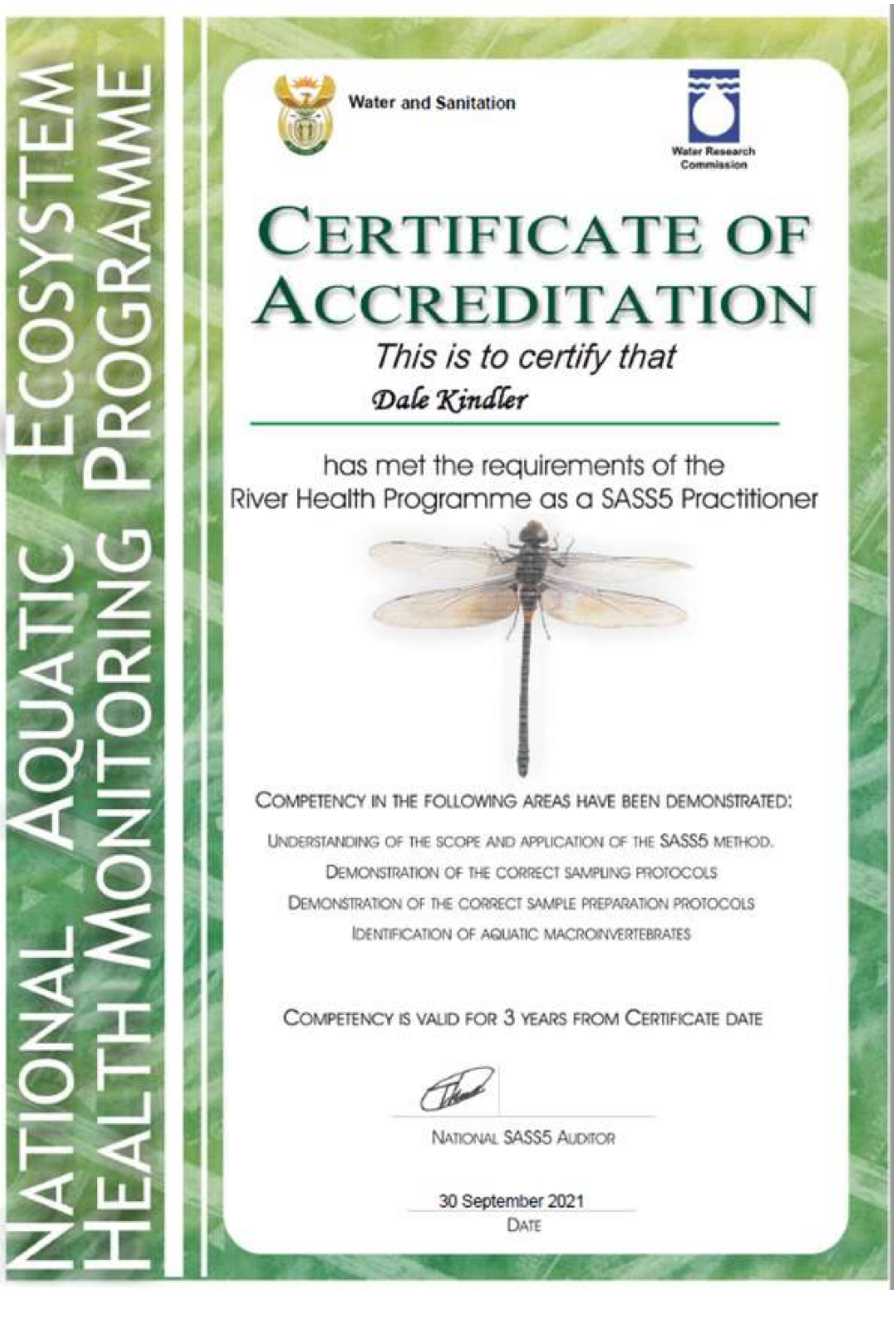
Dale Kindler

Freshwater Ecologist

The Biodiversity Company

28 August 2023

Appendix B – SASS Accreditation



NATIONAL AQUATIC ECOSYSTEM HEALTH MONITORING PROGRAMME

Water and Sanitation

Water Research Commission

CERTIFICATE OF ACCREDITATION

This is to certify that

Dale Kindler

has met the requirements of the River Health Programme as a SASS5 Practitioner

COMPETENCY IN THE FOLLOWING AREAS HAVE BEEN DEMONSTRATED:

UNDERSTANDING OF THE SCOPE AND APPLICATION OF THE SASS5 METHOD.

DEMONSTRATION OF THE CORRECT SAMPLING PROTOCOLS

DEMONSTRATION OF THE CORRECT SAMPLE PREPARATION PROTOCOLS

IDENTIFICATION OF AQUATIC MACROINVERTEBRATES

COMPETENCY IS VALID FOR 3 YEARS FROM CERTIFICATE DATE

NATIONAL SASS5 AUDITOR

30 September 2021

DATE

Appendix C – Specialist CV

Dale Kindler

M.Sc Aquatic Health

SACNASP registered Pr. Sci. Nat. 114743

Cell: +27 82 592 1970

Email: dale@thebiodiversitycompany.com

Identity Number: 8901135071083

Date of birth: 13 January 1989

Profile Summary

9 years experience with the mining and civil engineering sector in South Africa, providing specialist input into EIAs.

Providing aquatic ecological expertise for the assessment and management of freshwater systems.

The implementation of aquatic biomonitoring programmes in accordance with licensing.

Areas of Interest

Aquatic Ecology and Water Resource Management.

Renewable Energy & Infrastructure Development Projects, Sustainability and Conservation.

Fish Health and Histopathology.

Publication of scientific journals and articles.

Dragonflies as a monitoring tool

Key Experience

- Fish population structure assessments
- The use of macroinvertebrates to determine water and habitat quality
- Freshwater Ecological Assessments
- Monitoring Programmes (Baseline studies, water quality and biomonitoring)

Countries worked in (9)

Guinea

Mozambique

South Africa

Lesotho

Swaziland

Angola

Zimbabwe

Nigeria

Zambia

Nationality

South African

Languages

English – Proficient

Afrikaans – Conversational

Qualifications

- MSc (University of Johannesburg) – Aquatic Health.
- BSc Honours (University of Johannesburg) – Zoology
- BSc Zoology & Environmental Management
- SASS 5 Accredited – Department of Water Affairs and Forestry for the River Health Programme
- Professional Natural Scientist: Aquatic Health (Reg. No: 114743)

Project background and expertise can be requested as needed.

OVERVIEW

An overview of the specialist technical expertise include the following:

- Aquatic ecological state and functional assessments of rivers and dams.
- Monitoring plans for rivers.
- Toxicity and metal analysis of water, sediment and biota.
- Implementation of recognised biotic indices: Fish, Macroinvertebrates, Diatoms and Vegetation studies.
- Implementation of recognised abiotic indices: Intermediate Habitat Integrity Assessment (IHIA). Interpretation of Chemical Analyses and Toxicity Tests.
- Assistance with faunal surveys which includes mammals and reptiles (camera traps and various other trapping and catching techniques).

TRAINING

Some of the more pertinent training undergone include the following:

- SASS 5 Accredited – Department of Water Affairs and Forestry (Updated September 2021).
- Bioaccumulation assessment of fish communities.
- Safe removal and relocation of Baboon spiders – Boikarabelo Coal Mine (2012).
- Advanced 4 x 4 driving course – Through the University of Johannesburg (2012).
- Air Quality - Dust bucket and passive sample collection and lab submissions (2013).
- Trained in Health and Safety - Level 1 First Aid (2013)
- Trained in Basic Firefighting (2021)

EMPLOYMENT EXPERIENCE

CURRENT EMPLOYMENT: The Biodiversity Company (October 2015 – Present)

I am an aquatic ecologist at The Biodiversity Company and have conducted stand-alone specialist studies, and provided overall guidance of studies with a pragmatic approach for the management of biodiversity that takes into account all the relevant stakeholders, most importantly the environment that is potentially affected. We manage risks to the environment to reduce impacts with practical, relevant and measurable methods. These services are offered to numerous sectors, such as mining, agriculture, construction and natural resources. I was a divisional manager for a period (Nov 2019 – April 2022), thereafter stepping down to concentrate on specialist studies.

EMPLOYMENT: Prism EMS (January 2015 - September 2015)

As an aquatic ecologist at Prism my responsibilities included conducting specialist assessments of aquatic ecosystems, compilation of reports, and equipment maintenance and calibrations.

EMPLOYMENT: Golder Associates Africa (January 2013 – June 2014)

As an aquatic ecologist at Golder my responsibilities included assisting with specialist assessments of aquatic ecosystems, compilation of reports, equipment maintenance and calibrations, and management of samples. My role included assisting in: Ecological, Surface Water; Ground Water; and Air Quality Monitoring for the other divisions within the company.

Demonstrator and tutor: 2012 -University of Johannesburg, Gauteng

ADDITIONAL EXPERIENCE

Public consultation	The provision of specialist input in order to communicate proje findings as well as assist with providing feedback if and whe required.
Water use licenses	Consultation with the relevant authorities in order to establish th project requirements, as well as provide speciali (aquatics/wetland) input for the application in order to achiev authorisation.

ACADEMIC QUALIFICATIONS

University of Johannesburg, Johannesburg, South Africa (2015): MAGISTER SCIENTIAE (MSc) - Aquatic Health:

Title: Assessment of the reproductive status of *Barbus motebensis* (Marico Barb) from the upper Groot Marico River catchment, North West Province, South Africa.

University of Johannesburg, Johannesburg, South Africa (2012): BACCALAUREUS SCIENTIAE CUM HONORIBUS (Hons) – Zoology

Title: The identification and description of two spider species including an assessment of their behavioural and distributional pattern in Bakwena Cave, Irene, Pretoria, Gauteng, South Africa.

University of Johannesburg, Johannesburg, South Africa (2009 - 2011): BACCALAUREUS SCIENTIAE IN NATURAL AND ENVIRONMENTAL SCIENCES. Majors: Zoology and Environmental Management.

CONFERENCES

Southern African Society of Aquatic Sciences Congress July 2019, Held at Zebula Golf Lodge, Bela-Bela, Limpopo Province. Fish species composition of the upper reaches of the Limpopo River and water quality trends, Lephalale, South Africa.

PUBLICATIONS

Kindler D, Wagenaar GM, Weyl OLF. 2015. An assessment of the reproductive biology of the Marico barb *Barbus motebensis* from the upper Groot Marico catchment, South Africa. African Journal of Aquatic Science; 40(4):425-431. http://dx.doi.org/10.2989/16085914.2015.1106400

- End of Report -