Water Resource Report for the proposed Richards Bay Combined Cycle Gas Turbine (CCPP) Power Plant and associated infrastructure near Richards Bay

Richards Bay, KwaZulu-Natal

January 2018 (Updated February 2019)

CLIENT

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Report Name	**Water Resource Report for the proposed Richards Bay Combined Cycle Gas Turbine (CCPP) Power Plant and associated infrastructure near Richards Bay**	
Submitted to	**Afzelia Environmental Consultants**	
Survey/Report (Wetlands)	**Andrew Husted** **(Pr. Sci. Nat. 40213/11)**	
Survey/Report (Aquatic Ecology)	**Russell Tate** **(Pr. Sci. Nat.400089/15)**	

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[1] A Painted Reed Frog *(Hyperoliu marmoratus)* sampled within the project area (January 2018)

EXECUTIVE SUMMARY

Afzelia Environmental Consultants (Pty) Ltd (Afzelia) were appointed by Savannah Environmental Consultants (Pty) Ltd (Savannah) to provide supporting specialist studies for the proposed development of a Combined Cycle Power Plant (CCPP) and associated infrastructure on a site near Richards Bay, KwaZulu-Natal Province. The intent of these specialist studies was to provide supporting information for the Environmental Impact Assessment (EIA) and Water Use License Application (WULA) processes.

The Biodiversity Company was commissioned by Afzelia to conduct the specialist studies to supplement the abovementioned applications. This water resource assessment comprises of both wetland and aquatic ecology specialist components. An assessment of the water resource systems was conducted from 25th January 2018, which constitutes a wet season survey.

Standard methodologies were used to delineate the wetland areas, and to determine the Present Ecological Status (PES), Ecological Importance and Sensitivity (EIS) and ecological functioning for the water resources.

A total of two (2) Hydrogeomorphic (HGM) types were identified and delineated for the project, namely a channelled valley bottom wetland and wetland flat types.

The focus for the project and biodiversity offset area was the flat type wetland systems, and not the channelled valley bottom wetland which is not located directly within the project area. The ecological assessments were therefore being prioritized for, and focussed on the wetland flats.

Approximately 91 ha of wetlands have been delineated for the project, with approximately 38 ha and 53 ha being delineated for the project area and biodiversity offset area respectively.

The overall wetland health for the identified wetlands for the project and biodiversity offset areas was determined to be Moderately Modified (Class C).

The wetland flats for both areas had overall intermediate levels of service. The indirect benefits associated with both areas also had an intermediate level of service. The level of service for the direct benefits was determined to be moderately low and intermediate for the biodiversity offset area and project area respectively. It is also evident from the findings that the benefits associated with biodiversity are higher for the project area (moderately high) as opposed to the biodiversity offset area (intermediate). No services providing moderately high (or higher) benefits are expected for the offset area, with moderately high benefits expected for the project area.

The EIS of the wetland systems was determined to be High (Class B) and Moderate (Class C) for the project area and biodiversity offset area respectively. The hydrological / functional importance for both areas was rated as Moderate. The direct human benefits were rated as Low (Class D) and Moderate (Class C) for the biodiversity offset area and project area respectively.

The aquatic biodiversity of the identified inundated freshwater wetlands was determined to be high. The PES of the above-mentioned channelled valley bottom wetland system, referred to as the Eastern Unnamed Tributary in this study, was found to be largely modified (Class D) as a result of channel, flow and bed modification. A single listed fish species was expected to

occur on the project site. However, several rare species are known from the project area and further investigation was recommended. The listed fish species was *Oreochromis mossambicus* which is threatened by hybridisation. Thus, the proposed project presents no risk to the threatened species.

The proposed project will result in the loss of wetland areas, and the subsequent loss of ecological services. This loss is the key consideration for the impact assessment, with the loss of wetland areas unavoidable due to the proposed project requirements. No mitigation is possible for the loss of wetlands since it results in significant residual impacts, and a wetland offset strategy is therefore required.

An impact assessment was conducted for the remaining wetland portions which will not be lost as a result of the facility, these systems are likely to be impacted on by indirect aspects of the project. The significance of these impacts was less when compared to the direct loss of the wetland area (and the extent thereof), but equally important to assess and mitigate.

The impacts associated with the proposed project are high in significance, particularly for the expected loss of wetland area. The loss of wetland area cannot be mitigated, and a wetland offset strategy must be conducted to compensate for this loss. The impact significance for the remaining project aspects varied from high to medium without mitigation, but this significance is reduced to between medium and low, based on the assumption that mitigation measures will be implemented.

Careful consideration must be afforded to each of the recommendations provided herein, specifically the requirements for a wetland offset plan. In the event that environmental authorisation is issued for this project, proven ecological (or environmental) controls and mitigation measures must be entrenched in the management framework. It is strongly recommended that a comprehensive biodiversity (encompassing wetlands and downstream riverine habitats) action plan be compiled prior to the issuing of any environmental authorisation.

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Declaration

I, Russell Tate, 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.

Russell Tate

Aquatic Specialist

The Biodiversity Company

20/02/2018

Declaration

I, Andrew Husted, 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;
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- 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.

Andrew Husted

Aquatic / Wetland Ecologist

The Biodiversity Company

11 January 2018

1 Introduction

Afzelia Environmental Consultants (Pty) Ltd (Afzelia) were appointed by Savannah Environmental Consultants (Pty) Ltd (Savannah) to provide supporting specialist studies for the proposed development of a Combined Cycle Power Plant (CCPP) and associated infrastructure on a site near Richards Bay, KwaZulu-Natal Province. The intent of these specialist studies was to provide supporting information for the Environmental Impact Assessment (EIA) and Water Use License Application (WULA) processes.

The Biodiversity Company was commissioned by Afzelia to conduct specialist studies to supplement the abovementioned applications. This water resource assessment comprises of both wetland and aquatic ecology specialist components. An assessment of the water resource systems was conducted from 25th January 2018, which constitutes a wet season survey.

This report presents the results of an aquatic and wetland ecological study on the environments associated with the proposed expansion project. This report should be interpreted after taking into consideration the findings and recommendations provided by the specialist herein. Further, this report should inform and guide the Environmental Assessment Practitioner (EAP) and regulatory authorities, enabling informed decision making, as to the ecological viability of the proposed project.

1.1 Project Description

The Richards Bay CCPP involves the construction of a gas-fired power station which will provide mid-merit2 power supply to the electricity grid. The weekly mid-merit power supply will be between a range of 20% to 70% of the total electricity supply produced by the Richards Bay CCPP. The power station will have an installed capacity of up to 3 000MW, to be operated on natural gas, with diesel as a back-up fuel. The natural gas is to be supplied by potential gas suppliers via a gas pipeline to the CCPP from the supply take-off point at the Richards Bay Harbour. The Liquefied Natural Gas (LNG) terminal infrastructure at the port and the gas supply pipeline to the boundary fence of the Richards Bay CCPP does not form part of the scope of this assessment as this project focuses only on the footprint activities inside Eskom's boundary fence on site 1D of the Richards Bay Industrial Development Zone (IDZ).

The main infrastructure associated with the facility includes the following:

- Gas turbines for the generation of electricity through the use of natural gas or diesel (back-up resource).
- Heat recovery steam generators (HRSG) to capture heat from high temperature exhaust gases to produce high temperature and high-pressure dry steam to be utilised in the steam turbines.
- Steam turbines for the generation of additional electricity through the use of dry steam generated by the HRSG.

[2] Mid-merit electricity generation capacity refers to the generation of electricity which is adjusted according to the fluctuations in demand in the national grid.

- Bypass stacks associated with each gas turbine.
- Dirty Water Retention Dams.
- Exhaust stacks for the discharge of combustion gases into the atmosphere.
- A water treatment plant for the treatment of potable water and the production of demineralised water (for steam generation).
- Water pipelines and water tanks to transport and store water of both industrial quality and potable quality (to be supplied by the Local Municipality).
- Dry-cooled system consisting of air-cooled condenser fans situated in fan banks.
- Closed Fin-fan coolers to cool lubrication oil for the gas and steam turbines.
- A gas pipeline and a gas pipeline supply conditioning process facility for the conditioning and measuring of the natural gas prior to being supplied to the gas turbines. It must be noted however that the environmental permitting processes for the gas pipeline construction and operation will be undertaken under a separate EIA Process
- Diesel off-loading facility and storage tanks.
- Ancillary infrastructure including access roads, warehousing, buildings, access control facilities and workshop area, storage facilities, emergency back-up generators, firefighting systems, laydown areas and 132kV and 400kV switchyards.
- A power line to connect the Richards Bay CCPP to the national grid for the evacuation of the generated electricity. It must be noted however that the due environmental permitting processes for the development of the power line component are being undertaken under a separate EIA Process.

1.2 Aim and Objective

The aim of the assessment was to provide information to guide the proposed Richards Bay CCPP project with respect to the current ecological state and functioning of the aquatic and wetland ecosystems in the area of study. As part of this assessment, the following objectives were established:

- The determination of the baseline Present Ecological Status (PES) of the local river and wetland systems;
- The delineation and assessment of wetlands within 500m of the proposed development area;
- The evaluation of the extent of site-related impacts;
- A risk assessment for the proposed development; and
- The prescription of mitigation measures and recommendations for identified risks.

2 Description of the Project Area

The project area (Erf 2/11376 and Erf 4/11376) is located in Richards Bay on the north coast of KwaZulu-Natal, approximately 170 km north of Durban, in the uMhlathuze Local Municipality of the greater UThungulu District Municipality. A biodiversity offset area has been proposed for Erf 1/11376, which will also be considered for this assessment. A locality map of the project area is presented in Figure 1. Figure 2 presents the project and proposed biodiversity offset area on a local scale.

The project area lies approximately 5 km west of Richards Bay along the Western Arterial highway in the Industrial zone of Richards Bay, with Mondi Richards Bay bordering the study area on the east. Areas to the north and south are bordered by a railway line and associated service road. The project area is approximately 71 ha in extent.

The project area is located within the Pongola - Mtamvuna Water Management Area (WMA 4) within the W12F quaternary catchment. One Sub Quaternary Reach (SQR) will be potentially affected by the proposed project. The SQR is a reach of the Nseleni River system and was identified as the W12H-3459 SQR (Table 1). It is however anticipated that the proposed project will potentially affect the Unnamed Tributary that lies to the east of the project area. For the purposes of this study, the watercourse is referred to as the Eastern Unnamed Tributary. The extent of the project area was traversed on foot for the wetland assessment, and five (5) aquatic sampling sites were considered for the study (Figure 3).

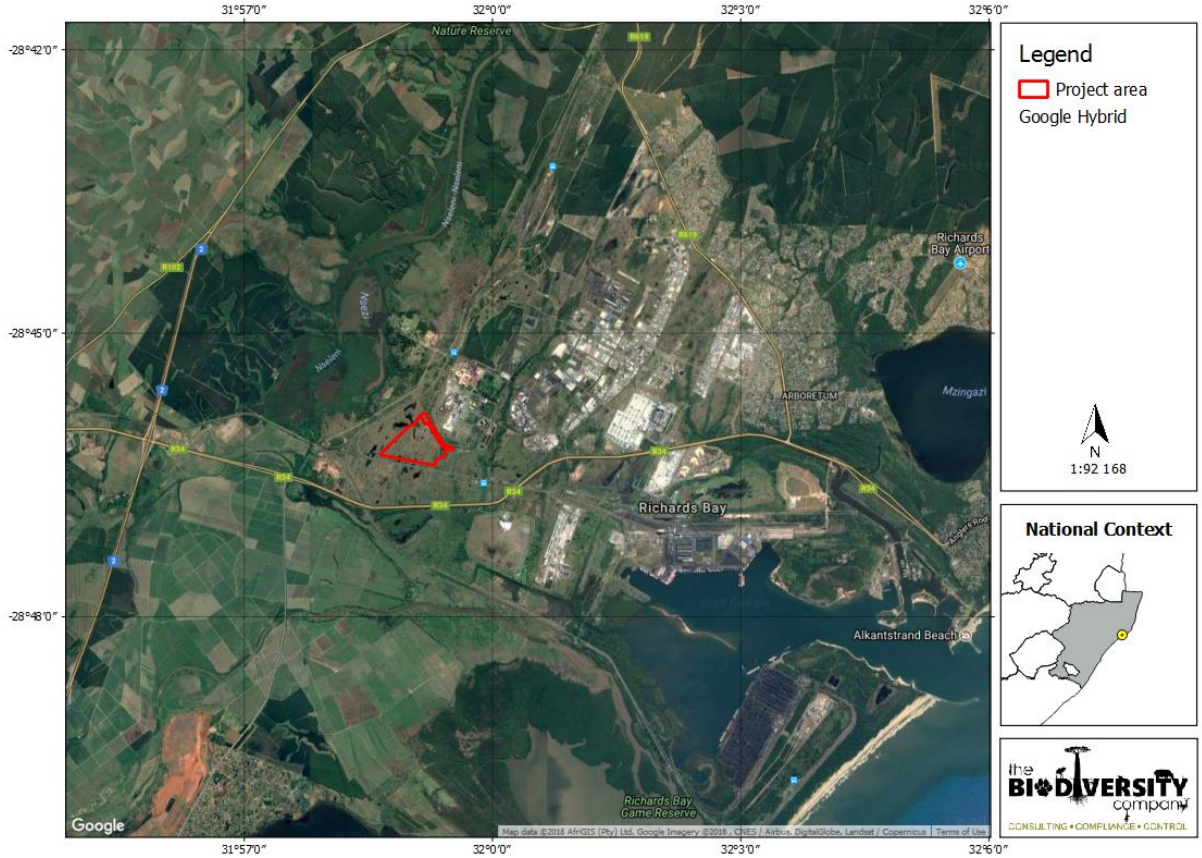

Figure 1: Location of the Richards Bay CCPP project area

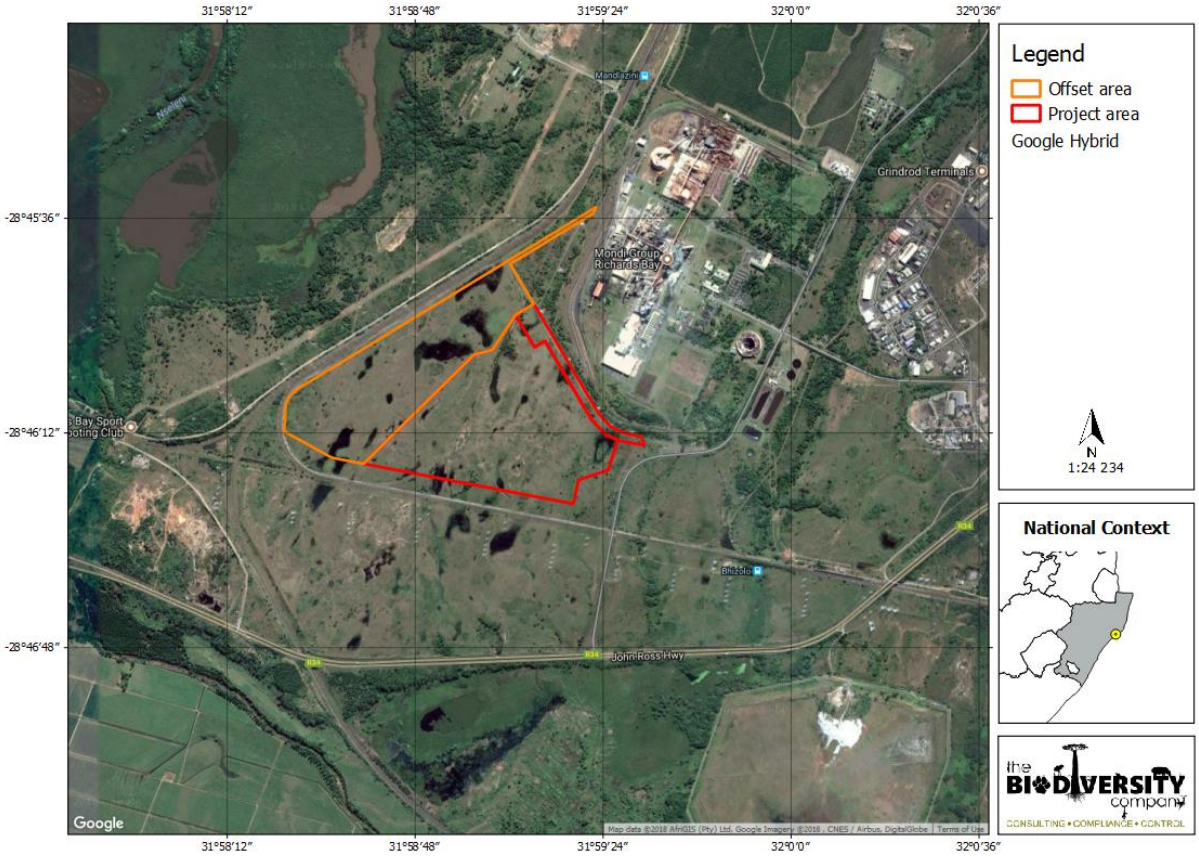

Figure 2: A closer locality map for the project area and proposed offset area

Table 1: The desktop information peratining to the W12H-3459 Sub Quaternary Reach

Component/Catchment	W12H-3459
Present Ecological Status	Largely Modified (class D)
Ecological Importance Class	High
Ecological Sensitivity	Very High
Default Ecological Category	Natural (class A)

Based on the above table (Table 1), the desktop PES of this reach of the Nseleni River system was a class D or largely modified. The ecological importance and sensitivity of the river reach was rated as high and very high respectively. The defined Default Ecological Category for the river was class A or natural.

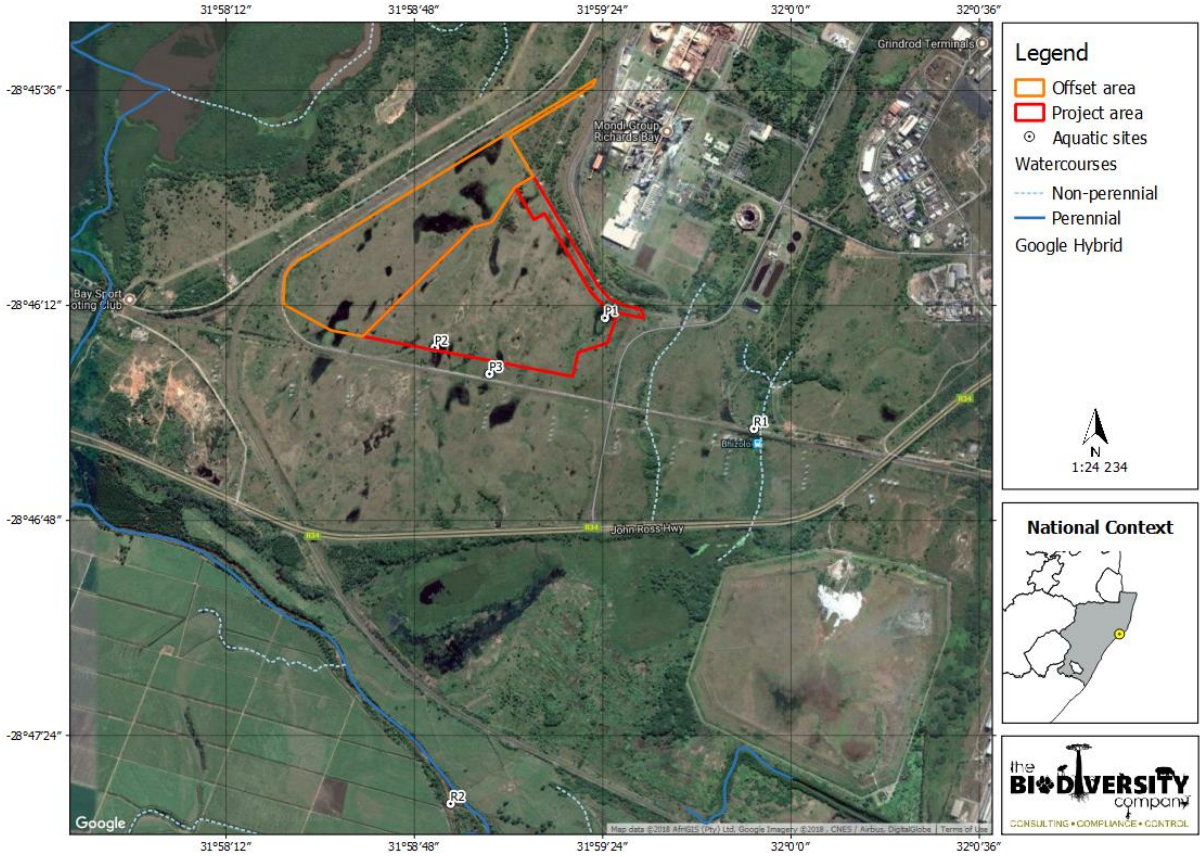

Figure 3: Location of aquatic sampling points

Table 2: Details of the aquatic sampling points (Photographs: January 2018)

Site	Broader Habitat Characterisation	Photograph
P1	Freshwater Wetland System	

Site	Broader Habitat Characterisation	Photograph
P2	Freshwater Wetland System	
P3	Freshwater Wetland System	
R1	Eastern Unnamed Tributary	

Site	Broader Habitat Characterisation	Photograph
R2	Nseleni River System within the Estuarine Functional Zone	

3 Methodology

3.1 Desktop Assessment

The following information sources were considered for the desktop assessment;

- Information as presented by the South African National Biodiversity Institutes (SANBI's) Biodiversity Geographic Information Systems (BGIS) website (http://bgis.sanbi.org);
- Aerial imagery (Google Earth Pro);
- Land Type Data (Land Type Survey Staff 1972 - 2006);
- The National Freshwater Ecosystem Priority Areas (Nel et al. 2011)
- Ecological Assessment, EIA report (Rautenbach, 2018); and
- Contour data (5m).

3.2 Wetland Assessment

The National Wetland Classification Systems (NWCS) developed by the South African National Biodiversity Institute (SANBI) was considered for this study. This system comprises a hierarchical classification process of defining a wetland based on the principles of the hydrogeomorphic (HGM) approach at higher levels. In addition, the method also includes the assessment of structural features at the lower levels of classification (Ollis, et al. 2013).

3.2.1 Wetland Delineation

The wetland areas are delineated in accordance with the DWAF (2005) guidelines, a cross section is presented in Figure 4. The outer edges of the wetland areas were identified by considering the following four specific indicators:

- The Terrain Unit Indicator helps to identify those parts of the landscape where wetlands are more likely to occur;
- The Soil Form Indicator identifies the soil forms, as defined by the Soil Classification Working Group (1991), which are associated with prolonged and frequent saturation.
    - The soil forms (types of soil) found in the landscape were identified using the South African soil classification system namely; Soil Classification: A Taxonomic System for South Africa (Soil Classification Working Group 1991);
- The Soil Wetness Indicator identifies the morphological "signatures" developed in the soil profile as a result of prolonged and frequent saturation; and
- The Vegetation Indicator identifies hydrophilic vegetation associated with frequently saturated soils.

Vegetation is used as the primary wetland indicator. However, in practise the soil wetness indicator tends to be the most important, and the other three indicators are used in a confirmatory role.

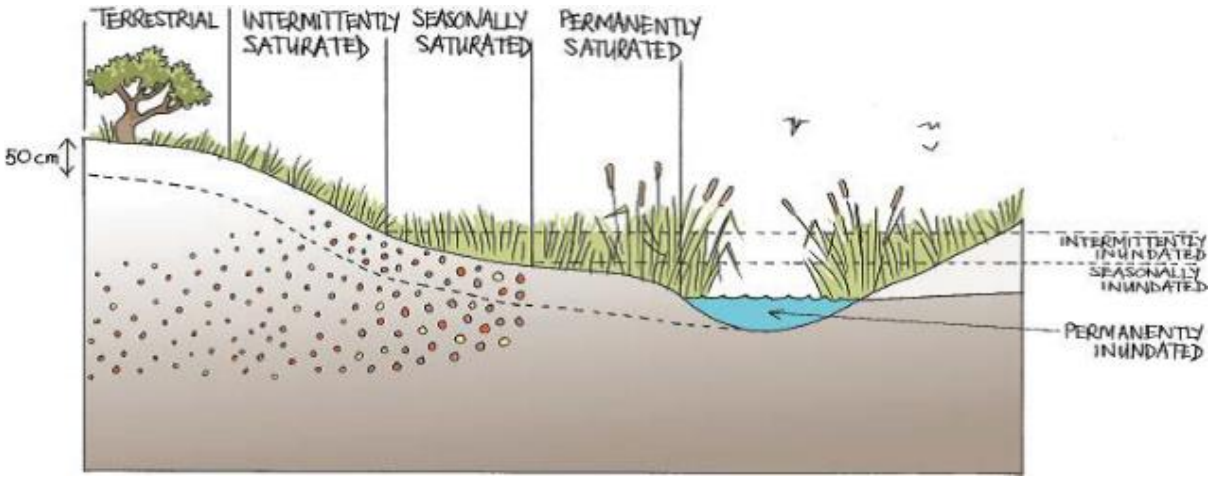

Figure 4: Cross section through a wetland, indicating how the soil wetness and vegetation indicators change (Ollis et al. 2013)

3.2.2 Wetland Present Ecological Status

The overall approach is to quantify the impacts of human activity or clearly visible impacts on wetland health, and then to convert the impact scores to a Present Ecological Status (PES) score. This takes the form of assessing the spatial extent of impact of individual activities/occurrences and then separately assessing the intensity of impact of each activity in the affected area. The extent and intensity are then combined to determine an overall magnitude of impact. The Present State categories are provided in Table 3.

Table 3: The Present Ecological State categories (Macfarlane et al. 2009)

Impact Category	Description	Impact Score Range	Present State Category
None	**Unmodified, natural**	**0 to 0.9**	**A**
Small	**Largely Natural** with few modifications. A slight change in ecosystem processes is discernible and a small loss of natural habitats and biota may have taken place.	**1.0 to 1.9**	**B**
Moderate	**Moderately Modified.** A moderate change in ecosystem processes and loss of natural habitats has taken place, but the natural habitat remains predominantly intact.	**2.0 to 3.9**	**C**
Large	**Largely Modified.** A large change in ecosystem processes and loss of natural habitat and biota has occurred.	**4.0 to 5.9**	**D**
Serious	**Seriously Modified.** The change in ecosystem processes and loss of natural habitat and biota is great, but some remaining natural habitat features are still recognizable.	**6.0 to 7.9**	**E**
Critical	**Critical Modification.** The modifications have reached a critical level and the ecosystem processes have been modified completely with an almost complete loss of natural habitat and biota.	**8.0 to 10**	**F**

3.2.3 Wetland Ecosystem Services

The assessment of the ecosystem services supplied by the identified wetlands was conducted per the guidelines as described in WET-EcoServices (Kotze, et al. 2009). An assessment was undertaken that examines and rates the following services according to their degree of importance and the degree to which the services are provided (Table 4).

Table 4: Classes for determining the likely extent to which a benefit is being supplied

Score	Rating of likely extent to which a benefit is being supplied
< 0.5	Low
0.6 - 1.2	Moderately Low
1.3 - 2.0	Intermediate
2.1 - 3.0	Moderately High
> 3.0	High

3.2.4 Ecological Importance and Sensitivity

The method used for the EIS determination was adapted from the method as provided by DWS (1999) for floodplains. The method takes into consideration PES scores obtained for WET-Health as well as function and service provision to enable the assessor to determine the most representative EIS category for the wetland feature or group being assessed. A series of determinants for EIS are assessed on a scale of 0 to 4, where 0 indicates no importance

and 4 indicates very high importance. The mean of the determinants is used to assign the EIS (Rountree et al., 2012) category as listed in Table 5.

Table 5: Description of Ecological Importance and Sensitivity categories

EIS Category	Range of Mean	Recommended Ecological Management Class
Very High	3.1 to 4.0	**A**
High	2.1 to 3.0	**B**
Moderate	1.1 to 2.0	**C**
Low Marginal	< 1.0	**D**

3.3 Aquatic Assessment

Methodologies applied for this study were selected in accordance to the aquatic system type. Therefore, freshwater wetland methodologies were utilised for the sites P1-P3 and riverine assessment methodologies for the sites R1 and R2. It is noted that the site R2 was determined to be within the functional estuary zone and therefore was not considered in this assessment.

3.3.1 Permanent Freshwater Wetlands

3.3.1.1 Water Quality

Water quality was measured *in situ* using a handheld calibrated Extech ExStik II meter. The constituents considered that were measured included: conductivity (µS/cm), temperature (°C) and Dissolved Oxygen (DO) in mg/l.

3.3.1.2 Aquatic Invertebrates

Live sampling was performed as adapted from Ferreira et al. (2012). The sampling for macroinvertebrates was performed using a standard sweep net of 500 µm mesh. Sweeps were performed for each of the type of substrate found in each waterbody which can include stones, gravel, sand and mud. The length of time the kick and sweep method was applied per substrate type was dependent on the size of substrate per waterbody. The size and diversity of the various substrates was rated and ranked in order to provide an indication of its suitability to support aquatic macroinvertebrate life. Sweeps of vegetation was performed for both marginal and submerged vegetation; the length of vegetation sampled was determined by the amount of vegetation present in each waterbody, and the vegetation was ranked and rated in order to give an indication of the suitability of vegetation biotopes for aquatic macroinvertebrates.

3.3.1.3 Fish Assessment

A basic qualitative fish assessment in the freshwater wetland systems was conducted utilising a Haltech Electoshocker. Fish species were identified and released at the point of capture.

3.3.2 River Systems

3.3.2.1 Water Quality

Water quality was measured *in situ* using a handheld calibrated Extech ExStik II meter. The constituents considered that were measured included: conductivity (µS/cm), temperature (°C) and Dissolved Oxygen (DO) in mg/l.

3.3.2.2 Aquatic Habitat Integrity

The Intermediate Habitat Assessment Index (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 was completed for Eastern Unnamed Tributary (R1). *Figure 11* confirms that drainage from the project area predominantly drains into the Eastern Unnamed Tributary. The estuarine zone was not considered in this assessment (R2).

The IHIA model was used to assess the integrity of the habitats from a riparian and instream 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 that are comparable to the characteristics of natural habitats of the region (Kleynhans, 1996). The criteria and ratings utilised in the assessment of habitat integrity in the current study are presented in Table 6 and Table 7 respectively.

Table 6: Criteria used in the assessment of habitat integrity (Kleynhans, 1998)

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.
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.

Criterion	Relevance
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 river bank resulting in a loss or modification of both instream and riparian habitats. Increased erosion can be the result of natural vegetation removal, overgrazing or exotic vegetation encroachment.

Table 7: Descriptions used for the ratings of the various habitat criteria

Impact Category	Description	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

3.3.2.3 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 the monitoring of the health of an aquatic ecosystem.

3.3.2.3.1 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 were identified using the "Aquatic Invertebrates of South African Rivers" Illustrations book, by Gerber and Gabriel (2002). Identification of organisms was made to family level (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 Natal Coastal Plain (Figure 5).

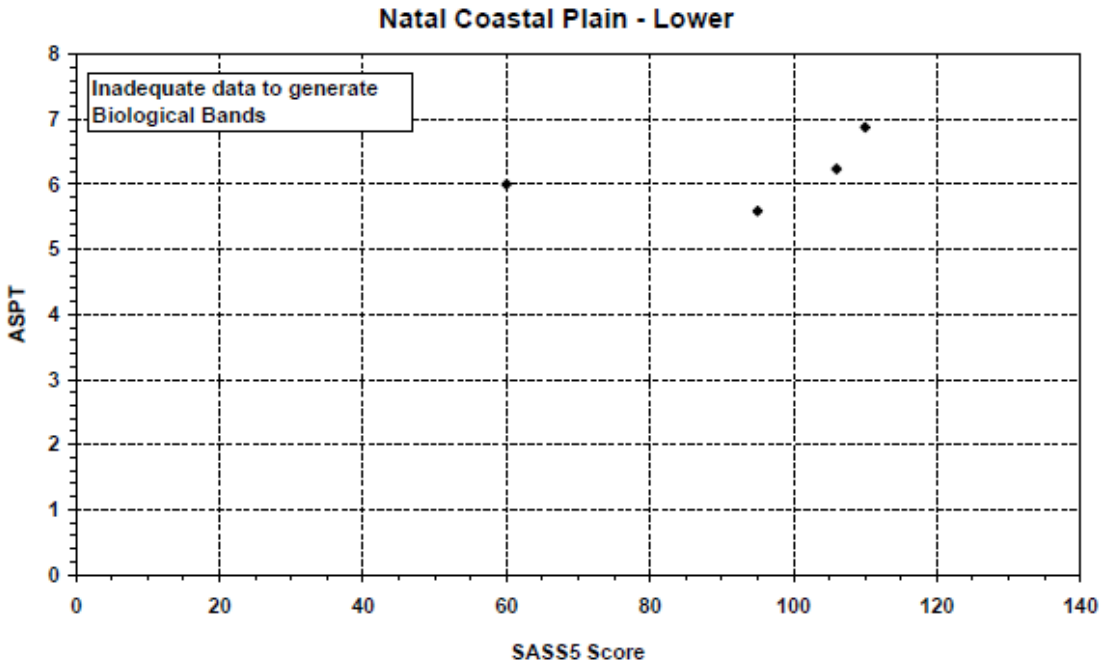

Figure 5: Guidelines used for the interpretation and classification of the SASS5 scores (Dallas, 2007)

3.3.2.4 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.

3.3.2.5 Fish Assessment

A basic fish community assessment was conducted at the freshwater sites. The estuary was not considered in this assessment. A qualitative fish survey was conducted whereby the timed sampling of a river reach was conducted using a Haltech Electroshocker.

3.3.2.6 Present Ecological Status

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 water course. This was completed using the river ecoclassification manual by Kleynhans and Louw (2007).

3.4 Impact Assessment

The impact assessment methodology was provided by Savannah. The EIA report has been compiled in line with the EIA Regulations of 2014, as amended on 07 April 2017. The broad approach to the significance rating methodology is to determine the environmental risk by considering the consequence of each impact (comprising Nature, Extent and Duration, Magnitude) and relate this to the Probability of the impact occurring. This determines the environmental risk. In addition, other factors, including cumulative impacts, public concern, and potential for irreplaceable loss of resources have also been considered.

4 Limitations and Assumptions

- A considerable extent of the project area is regarded to be highly transformed resulting from historical and current disturbances. Additionally, the developments within and on the periphery of the project area have also contributed to hindering the effective application of wetland indicators, which may impact on the accuracy of the delineation (Figure 6). A key disturbance appears to be deforestation of resources within the project area.
- The GPS used for wetland delineations is accurate to within five meters. Therefore, the wetland delineation plotted digitally may be offset by at least five meters to either side.
- Wetland systems identified at desktop level within 500 m of the project area were considered for the identification and desktop delineation, with wetland areas within the project area being the focus for ground truthing.
- No wetland buffer assessment has been completed for this project.

- Findings from the groundwater study were not yet available at the time of compiling this report. Thus, any linkages with groundwater systems has not yet been confirmed for this study, and have been assumed to be correct based on desktop data.
- The aquatic assessment only considered freshwater ecosystems and did not consider the estuarine habitats.
- The available aquatic macroinvertebrate data for the ecoregion in which the project area is located was poor. Therefore, interpretations of the results are of low confidence.
- For this update (February 2019), it has been assumed that the baseline findings

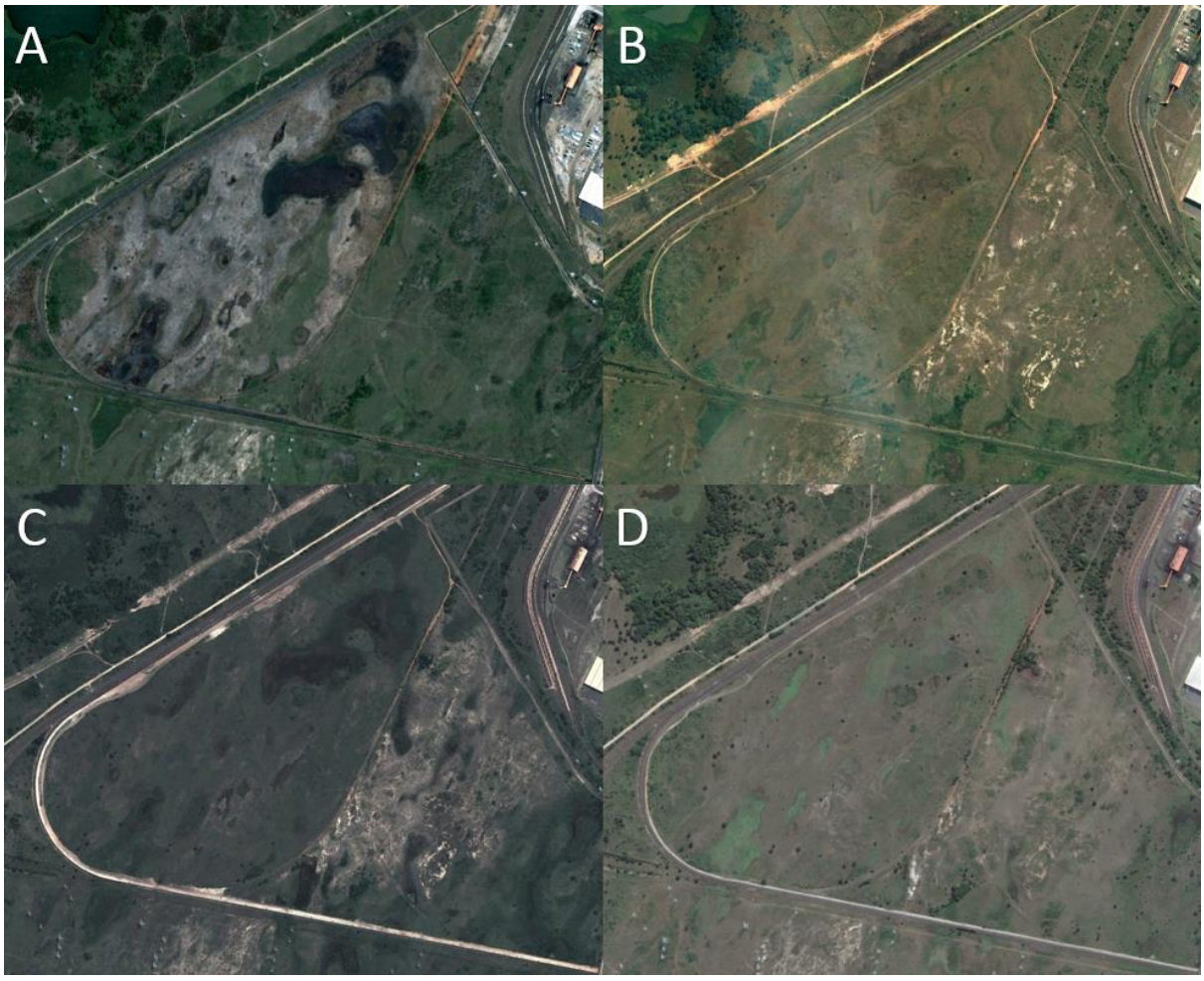

Figure 6: A Google Earth time series depicting the transformation of the area. A: 2004. B: 2010. C: 2012. D: 2017

5 Results and Discussion

5.1 Desktop Soils

According to the land type database (Land Type Survey Staff, 1972-2006) the project area is located within the Hb75 land type (Figure 7). The land type is described in the table below (Table 8).

Table 8: The expected soil features for the land type present

Land Type	Expected Soil Features
Hb75	GREY REGIC SANDS; Regic sands and other soils

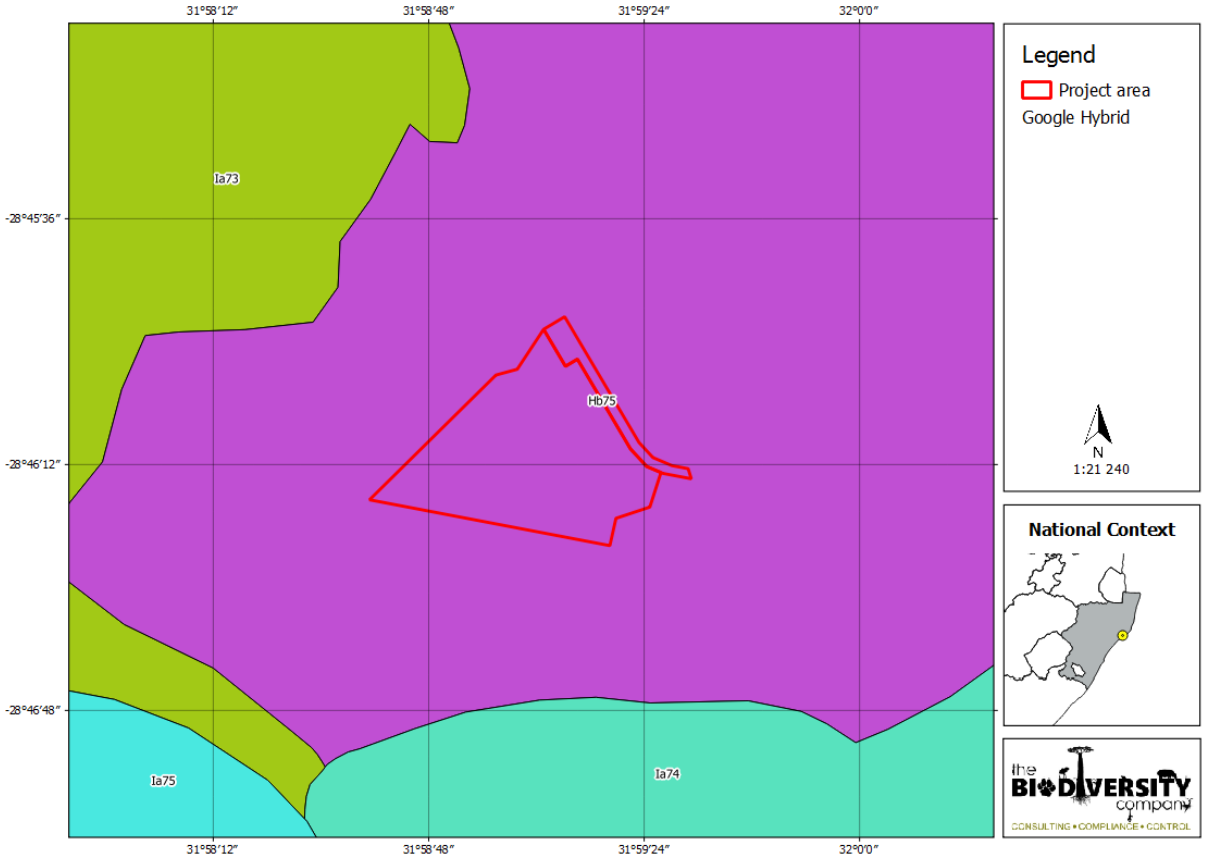

Figure 7: The land types in the project assessment area (MRA)

5.2 Desktop Vegetation

The project area is situated within the following KZN vegetation biomes and vegetation types, namely Freshwater Wetlands and Maputaland Wooded Grassland. The Subtropical Freshwater Wetlands ordinarily occurred in low lying areas and were dominated by reeds, sedges, rushes and water-logged meadows dominated by grasses. The dominant vegetation type in the study area is Maputaland Wooded Grassland. This vegetation type typically

supported coastal sandy grasslands rich in geoxylic suffritices, dwarf shrubs, small trees and very rich herbaceous flora.

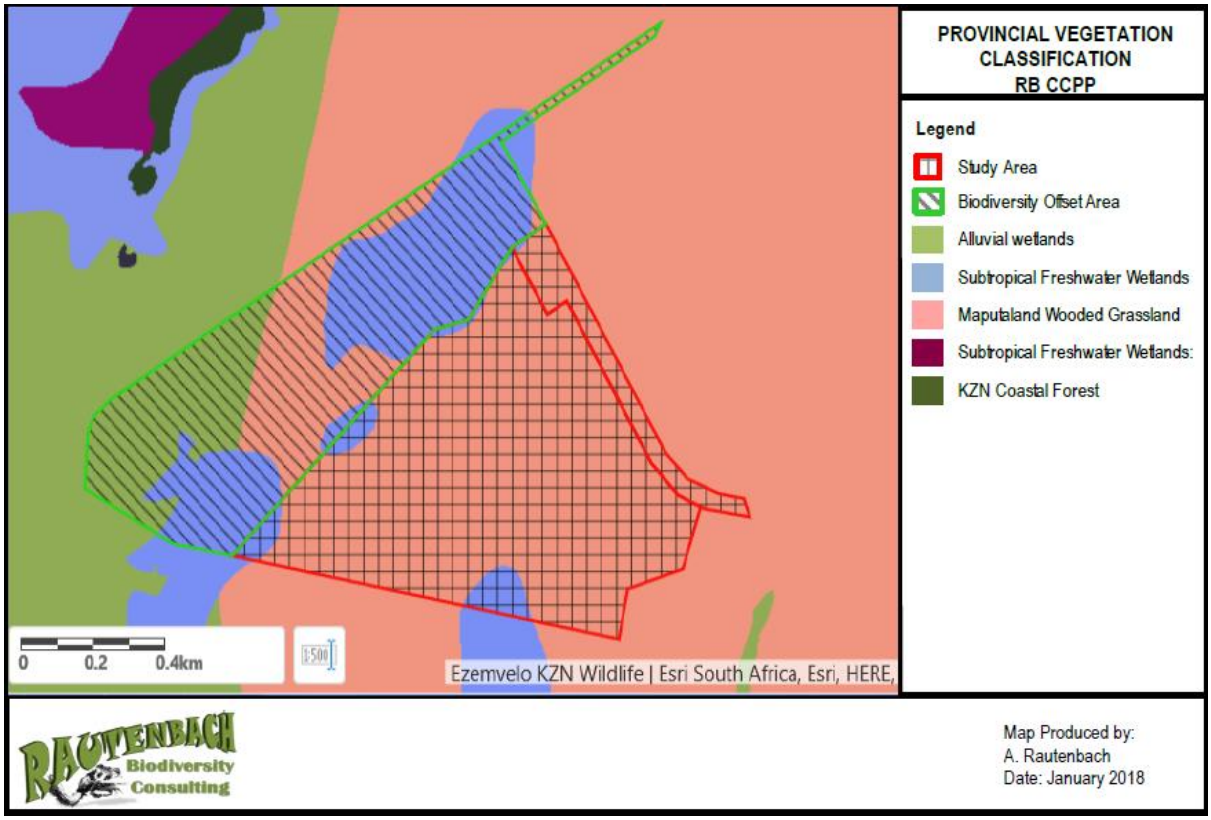

Figure 8: Vegetation types on the study area. Most of the study area falls within the Maputaland Wooded Grassland vegetation type (Rautenbach, 2018).

5.3 Wetland National Freshwater Priority Areas

One (1) Freshwater Ecological Priority Areas (FEPA) wetland type was identified within the assessment area of the project, namely a Wetland Flat. The systems are classified as natural or good (class A/B), with more than 75% natural land cover. The rank of the systems is a Rank 2, suggesting ecological significance on a local and regional scale. It is likely that these wetlands are within a sub-quaternary catchment which is regarded as high conservation priority. These FEPA wetlands are within a sub-quaternary catchment that has sightings or breeding areas for threatened wattled cranes, grey crowned cranes and blue cranes. The FEPA wetland systems are listed in Table 9. The location of the FEPA wetlands in reference to the proposed extension is provided in Figure 9. A 500m study area has been demarcated for the project area.

Table 9: NFEPA description for the FEPA sites

Classification Levels				Wetland Vegetation Class	Natural / Artificial	Wetland Condition	Wetland Rank
System	Ecoregion	Landscape Position	HGM				
Inland System	Natal Coastal Plain	Bench	Flat	Indian Ocean Coastal belt	Natural	AB	Rank 2

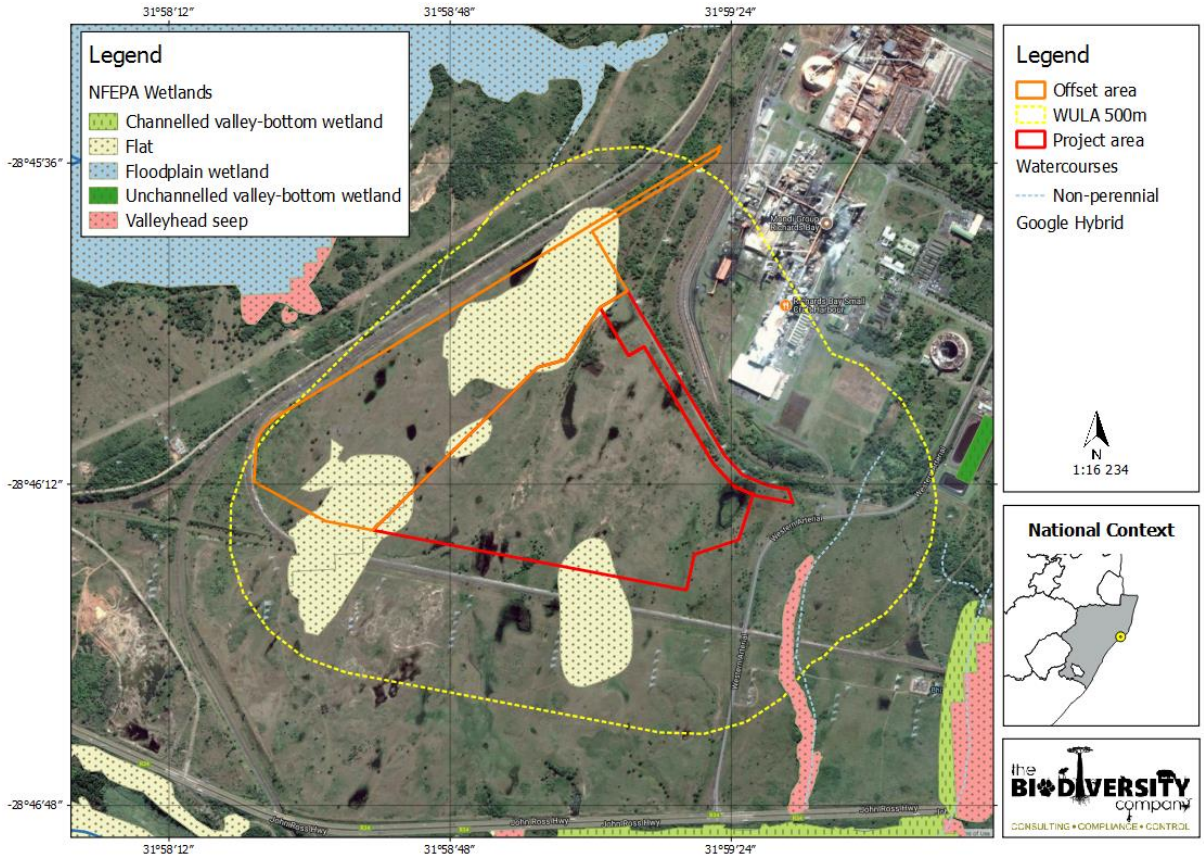

Figure 9: The FEPA wetlands in the project assessment area

5.4 Aquatic National Freshwater Priority Areas

The associated SQR's are not considered to be Freshwater NFEPA's. However, an estuary FEPA is located downstream of the project area. These areas are the reaches of an estuary which are considered to be the functional zone. These areas need to be managed to maintain the surrounding landuse in a good condition (Nel et al. 2011).

5.5 Wetland Assessment

An assessment of the water resource systems was conducted from 25th January 2018, which constitutes a wet season survey.

The National Aeronautics and Space Administration (NASA) Shuttle Radar Topography Mission (SRTM) (V3.0, 1 arcsec resolution) Digital Elevation Model (DEM) was obtained from the United States Geological Survey (USGS) Earth Explorer website. Basic terrain analysis was performed on this DEM using the SAGA GIS software that encompassed a slope and

channel network analyses in order to detect catchment areas and potential drainage lines respectively. A 3-dimensional (3-D) representation and watershed basins with surface flow direction for the project area are presented in Figure 10 and Figure 11 respectively.

The normalized difference vegetation index (NDVI) was created to provide a graphical indicator to determine the extent of live green vegetation or not, to assist with the delineation of wetland area. Landsat data was processed for numerous time periods, and an example of the NDVI data generated for data acquired is presented in *Figure 12*.

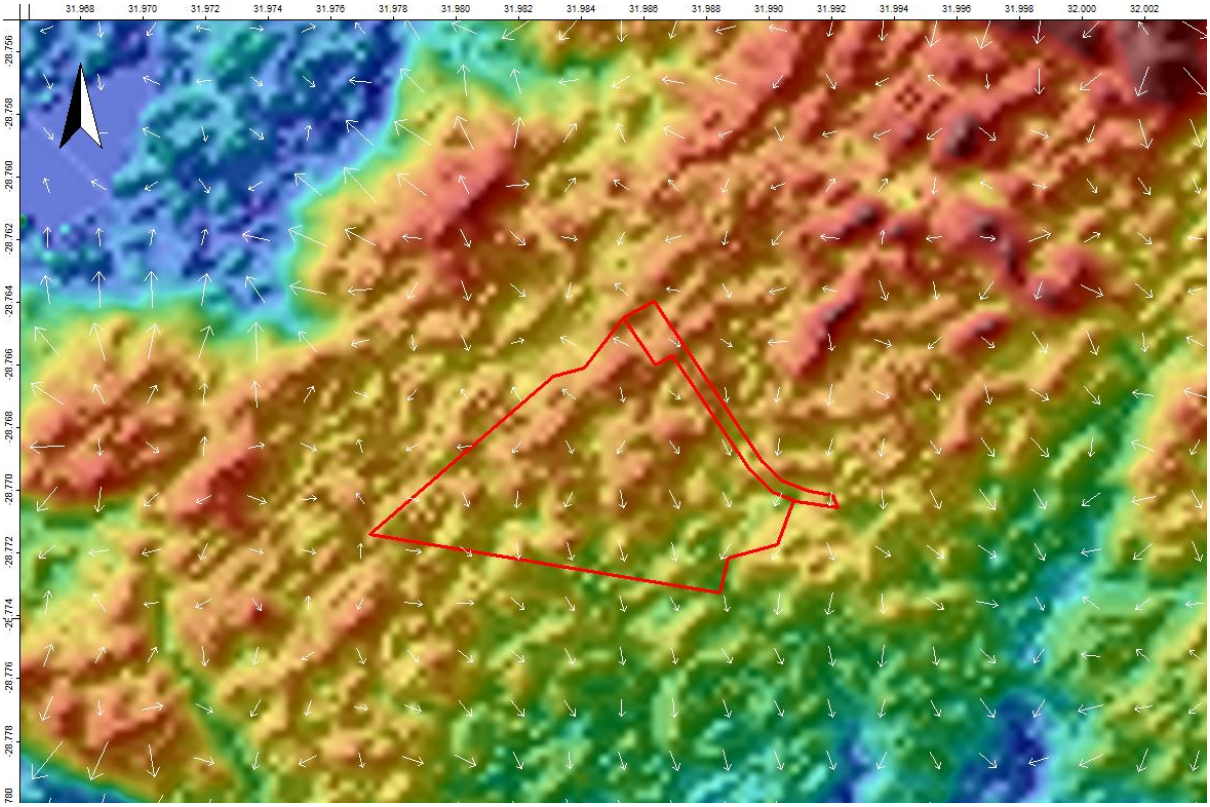

Figure 10: A 3D representation for the project area

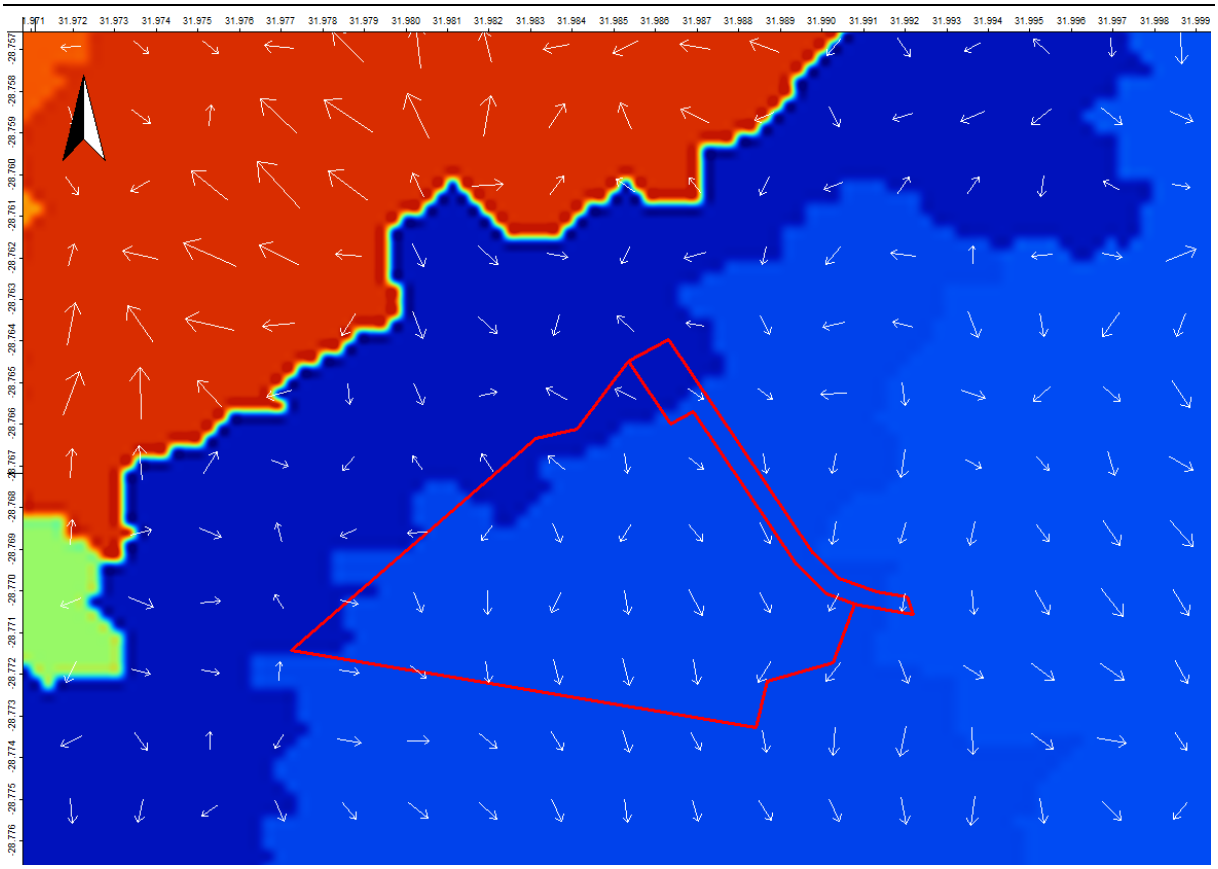

Figure 11: The watershed basins and flow direction for the project area

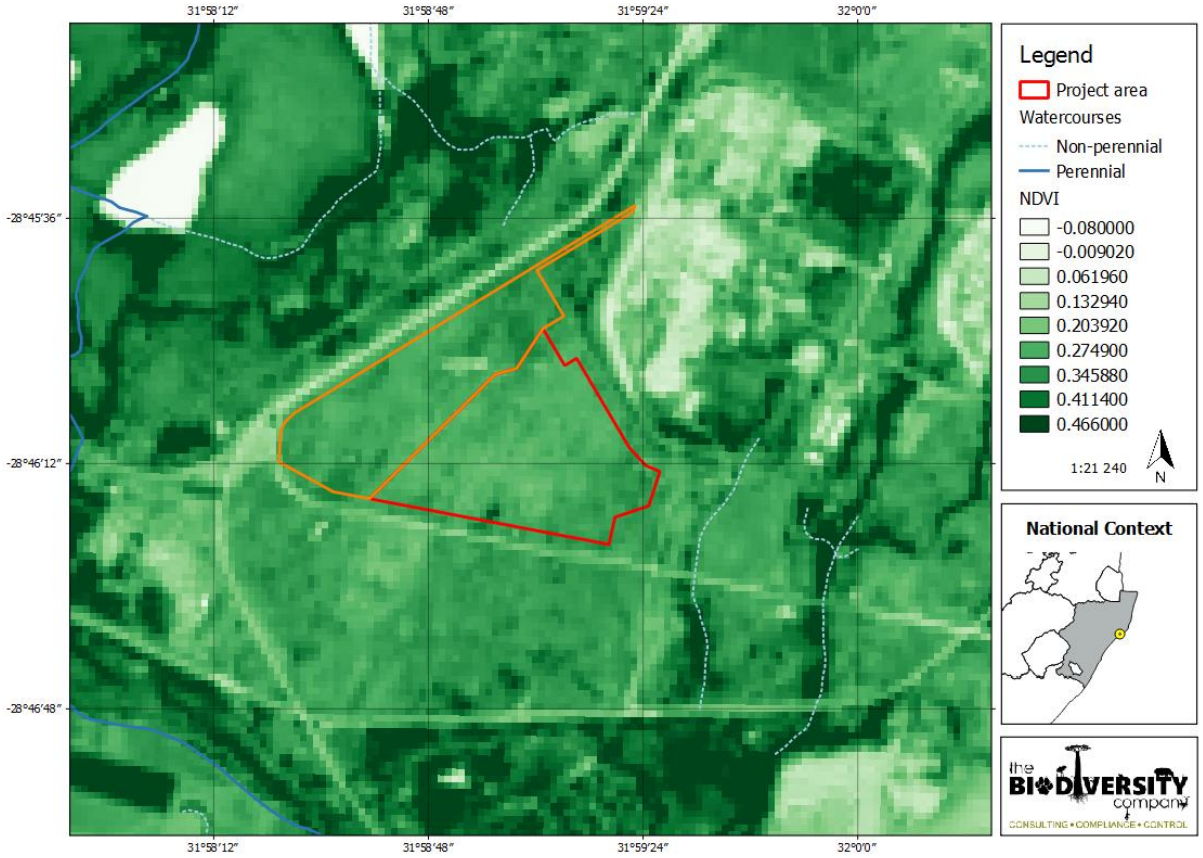

Figure 12: The Normalized Difference Vegetation Index data created for the project area

The wetland delineation is shown in Figure 13, with the delineated zones of saturation presented in Figure 14. The wetland classification as per SANBI guidelines (Ollis *et al.*, 2013) is presented in Table 12. A total of two (2) HGM types were identified and delineated for the project, namely a channelled valley bottom wetland and wetland flat types. An illustration of the HGM types in the relevant landscape, and the hydro-dynamics of the systems are presented in Figure 18.

The focus for the project area and the biodiversity offset area are the wetland flat type wetlands, and not the channelled valley bottom wetland which is not located within the project area. The ecological assessments have therefore been prioritized for, and focussed on the wetland flats.

A wetland flat is regarded as a level or near-level wetland area that is not fed by water from a river channel, and which is typically situated on a plain or a bench (Ollis *et al.*, 2013). According to Ollis *et al.* (2013) horizontal water movements of water within these wetlands, if present, are multi-directional, due to the lack of any significant change in gradient within the wetland.

Approximately 91 ha of wetlands have been delineated for the project, with approximately 38ha and 53ha being delineated for the project area and biodiversity offset area respectively. For this study, the wetland flats have been collectively assessed for the project area and biodiversity offset area, allowing for a comparison between the two study areas. This approach will also allow for a more detailed consideration for any proposed offset plan.

Wetland vegetation which was recorded for the study includes *Typha capensis, Imperata cylindrica, Cyperus congestus, C. marginatus, C. dives, C. natalensis* and *Pycreus polystachyos.* Figure 16 presents photographs of vegetaton recorded for the project area. It must be noted that *Cyperus esculentes, C. rotandus* are regarded as commonly occurring weeds which occur extensively outside of wetlands but may be found in some disturbed areas inside of wetlands (DWAF, 2005).

The range of Soil Forms identified for the study included the Katspruit (permanent wetland zone), Champagne (permanent zone), Longlands (seasonal zone), Westleigh (seasonal zone), Clovelly (non-wetland) and Namib (non-wetland) forms. Photographs of Soil Form and Soil Wetness encountered in the project area presented in Figure 15.

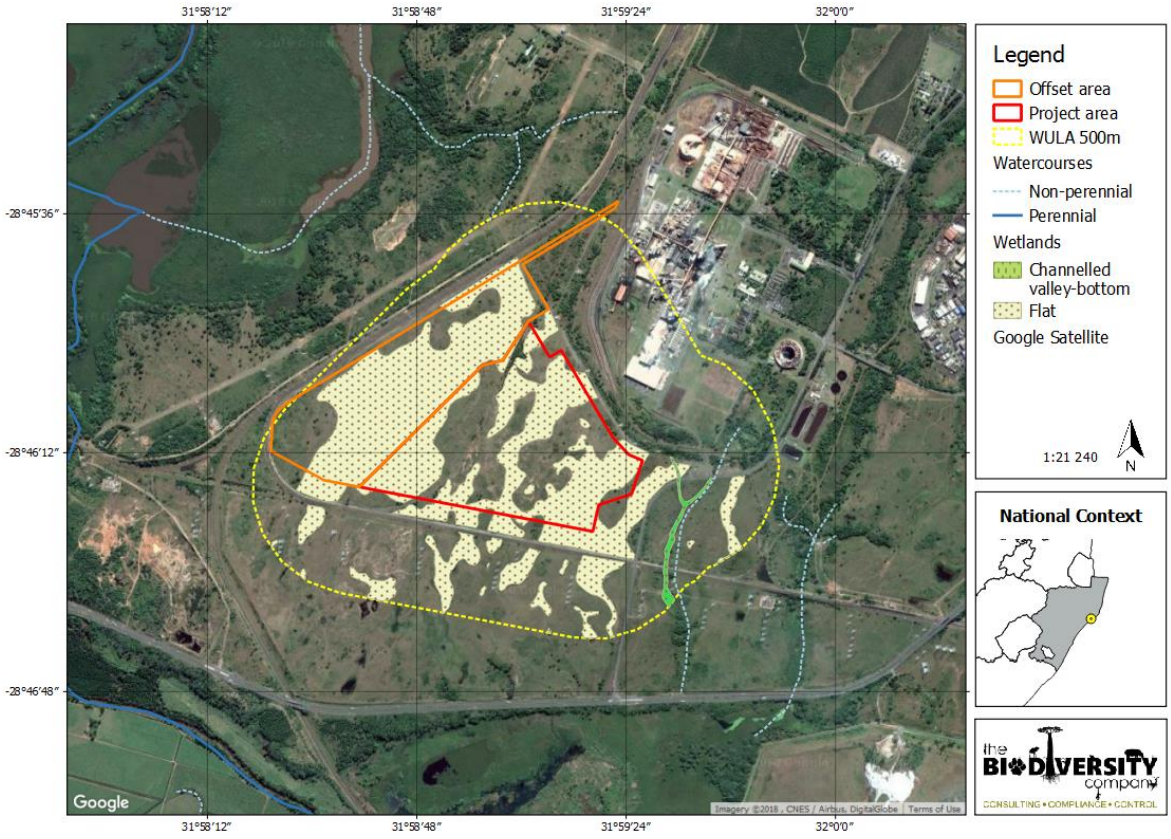

Figure 13: The delineated wetlands for the study

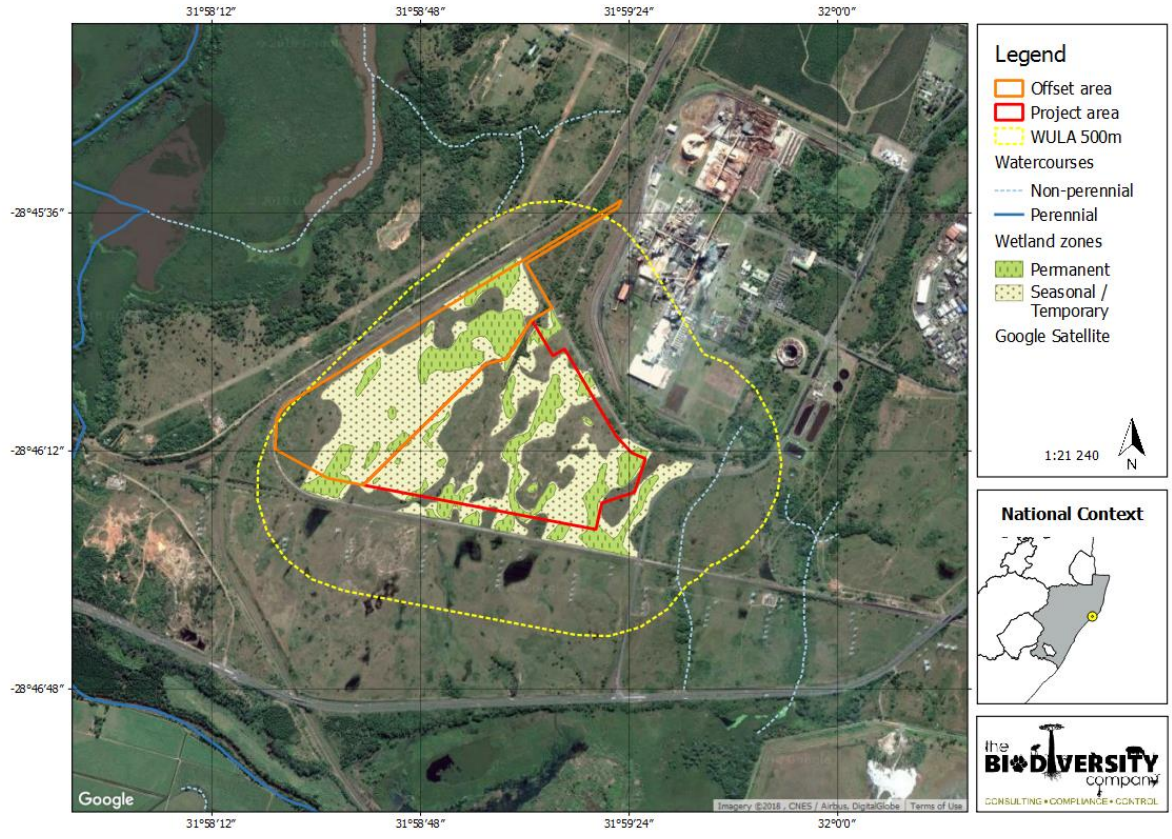

Figure 14: The delineated wetlands zones of saturation for the study

Table 10: Wetland classification as per SANBI guideline (Ollis et al. 2013)

Level 1	Level 2		Level 3	Level 4		
System	**DWS Ecoregion/s**	**NFEPA Wet Veg Group/s**	**Landscape Unit**	**4A (HGM)**	**4B**	**4C**
Inland	Natal Coastal Plain	Indian Ocean Coastal belt	Plain	Flat	N/A	N/A
Inland	Natal Coastal Plain	Indian Ocean Coastal belt	Valley Floor	Channelled Valley Bottom	N/A	N/A

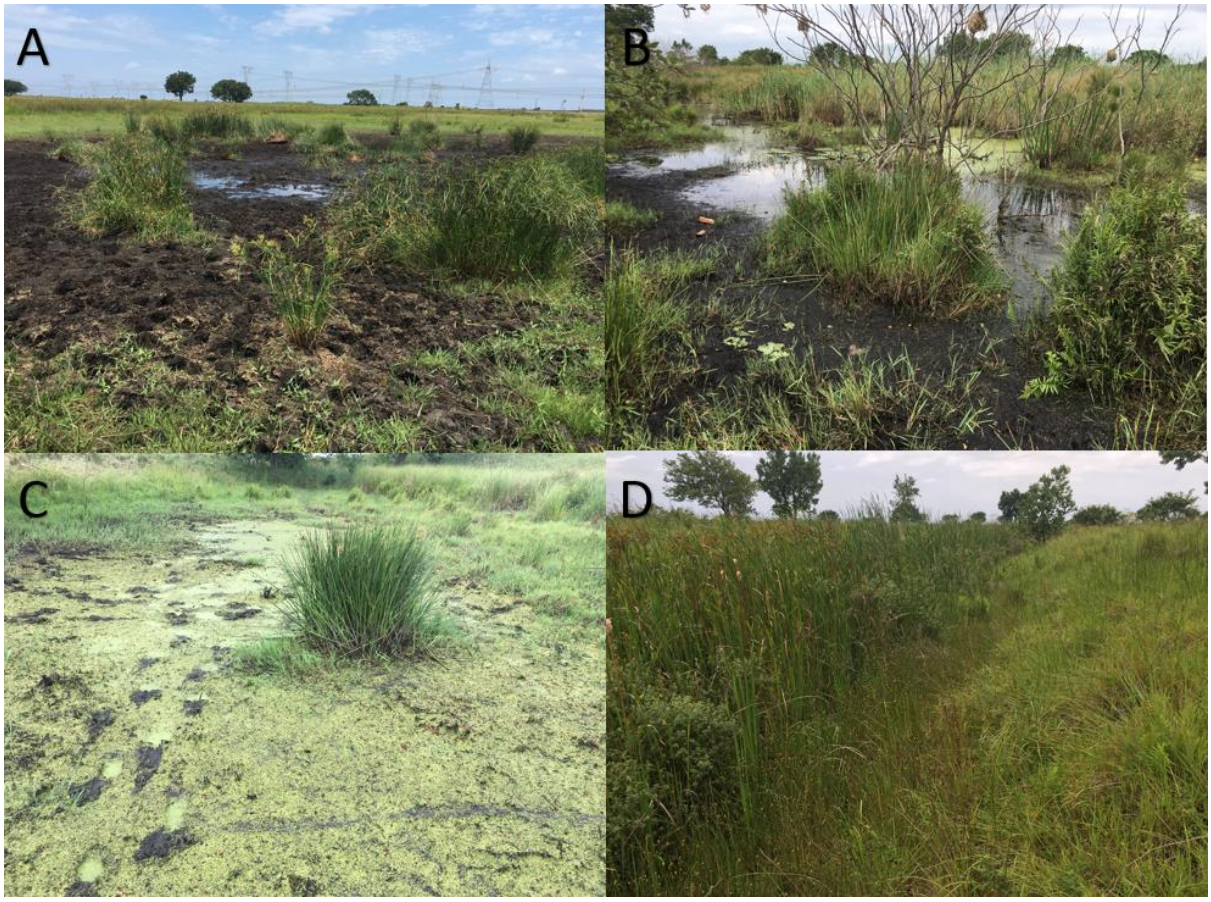

Figure 15: A photo collage of some wetland areas identified for the project (January 2018). A, B & C: Wetland flat. D: Channelled valley bottom system

Figure 16: Photographs of wetland vegetation recorded for the project. A: Eliocharus acutangular. B: Cyperus dives. C: Schoenoplectus brachyceras. D: Pycreus polystachyos. E: Setaria sphacelata var. sphacelate. F: Imperata cylindrica. G: Cyperus obtusiflorus. H: Cyperus fastigiatus (January 2018)

Figure 17: Photographs of Soil Forms and Soil Wetness considered for the study. A: Katspruit. B: Westleigh, C & D: Mottling (January 2018)

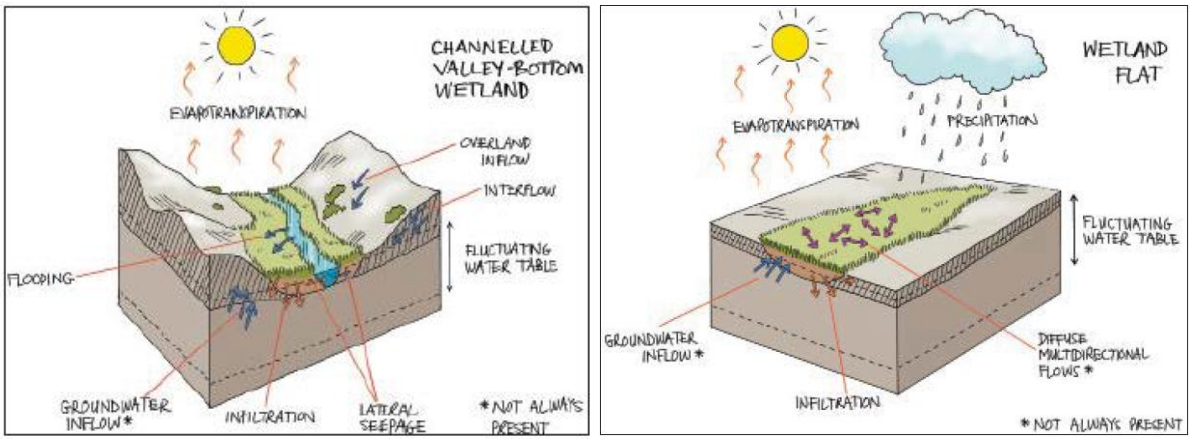

Figure 18: Conceptual illustration of wetlands, showing the typical landscape setting and the dominant inputs, throughputs and outputs of water (Ollis et al. 2013).

5.5.1 Present Ecological State

The PES for the assessed wetland areas is presented in Table 15. Photographs of aspects that have contributed to the modifications of the systems are presented in Figure 19. The overall wetland health for the wetlands for the project and biodiversity offset areas was determined to be Moderately Modified (Class C). Figure 18 depicts the PES of the wetland systems.

Figure 19: Photographs of aspects impacting on the wetlands. A: Livestock farming. B: Vehicles access. C: Harvesting of resources. D: Infrastructure and impoundments (January 2018)

The primary source of water for a wetland flat is typically precipitation, with the exception of wetland flats situated on a coastal plain where groundwater may rise to or near the ground surface (Ollis *et al.* 2013). The hydrology of the project area and the biodiversity offset area has been altered largely due to the development of the area, historical land uses and the placement of impoundments within the (project) area. The development of the area has created reduced catchment areas for the two areas, which are bordered by road and rail routes. The historical deforestation has altered the topography of the project area to some considerable extent. The rail / road routes and the deforested areas have resulted in altered flow dynamics for these areas. Surface run-off has been re-directed and concentrated in certain areas within the project area and the biodiversity offset area. Evidence of altered hydrodynamics for the wetland flats is the construction of impoundments within the lower lying areas, and the placement of culverts below the railway lines. These structures have also impeded flows across the catchment area. It was also apparent from the site visit that water

is being directed from the adjacent facility into the project area, which has also contributed to higher levels of saturation in these discharge areas.

The geomorphology of the wetlands has also been impacted on due to the historical and current land uses. The deforestation of the project area had a direct impact on portions of the wetland areas, with these areas being cleared for the harvesting of trees. Indirect impacts associated with the deforestation included the construction of access roads and stockpiles which altered the structure of the wetland areas. The current land uses, notably livestock farming has resulted in wetland areas being trampled and overgrazed. The intensive livestock farming has resulted in the onset of erosion within certain portions of the project area and biodiversity offset area, and also the expanse of wetland areas. Despite these impacts and pressures, the systems currently represent wetland flats which are characterised by multidirectional horizontal water movements.

The vegetation of the wetland systems within the project area and the offset area has been impacted on by the livestock farming practices. Vegetation within these areas has been trampled and overgrazed by cattle. Evidence of overgrazed systems and cattle paths is present within both areas. The historical land uses which included deforestation has resulted in a loss of vegetation (notably tree species) within the project area. This activity required large areas to be cleared which resulted in portions of wetland areas also being cleared, and also indirect impacts to the wetlands stemming from the deforestation activities. Wetland areas within the project area are also being harvested by local communities for resources which has also imposed pressures on these systems, due to vegetation being removed. Disturbances to both the project area and the biodiversity offset area have resulted in the establishment of alien vegetation within these areas, which included *Lantana camara, Psidium guajava* and *Schinus terebinthifolius.*

Table 11: Summary of the scores for the wetland Present Ecological State

HGM Type	Hydrology		Geomorphology		Vegetation	
	Rating	Score	Rating	Score	Rating	Score
Wetland Flats (Offset area)	C: Moderately Modified	3.5	B: Largely Natural	1.2	D: Largely Modified	4.6
Overall PES Score	3.1		Overall PES Class		C: Moderately Modified	
Wetland Flats (Project area)	C: Moderately Modified	3.5	B: Largely Natural	1.1	D: Largely Modified	4.1
Overall PES Score	3.0		Overall PES Class		C: Moderately Modified	

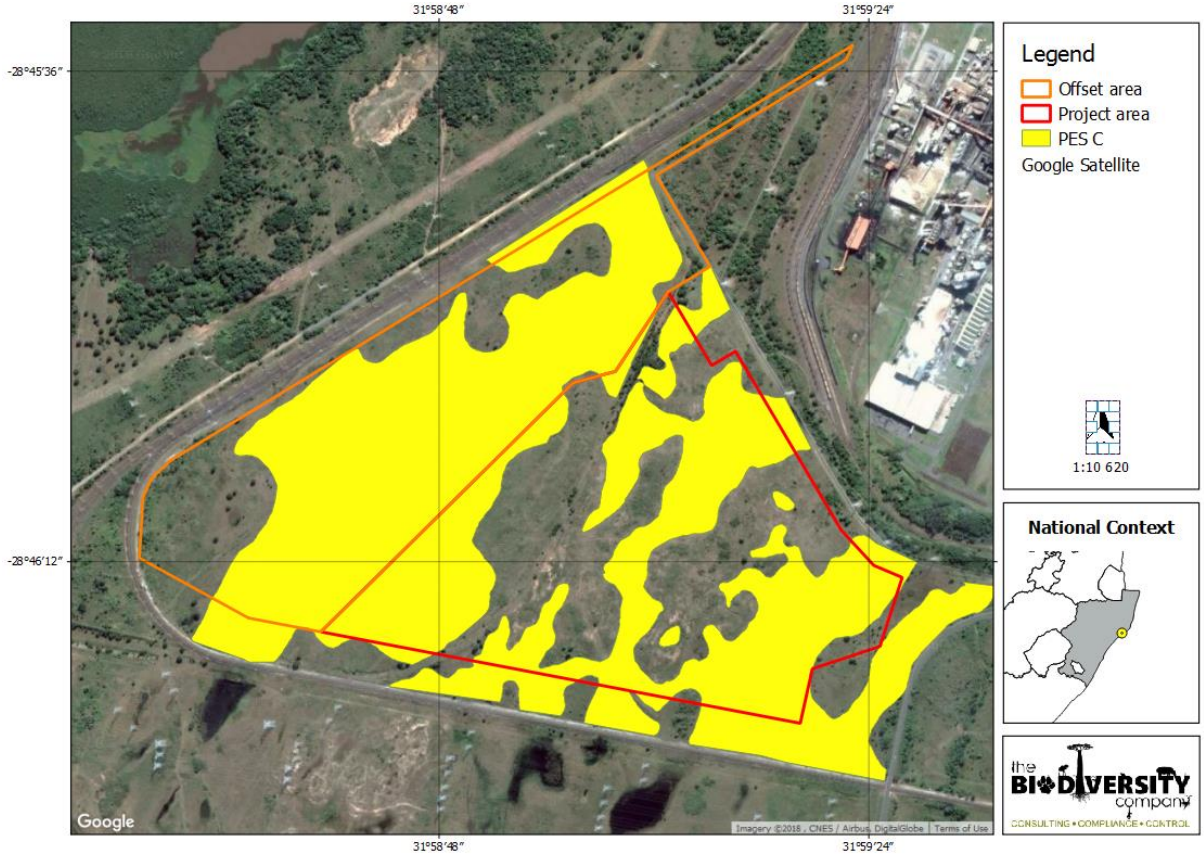

Figure 20: The depicted Present Ecological State of the wetlands

5.5.2 Ecosystem Services Assessment

The Ecosystem services provided by the HGM types present at the site were assessed and rated using the WET-EcoServices method (Kotze et al. 2009). The summarised results for the HGM types are shown in Table 12. Photographs of aspects which were considered for the assessment of ecological services is presented in Figure 21. The wetland flats for both areas had overall intermediate level of service. Table 13 presents a summary of the indirect and direct benefits associated with the two study areas. The indirect benefits associated with both areas also had an intermediate level of service. The level of service for the direct benefits was determined to be moderately low and intermediate for the offset area and project area respectively. It is also evident from the findings that the benefits associated with biodiversity are higher for the project area (moderately high) as opposed to the biodiversity offset area (intermediate).

No services providing moderately high (or higher) benefits are expected for the biodiversity offset area, with moderately high benefits expected for the project area. These moderately high benefits are associated with the enhancement of water quality, the maintenance of biodiversity and the provision of harvestable resources.

Table 12: The Eco-Services being provided by the wetland areas

Wetland Area					Project area	Offset area
Ecosystem Services Supplied by Wetlands	Indirect Benefits	Regulating and supporting benefits	Flood attenuation		1.7	1.9
			Streamflow regulation		1.2	1.3
			Water quality enhancement benefits	Sediment trapping	1.4	1.9
				Phosphate assimilation	1.7	2.1
				Nitrate assimilation	1.9	2.1
				Toxicant assimilation	1.8	2.2
				Erosion control	1.3	1.6
			Carbon storage		1.3	1.7
	Direct Benefits	Biodiversity maintenance			2.0	2.8
		Provisioning benefits	Provisioning of water for human use		0.9	1.2
			Provisioning of harvestable resources		1.4	2.6
			Provisioning of cultivated foods		0.6	1.8
		Cultural benefits	Cultural heritage		0.0	0.0
			Tourism and recreation		0.4	1.3
			Education and research		1.0	1.3
Overall					18.7	25.8
Average					1.2	1.7

Table 13: A summary of the indirect and direct benefits provided by the wetlands

Wetland Area	Project area	Offset area
Indirect Benefits (incl water quality enhancement)	1.5	1.9
Direct Benefits (social / cultural benefits)	0.7	1.4
Biodiversity maintenance (direct benefits)	2.0	2.8

Figure 21: Photographs of aspects considered for ecosystem services. A: Snake eagle (food source). B: Painted reed frog (habitat). C: Mongoose species. D: Harvesting of vegetation. E: Imperata cylindrica (seasonal zone). F: Water retention (January 2018)

5.5.3 Ecological Importance and Sensitivity

The EIS assessment was applied to the wetland areas described in the previous section in order to assess the levels of sensitivity and ecological importance of the wetland. The systems associated with the project area and offset area have been considered separately for this component of the study, with the wetland flat associated with the offset area encroaching into a portion of the project area. The results of the assessment are shown in Table 14. Figure 22 depicts the EIS of the wetland systems. The following findings from the biodiversity assessment (Rautenbach, 2018) were considered for the EIS classification:

From a vegetation perspective the sensitivities relating to the proposed development are the presence of:

- Provincially protected species, endemic species and species protected under the Natural Forest Act. Removal/destruction of tree species would require permit authorization;
- The potential presence of several Threatened flora species;
- Wetland vegetation over certain parts of the study area.

From a fauna perspective, the sensitivities relating to the proposed development are the presence of:

- *C. mariquensis* (Near Threatened) and *Hemisus guttatus* (Vulnerable) in wetland areas. A buffer zone width of 60 m around surface water bodies is proposed to protect these wetland dependent species;
- The potential presence of *Balearica regulorum* (EN);
- The presence of provincially protected bird species.

The EIS of the wetland systems was determined to be High (Class B) and Moderate (Class C) for the project area and biodiversity offset area respectively.

The hydrological / functional importance for both areas was rated as Moderate. The direct human benefits were rated as Low (Class D) and Moderate (Class C) for the biodiversity offset area and project area respectively.

Table 14: The Ecological Importance and Sensitivity results for the wetland areas

Wetland Important & Sensitivity	Wetland Flats (Offset area)	Wetland Flats (Project area)
Ecological Importance & Sensitivity	**1.8**	**2.2**
Hydrological / Functional Importance	**1.5**	**1.9**
Direct Human Benefits	**0.5**	**1.4**

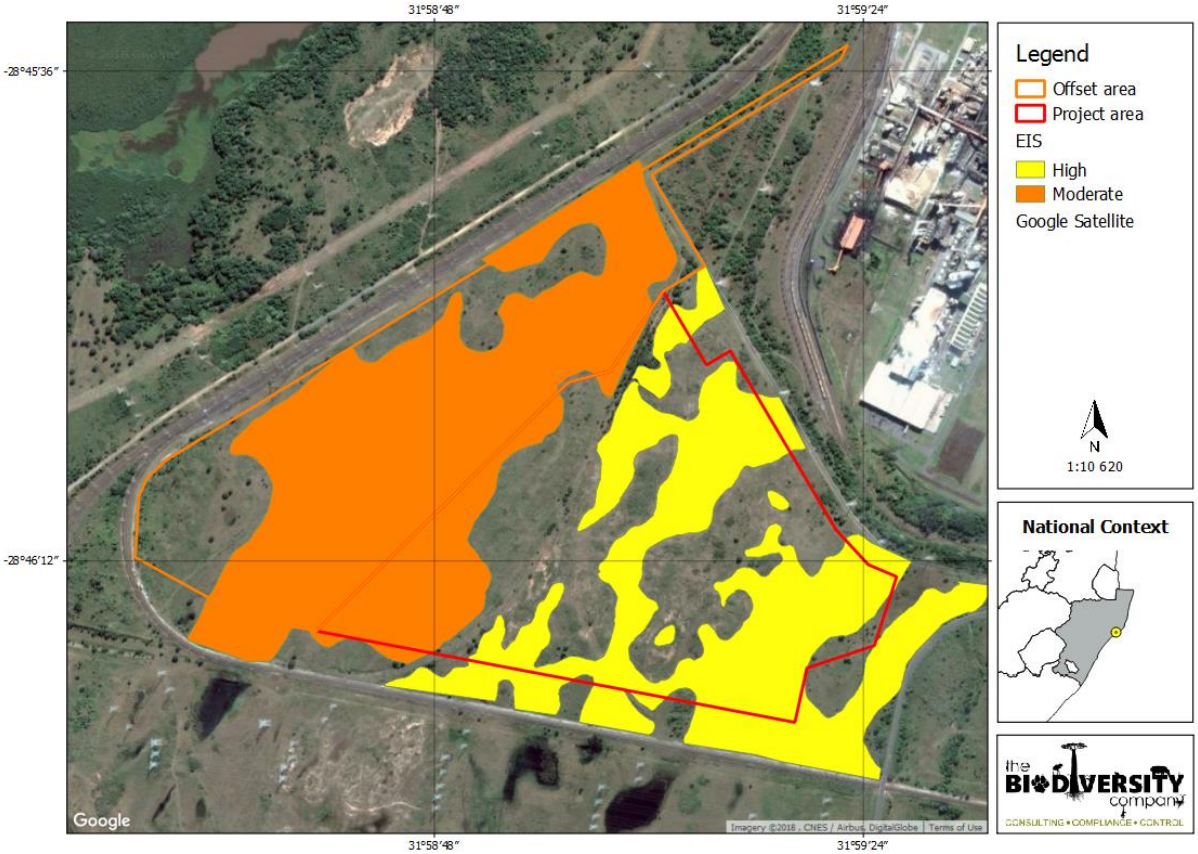

Figure 22: The depicted Ecological Importance and Sensitivity of the wetlands

5.6 Aquatic Ecology

5.6.1 *In situ* Water Quality

The water quality results of the survey are presented in Table 15.

Table 15: In situ water quality results for the January 2018 survey

Constituent	P1	P2	P3	R1	R2	Water Quality Guideline
pH	6.0	6.6	6.6	6.9	6.8	6.5–9
Temperature (°C)	30	29	31	27	28	5–30
Conductivity (µS/cm)	793	675	346	1330	6980	<700**
DO (mg/l)	2.8	5.1	4.5	3.2	5.8	>5
*Red shading indicates levels not within recommended guidelines (DWAF, 1996) **conductivity value guideline for the freshwater waterbody are based on specialist opinion						

The results of the water quality analysis indicated pH ranges from 6.0 at P1 to 6.9 at R1. Water temperatures ranged from 27°C at R1 to 31°C at P3. The concentrations of dissolved solids ranged from 346 µS/cm at P3 to 6980 at R2. The levels dissolved oxygen were found to range from 2.8 mg/l at P1 to 5.8 mg/l at R2.

The pH at the site P1 was determined to be below threshold effect concentrations for sensitive aquatic ecology. The pH of this waterbody is however anticipated to be natural. The lowered pH can be related to the abundance of detritus in the waterbody. The decomposition of the detritus and subsequent formation of carbon dioxide has contributed to a lowered pH value.

Water quality guidelines for freshwater wetland systems have not been defined. Considering this, no interpretations of water quality states can be made. However, comparisons between the waterbodies can provide an indication of the baseline conditions. In comparison to the sites P2 and P3, the levels of conductivity was determined to be elevated at the site P1. Due to the proximity of the sites to each other, this range in the conductivity seen in the freshwater wetland system has been influenced by the historical transitional activities as depicted in *Figure 6*. In addition, differences in the amount of detritus within the physical surrounding landuse have also resulted in some changes to the dissolved solid content of the freshwater wetland systems.

The riverine sampling point R1 was determined to have excessive dissolved solid content (>700 µS/cm). The source of the dissolved solids in the catchment can be attributed to the surrounding/upstream industrial activities. The levels of dissolved solids at the sampling point R2 confirms that the area is within the estuary functional zone with elevated levels of dissolved solids.

The levels of dissolved oxygen were determined to be out of range of the threshold effect levels. The low levels of dissolved oxygen are however anticipated to be natural for the area and a result of the decomposition of detritus in the wetland systems.

In conclusion, water quality within the freshwater wetland systems is variable and requires additional assessment. Water quality in the unnamed tributary on the eastern border (R1) of the project area was determined to have excessive dissolved solid content as a result of upstream/adjacent industrial activities. Water quality in the river reach immediately downstream of the project area (R2) was determined to be in line with the estuarine classification.

5.6.2 Intermediate Habitat Integrity Assessment

The results for the instream and riparian habitat integrity assessment for the aquatic systems associated with the Eastern Unnamed Tributary are presented in Table 16.

Table 16: Results for the instream habitat integrity assessment associated with the Eastern Unnamed Tributary

Criterion	Average Score	Score
Instream		
Water abstraction	0	0
Flow modification	20	10.4
Bed modification	20	10.4
Channel modification	22.5	11.7
Water quality	15	8.4
Inundation	15	6
Exotic macrophytes	0	0
Exotic fauna	0	0
Solid waste disposal	0	0
Total Instream Score		**53**
Instream Category		**class D**
Riparian		
Indigenous vegetation removal	20	10.4
Exotic vegetation encroachment	0	0
Bank erosion	5	2.8

Criterion	Average Score	Score
Instream		
Channel modification	20	9.6
Water abstraction	0	0
Inundation	20	8.8
Flow modification	20	9.6
Water quality	15	7.8
Total Riparian Score		**51**
Riparian Category		**class D**

The IHIA completed for the Eastern Unnamed Tributary determined that the riparian and instream habitat integrity was largely modified (class D). Landuse in the catchment of the river system has resulted in the cumulative deterioration of the habitat components considered in the assessment. Notably, channel, flow and bed modification has resulted in large impacts to the considered river reach. Based on the available desktop imagery, the lower reach of the river system is impounded before its confluence with the Nseleni River system. The impoundment covers a linear reach of approximately 3km, which represents 50% of the tributary system and a significant portion of the considered river reach. In addition to impacts to the instream habitat, riparian habitat has been altered through industrial development encroachment and extensive livestock and subsistence agriculture (Figure 23).

Figure 23: Livestock Agriculture in the Project Area (January 2018)

5.6.3 Aquatic Macroinvertebrates

The results of the invertebrate biotope habitat availability assessment for the study sites considered in this assessment are provided in Table 17.

Table 17: Biotope availability at the selected sites (Rating 0 (low)-5 (high))

Biotope	Weighting (Wetlands)	Weighting (Rivers	P1	P2	P3	R1
Stones in current (SIC)	1	6	0	0	0	0
Stones out of current (SOOC)	1	6	0	0	0	0
Bedrock	1	5	0	0	0	0
Aquatic vegetation	15	8	3	3	3	2
Marginal vegetation in current	1	5	0	0	0	3
Marginal vegetation out of current	15	6	2	3	3	3
Gravel	5	5	0	0	0	0
Sand	5	3	0	0	0	0
Mud	1	1	3	3	3	4
Biotope Score (X / 45)			8	9	9	9
Weighted Biotope Score (%)			35	41	41	24

The results of the biotope assessment indicated homogenous habitat features in the selected freshwater wetland systems. Invertebrate biotopes consisted largely of submerged aquatic macrophytes in the form of *Nymphaea nouchalia* (Figure 24).

Figure 24: Nymphaea nouchalia observed in the freshwater wetlands in the project area (January 2018)

Aquatic habitat in the Unnamed Eastern Tributary consisted predominately of vegetated biotope consisting of a variety of marginal plants. The absence of typical habitat in the river reach however has resulted in poor habitat availability. As a result of poor habitat availability, a low diversity of macroinvertebrates can be expected at the site R1. The aquatic macroinvertebrate results for the January 2018 survey is presented in Table 18.

Table 18: Macroinvertebrate assessment results recorded during the low flow (June 2017) survey

Site	SASS Score	No. of Taxa	ASPT*
P1	39	11	3.5
P2	55	12	4.5
P3	72	17	4.2
R1	73	17	4.3

*ASPT: Average score per taxon

The results of the macroinvertebrate assessment for the freshwater wetland systems (P1-P3) indicated a variation of diversity from 11 families at P1 to 17 families at P3. The taxa observed in the freshwater pan systems were predominantly composed of the order Hemiptera with some contributions to the overall diversity from Odonata. The effective water quality tolerances

of the macroinvertebrate assemblage was determined to be high with an ASPT ranging between 3.5 and 4.5 at the sites. This result confirms the water quality assessment. The tolerance of the invertebrate community can be attributed to the ecosystem type assessed, water quality in the freshwater wetland systems was recorded as having elevated dissolved solids and low concentrations of dissolved oxygen.

Although the diversity of macroinvertebrate families was low, on a species level it is anticipated that diversity in the freshwater wetland systems would be high given the sub-tropical nature of the region. An effective expression of the species diversity was the adult dragonfly species observed at the site (Figure 25). Eighteen species of dragonfly were observed during the survey and are presented in Table 19 with the interpretation guideline provided in Figure 26.

Figure 25: Odonate diversity observed in the project area (January 2018). A: Lestes tridens, B: Diplacodes luminans; C: Hemistigma albipunctum; D: Acisoma variegatum

Table 19: Dragonfly species observed during the January 2018 survey

Species	Common Name	Dragonfly Biotic Index (DBI)
Acisoma inflatum	Stout Pintail	2
Acisoma variegatum	Slender Pintail	2
Diplacodes lefebvrii	Black Percher	3
Diplacodes luminans	Barbet percher	3
Crocothemis erthraea	Broad Scarlet	0
Rhyothemis semihyalina	Phantom Flutterer	1
Pantala flavescens	Pantala	0
Tramea basilaris	Keyhole Glider	0
Hemistigma albipunctum	African Piedspot	3
Palpopleura jucunda	Yellow-veined Widow	2
Nesciothemis farinose	Eastern Blacktail	1
Orthetrum trinacria	Long Skimmer	1
Orthetrum caffrum	Two Striped Skimmer	3
Agriocnemis ruberrima	Orange Wisp	9
Azuragrion nigridorsum	Sailing Bluet	3
Ischnura senegalensis	Tropical Bluetail	0
Ceriagrion sp.	Citril	0
Lestes tridens	Spotted Spreadwing	3
Total Species		**18**
Total DBI		**36**
Overall DBI Score		**2**

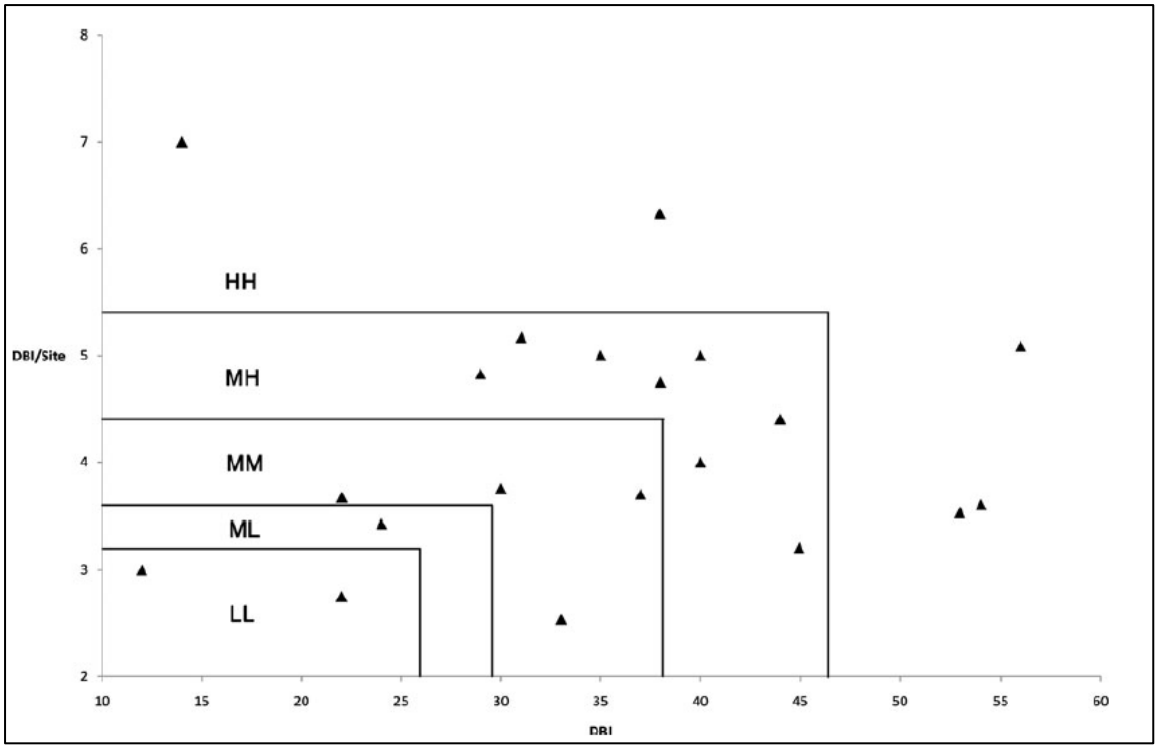

Figure 26: Dragonfly Biotic Index (DBI) interpretation guidelines (Samaika and Samways, 2012)

Based on the results of the Dragonfly Biotic Index (DBI), the project area considered was classified as MM which indicates a moderate biotope diversity at the site. Considering the low DBI score obtained at the site, a low diversity of endemic dragonfly species were observed. However, several range restricted, particularly in South Africa, dragonfly species are known from this region and therefore further investigation is required.

The results of the assessment completed in the Eastern Unnamed Tributary found poor macroinvertebrate diversity and low sensitivities. These scores are effectively representing the modified aquatic habitat and thereby confirm the poor quality of the environment associated with the Eastern Tributary. The results of the MIRAI are provided in Table 20.

Table 20: MIRAI for the Eastern Tributary from the January 2018 survey

Invertebrate Metric Group	Score Calculated
Flow modification	29
Habitat	42
Water Quality	53
Connectivity	**50**
Ecological Score	**43**
Invertebrate Category	**class D**

The results of the MIRAI indicated that the macroinvertebrate community in the Eastern Unnamed Tributary was in a largely modified state (class D). The modified state was primarily

attributed to the flow modification criterion. Flow within the considered river reach has been impacted on via several impoundments and therefore flow sensitive taxa were largely absent from the considered sample.

Overall, the macroinvertebrate assemblages sampled at the sites were effective indicators in each of the ecosystem types considered.

5.6.4 Fish Assessment

A single fish species, *Enteromius viviparous,* was sampled during the January 2018 survey. The fish species was restricted to the P1 within a freshwater wetland ecosystem. During the survey, no direct surface flow between the wetland system at P1 or the Eastern Unnamed Tributary was observed or is expected during un-exceptional flow periods.

The low levels of fish species in the freshwater wetland systems corroborates that there is limited connectivity with the adjacent river systems. It is anticipated that only during periods of severe flooding, will connectivity within the wetlands areas allow for the movement of fish into the wetland systems. No fish species were sampled in the Eastern Unnamed Tributary despite extensive sampling. The absence of fish species from the Eastern Unnamed Tributary could largely be attributed to sampling effort and method. Dissolved solid content in the river reach reduced the effective use of the electroshocker.. An expected fish species list for the project area is provided below (Table 21).

Table 21: Expected freshwater fish species in the W12H-3459 Sub Quaternary Reach

Expected fish species	Observed	IUCN status
Micropanchax johnstoni	No	LC
Micropanchax katangae	No	LC
Micropanchax myaposae	No	LC
Enteromius gurneyi	No	LC
Enteromius paludinosus	No	LC
Enteromius trimaculatus	No	LC
Enteromius viviparus	No	LC
Clarias gariepinus	No	LC
Ctenopoma multispine	No	LC
Clarias theodorae	No	LC
Marcusenius macrolepidotus	No	LC
Oreochromis mossambicus	No	NT
Pseudocrenilabrus philander	No	LC
Coptodon rendalli	No	LC
Tilapia sparrmanii	No	LC

As observed above, a total of 15 fish species are expected to be in the river reaches associated with the proposed project. However, it is noted that no estuarine fish species were considered in this assessment and therefore there will likely be additional fish species in the downstream river reach.

A single listed fish species was expected to occur on the project site. The fish species was *Oreochromis mossambicus* which is threatened by hybridisation. Thus, the proposed project presents no risk to the threatened species.

5.6.5 Present Ecological State

The results for the reach based PES assessment (Kleynhans and Louw, 2007) is presented in Table 22.

Table 22: PES of the Eastern Unnamed Tributary January 2018

Aspect assessed	Ecological Score	Ecological Category
Instream Ecological Category	53	class D
Riparian Ecological Category	51	class D
Aquatic Invertebrate Ecological Category	43	class D
Ecostatus	**45**	class D

The results of the PES assessment derived a largely modified ecological category (class D) for the considered river reach. The modified status of the river reach can be attributed to a combination of flow modification, habitat and water quality related drivers.

6 Impact Assessment

6.1 Existing Impacts

The following existing impacts were observed in or adjacent to the project and offset areas:

- The development of the area has altered the surface flow dynamics, creating directional surface run-off across the assessed areas. Water typically exits a wetland flat through evapotranspiration and infiltration (Ollis et al. 2013), which has been inhibited due to the changes in topography and slope for the catchment area.
- Hydrological inputs from the adjacent facility has altered the hydrological regimes of portions of the project area, with these portions experiencing prolonged periods of saturation. These inputs have also contributed to an increase in water volume for the project area.
- The removal of vegetation due to historical deforestation of the project area, and current livestock farming in the area. Livestock farming has resulted in vegetation being trampled and overgrazed.
- Historical disturbances and current land uses have resulted in the onset and establishment of alien vegetation across the project and offset areas.
- Industrial activities in the upper reaches of the Eastern Unnamed Tributary have resulted in the modification of the aquatic environment (class D). Cumulative impacts in the form of a large impoundment have further altered the natural hydrology of the Eastern Unnamed Tributary.

6.2 Potential Impacts

The proposed project will result in the loss and modifications of water resources, notably the delineated wetland areas. The following list provides a framework for the anticipated impacts associated with the project.

1. Loss / degradation of wetlands
    a. Project activities that can cause loss of habitat
        i. Physical removal of vegetation
        ii. Soil excavations
        iii. Dewatering of working areas
        iv. Access roads and servitudes
        v. Construction camps & laydown areas
        vi. Infrastructure development
        vii. Linear trench excavation and berm creation
        viii. Soil dust precipitation
        ix. Vehicle, machine and facility emissions
        x. Stochastic events such as fire (cooking fires or cigarettes from staff)
    b. Secondary impacts anticipated
        i. Loss of shallow recharge zones
        ii. Increased potential for soil erosion (in conjunction with alterations in hydrological regimes)
        iii. Increased potential for establishment of alien & invasive vegetation
        iv. Loss of ecosystem services
2. Spread and/or establishment of alien and/or invasive species
    a. Project activities that can cause the spread and/or establishment of alien and/or invasive species
        i. Vegetation removal
        ii. Soil excavations and soil transportation
        iii. Transportation vehicles potentially spreading seed while moving on, to and from working areas
        iv. Unsanitary conditions surrounding infrastructure promoting the establishment of alien and/or invasive rodents
        v. Creation of infrastructure suitable for breeding activities of alien and/or invasive birds
3. Environmental pollution due to increased sedimentation and erosion of watercourses
    a. Project activities that can cause pollution in water courses
        i. Erosion
        ii. Clearing of vegetation
        iii. Earth moving (removal and storage of soil)
        iv. Blasting and excavation
        v. Soil dust precipitation
    b. Secondary impacts associated with pollution in water courses
        i. Groundwater pollution
        ii. Loss of ecosystem services
4. Impaired water quality (surface and groundwater)
    a. Project activities that can cause pollution in watercourses
        i. Clearing of vegetation, erosion of exposed areas
        ii. Chemical (organic/inorganic) spills

iii. Untreated runoff or effluent
iv. Elevated water temperatures
v. Soil dust precipitation
vi. Produce stockpiles and storage

5. Alterations in hydrological regime (flow of surface and sub-surface water)
    a. Project activities that can cause alterations in hydrological regime
        i. Vegetation removal
        ii. Excavations and infrastructure development
        iii. Road network creation
        iv. Alterations to surface topography (due to voids and surface structures)
        v. Dewatering or changes to groundwater interactions
    b. Secondary impacts associated with alterations in hydrological regime
        i. Loss of ecosystem services
        ii. Worsening of the ecological status of wetlands
        iii. Increased or reduced runoff dependent on system manipulation
        iv. Loss of soil fertility and topsoil recharge through interruption of seasonal recharge and natural flow, including natural sedimentation
        v. Scouring and erosion of wetlands

6.3 Assessment of Significance

The proposed project will result in the loss of wetland areas, and the subsequent loss of ecological services. This loss is the key consideration for the impact assessment, with the loss of wetland areas unavoidable. No mitigation is possible for the loss of wetlands, and a wetland offset strategy is therefore required.

An impact assessment has been conducted for the remaining wetland portions which will not be lost as a result of the facility, these systems are likely to be impacted on by indirect aspects. The significance of these impacts is far less when compared to the loss of the wetland area (and the extent thereof), but equally important to assess and mitigate.

The tables below show the significance of potential impacts associated with the proposed project before and after implementation of mitigation measures.

Nature: Loss /degradation of wetlands – Project life		
The most notable impact is the expectant loss of some water resources, the delineated wetlands in particular. The significance of the loss if regarded as high, and because avoidance is not possible for this project, mitigation has not been considered and the significance remains high for the duration of the project.		
	Without mitigation	**With mitigation**
Extent	Moderately high	Moderately high
Duration	Permanent	Permanent
Magnitude	Very high	Very high
Probability	Definite	Definite
Significance	**High**	**High**
Status (positive or negative)	Negative	Negative
Reversibility	None	None
Irreplaceable loss of resources?	Definite	Definite

Can impacts be mitigated?	No	No
Mitigation:		
The loss of wetland is unavoidable with the proposed layout. The only alternative would be to consider avoiding the wetland areas which is not regarded as mitigation. Additionally, the proposed layout will also impact on the surface and groundwater linkages sustaining these wetland flats. In the event that the project is approved, local stakeholders and authorities must be consulted for the feasibility and requirements for a wetland offset strategy.		
The wetland offset strategy must identify and quantify the wetland offset target. The types of offsets available must be described, and options for due consideration in determining the offset provided. A key component of this strategy would be to ensure the securing of the proposed offsite areas by means of proclamation. Approval of the wetland offset strategy is required before construction can be initiated. Additionally, the proclamation is required prior to construction.		
Residual Risks:		
Expected to be considerably high due to the loss of these wetland areas.		

Nature: Spread and/or establishment of alien and/or invasive - Construction		
This impact is of greatest concern during the construction phase of the project, when ideal opportunities are plentiful and conditions optimal for the establishment of alien vegetation in the area. The spread of alien invasive vegetation within the wetland systems can be exacerbated if not properly managed and may even introduce new alien species to sensitive areas as a result of disturbance.		
	Without mitigation	**With mitigation**
Extent	Moderate	Low
Duration	Short term (2-5 years)	Short term (2-5 years)
Magnitude	High	Low
Probability	Most likely	Some possibility, but low likelihood
Significance	**Medium**	**Low**
Status (positive or negative)	Negative	Negative
Reversibility	Medium	Medium
Irreplaceable loss of resources?	Some possibility, but low likelihood	Distinct possibility
Can impacts be mitigated?	Yes	Yes
Mitigation:		
An alien invasive plant management plan needs to be compiled and implemented prior to construction to control and prevent the spread of invasive aliens, Clean vehicles on-site, and prioritize vehicles gaining access from surrounding areas		
Residual Risks:		
Expected to be Low if mitigation measures are properly implemented.		

Nature: Sedimentation and erosion of watercourses - Construction
Construction activities will temporarily denude the vegetation on the site and expose the soils to the erosive elements. Changes in the topography (more slopes) due to the placement of stockpiles and clearing / shaping of areas is also likely to increase the run-off volumes and velocities across the site. This could be exacerbated by the increase in the extent of hardened surfaces. These aspects will all contribute to soil erosion, resulting in the loss of topsoil and formation of erosion gullies. Water resources may become laden with sediment, resulting the loss of habitat and impaired water quality. Sedimentation of these systems will also reduce the holding volume of the systems, possibly reducing the ephemeral lifespan on the systems.

	Without mitigation	With mitigation
Extent	Moderate	Moderately low
Duration	Short term (2-5 years)	Short term (2-5 years)
Magnitude	High	Moderate
Probability	Most likely	Some possibility, but low likelihood
Significance	**Medium**	**Low**
Status (positive or negative)	Negative	Negative
Reversibility	Medium	Medium
Irreplaceable loss of resources?	Some possibility, but low likelihood	Distinct possibility
Can impacts be mitigated?	Yes	Yes
Mitigation:		
Compilation of a soil stripping guideline to preserve high value topsoil for rehabilitation. Also input into the location of stockpiles away from preferential flow paths. Where possible, reduce the footprint area of exposed ground during periods of high rainfall. Prioritize vegetation clearing for the winter months as much as possible. The disturbance footprint area must be kept to a minimum and clearly demarcated. Existing headcuts must be rehabilitated during the construction phase. Compile a suitable stormwater management plan, Construct cut-off berms downslope of working areas. Exposed areas must be ripped and vegetated to increase surface roughness. Create energy dissipation at discharge areas to prevent scouring, Temporary and permanent erosion control methods may include silt fences, retention basins, detention ponds, interceptor ditches, seeding and sodding, riprap of exposed areas, erosion mats, and mulching. Rehabilitation: Compacted areas must be ripped (perpendicularly) to a depth of 300mm. A seed mix must be applied to rehabilitated and bare areas. Any gullies or dongas must also be backfilled. The area must be shaped to a natural topography.		
Residual Risks:		
Expected to be Low if mitigation measures are properly implemented.		

Nature: Impaired water quality – Construction / Operation		
Threats to the water quality will be present during the construction and operational phases of the project. During the construction phase water quality is at risk due to erosion of the area, resulting in sedimentation of the water resources. There is a continuous risk of malfunctioning equipment and machinery, or poorly maintained vehicles that will leak or spill contaminants into the systems. The management and disposal of all forms of waste will be a risk for the duration of the project. During the operational phase of the project, impacts to the water quality due to leaks /spillages or increased temperatures would need to be managed. Dirty water may not be permitted for release into the environment, nor pumped into the groundwater system.		
	Without mitigation	**With mitigation**
Extent	Moderate	Moderately low
Duration	Permanent	Permanent
Magnitude	High	Moderate
Probability	Most likely	Distinct possibility
Significance	**High**	**Medium**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	None	None

Can impacts be mitigated?	Yes	Yes
Mitigation:		
Contractors used for the project must have spill kits available to ensure that any fuel or oil spills are clean-up and discarded correctly. A suitable stormwater management plan must for formulated for the project. The plan must ensure that clean and dirty water are separated, that only clean water is diverted into the water resources and that the discharge of water will not result in scouring and erosion of the receiving systems. Dirty water must be treated and within acceptable DWS drinking water standards (or aquatic ecosystem standards) before being discharged. As much material must be pre-fabricated and then transported to site to avoid the risks of contamination associated with mixing, pouring and the storage of chemicals and compounds on site. All chemicals and toxicants used during construction and operation must be stored in bunded areas. All machinery and equipment should be inspected regularly for faults and possible leaks, these should be serviced off-site (pre-use inspection). All servicing and re-fueling of machines and equipment must either take place off-site, or in controlled and bunded working areas. Adequate sanitary facilities and ablutions on the servitude must be provided for all personnel throughout the project area. Use of these facilities must be enforced (these facilities must be kept clean so that they are a desired alternative to the surrounding vegetation). Have appropriate action plans on site, and training for contactors and employees in the event of spills, leaks and other potential impacts to the aquatic systems. All waste generated on-site during construction must be adequately managed. Separation and recycling of different waste materials should be supported. Should a chemical spill take place, an aquatic ecologist must be contracted to identify the extent of the impact and assist with additional mitigation measures.		
Residual Risks:		
Expected to be Medium if mitigation measures are properly implemented.		

Nature: Alterations in hydrological regime - Construction		
The primary source of water for a wetland flat is typically precipitation, with the exception of wetland flats situated on a coastal plain where groundwater may rise to or near the ground surface (Ollis et al. 2013). The development of the area will result in a loss of catchment area, thus reducing the amount of run-off sustaining the systems. It is expected that run-off will be diverted around the working area to separate clean and dirty water, by-passing some wetland flat systems. The extent of compaction of the area will also reduce the infiltration potential of the area, resulting in a reduction of the shallow recharge area. The expected excavations, shaping and contours will also alter the topography of the project area, resulting in changes to the surface flow dynamics across the catchment. The removal of vegetation, compounded by the hardening of surfaces will also result in an increase in run-off volumes and velocities for the area.		
	Without mitigation	**With mitigation**
Extent	Moderate	Moderately low
Duration	Short term (2-5 years)	Short term (2-5 years)
Magnitude	High	Moderate
Probability	Most likely	Some possibility, but low likelihood
Significance	**Medium**	**Low**
Status (positive or negative)	Negative	Negative
Reversibility	Medium	Medium
Irreplaceable loss of resources?	Some possibility, but low likelihood	Distinct possibility
Can impacts be mitigated?	Yes	Yes
Mitigation:		
Rehabilitation of the working areas must be concurrent with the construction phase of the project, where possible. Any loss/alteration of flow dynamics must be quantified, and mitigation options to re-introduce water in a safe and environmentally friendly way must be assessed. Compile a suitable stormwater management plan. Divert clean water around the project area, and consider a release into rock-filled trenches within the project area.		

Rehabilitation: All voids must be backfilled, and surface temporary infrastructure must be removed from the project area. Compacted areas must be ripped (perpendicularly) to a depth of 300mm. A seed mix must be applied to rehabilitated and bare areas. Any gullies or dongas must also be backfilled. The area must be shaped to a natural topography. Trees (or vegetation stands) removed must be replaced. No grazing must be permitted to allow for the recovery of the area.		
Residual Risks:		
Expected to be Low if mitigation measures are properly implemented.		
Nature: Alterations in hydrological regime - Operation		
The placement of the facility within the catchment will result in the permanent loss of catchment area. This will result in a loss of infiltration area, affects to the groundwater table (probably rising) and altered surface flow dynamics.		
	Without mitigation	**With mitigation**
Extent	Moderate	Moderately low
Duration	Permanent	Permanent
Magnitude	High	Moderate
Probability	Most likely	Distinct possibility
Significance	**High**	**Medium**
Status (positive or negative)	Negative	Negative
Reversibility	Medium	Medium
Irreplaceable loss of resources?	Some possibility, but low likelihood	Some possibility, but low likelihood
Can impacts be mitigated?	Yes	Yes
Mitigation:		
Compilation of a soil stripping guideline to preserve high value topsoil for rehabilitation. Also input into the location of stockpiles away from preferential flow paths. Where possible, reduce the footprint area of exposed ground during periods of high rainfall. Prioritise vegetation clearing for the winter months. The disturbance footprint area must be kept to a minimum and clearly demarcated. Existing headcuts must be rehabilitated during the construction phase. Compile a suitable stormwater management plan, Construct cut-off berms downslope of working areas. Exposed areas must be ripped and vegetated to increase surface roughness. Create energy dissipation at discharge areas to prevent scouring, Temporary and permanent erosion control methods may include silt fences, retention basins, detention ponds, interceptor ditches, seeding and sodding, riprap of exposed areas, erosion mats, and mulching.		
Residual Risks:		
Expected to be high due to the loss of these wetland areas.		

6.4 Cumulative Impact

The results of the impact assessment indicate that there will be a negative impact to water resources in the considered study area. The most notable impact will be the loss of wetland areas, and the subsequent loss of ecological services provided by these systems. The following overview is provided:

- The Richards Bay Coal Railway line has caused fragmentation of the water resources, specifically the wetland areas which are traversed by the railway line. Further development of the area, including an informal dirt access road has also contributed further fragmentation of the water resources. These developments have resulted in the direct loss of wetland areas.
- The development of the project area and surrounds, has resulted in a loss of catchment area, and altered surface flow hydrodynamics. Catchment areas have not only been

reduced, but surface flow has been impeded and diverted through culvert systems, reducing the potential for infiltration.

- The historical and current land uses have impacted on the wetland and riverine systems both directly and indirectly. The deforestation of the area has resulted in wetland areas being partially cleared to accommodate access. The current land use of livestock farming has resulted in the wetland areas being trampled and overgrazed. As the greater area is developed, more intensive livestock farming is expected due to the limited area available for this land use. These disturbances have also resulted in the onset and establishment of alien vegetation in the wetland systems.

Nature: Cumulative impact		
The project area is located within the Richards Bay Industrial Development Zone, an area earmarked for the future development of various industries. Impacts associated with these developments will probably be similar to impacts expected from the currently proposed project.		
	Overall impact of the proposed project considered in isolation	**Cumulative impact of the project and other projects in the area**
Extent	Moderately high	High
Duration	Permanent	Permanent
Magnitude	Very high	Very high
Probability	Definite	Definite
Significance	**High**	**High**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Definite	Definite
Can impacts be mitigated?	No	No
Mitigation:		
Taking into consideration the nature of the proposed project, resulting in the loss and modifications to water resources, and also the historical loss / impacts of water resources, mitigation for this loss is highly unlikely. A wetland offset strategy must be compiled for the expectant loss of wetland area. The strategy should not only consider the expect loss of wetland for this project, but rather a cumulative loss for the larger catchment areas.		
Residual Risks:		
Expected to be Low if mitigation measures are properly implemented.		

6.5 Environmental Management Programme

An Environmental Management Program (EMPr) for the proposed development is required in terms of Sections 2 and Section 28 of the National Environmental Management Act (1998). The EMPr is a legally binding document on the applicant as a condition of approval of the Project by the Department of Environment Affairs and Development Planning (DEADP), in addition to other conditions that may be stipulated in the Record of Decision / Environmental Authorisation.

Table 23 and Table 24 present the recommended mitigation measures and the respective timeframes and responsibilities for the loss of, and impacts to the wetland areas.

Table 23: Mitigation measures including requirements for timeframes and responsibilities for the loss of wetlands

Objective: Compensate for the loss of wetlands			
Project components	Infrastructure Development		
Potential impacts	Loss of wetland area, and services		
Activity / risk source	Vegetation / soil clearing. Excavations. Loss of groundwater connectivity. Loss of interflow. Completely altered geology.		
Target / objective	Compensation for a net-gain of in hectare equivalent, specifically for functional value		
Mitigation Measures		**Timeframe**	**Responsibility**
The loss of wetland is unavoidable, and the only mitigation would be to avoid the wetland area. *A wetland offset strategy must be compiled for the project. A key component of this strategy would be to ensure the securing of the proposed offsite areas by means of proclamation. The proposed offsite area/s may not be subjected by further development or any other land use / activity within the foreseeable future.*		Pre-Authorisation	Applicant / EAP / Wetland specialist

Table 24: Mitigation measures including requirements for timeframes and responsibilities for impacts to wetlands

Objective: Limit impacts to the remaining on-site wetland areas		
Project components	Infrastructure Development & operation of the facility	
Potential impacts	Degradation of remaining wetland areas, and impaired services	
Activity / risk source	Vegetation / soil clearing. Excavations. Spills / leaks. Sedimentation of resources. Waste handling and disposals. Altered stormwater. Loss of groundwater connectivity. Loss of interflow. Completely altered geology.	
Target / objective	Minimise the impacts to the remaining on-site wetland areas, to enable these systems to provide key ecological services	
Mitigation Measures	**Timeframe**	**Responsibility**
Rehabilitation of the working areas must be concurrent with the construction of the project. Any loss/alteration of flow dynamics must be quantified, and mitigation options to re-introduce water in a safe and environmentally friendly way must be assessed.	Operation Closure	Applicant / Contractor
Separate clean and dirty water. Construct diversion berms and drains around working areas. Incorporate green /soft engineering storm water measures. Avoid unnecessary vegetation clearing, and avoid preferential surface flow paths. No cleaning of vehicles, machines and equipment in water resources. No servicing of machines, vehicles and equipment on site, unless in designated areas which can accommodate leaks and spills. Storage of potential contaminants in bunded areas. All contractors must have spill kits available, and be trained in the correct use thereof. *All released water must be within DWAF (1996) water quality standards for aquatic ecosystems, and discharge must be managed to avoid scouring and erosion of the receiving systems. Contaminated water must not be discharged into the watercourses. Clean and dirty water must be separated. This water could be looked at for treatment and then re-introduced to mitigate losses to the catchment yield.* *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 must be provided for all personnel throughout the project area, Have action plans on site, and training for contactors and employees in the event of spills, leaks and other impacts to the aquatic systems; All waste generated on-site must be adequately managed. Separation and recycling of different waste materials should be supported.*	Construction Operation	Applicant / Contractor
Compile a suitable stormwater management plan, Construct cut-off berms downslope of working areas, demarcate footprint areas to be cleared to avoid unnecessary clearing, Exposed areas must be ripped and vegetated to increase surface roughness, Create energy dissipation at discharge	Construction Operation	Applicant / Contractor

areas to prevent scouring, Temporary and permanent erosion control methods may include silt fences, retention basins, detention ponds, interceptor ditches, seeding and sodding, riprap of exposed areas, erosion mats, and mulching.		
Separate clean and dirty water, continue with surface water and biomonitoring programmes. All chemicals and toxicants during construction must be stored in bunded areas. All machinery and equipment should be inspected regularly for faults and possible leaks, these should be serviced off-site. 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 must be provided for all personnel throughout the project area. Have action plans on site, and training for contactors and employees in the event of spills, leaks and other impacts to the aquatic systems. All waste generated on-site must be adequately managed. Separation and recycling of different waste materials should be supported.	Construction Operation	Applicant / Contractor
An alien invasive plant management plan needs to be compiled and implemented prior to construction to control and prevent the spread of invasive aliens, Clean vehicles on-site, and prioritise vehicles gaining access from surround areas.	Construction Operation Closure	Applicant / Contractor
All voids must be backfilled, and surface infrastructure must be removed from the site. Soils must be replaced in the correct sequence / profile. Compacted areas must be ripped (perpendicularly) to a depth of 300mm. A seed mix must be applied to rehabilitated and bare areas. Any gullies or dongas must also be backfilled. The area must be shaped to a natural topography. Trees (or vegetation stands) removed must be replaced. No grazing must be permitted to allow for the recovery of the area. Attenuation ponds mimicking flats should be created in in the area to retain water in the catchment.	Closure	Applicant

6.6 Recommendations

These recommendations may supplement the prescribed mitigation measures, but these recommendations must be investigated prior to the issuing of environmental authorisation. These recommendations must be investigated for the feasibility to realistically achieve what is intended for this project. The following recommendations are applicable for this project:

1. In the event that wetland areas will be impacted on, or lost, a wetland offset (mitigation) strategy is required. A key component of this strategy would be to ensure the securing of the proposed offsite areas by means of proclamation. The proposed offsite area/s may not be subjected by further development or any other land use / activity within the foreseeable future.
2. It is recommended that this wetland study be updated once the groundwater investigation has been completed. Findings from the groundwater study may provide further insight into the hydropedology and interflow characteristics of the project and offset areas.
3. Aquatic and Wetland Biomonitoring is recommended on an annual basis. A specialist component recommended to be included in the aquatic biomonitoring programme is the Odonata monitoring.

6.7 Offset considerations

A Memorandum of Agreement (MoA) dated August 2006 was entered into between Ezemvelo KwaZulu-Natal Wildlife and the uMhlathuze Municipality in respect of the rehabilitation plan for a portion of site 1D of the Richards Bay Industrial Development Zone (IDZ) to be utilised by Pulp United. It is understood that the intended project (2006) has not, and will not materialise, and this agreement is now being considered for the Richards Bay CCPP. Table 28 presents corresponding comments on the suitability of the proposed offset area/s. Whilst this study does not constitute a formal wetland offset strategy, and taking into account the project recommendations herein, the following aspects are noteworthy:

- An offset strategy is required in order to determine the appropriate offset allocation in order to provide appropriate and adequate compensation for residual impacts. The objectives of the offset should be:
    - A no-net loss of wetland functional area from the local landscape;
    - A no-net loss, or gain, in local wetland biodiversity; and
    - The offset site should be stable and self-sustaining.
- The proposed offset area must be secure by means of formal protection so as to contribute to meeting national biodiversity and protection targets for the representation and persistence of different wetland types.
- Wetlands within the project area can also be rehabilitated for the improvement in wetland condition, function, and associated biodiversity. Rehabilitation involves the manipulation of the physical, chemical, or biological characteristics of a degraded wetland system in order to repair or improve wetland integrity and associated ecosystem services.

Table 25: General guidelines on the suitability of offsite wetlands for meeting water resource and ecosystem service requirements (Macfarlane et al., 2014), and corresponding comments

Criterion	Site attributes	Acceptability Guidelines	Comment
Wetland type	Wetland is of the same type as the impacted wetland.	Ideal	The wetlands on both portions are ideal
	Wetland is of a different type to the impacted wetland.	Acceptable	
Key services targeted	Selected wetland is well placed to contribute meaningfully towards improving key regulating and supporting services identified.	Ideal	
	Selected wetland is reasonably placed to improve key regulating and supporting services identified.	Acceptable	The wetlands are in separate catchment areas, in the upper reaches

	Selected wetland is poorly placed to improve key regulating and supporting services identified.	Generally unacceptable	
Offset site location relative to impacted wetland	Selected wetland is located within the same local catchment as the impacted wetland. Selected wetland is located within the same local catchment as the impacted wetland.	Ideal	The wetlands are in separate catchment areas, in the upper reaches
	Selected wetland is located within the same quaternary catchment.	Acceptable	
	Selected wetland is located within the same tertiary catchment.	Generally unacceptable	
	Selected wetland is located in a different tertiary catchment.	Generally unacceptable	

7 Conclusion

A total of two (2) HGM types were identified and delineated for the project, namely a channelled valley bottom wetland and wetland flat types.

The focus for the project area and the offset area were the wetland flat type wetlands, and not the channelled valley bottom wetland which is not located within the project area. The ecological assessments were therefore being prioritized for, and focussed on the wetland flats.

Approximately 91 ha of wetlands have been delineated for the project, with approximately 38 ha and 53 ha being delineated for the project area and biodiversity offset area respectively.

The overall wetland health for the wetlands for the project and biodiversity offset areas was determined to be Moderately Modified (Class C).

The wetland flats for both areas had overall intermediate level of service. The indirect benefits associated with both areas also had an intermediate level of service. The level of service for the direct benefits was determined to be moderately low and intermediate for the biodiversity offset area and project area respectively. It is also evident from the findings that the benefits associated with biodiversity are higher for the project area (moderately high) as opposed to the offset area (intermediate). No services providing moderately high (or higher) benefits are expected for the biodiversity offset area, with moderately high benefits expected for the project area.

The EIS of the wetland systems was determined to be High (Class B) and Moderate (Class C) for the project area and biodiversity offset area respectively. The hydrological / functional importance for both areas was rated as Moderate. The direct human benefits were rated as Low (Class D) and Moderate (Class C) for the biodiversity offset area and project area respectively.

The aquatic biodiversity of the freshwater wetlands was determined to be high. The PES of the Eastern Unnamed Tributary was found to be largely modified (Class D). A single listed fish

species was expected to occur on the project site. The fish species was *Oreochromis mossambicus* which is threatened by hybridisation. Thus, the proposed project presents no risk to the threatened species.

The proposed project will result in the loss of wetland areas, and the subsequent loss of ecological services. This loss is the key consideration for the impact assessment, with the loss of wetland areas unavoidable. No mitigation is possible for the loss of wetlands, and a wetland offset plan is therefore required.

An impact assessment has been conducted for the remaining wetland portions which will not be lost as a result of the facility, these systems are likely to be impacted on by indirect aspects. The significance of these impacts is far less when compared to the loss of the wetland area (and the extent thereof), but equally important to assess and mitigate

The impacts associated with the proposed project are high in significance, particularly for the expected loss of wetland area. The loss of wetland area cannot be mitigated, and a wetland offset plan must be conducted to compensate for this loss. The impact significance for the remaining project aspects varied from high to medium without mitigation, but this significance is reduced to between medium and low, based on the assumption that mitigation measures will be implemented.

Careful consideration must be afforded to each of the recommendations provided herein, specifically the requirements for a wetland offset strategy. In the event that environmental authorisation is issued for this project, proven ecological (or environmental) controls and mitigation measures must be entrenched in the management framework. It is strongly recommended that a comprehensive biodiversity (encompassing wetlands) action plan be compiled prior to the issuing of any environmental authorisation.

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Preliminary Wetland Offset Plan for the proposed Richards Bay Combined Cycle Power Plant (CCPP) and Associated Infrastructure near Richards Bay

uMhlathuze, KwaZulu-Natal

February 2019

CLIENT

Prepared for:

Eskom Holdings SOC

Prepared by:

The Biodiversity Company

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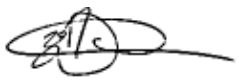
Report Writer	**Ndumiso Dlamini** **(Pr. Sci. Nat 116579)**	
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Report Writer / Reviewer	**Andrew Husted** **(Pr. Sci. Nat. 40213/11)**	
Andrew Husted is Pr. Sci. Nat registered (400213/11) in the following fields of practice: Ecological Science, Environmental Science and Aquatic Science. Andrew is an Aquatic, Wetland and Biodiversity Specialist with more than 12 years' experience in the environmental consulting field. Andrew has completed numerous wetland training courses, and is an accredited wetland practitioner, recognised by the DWS, and also the Mondi Wetlands programme as a competent wetland consultant		
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 Environmental Impact Assessment Regulations, 2017. 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 principals of science.		

Note: Photographs from the project area (January 2018)

Executive Summary

The Biodiversity Company was commissioned to compile a Wetland Offset Plan to supplement the requirements in support of the relevant environmental authorisations and licences pertaining to the Richards Bay Combined Cycle Power Plant (CCPP) project in the Richards Bay area, within the uMhlathuze Local Municipality.

The Richards Bay CCPP involves the construction of a gas-fired power station which will provide mid-merit power supply to the electricity grid. The potential impacts of the proposed project were determined to be the irreversible loss of 28ha of wetland habitat within the project site. A preliminary wetland offset plan is therefore required to propose options to compensate for significant residual impacts and offset the loss of these wetlands.

The technique described in the SANBI & DEA Guidelines for Wetland Offsets (2016) was used as the technical basis on which to calculate the recommended offset target. The principles of this approach have been developed with the aid and use of the national Working for Wetlands wetland rehabilitation programme.

The project area (Erf 2/11376 and Erf 4/11376) is located in Richards Bay on the north coast of KwaZulu-Natal. A biodiversity offset area was proposed for Erf 1/11376, adjacent to the project area was considered for the wetland baseline assessment.

The offset area (Erf 1/11376) adjacent to the project was previously proposed as a biodiversity offset area in the Memorandum of Agreement (MoA) dated August 2006 between the uMhlathuze Local Municipality and Ezemvelo. The wetlands within this portion, for the purpose of this report will be referred to as MoA wetlands and the offset area as MoA offset area to limit ambiguity. The MoA further includes three sites that were intended to be proclaimed under the National Environmental Management: Protected Areas Act as nature reserves. These areas include Lake Nsezi, Southern Sanctuary and Lake Mzingazi which are referred to as KZN Ezemvelo Stewardship sites in this report.

A total of two (2) HGM types were identified and delineated for the project area, namely channelled valley bottom wetland and wetland flat types. A single channelled valley bottom was identified and delineated beyond the eastern boundary of the project area. Several wetland flats were identified in the project area and the original offset area.

A total of 28 ha and 30 ha of wetland habitat was delineated for the project area and offset area respectively. It is assumed that the proposed project will result in the direct loss of 28 ha wetlands within the project area (only). The initial biodiversity offset area has 30 ha of wetland habitat associated with it. The wetlands to be lost were determined to have a Class C PES score, and intermediate level of service and a High (B) EIS. The minimum target to offset the loss of wetland habitat was determined to be 19.6 ha to offset the functionality and 13.9 ha to offset the ecosystem services. The species conservation targets were not calculated as the target species were not confirmed on the project area.

The MoA wetlands within the proposed (original) offset area were Class C PES score, and intermediate level of service and a moderate (C) EIS, much like the wetlands to be lost. The offset contributions of the wetlands were determined to be 2 ha to offset the functionality and 24 ha to offset the ecosystem conservation. Although, the candidate offset wetlands were

determined to be acceptable according to the priority matrix and the ecosystem offset target is met, there are several factors that make this option unsuitable for the proposed offsetting of wetlands to be lost, the greatest of which is the deficit in the offset of the functionality and expected management difficulty of the offset area.

An alternative wetland offset plan (Option 2) was identified with the aid of KZN Ezemvelo. The plan entails three areas earmarked by KZN Ezemvelo for inclusion in their stewardship programme. The three areas cover a combined approximate area of 2531 ha of which 1924 ha (76%) is water resources (wetland). As a result of the proposed stewardship, 1924 ha of wetland would be available to offset the expectant loss of wetlands through the development of the Richards Bay CCPP. The wetlands within the three areas were grouped into a single wetland group for the purpose of wetland offset calculation and a worst-case scenario, 50% functionality. This offset option would result in a net-gain of 361.4 ha of wetland in terms of functionality and 1910.1 ha of wetland in terms of the ecosystem conservation.

The stewardship would further result in the wetlands and areas around the wetlands being placed under protection by KZN Ezemvelo and benefit from the nature conservation management program which would increase the biodiversity value of the areas over time instead of the expected decline in the current state.

The stewardship areas are considered Rank 2 Estuarine habitats and a Rank 2 Floodplain habitat that is marked as crane habitat. The Ecosystem Threat Status is considered Critical (CR) for all the habitat within the areas. The KZN CBA considers the habitat occurring within the areas as irreplaceable. The proposed stewardship offset option would benefit the local area in terms of habitat preservation, water resources preservation and ecosystem restoration and preservation.

The preliminary wetland offset plan offers a conceptual solution as to the requirements of a final wetland offset plan. It is important to note that the preliminary plan is designed under various conditions which are as follows:

1. The preliminary plan considered the Memorandum of Agreement between KZN Ezemvelo and uMhlathuze Municipality. In the MoA, Lake Nzesi, Lake Mzingazi and Southern Sanctuary area were to be proclaimed as nature reserves. It is therefore assumed that the proposed offset for this project will include all three (3) stewardship areas. Furthermore, it is the opinion of the specialist that securing and protecting these three areas would be the best possible path of action in wetland offsets.
2. Eskom, the project developers, will aid KZN Ezemvelo fulfil the requirements of the MoA in terms of proclamation of the areas as nature reserves. The management of these nature reserves will be the sole responsibility of the nature conservation board, in this instance KZN Ezemvelo. Eskom will not be required to manage, partly or wholly, these areas in terms of financial requirements and resources (human and equipment).
3. The implementation of any rehabilitation measures and work required within the areas once proclaimed will be the responsibility of KZN Ezemvelo. Eskom may support in this instance depending on costs incurred during the process of proclamation and related exercises.

4. It must be expressly stated that, should this preliminary plan be approved, Eskom must not be expected to undertake a separate offset plan or rehabilitation of wetlands apart from those resulting from the proposed project and related activities.

In light of all the information, it is therefore recommended that the KZN Ezemvelo Stewardship Programme offset option be considered as not only will wetland loss be outweighed by wetland gains to be offset, the option would offer wetland conservation and protection at a catchment level and contribute to the national requirements for water resource conservation.

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1 Introduction

The Biodiversity Company was commissioned to compile a Wetland Offset Plan to supplement the requirements in support of the relevant environmental authorisations and licences pertaining to the Richards Bay Combined Cycle Power Plant (CCPP) project in the Richards Bay area, within the uMhlathuze Local Municipality.

The Richards Bay CCPP involves the construction of a gas-fired power station which will provide mid-merit power supply to the electricity grid. The potential impacts of the proposed project were determined to be the irreversible loss of 28ha of wetland habitat within the project site. A preliminary wetland offset plan is therefore required to propose options to compensate for significant residual impacts and offset the loss of these wetlands.

This report presents the results of a wetland ecological review on the environments associated with the proposed project and the development of a wetland offset plan for the wetlands to be lost as a result of the project. This report should be interpreted after taking into consideration the findings and recommendations provided by the wetland specialist herein. Further, this report should inform and guide the Environmental Assessment Practitioner (EAP) and regulatory authorities, enabling informed decision making, as to the ecological viability of the proposed project.

1.1 Aim and Objective

The aim of the assessment was to provide information to guide the offset plan compiled for the proposed CCPP project with respect to the wetland systems which are proposed to be lost as a result of the project. As part of this wetland offset assessment, the following objectives were established:

- The determination of the offset targets;
- Identification of candidate wetlands for offset; and
- The prescription of rehabilitation measures and recommendations for identified offset wetland areas.

2 Description of the Project Area

The project area (Erf 2/11376 and Erf 4/11376) is located in Richards Bay on the north coast of KwaZulu-Natal, approximately 170 km north of Durban, in the uMhlathuze Local Municipality. A biodiversity offset area was proposed for Erf 1/11376, which was considered for the wetland baseline delineation and impact assessment. A locality map of the project area is presented in Figure 1. Figure 2 presents the project and proposed (original) biodiversity offset area on a local scale.

The project area is approximately 71 ha in extent. The project area is located within the Pongola - Mtamvuna Water Management Area (WMA 4) within the W12F quaternary catchment. One Sub Quaternary Reach (SQR) will be potentially affected by the proposed project.

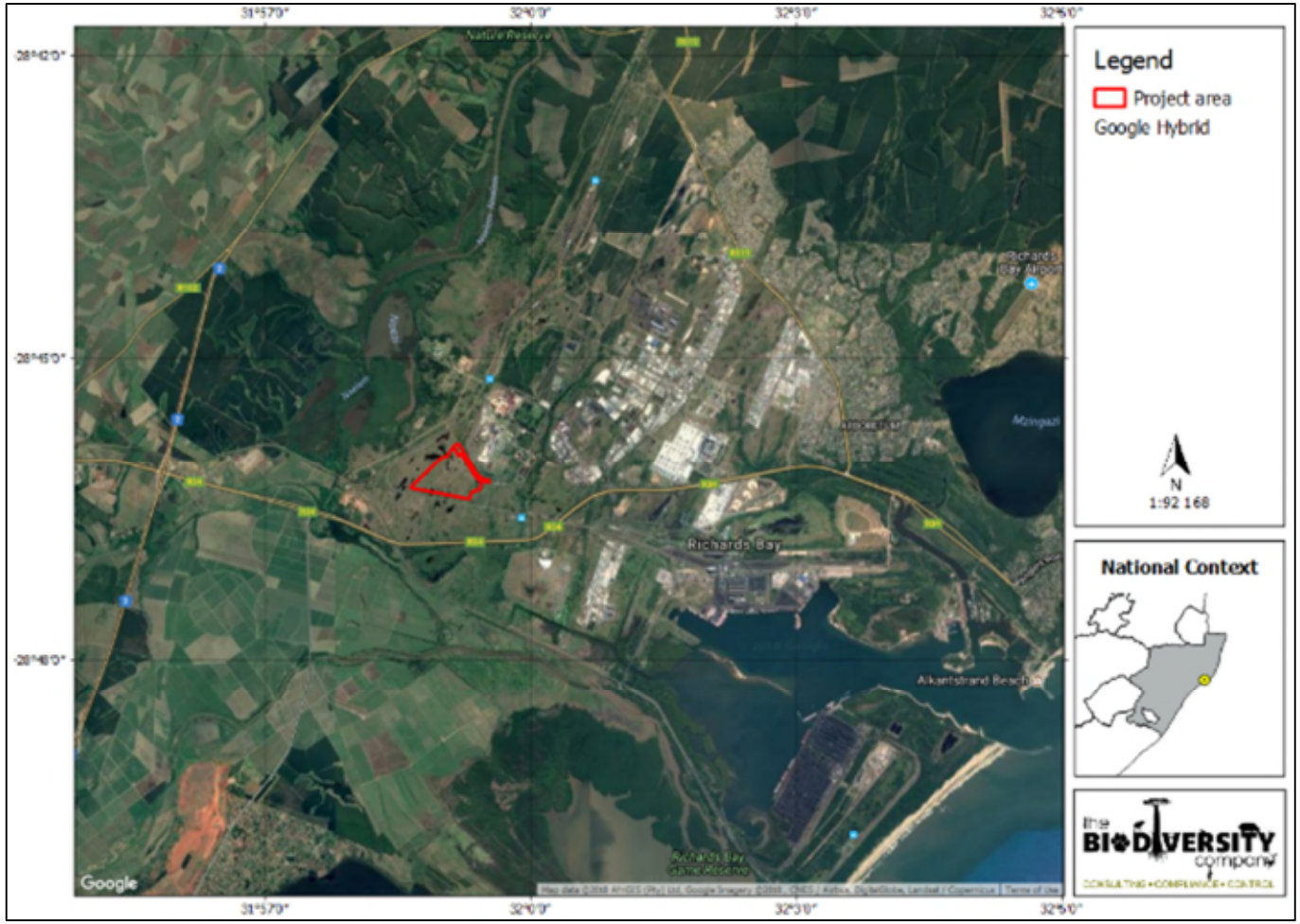

Figure 1: Location of the Richards Bay CCPP project area

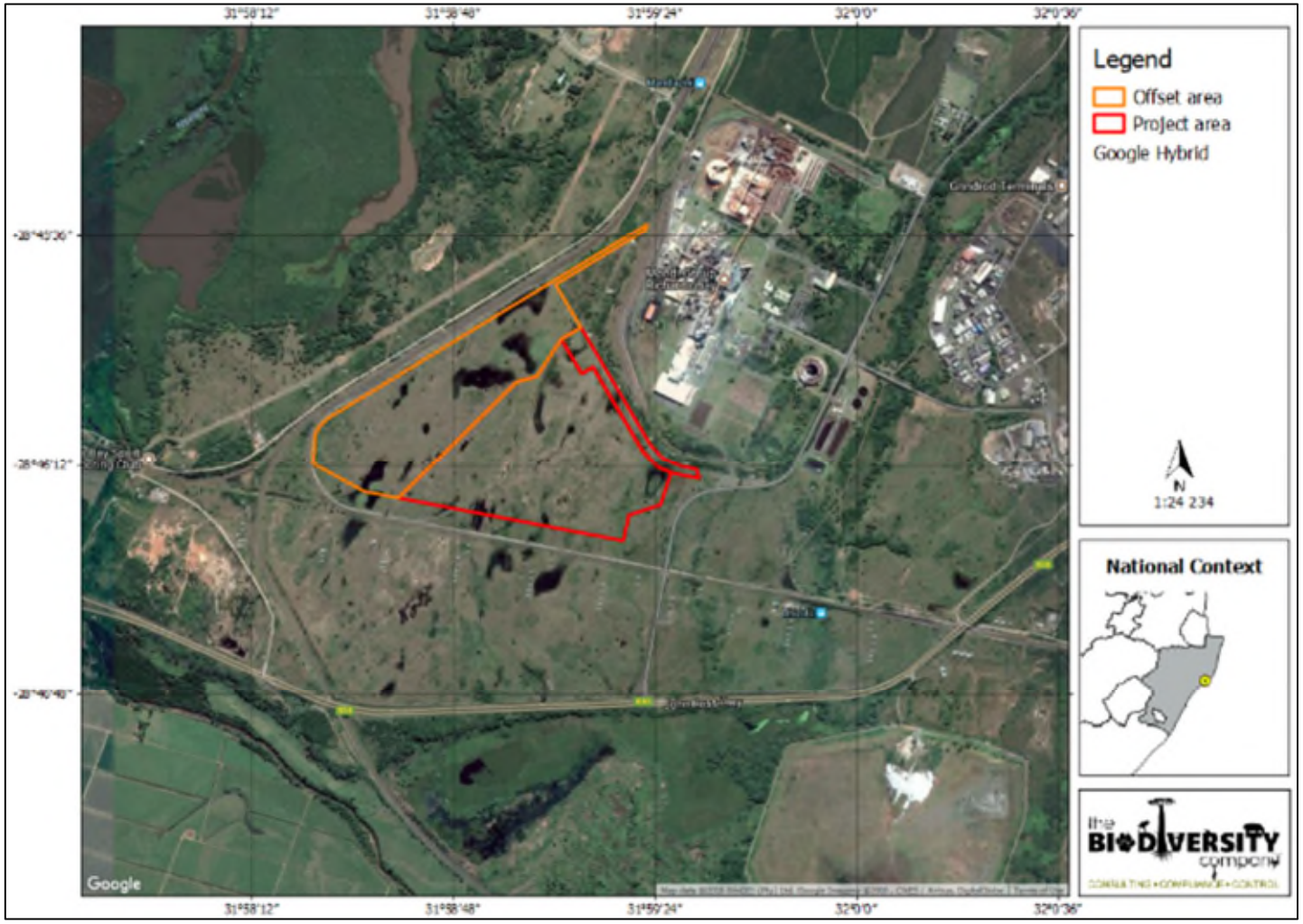

Figure 2: A closer locality map for the project area and proposed offset area

2.1 Property Area

The offset area adjacent to the project was previously proposed as a biodiversity offset area in the Memorandum of Agreement (MoA) between the Municipality and Ezemvelo dated August 2006. The biodiversity offset was based on the 1 hectare loss of the KwaMbonambi Grassland System due to the Pulp United proposed development at the time. The offset would be a consolidated 10 hectares of new area to be rehabilitated that would result in a viable KwaMbonambi grassland system so as to achieve no net loss in quality and quantity of these critically endangered grasslands. The proposed development was however never undertaken, although the principles of the biodiversity offset that had been established in the MoA still have relevance and need to be considered according to Ezemvelo. The wetlands within this portion, for the purpose of this report will be referred to as MoA wetlands and the offset area as MoA offset area to limit ambiguity.

The MoA further includes three sites that were intended to be proclaimed under the National Environmental Management: Protected Areas Act 57 of 2003 as nature reserves. These areas include Lake Nsezi, Southern Sanctuary and Lake Mzingazi which are referred to as KZN Ezemvelo Stewardship sites in this report.

3 Wetland Offset Rationale

The underlying principle of biodiversity offsets is to reach “no net loss” and preferably a “net gain” in terms of the functions and values provided by wetlands. The wetland offset guidelines (SANBI & DWS, 2016) describe “no net loss” as the principle that implies that losses resulting from the project and the gains achieved through wetland offsets balance out. Wetland offsets fall within the biodiversity offsets with focus being placed on the wetland ecosystems. The consideration and implementation of a wetland offset is considered to be the last and least favoured option within the mitigation hierarchy as presented in Figure 3.

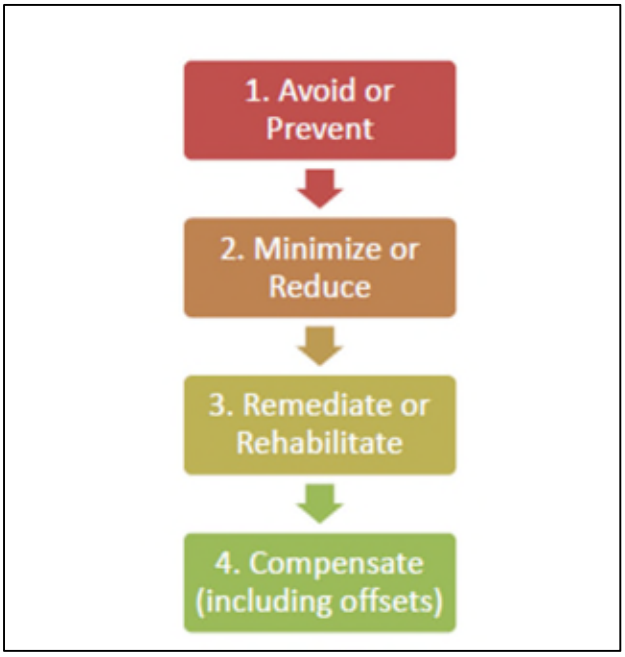

Figure 3: Mitigation hierarchy (Wetland Offset Guidelines, 2016)

A total wetland area of 28 ha and 30 ha were delineated for the project area and the adjacent proposed MoA biodiversity offset area respectively. The proposed development of the Richards Bay CCPP project will likely result in the direct loss of 28 hectares of wetland habitat, which equates to 100% of the wetland area delineated for the project area. The expected loss of wetlands evokes the need for a wetland offset plan. The goals for wetland offsets (SANBI & DWS, 2016) in the South African context, according to the guidelines, are:

1. Providing appropriate and sufficient compensation for significant residual impacts to wetlands by:
    a. Appropriate and sufficient gains in wetland functional area and condition that is equal to or greater than the losses due to negative impacts.
    b. Direct Offset activities that will improve the key regulating and supporting ecosystem services.
    c. Ensuring appropriate and sufficient compensation for important ecosystem services provided by wetlands so that the proposed offset measures improve the position of affected communities.
2. Contributing to meeting the national biodiversity and conservation targets; and
3. Adequate compensation for residual impacts to threatened and important species, including wetland dependant species.

In the attempt to achieve the goals for the wetland offsets, the following options may be considered:

- Protection: through legal mechanisms such as declaration of a protected environment under the National Environmental Management: Protected Areas Act.

- Averted loss: physical activities which prevent the loss or degradation of wetland areas (such as the stabilisation of head cut erosion or removal of alien plants).
- Rehabilitation: the manipulation of physical, chemical or biological attributes of a degraded system such as to improve the functioning.
- Establishment: the development of new wetland systems where none existed to replace wetland areas that are lost as a result of a project.
- Direct compensation: this involves directly compensating affected parties for the ecosystem services lost as a result of a project.

4 Approach

4.1 Wetland Assessment

A key component in the requirements for a wetland offset is the determination of the wetland boundary, wetland functionality and health. Figure 4 presents the requirements for a wetland assessment prior to the determination of the required offset targets. The wetland assessment for the proposed project has been completed in a report titled “Water Resource Report for the proposed Richards Bay Combined Cycle Power Plant (CCPP) and associated infrastructure near Richards Bay” that was compiled by The Biodiversity Company (2018) and the findings are summarised in Section 6.1.

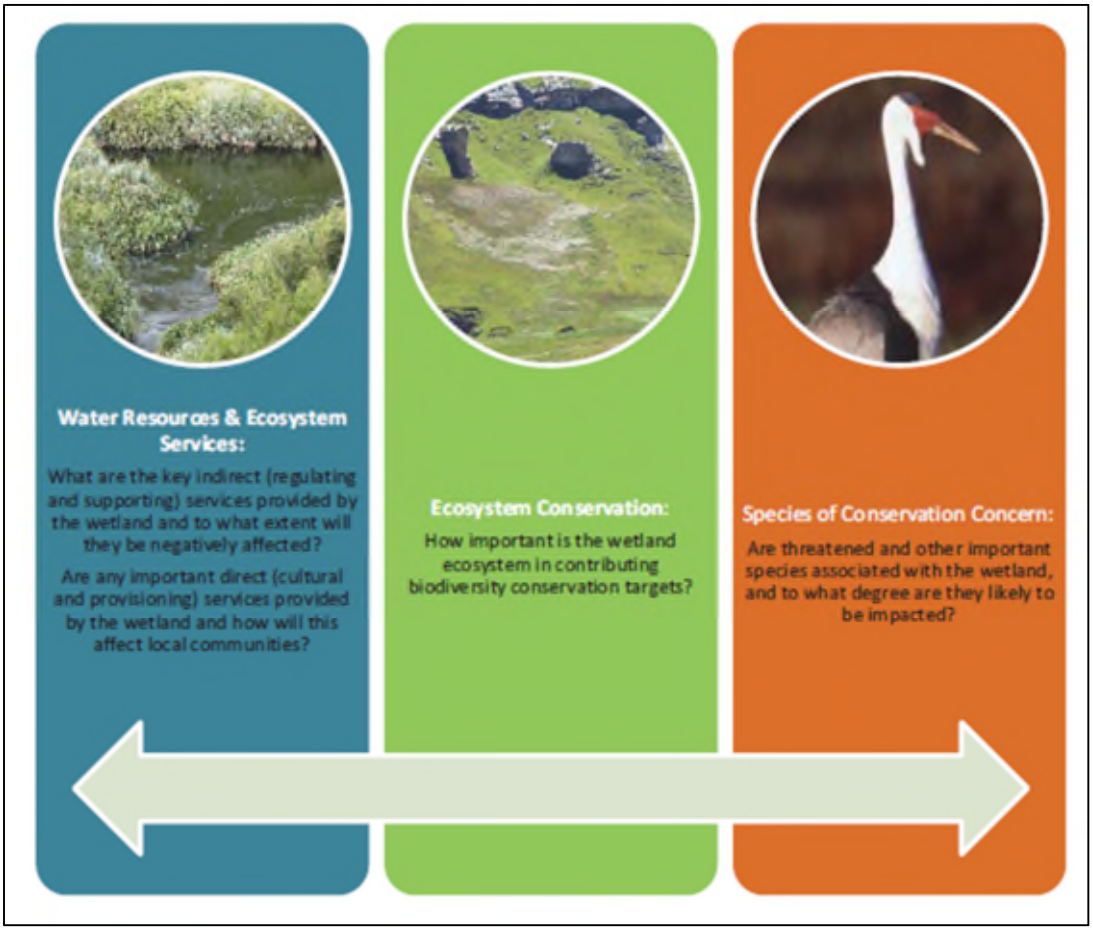

Figure 4: The key components to consider prior to wetland offset determination (SANBI and DEA, 2016)

4.2 Wetland Offset Calculation

The technique described in the SANBI & DEA Guidelines for Wetland Offsets (2016) was used as the technical basis on which to calculate the recommended offset target. The principles of this approach have been developed with the aid and use of the national Working for Wetlands wetland rehabilitation programme. Although not without limitations accurate, the technique does offer a way to independently and objectively audit both the setting of quantitative rehabilitation objectives, and the effectiveness of rehabilitation/ restoration in achieving these objectives once an offset plan has been implemented.

In conforming to these guidelines, the wetland hectare-equivalent value of the wetland within the pre-development scenario was calculated. A hectare equivalent is a quantitative expression of the ecological integrity of a wetland unit under a given land-use. It represents the common currency that enables the wetland functional area restored to the landscape through the means listed in Section 3 to be compared to that removed from the landscape by a development. Most environmental authorities advocate a no-net-loss of resources approach, be it to biodiversity or wetland functioning, and the hectare equivalent provides the conceptual means of judging whether the wetland condition or functionality requirements have been satisfied. The outline of the calculation of functional hectare equivalents is presented in Figure 5.

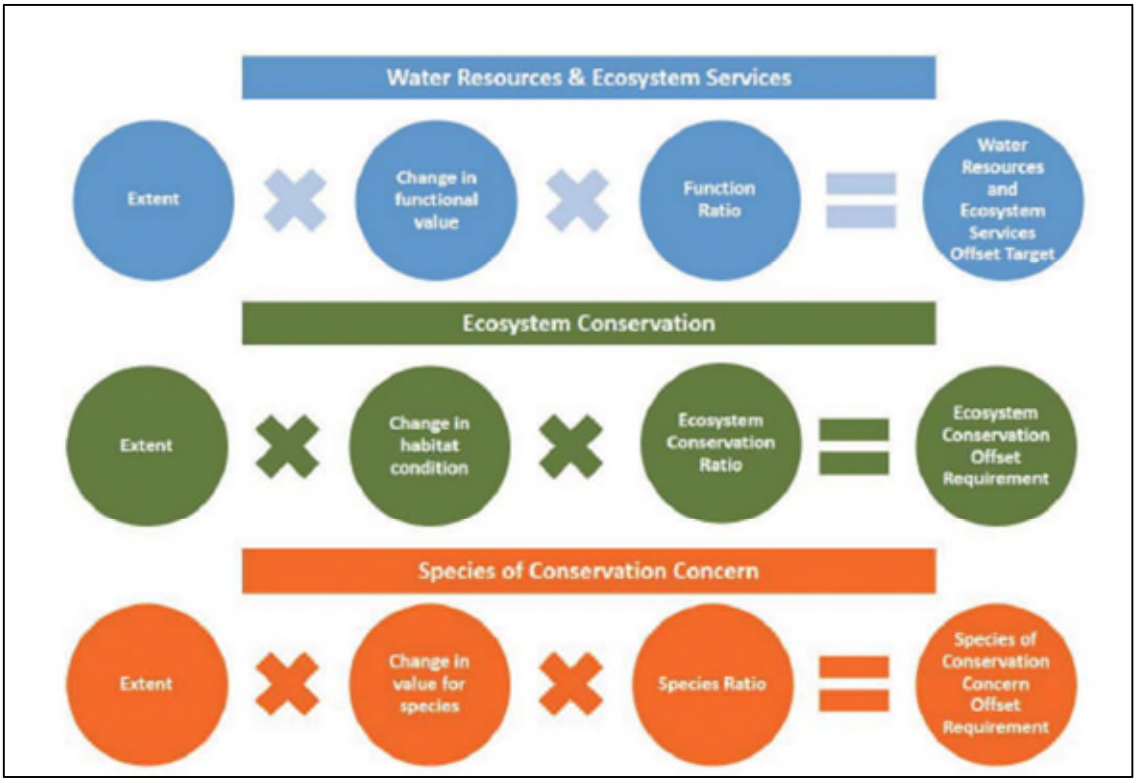

Figure 5: The outline of the approach used to identify the required offset targets

The various wetland offset ratios recommended in the wetland guidelines (2016) will be interrogated, and where appropriate adjusted and rationalised based on the particular environmental conditions associated with the site. It is envisaged that the offset target will have all three components, namely the Water Resources and Ecosystem Services (the amount of functional wetland habitat represented by the candidate offset wetland), an Ecosystem Conservation component (the biodiversity value to be represented by the candidate offset wetland) and the Species of Conservation Concern. These targets will be expressed in hectare-equivalents and/or hectares and may encompass a range of potential options for the client's consideration

4.2.1 Water Resources and Ecosystem Services Offset Target

The functional wetland area that is represented by the candidate offset wetland must be equivalent or greater than the functional wetland areas lost as a result of the development. The determination of offset targets is largely based on theory and past experience thus making the offset plan susceptible to failure. The failure of offset plans can be attributed to the proposed interventions that may be inadequate or incorrect within a certain setting for the envisioned goal (McCulloch, 2015).

To address the risk of failure, two divisors to the calculation of offset value associated with the candidate wetland are attached. These divisors refer to the risk of failure due to implementation and the temporal risk associated with implementation. These divisors are thought to encourage the rehabilitation and conservation of intact and / or degraded wetlands as this nullifies the divisors, and often results in a net gain of wetland habitat. This is believed to mitigate the risk of failure of the offset interventions proposed.

4.2.2 Ecosystem Conservation Offset Target

The Ecosystem Conservation Offset Target seeks to maintain the habitat structure of the wetlands in the local area based on their protection status and level. This aims to negate the loss of protected habitats within the local area. The SANBI guidelines for wetland offsets (DWA and SANBI, 2016 recommend several mitigatory measures that are related to the conservation status of wetlands as outlined in the NFEPA wetland classification for South Africa. The habitat protection module further considers the classification of vegetation types and protection as described by Mucina and Rutherford (2006). The wetlands within the project area fall within the Indian Ocean Coastal Belt Group and comprises of wetland flats. These wetland types are considered to have an ecosystem threat status of Least Threatened to Vulnerable (DWA and SANBI, 2016). They are considered to be moderately protected.

4.2.3 Species Offset Target

It should be noted that the wetland offset makes provisions for a species offset target. This is relevant for situations where:

- Wetland species of conservation importance are identified within the site.
- The wetland habitat is particularly suitable for species or populations of conservation importance.
- The wetland habitat is degraded, but the surrounding buffer is intact and offers good potential to support species or populations of conservation importance.
- The wetland habitat is degraded, but ecological connectivity to other aquatic habitats is good.

In the case of the proposed development site, there is a clear indication of the occurrence of species of conservation significance. The biodiversity and species information provided herein was provided by Anita Rautenbach, the contracted faunal specialist. Appendix A presents a methodology for the assessment of biodiversity for this project.

5 Limitations and Assumptions

The following are applicable to this study:

- The hectare equivalents for the wetland functionality and ecosystem conservation targets were calculated for this study. The species conservation targets could not be calculated as the expected species were not confirmed in the project area;
- The surface area of the three Ezemvelo Stewardship areas was too great to be comprehensively ground truthed for the purpose of the report taking into consideration man-hours and financial costs. Due to this, a rapid assessment was conducted of these areas, with ground truthing only conducted at selected representative sites to identify wetland types and species of conservation concern;
- Detection probabilities of rare and cryptic species such as *C. mariquensis* and *H. guttatus* are generally low and it is virtually impossible to confirm that a species is truly

absent from a site based on a single site visit. Surveys for Red Listed species must be based on multiple visits conducted in different seasons to improve detection probability and

- Dense *Cyperus papyrus* swamps along most of the riparian edges along Lake Nsezi excluded access to the water's edge.

6 Results and Discussion

6.1 Desktop and Baseline Information

The desktop findings for the project are summarised in Table 1.

Table 1: Desktop information for the areas associated with the project

Area	Desktop Soils	Desktop Vegetation	NFEPA Wetlands
Project Area	Hb75: grey regic sands; Regic sands and other soils	Maputaland Wooded Grassland. The Subtropical Freshwater Wetlands	Wetland Flat – Rank 2
Offset Area	Hb75: grey regic sands; Regic sands and other soils	Alluvial Freshwater Wetlands Maputaland Wooded Grassland. The Subtropical Freshwater Wetlands	Wetland Flat – Rank 2

A total of two (2) HGM types were identified and delineated for the project area, namely channelled valley bottom wetland and wetland flat. A single channelled valley bottom was identified and delineated beyond the eastern boundary of the project area. Several wetland flats were identified in the project area and the original offset area as presented in Figure 6.

The focus for the project area and the offset area were the wetland flat type wetlands, and not the channelled valley bottom wetland which would not be lost as a result of the project area. The ecological assessments are therefore being prioritized for and focussed on the wetland flats.

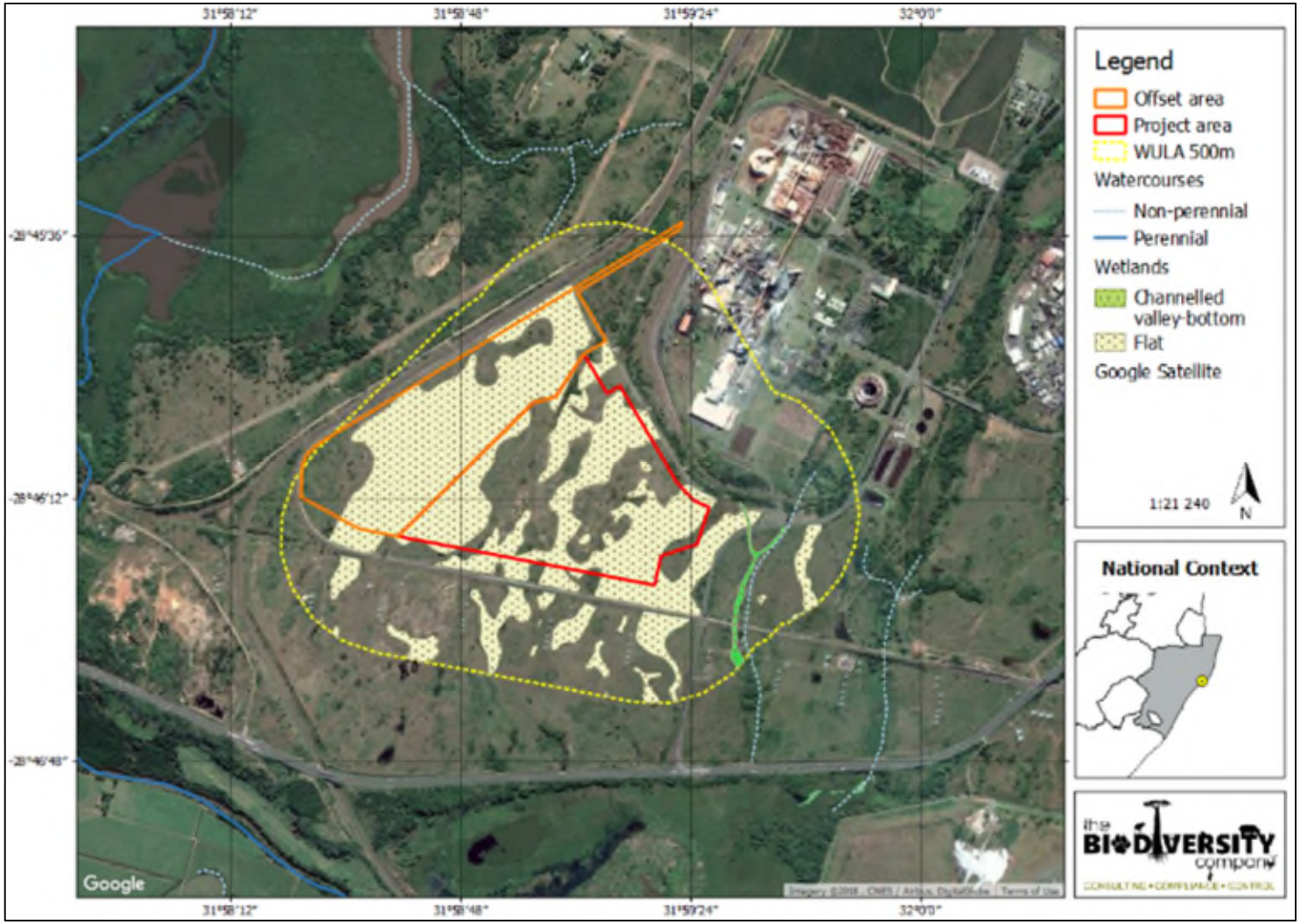

Figure 6: The delineated wetlands for the proposed project

In total 91 ha of wetlands have been delineated for the project, with approximately 28 ha and 30 ha being delineated for the project area and offset area respectively. It is assumed that the proposed project will result in the direct loss of 28 ha wetlands within the project area (only). The initial biodiversity offset area has 30 ha of wetland habitat associated with it.

The overall wetland health for the wetlands for the project and offset areas was determined to be Moderately Modified (Class C) as presented in Figure 8. The wetland flats for both areas (Figure 7) had overall intermediate level of service. The indirect benefits associated with both areas also had an intermediate level of service. The level of service for the direct benefits was determined to be moderately low and intermediate for the offset area and project area respectively. It is also evident from the findings that the benefits associated with biodiversity are higher for the project area (moderately high) as opposed to the offset area (intermediate). No services providing moderately high (or higher) benefits are expected for the offset area, with moderately high benefits expected for the project area.

The EIS of the wetland systems was determined to be High (Class B) and Moderate (Class C) for the project area and offset area respectively. The hydrological / functional importance for both areas was rated as Moderate. The direct human benefits were rated as Low (Class D) and Moderate for the offset area and project area respectively. A summary of the findings of the wetland assessment is presented in Table 2

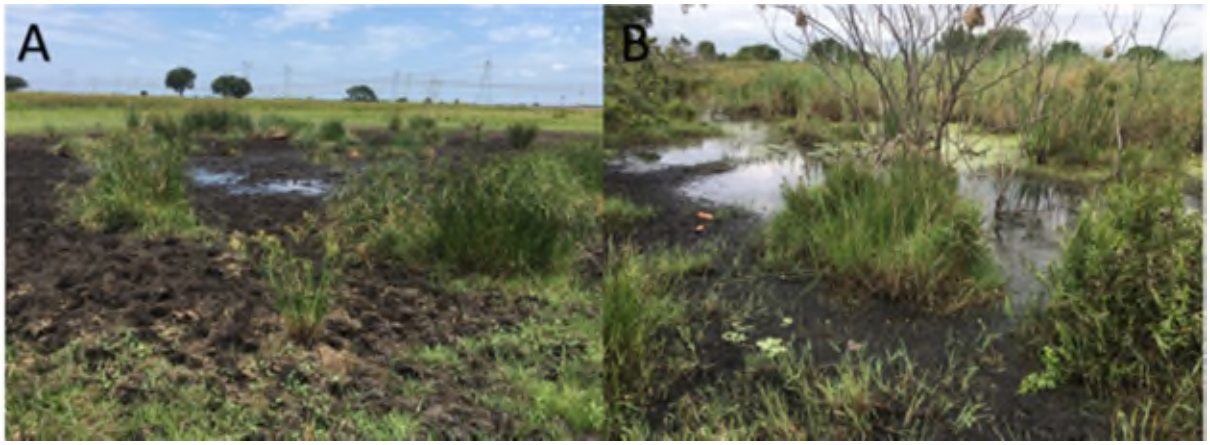

Figure 7: The identified wetland flat areas (January 2018)

Table 2: Summary of wetland assessment findings

Area	Wetland type	Size	PES	Ecoservices (>2)	EIS
Project Area	Wetland flat	28ha	Class C		Class B
Offset Area	Wetland flat	30ha	Class C	• Phosphate assimilation • Nitrate assimilation • Toxicant assimilation • Biodiversity maintenance • Provision of harvestable resources	Class C

Figure 8: The PES of the delineated wetland flats associated with the project and offset areas

7 Impact Identification

7.1 Existing impacts

The following existing impacts (Figure 9) were observed in or adjacent to the project area and original offset area:

- The development of the area has altered the surface flow dynamics, creating directional surface run-off across the assessed areas. Water typically exits a wetland flat through evapotranspiration and infiltration (Ollis et al. 2013), which has been inhibited due to the changes in topography and slope for the catchment area.
- Hydrological inputs from the adjacent facility has altered the hydrological regimes of portions of the project area, with these portions experiencing prolonged periods of saturation. These inputs have also contributed to an increase in water volume for the project area.
- The removal of vegetation due to historical deforestation of the project area, and current livestock farming in the area. Livestock farming has resulted in vegetation being trampled and overgrazed.
- Historical disturbances and current land uses have resulted in the onset and establishment of alien vegetation across the project and offset areas.

Figure 9: Photographs of aspects impacting on the wetlands. A: Livestock farming. B: Vehicles access. C: Harvesting of resources. D: Infrastructure and impoundments (January 2018)

7.2 Potential Impacts

The project layout and supporting infrastructure as shown in Figure 10, and is overlain over the delineated wetland areas. It is clear that a significant amount, 28 ha, of wetland habitat will be directly lost as a result of the proposed project. Further loss is likely due to indirect loss, which may result from altered topography, loss of surface and sub-surface hydrodynamics.

Figure 10: The proposed project aspects in relation to the wetlands

The following provides a description of potential impacts that will not only affect the wetland areas; but also the project area as a whole and potentially the offset area:

1. Loss / degradation of wetlands
2. Spread and/or establishment of alien and/or invasive species
3. Environmental pollution due to increased sedimentation and erosion of watercourses
4. Impaired water quality (surface and groundwater)
5. Alterations in hydrological regime (flow of surface and sub-surface water).

The most notable impact will be the expectant loss of wetlands; however, the indirect impacts which may arise from the project activities and loss of wetlands may impact on the MoA biodiversity offset area adjacent to the project site, and subsequently the wetlands earmarked for potential offset sites.

8 Wetland Offset Requirements Determination

The proposed development will result in the complete loss of the following wetlands as presented in Table 3.

Table 3: Wetland Areas to be lost through proposed development

Wetland Type	PES	EcoServices	Size (Ha)
Flat	Class C	Biodiversity maintenance	28

8.1 Hectare Equivalents

Wetland hectare equivalents are determined using three wetland calculators. The hectare equivalents for the wetland functionality and ecosystem conservation targets were calculated for this study. The species conservation targets were not calculated as the target species were not confirmed to present in the project area.

8.2 Offset Targets

The wetland offset calculator was applied to determine the minimum hectare equivalents to offset the loss of the wetlands within the proposed CCPP area.

Table 4 and Table 5 present the determined hectare equivalents for the Water Resources and Ecosystem Services and ecosystem conservation targets. A summary of the expected species conservation target is presented in Table 6.

The total hectares required to be reclaimed and rehabilitated equate to 19.6 ha for the functionality (Table 4). The ecosystem conservation targets equate to 13.9 ha (Table 5). The species offset targets has been conservatively estimated to be 100 ha. These targets represent the minimum required functional wetland units for a successful wetland offset attempt.

Table 4: Wetland Offset calculator – Functionality Targets

Water Resources and Ecosystem Services Targets			
			Wetland Flat
Impact Assessment	**Prior to development**	Wetland size (ha)	28
		Functional value (%)	70
	Post development	Functional value (%)	0
		Change in functional value (%)	70
	Key Regulating and Supporting Services Identified		Biodiversity Maintenance
	Development Impact (Functional hectare equivalents)		19.6
Offset calculation	**Offset Ratios**	Triggers for potential adjustment in exceptional circumstances	None
		Functional Importance Ratio	1.0
	Functional Offset Target (Functional hectare equivalents)		19.6
Further considerations	**Have other key Provisioning or Cultural Services Identified that require compensation?**		N/A
	Additional compensatory mechanisms proposed		N/A

Table 5: Wetland Offset calculator – Ecosystem Conservation Targets

Ecosystem Conservation Targets				
				Wetland Flat
Impact Assessment	**Prior to development**		Wetland size (ha)	28
			Habitat intactness (%)	80
	Post development		Habitat intactness (%)	0
			Change in habitat intactness (%)	80
	Development Impact (Habitat hectare equivalents)			22.4
Determining offset ratios	**Ecosystem Status**		Wetland Vegetation Group (or type based on local classification)	Indian Ocean Coastal belt
		Threat status of wetland	Threat status	LT
			Threat status Score	1
		Protection level of wetland	Protection level	Poorly protected
			Protection level Score	1
		Ecosystem Status Multiplier		1
	Regional and National Conservation context	Priority of wetland as defined in Regional and National Conservation Plans	Moderate importance	0.75
		Regional & National Context Multiplier		0.8
	Local site attributes	Uniqueness and importance of biota present in the wetland	Moderate biodiversity value	0.75
		Buffer zone integrity (within 500m of wetland)	Buffer compatibility score	1
		Local connectivity	Good connectivity	1
		Local Context Multiplier		0.8
	Ecosystem Conservation Ratio			0.62
Offset Calculation	**Development Impact (Habitat hectare equivalents)**			22.4
	Ecosystem Conservation Ratio			0,6
	Ecosystem Conservation Target (Habitat hectare equivalents)			13.9

The species of conservation concern targets could not be calculated as these species were not confirmed to be within the project area. It is; however, noted that these species may occur, and should they be positively identified must relocated to a suitable habitat.

9 Wetland Offset Plan – Option 1

The MoA offset area lies adjacent to the project area to the west. A wetland flat of 30 ha was identified, delineated and assessed within the offset area perimeter. A total of 51.5 ha of wetland area was delineated for the MoA biodiversity offset area, which extends beyond the MoA offset area perimeter. To determine the suitability of the wetlands within the MoA offset area for the purpose of wetland offsets, the potential gains or contributions of the selected wetlands was assessed. Table 6 and Table 7 presents the findings of the suitability assessment.

Table 6: Suitability of wetland for functionality offsets

Contribution Towards Water Resources and Ecosystem Services Targets				
Wetland attributes	Wetland Reference		Wetland Flat in MoA Offset area	
Alignment with site selection guidelines	**Criterion**	**Relevance**	**Site attributes**	**Acceptability Guidelines**
	Wetland type	Targeted wetlands should typically be of the same type to ensure that similar services to those impacted are improved through offset activities.	Wetland is of the same type as the impacted wetland.	Ideal
	Key services targeted	Targeted wetlands should be prioritised and selected based on their ability to compensate for key regulating and supporting services impacted by the proposed development.	Selected wetland is reasonably placed to improve key regulating and supporting services identified.	Acceptable
	Offset site location relative to impacted wetland	Targeted wetlands should ideally be located as close to the impacted site as possible.	Selected wetland is located within the same quaternary catchment.	Acceptable
	Overall comment on alignment with site selection guidelines	The wetland is acceptable as an offset candidate		
Preliminary Offset Calculation	**Prior to offset activities**	Wetland size (ha)	30	
		Functional value (%)	70	
	Following successful offset implementation	Functional value (%)	80	
		Change in functional value (%)	10	
	Preliminary Offset Contribution (Functional hectare equivalents)		3	
Final Offset Calculation	**Criterion**	**Relevance**	Offset activity	Adjustment factor
	Types of offset activities proposed	The risk of offset failure is linked to the type of offset activity planned with wetland establishment considered less preferable and riskier than rehabilitation or averted loss activities.	Rehabilitation & Protection	0,66
	Final Offset Contribution (Functional hectare equivalents)		2	

Table 7: Suitability of wetland for ecosystems offsets

Contribution Towards Ecosystem Conservation Targets				
Wetland attributes	Wetland Reference		Wetland Flat in MoA Offset area	
	Wetland Vegetation Group (or type based on local classification)		Indian Ocean Coastal belt	
	Threat status of wetland		Threat status	**LT**
Alignment with site selection guidelines	**Criterion**	**Relevance**	**Site attributes**	**Acceptability Guidelines**
	Like for Like	Targeted wetlands should be aligned with "like-for-like" criteria to ensure that gains associated with wetland protection are commensurate with losses.	Wetland is of the same wetland type within the same wetland vegetation group	Ideal
	Landscape planning	To what degree is wetland selection aligned with Regional and National Conservation Plans	Wetlands have been identified as moderately important in landscape planning	Acceptable
	Wetland condition	The habitat condition of the wetland should ideally be as good / better that that of the impacted site prior to development (or at least B PES Category in the case of largely un-impacted wetlands)	Final habitat condition is likely to be better than that of the impacted wetland.	Ideal
	Local biodiversity value	Wetlands that are unique or that are recognised as having a high local biodiversity value should be prioritised for wetland protection.	The wetland is characterised by habitat and / species of moderate biodiversity value.	Acceptable
	Viability of maintaining conservation values	Connectivity and consolidation with other intact ecosystems together with the potential for linkage between existing protected areas is preferable.	The wetland is well connected to other intact natural areas	Acceptable
	Overall comment on alignment with site selection guidelines	The wetland is acceptable as an offset candidate		
Preliminary Offset Calculation	Wetland areas to be secured	Wetland size (ha)	30	
		Habitat intactness (%)	80	
		Wetland habitat contribution (hectare equivalents)	24	
	Buffer zones to be secured	Area of wetland buffer zone included in the wetland offset site	0	
		Integrity of buffer zone	1	
		Buffer zone hectare equivalents	0	
		Buffer zone contribution (hectare equivalents)	0	
Final Offset Calculation	**Criterion**	**Relevance**	Site attributes	Adjustment factor
	Security of tenure	Offset activities that formally secure offset sites for longer than the minimum requirement is more likely to be maintained in the long-term and are therefore preferred.	Minimum acceptable security of tenure for shortest acceptable period	1
	Offset Contributions	Wetland habitat contribution (hectare equivalents)	24	
		Buffer zone contribution (hectare equivalents)	0	
		Functional Offset Contribution (hectare equivalents)	24	

The wetland within the MoA offset area was determined to be an acceptable candidate to contribute to the overall wetland offset as the wetland was identified as a like-for-like wetland, the wetland was in close proximity to the wetlands to be lost, and the wetland currently provides elevated levels of ecoservices, among other criteria. However, in terms of the wetland suitability to offset the Water Resources and Ecosystem Services and ecosystem conservation, the wetland was determined to contribute 2 ha of functional wetland towards the functionality offset (resulting in a deficit for the required functionality offset target) and 24 ha toward the ecosystem offset (resulting in a net gain for the required ecosystem offset target).

9.1 Wetland Offset Evaluation – Option 1

The findings from the offset calculation below suggest that the identified wetlands, located in the MoA offset area, will not be adequate to meet the minimum requirements for the all components of the wetland offset targets. Table 8 presents a summary of the minimum offset target requirements and the offset deficit / contributions determined from the wetlands to impacted and the potential candidate offset wetlands, respectively.

Table 8: The calculated minimum offset requirements and offset contributions

Offset Target	Offset Minimum requirements (Hectare equivalents from wetlands to be lost)	Offset contribution (Hectare equivalents from the MoA biodiversity offset area wetlands)	Deficit/Gain (Offset contribution – Overall Offset Component Minimum Target Requirements)
Functional Offset	19,6	2	-17,6 (net loss)
Ecosystem Conservation	13,9	24	10,1 (net gain)

Although, the potential candidate offset wetlands were determined to be acceptable according to the priority matrix on the basis that the ecosystem offset target can be met, there are several factors that make this option unsuitable for the proposed offsetting of the wetlands to be lost. These are some reasons why this option is considered to unsuitable:

1. There is too large a deficit between the minimum offset requirements and offset contributions for the Water Resources and Ecosystem Services offset target;
2. The proposed offset area is adjacent to the project area; although proximity is favoured, given the nature of the project and expected loss of wetlands, the wetland proposed for an offset may be continuously at risk from altered hydrology, impacts from on-going activities of the CCPP and potential residual impacts from minimal disturbances;
3. The offset area is in a separate watershed to the project area, which is already more extensively developed (and altered) when compared to the watershed associated with the project area, this will hamper rehabilitation initiatives for the wetland offset;

4. To protect the offset wetlands, a minimum buffer of 200m would be required around the wetlands. The buffer is not feasible due to the proposed project activities and the land uses that surround the project area. Furthermore, the client would need to either purchase land within the 200m buffer or make land management agreements to ensure the protection of the MoA area offset wetlands;
5. The species of conservation concern were not recorded in the MoA offset area, and it is likely the area does not accommodate these species; and
6. Given the large deficit in the functionality target, additional offset wetland areas would need to be identified, assessed and placed under the management of the client to ensure protection. This would incur additional costs to the client.

The following recommendations are made with regard to the original proposed MoA offset area:

- The MoA offset area should be re-purposed and incorporated to a greening and sustainable initiative for the Richards Bay CCPP, should the property be under Eskom ownership. This initiative will be designed and implemented by Eskom as convenient to them;
- Land uses in the MoA offset area, cattle farming must cease, and the area must be conserved;
- The wetlands in the MoA offset area must be rehabilitated, protected, monitored and maintained as part of the Richards Bay CCPP environmental programme; and
- An alternative offset option (Section 10) or site must be identified and developed to adequately offset the wetland habitat to be lost on the project site.

10 Wetland Offset Plan – Option 2

An alternative option to offset the expectant loss of wetlands on the project site, is to primarily utilize the following two principles as outlined by the 2016 Wetland Offset Guideline:

1. **No Net Loss:** This principle overarches the policy and design of offset and is the most significant. To achieve a no net loss with regards to a development, the project's impacts are balanced or outweighed by measures taken to avoid, minimise, rehabilitate on site and offset such that no loss remains. It is outlined that unavoidable loss should be offset through the security and sustainability of the wetland network through averted loss, improved management and long-term protection of wetlands.
2. **Landscape and Catchment context:** The wetland offset should be designed and implemented in the context of a broader area than just the project area. In essence, the offset should consider the current situation of the overall catchment water resource situation (surface and groundwater) and contribute to the improvement of water resource function and services. In the case of a catchment scale offset, it is developed with a long-term viability and their expected contribution to the conservation of water resources priority areas and the ecosystems services offered.

The proposed option 2 offset plan is in conjunction with KwaZulu-Natal Ezemvelo Wildlife (KZN Ezemvelo) and includes three (3) broad areas which have been earmarked for KZN Ezemvelo Stewardship. Figure 11 presents the areas for the KZN Ezemvelo Stewardship in relation to the project area. It is evident that the proposed areas meet the requirements to take an no net less approach through improving and securing the wetland network and conserve water resources within the landcape from a catchment level. The three areas lie adjacent to the three water resources, Nsezi Lake, Mhlathuze Estuary and Mzingazi Lake.

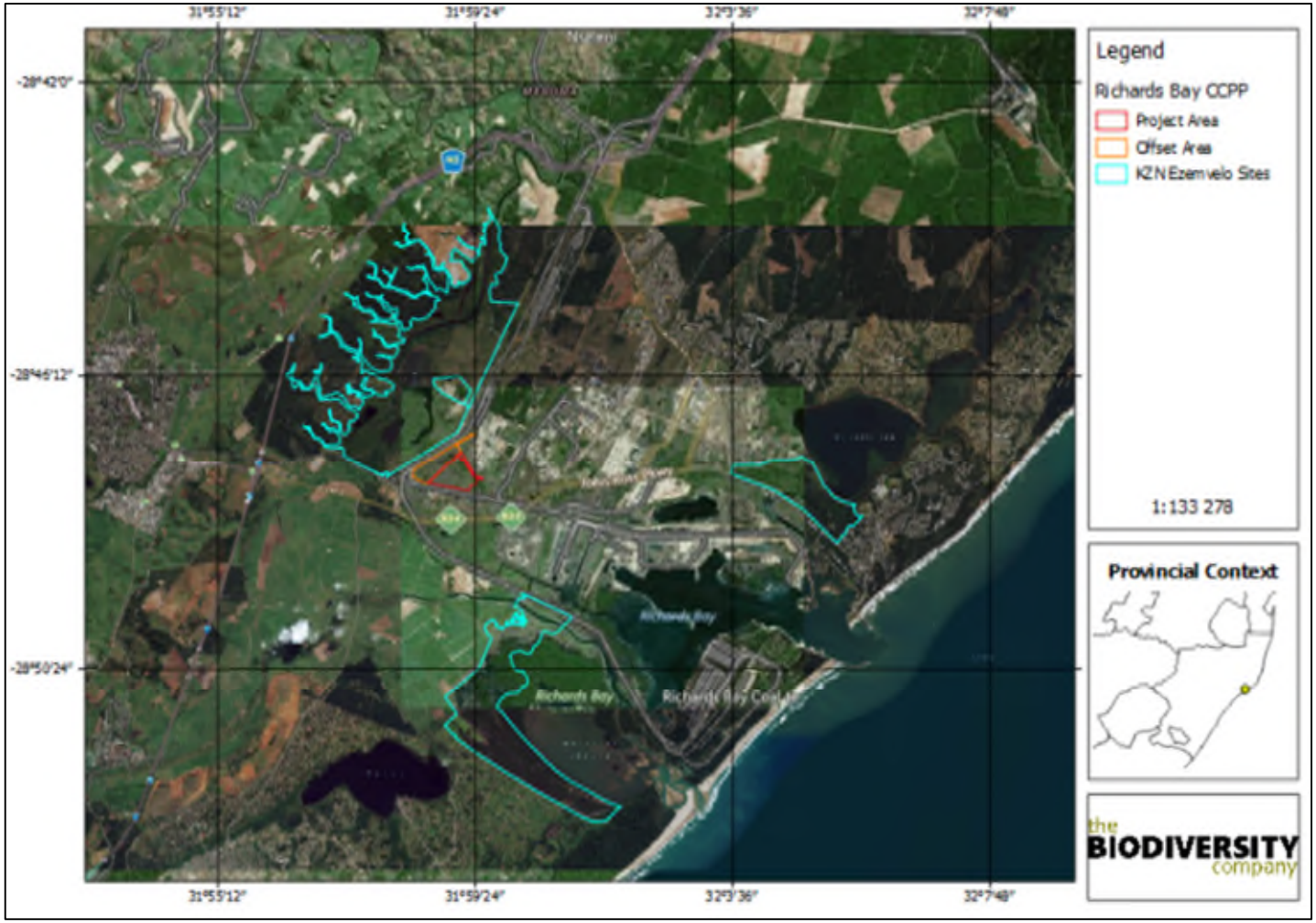

Figure 11: The proposed alternative offset sites from KZN Ezemvelo

10.1 Sample Site Description

The proposed areas for KZN Ezemvelo Stewardship are described in the following section. A targeted species survey was conducted for *C. mariquensis* (listed as NT) and *H. guttatus* (listed as VU) as part of the wetland biodiversity offset plan for the proposed development.

Due to limited habitat available to *C. mariquensis* at Mzingazi Dunes, sites 4 and 5 were located within the same 1 x 1 km grid. The georeferenced localities of the final sample locations are presented in Table 9.

Table 9: Georeferenced localities of sample locations after final site selection.

Site number	Georeferenced locality		General area
	LATITUDE	LONGITUDE	
1	-28.73832°	31.96833°	Lake Nsezi
2	-28.74588°	31.96549°	Lake Nsezi
3	-28.74947°	31.96560°	Lake Nsezi
4	-28.77283°	31.08432°	Lake Nsezi
5	-28.77277°	32.08333°	Mzingazi Dunes
6	-28.73814°	31.97058°	Mzingazi Dunes

A total of six small mammals, comprising of two species from the genus Crocidura, one species from the genus *Amblysomus*, one species from the genus *Mus* and one species from the genus *Dendromys* were captured over 470 trap nights (Figure 8; Appendix 1). None of the target species were trapped at any of the sample locations. External morphological measurements of captured shrews are presented in Table 9.

Table 10: External morphological measurements of captured shrews.

Species	Site	Tl (mm)	T (mm)	Hf sc/cu (mm)	E (mm)	Notes
Crocidura hirta	2	125	45	13.42/14.32	7.85	Identification based on descriptions by Skinner & Chimimba, 2005.
Crocidura hirta	3	117	47	13.5/14.5	7.56	Identification based on descriptions by Skinner & Chimimba, 2005.
Crocidura cf. *cyanea*	5	125	53	13.73/13.59	8.92	Identification based on descriptions by Skinner & Chimimba, 2005.

Night time searches and audio recordings

Frog species from six Families and 7 Genera were observed and recorded; however, the presence of *H. guttatus* could not be confirmed on any of the sample locations.

Incidental sightings of conservation significant fauna species

Although not part of the current scope of work, the following conservation significant fauna species were observed and should be noted (Figure 12).

A total of six rodent and shrew specimens were captured over 470 trap nights. This included two species from the genus *Crocidura*, one species from the genus *Amblysomus*, one species from the genus *Mus* and one species from the genus *Dendromys*.

This low capture rate may be related to seasonal patterns of resource availability. Similar seasonal patterns were also found at Phinda (Rautenbach et al., 2014), Mkhuze and Kube Yini Game Reserves (Delcros et al., 2015) as well as Umtamvuna Game Reserve (Dr. Leigh Richards, pers. comm.), where rodent and shrew species richness and abundance were found to be higher in the dry season than in the wet season, despite the presence of sufficient ground cover and higher plant diversity.

Reasons for this may include a delayed response in the temporal availability of resources or additionally, the higher food availability may have rendered the bait in traps less attractive to small mammals in the wet season than during the dry season when food abundance is low (Delcros et al., 2015).

The fossorial habitat of *H. guttatus* ensures that it is rarely observed, even at areas where they may be locally abundant. Nonetheless, Lake Nsezi as well as the Mzingazi Dunes area falls within their known distributional range.

Conservation of both species is dependent on the conservation of their highly specific habitats, and although none of the sample locations were occupied by any of the target species at the time of this assessment, the areas predicted to be suitable (i.e. Lake Nsezi, Mzingazi Dunes) are the candidate areas to be considered for conservation prioritisation for these species.

Figure 12: Faunal species observed within the three stewardship areas

10.1.1 Nsezi Lake

The area for the stewardship in this location consists of the Nsezi Lake and several tributaries that feed the lake on the north western portion (Figure 13). The streams are modified through

activities related to the forestry practices on the embankments and direct catchments of the streams. This area is comprised of water resources, which make up approximately 70% of the selected area and natural grassland, which makes up the additional 30% of the area. The complete area covers 1430 ha of which 1000 ha is water resources (wetlands). The wetlands within this area would not be a like-for-like wetland match for the wetlands to be lost.

Figure 13: KZN Ezemvelo Stewardship Site: Nsezi Lake

Figure 14 presents the locations for the targeted survey to confirm the presence of the species of conservation concern within the Nsezi Lake area.

Figure 14: The selected sites for targeted species survey – Nsezi Lake area (Sites 1 – 3 & 6 are final sample sites)

The habitat identified within this project area is presented in Figure 15.

Figure 15: Habitat within the Nsezi Lake area a) drainage line close to the riparian edge of Lake Nsez b) edge of the Cyperus papyrus swamp at Lake Nsezi

The presence of the species of conservation concern, that the survey had targeted, could not be confirmed within the project area. The species that were identified within the Nsezi Lake area included these listed in Table 11

Table 11: Faunal species identified in the Nsezi Lake area

Family	Scientific Name	Common Name	Sa Red List Status	Area Observed
Mammals				
Cercopithecidae	*Chlorocebus pygerythrus*	Vervet monkeys	LC/CITES App II	Lake Nsezi
Galagidae	*Otolemur crassidaudatus*	Thick-tailed bushbaby	LC/CITES App II	Lake Nsezi
Birds				
Accipitridae	*Stephanoaetus coronatus*	Crowned eagle	VU	Lake Nsezi Plantations

10.1.2 Mhlathuze Estuary (Southern Sanctuary)

This potential area for the KZN Ezemvelo Stewardship is located south east of the project area and consists of a portion of the Mhlathuze River floodplain and inundated land behind Mhlathuze Estuary (Figure 16). Several streams and wetland areas make up the portion of inundated land and feed the estuary. The water resources have been modified and impacted on by the adjacent agricultural practices and poor management of natural resources. The area covers 807 ha of land which is completely water resources (wetland) area. The wetlands within this area would not be a like-for-like wetland match for the wetlands to be lost.

Figure 16: KZN Ezemvelo Stewardship Site: Estuary

10.1.3 Mzingazi Lake

This area, earmarked for stewardship by KZN Ezemvelo, borders the Mzingazi Lake and consists of a large natural area, an unnamed stream and wetland area that flows from the Mzingazi Lake to the ocean and the southern banks of the Mzingazi Lake. The stream flowing from the Mzingazi Dam inundates a large flat area and may be considered a channelled valley bottom wetland. The area covers a total of 294 ha and approximately 40% (117 ha) of the area is considered wetland or watercourse area. The area has been modified by the construction of roads and residential areas adjacent to the area which result in continued residual impacts. The establishment of large woody trees and alien invasive plant species presents threats to the water resources within the selected area. The wetlands within this area would not be a like-for-like wetland match for the wetlands to be lost.

Figure 17: KZN Ezemvelo Stewardship Site: Mzingazi Lake

Sites considered for the targeted species survey at the Mzingazi Lake area are presented in Figure 18.

Figure 18: The selected sites for targeted species survey – Mzingazi Lake (Site 4 & 5 are final sample sites)

The wetlands within the Mzingazi Lake area is presented in Figure 19.

Figure 19: Wetland at Mzingazi Dunes

The presence of the species of conservation concern, that the survey had targeted, could not be confirmed within the project area. The species that were identified within the Mzingazi Lake area included these listed in Table 12.

Table 12: Faunal species identified in the Mzingazi Lake area

Family	Scientific Name	Common Name	Sa Red List Status	Area Observed
MAMMALS				
Cercopithecidae	*Chlorocebus pygerythrus*	Vervet monkeys	LC/CITES App II	Mzingazi Dunes
Hippopotamidae	*Hippopotamus amphibius*	Hippopotamus	LC/CITES App II	Mzingazi Dunes
Reptiles				
Chamaeleonidae	*Bradypodion melanocephalum*	Black-headed dwarf chameleon	VU/Endemic	Mzingazi Dunes
Birds				
Accipitridae	*Circaetus fasciolatus*	Southern-banded snake-eagle	CR	Mzingazi Dunes
	Circus ranivorus	African marsh harrier	EN	Mzingazi Dunes
Jacanidae	*Microparra capensis*	Lesser jacana	VU	Mzingazi Dunes

10.2 KZN Ezemvelo Stewardship

The proposed stewardship would follow the Biodiversity Stewardship South Africa (BSSA) programme which was conceptualised in 2005 and initiated in 2006 (KZN Ezemevelo). The BSSA is a tool designed to assist both national and provincial government to meet their respective mandates to conserve biodiversity outside of state-owned protected areas in terms of the Environmental Management: Protect Areas Act (57 of 2003). This programme assists in the implementation of provincial conservation plans through stewardship and further assists government to meet targets set out by the National Spatial Biodiversity Assessment and the National Biodiversity Framework. Furthermore, the goals of the BSSA are aligned with those of the Department of Environmental Affairs and Tourism's (DEAT) National Protected Areas Expansion Strategy and Community-Based Natural Resource management programme.

The primary goal for biodiversity stewardship is to achieve site security. The following are objectives that must be included during the process of obtaining stewardship (in order of priority):

- Conservation agencies must develop durable relationships with landowners, communities, local authorities and other government departments that control areas of biodiversity priority;
- The costs of conserving biodiversity must be shared between the public (through the state), the local municipality, the landowner and any specific direct beneficiaries of the resources conserved, or the area protected, on a basis which is equitable in relation to the benefits accrued to each party;
- Conservation agencies must strive to minimise costs and maximise efficiency (in terms of resources and personnel) in conserving biodiversity outside of state-owned protected areas;
- Options should be provided to recognise commitment to and investment in voluntary biodiversity conservation within farming and other land use systems; and

- Securing conservation investments must be of paramount importance, to ensure the sustainability of conservation effort and funding. Any conservation status afforded to critical biodiversity sites must thus be well managed, durable, legally sound, resilient to changing opinion on land use, and easily audited.

The identified sites, owned by uMhlathuze Municipality, have been earmarked for stewardship by KZN Ezemvelo and are intended to be included in their stewardship programme. These sites consist largely of wetland areas and it is for this reason that it has become an option for wetland offset in this case. In light of the inadequacy of the proposed MoA biodiversity offset area for the project and mutual needs of KZN Ezemvelo and the client, the obtaining of stewardship was considered to be a possibly better option.

It is envisaged that the client would assist KZN Ezemvelo to obtain stewardship, as an offset plan, with the following objective:

The costs of conserving biodiversity must be shared between the public (through the state), the local municipality, the landowner and any specific direct beneficiaries of the resources conserved, or the area protected, on a basis which is equitable in relation to the benefits accrued to each party

Under this scenario, the client would assist KZN Ezemvelo financially in this process.

10.3 Offset Calculation

The three areas considered for the KZN Ezemvelo Stewardship cover a combined approximate area of 2531 ha of which 1924 ha (76%) is water resources (wetland). It is understood that KZN Ezemvelo wants to place the areas under their stewardship which would in turn place these areas under protection and, more importantly, under the management of the nature conservation body.

As a result of the proposed stewardship, 1924 ha of wetland would be available to offset the expectant loss of wetlands through the development of the Richards Bay CCPP. The wetlands within the areas were grouped into a single wetland group for the purpose of wetland offset calculation and a worst-case scenario, 50% functionality, was applied to the wetlands to mitigate exaggerated results. Table 13 and Table 14 presents the results of the wetlands suitability assessment. The wetlands within the proposed KZN Ezemvelo Stewardship areas were determined to be acceptable for the wetland offset target in terms of Water Resources and Ecosystem Services and ideal to the offset targets for ecosystem services. The suitability of these systems to contribute towards species conservation targets has not yet been completed. However, preliminary findings from the Maxent model does suggest the presence of these conservation species in the three stewardship areas.

Table 13: Suitability of wetland for functionality offsets

Contribution Towards Water Resources and Ecosystem Services Targets				
Wetland attributes	Wetland Reference		KZN Ezemvelo Wetland Stewardship	
Alignment with site selection guidelines	**Criterion**	**Relevance**	Site attributes	Acceptability Guidelines
	Wetland type	Targeted wetlands should typically be of the same type to ensure that similar services to those impacted are improved through offset activities.	Wetland is of a different type to the impacted wetland.	May be acceptable
	Key services targeted	Targeted wetlands should be prioritised and selected based on their ability to compensate for key regulating and supporting services impacted by the proposed development.	Selected wetland is well placed to contribute meaningfully towards improving key regulating and supporting services identified.	Ideal
	Offset site location relative to impacted wetland	Targeted wetlands should ideally be located as close to the impacted site as possible.	Selected wetland is located within the same quaternary catchment.	Acceptable
	Overall comment on alignment with site selection guidelines	The selected sites will contribute to catchment scale biodiversity improvement and water resource health		
Preliminary Offset Calculation	**Prior to offset activities**	Wetland size (ha)	1924	
		Functional value (%)	50	
	Following successful offset implementation	Functional value (%)	80	
		Change in functional value (%)	30	
	Preliminary Offset Contribution (Functional hectare equivalents)		577,2	
Final Offset Calculation	**Criterion**	**Relevance**	Offset activity	Adjustment factor
	Types of offset activities proposed	The risk of offset failure is linked to the type of offset activity planned with wetland establishment considered less preferable and riskier than rehabilitation or averted loss activities.	Rehabilitation & Protection	0,66
	Final Offset Contribution (Functional hectare equivalents)		381	

Table 14: Suitability of wetland for ecosystems offsets

Contribution Towards Ecosystem Conservation Targets				
Wetland attribute	Wetland Reference		KZN Ezemvelo Wetland Stewardship	
	Wetland Vegetation Group (or type based on local classification)		Indian Ocean Coastal belt	
	Threat status of wetland		Threat status	VU
Alignment with site selection guidelines	**Criterion**	**Relevance**	Site attributes	Acceptability Guidelines
	Like for Like	Targeted wetlands should be aligned with "like-for-like" criteria to ensure that gains associated with wetland protection are commensurate with losses.	Wetland is of an alternative wetland type of the same or higher threat status as the impacted wetland, within the same wetland vegetation group	Acceptable
	Landscape planning	To what degree is wetland selection aligned with Regional and National Conservation Plans	Wetlands have been identified as being of high importance in landscape planning	Ideal
	Wetland condition	The habitat condition of the wetland should ideally be as good / better that that of the impacted site prior to development (or at least B PES Category in the case of largely un-impacted wetlands)	Final habitat condition is likely to be better than that of the impacted wetland.	Ideal
	Local biodiversity value	Wetlands that are unique or that are recognised as having a high local biodiversity value should be prioritised for wetland protection.	The wetland is characterised by habitat and / species of high biodiversity value.	Ideal
	Viability of maintaining conservation values	Connectivity and consolidation with other intact ecosystems together with the potential for linkage between existing protected areas is preferable.	The offset provides an opportunity to consolidate / expand existing protected areas	Ideal
	Overall comment on alignment with site selection guidelines	The selected sites will contribute to catchment scale biodiversity improvement and water resource health		
Preliminary Offset Calculation	Wetland areas to be secured	Wetland size (ha)	1924	
		Habitat intactness (%)	50	
		Wetland habitat contribution (hectare equivalents)	962	
	Buffer zones to be secured	Area of wetland buffer zone included in the wetland offset site	0	
		Integrity of buffer zone	1	
		Buffer zone hectare equivalents	0	
		Buffer zone contribution (hectare equivalents)	0	
Final Offset Calculation	**Criterion**	**Relevance**	Site attributes	Adjustment factor
	Security of tenure	Offset activities that formally secure offset sites for longer than the minimum requirement is more likely to be maintained in the long-term and are therefore preferred.	Highest possible level of protection permanently secured	2
	Offset Contributions	Wetland habitat contribution (hectare equivalents)	1924	
		Buffer zone contribution (hectare equivalents)	0	
		Functional Offset Contribution (hectare equivalents)	1924	

10.4 Wetland Offset Evaluation – Option 2

The wetlands found within the proposed stewardship areas were determined to far exceed the minimum offset requirements. This offset option would result in a net-gain of 361.4 ha of wetland in terms of Water Resources and Ecosystem Services and 1910.1 ha of wetland in terms of the ecosystem conservation as presented in Table 15.

Table 15: The calculated minimum offset requirements and offset contributions

Offset Target	Offset Minimum requirements (Hectare equivalents from wetlands to be lost)	Offset contribution (Hectare equivalents from the offset wetland)	Deficit/Gain (Offset contribution - Offset Minimum requirements)
Functional Offset	19,6	381	361,4 (net gain)
Ecosystem Conservation	13,9	1924	1910,1 (net gain)

Although the species of conservation concern offset could not be determined, the three areas provided habitat for different species that are considered species of conservation concern. The stewardship would further result in the wetlands and areas around the wetlands being placed under protection by KZN Ezemvelo and benefit from the nature conservation management program which would increase the biodiversity value of the areas over time instead of the expected decline in the current state. It is therefore recommended that this option be considered as not only will the wetland loss be outweighed by wetland gains; the option would offer wetland conservation and protection at a catchment level and contribute to the national requirements for water resource conservation.

The stewardship areas are considered Rank 2 Estuarine habitats and a Rank 2 Floodplain habitat that is marked as crane habitat (Figure 20). The Ecosystem Threat Status is considered Critical (CR) for all the habitat within the areas as presented in Figure 21. The KZN Critical Biodiversity Assessment (CBA) considers the habitat occurring within the areas as irreplaceable (Figure 22). The proposed stewardship offset option would benefit the local area in terms of habitat preservation, water resources preservation and ecosystem restoration and preservation. Additionally, any management and restoration work required for the offset implementation will be performed under the KZN Ezemvelo programmes.

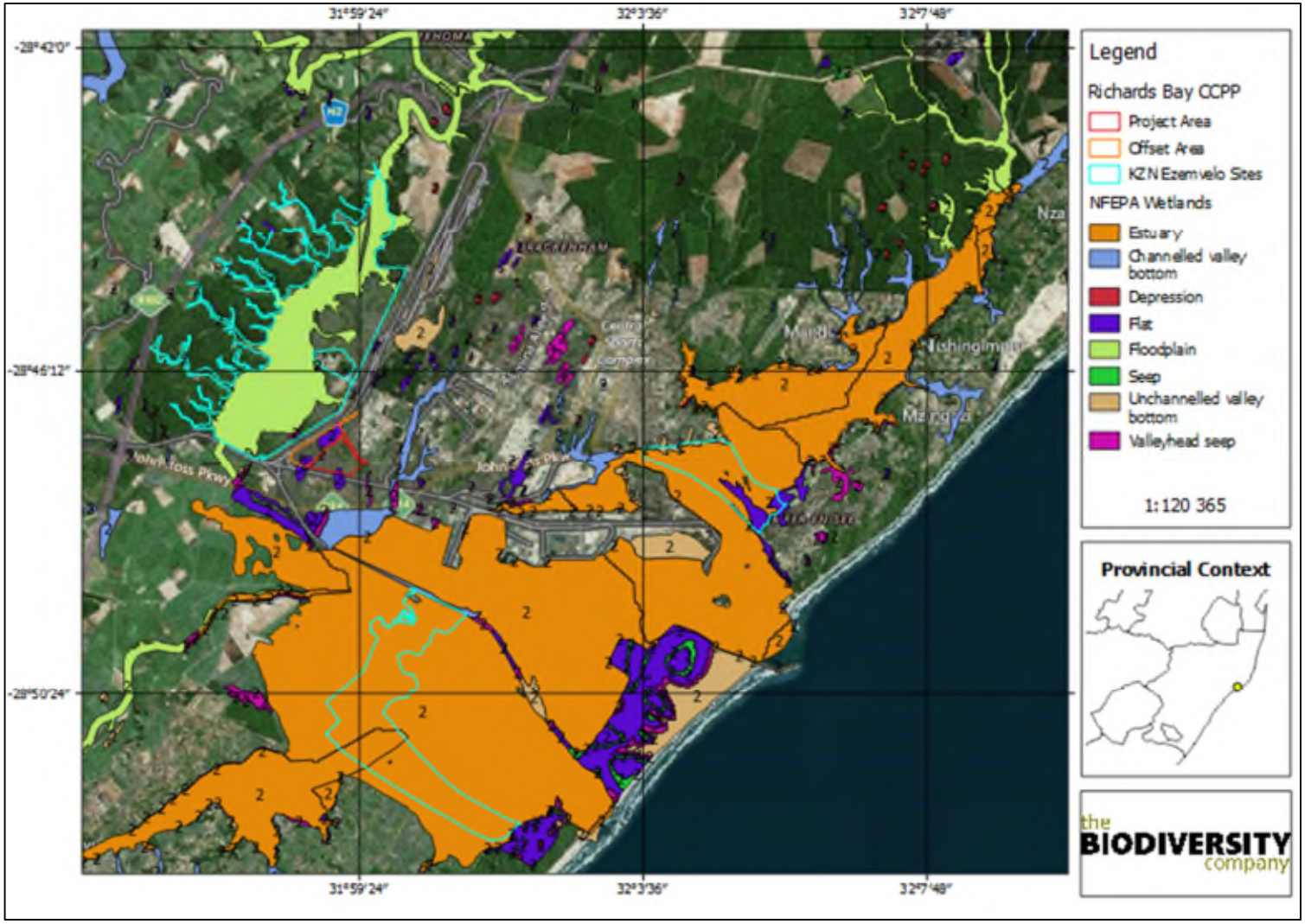

Figure 20: NFEPA Wetlands with FEPA Ranks (NFEPA, 2011)

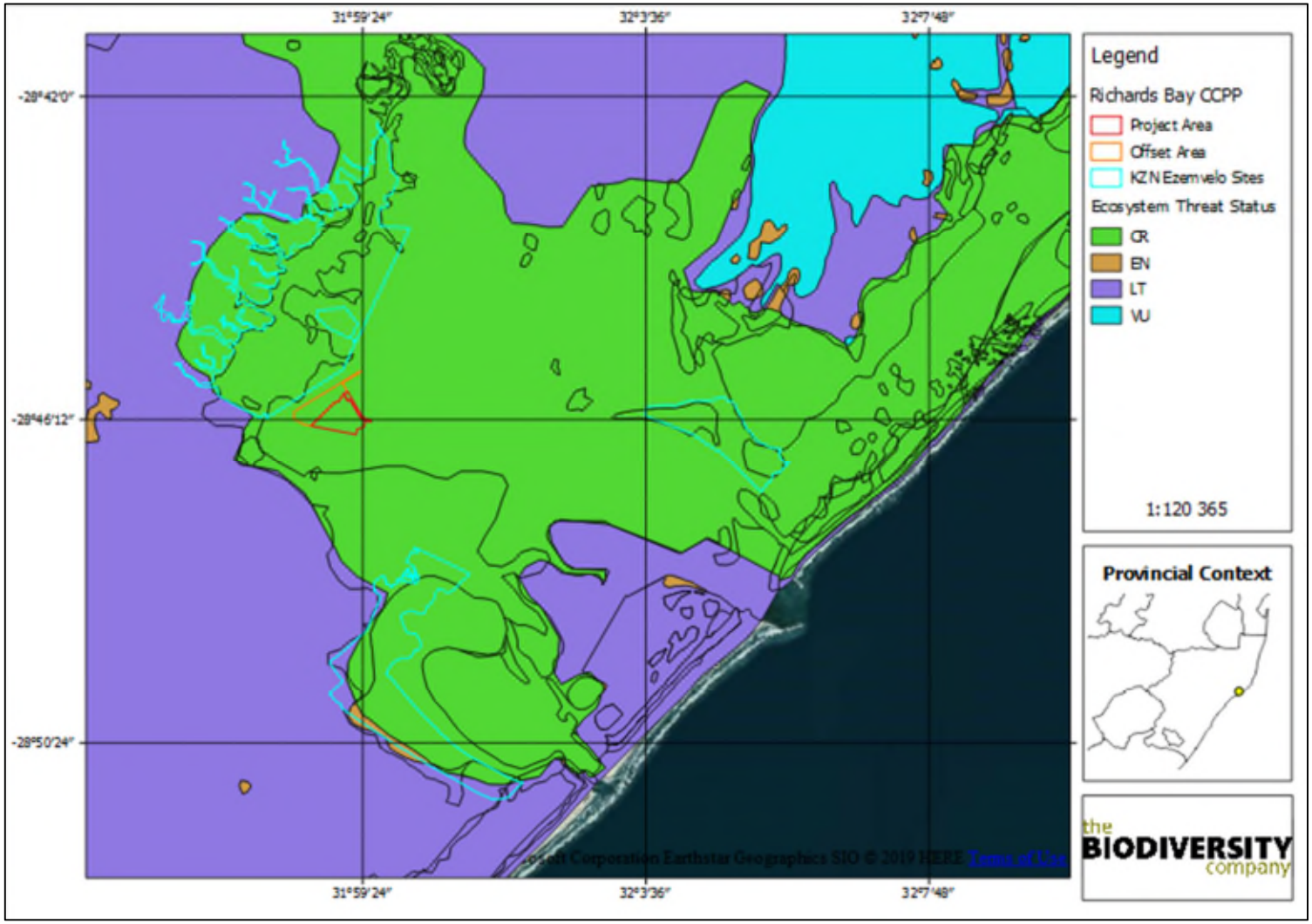

Figure 21: Ecosystem Threat Status (Mucina and Rutherford, 2006)

Figure 22: The KZN Critical Biodiversity Areas: Irreplaceable areas (NBA, 2011)

11 Wetland Offset Conditions

The preliminary wetland offset plan offers idea conceptual solution as to the requirements of a final wetland offset plan. It is important to note that the preliminary plan is designed under various conditions which are as follows:

1. The preliminary plan considered the Memorandum of Agreement between KZN Ezemvelo and uMhlathuze Municipality. In the MoA, Lake Nzesi, Lake Mzingazi and Southern Sanctuary area were to be proclaimed as nature reserves. It is therefore assumed that the proposed offset for this project will include all three (3) stewardship areas. Furthermore, it is the opinion of the specialist that securing and protecting these three areas would be the best possible path of action in wetland offsets.
2. Eskom, the project developers, will aid KZN Ezemvelo fulfil the requirements of the MoA in terms of proclamation of the areas as nature reserves. The management of these nature reserves will be the sole responsibility of the nature conservation board, in this instance KZN Ezemvelo. Eskom will not be required to manage, partly or wholly, these areas in terms of financial requirements and resources (human and equipment).
3. The implementation of any rehabilitation measures and work required within the areas once proclaimed will be the responsibility of KZN Ezemvelo. Eskom may support in this instance depending on costs incurred during the process of proclamation and related exercises.
4. It must be expressly stated that, should this preliminary plan be approved, Eskom must not be expected to undertake a separate offset plan or rehabilitation of wetlands apart from those resulting from the proposed project and related activities.

These conditions are for the benefit of both parties and more importantly the biodiversity and wetlands within the project area. The purpose of the preliminary wetland offset plan is to identify the best possible method to conserve wetlands in the local area and subsequently the country.

12 Wetland Offset Implementation

The following are standard requirements for any wetland offset:

- Wetland Offset Authorisation;
- Wetland Offset Implementation;
- Securing Appropriate Wetland Buffer;
- Formal Protection of Wetlands;
- Wetland Offset Management Plan and Implementation;
- Long-term Management Capacity;
- Wetland Offset Monitoring Plan; and

- Independent Audits, Review and Sign-off.

In the case of the proposed offset plan and envisaged end result several of these requirements will be achieved by virtue of the earmarked areas being proclaimed as nature reserves. It is assumed that KZN Ezemvelo, as the regulatory nature conservation body, has systems and plans in place to ensure the following requirements are met once the areas have been proclaimed:

- Wetland Offset Implementation;
- Securing Appropriate Wetland Buffer;
- Wetland Offset Management Plan and Implementation;
- Long-term Management Capacity;
- Wetland Offset Monitoring Plan; and
- Independent Audits, Review and Sign-off.

These requirements that are almost automatically met with proclamation are viewed as the most significant in ensuring that the wetland offset is a success. The points that Eskom will be likely to form part within this offset plan are the following:

- Wetland Offset Authorisation;
- Formal Protection of Wetlands; and
- Independent Audits, Review and Sign-off.

It is assumed that this report forms part of the Wetland Offset Authorisation which needs to be agreed upon with KZN Ezemvelo. Formal protection of the wetland areas is assistance in ensuring that the earmarked areas are proclaimed as nature reserves. The independent audit, review and sign-off will require Eskom to review the work performed in the offset plan implementation as this will be an investment, by Eskom, into the biodiversity capital of the province and country. According to the National Environmental Management: Protected Areas Act, for the proclamation of an area as a nature reserve the following must be met:

1. The area must be shown to meet the criteria prescribed for a nature reserve;
2. The area must be declared a nature reserve and management assigned to the land owner or a designate. An application must be submitted to the MEC/Minister in the prescribed format; and
3. Upon verification and approval by the MEC/Minister, an agreement to declare a nature reserve must be signed by the land owner.

13 Conclusion

The proposed Richards Bay CCPP project would result in the loss of 28ha of wetland flat habitat within the project area. The wetlands to be lost were determined to have a Class C PES score, and intermediate level of service and a High (B) EIS. The minimum target to offset the loss of wetland habitat was determined to be 19.6 ha to offset the functionality and 13.9 ha to offset the ecosystem services. The species conservation targets were not calculated as the target species were not confirmed on the project area, despite sampling undertaken.

The MoA biodiversity offset area was proposed adjacent to the project area. The wetlands identified within the proposed (original) offset area were Class C PES score, and intermediate level of service and a moderate (C) EIS, much like the wetlands to be lost. The offset contributions of the wetlands were determined to be 2 ha to offset the functionality and 24 ha to offset the ecosystem conservation. Although, the candidate offset wetlands were determined to be acceptable according to the priority matrix and the ecosystem offset target is met, there are several factors that make this option unsuitable for the proposed offsetting of wetlands to be lost, the greatest of which is the deficit in the offset of the functionality and expected management difficulty of the offset area.

An alternative wetland offset plan (Option 2) was identified with the aid of KZN Ezemvelo. The plan entails three areas earmarked by KZN Ezemvelo for inclusion in their stewardship programme. The three areas cover a combined approximate area of 2531 ha of which 1924 ha (76%) is water resources (wetland). As a result of the proposed stewardship, 1924 ha of wetland would be available to offset the expectant loss of wetlands through the development of the Richards Bay CCPP. The wetlands within the three areas were grouped into a single wetland group for the purpose of wetland offset calculation and a worst-case scenario, 50% functionality. This offset option would result in a net-gain of 361.4 ha of wetland in terms of functionality and 1910.1 ha of wetland in terms of the ecosystem conservation.

The stewardship would further result in the wetlands and areas around the wetlands being placed under protection by KZN Ezemvelo and benefit from the nature conservation management program which would increase the biodiversity value of the areas over time instead of the expected decline in the current state.

The stewardship areas are considered Rank 2 Estuarine habitats and a Rank 2 Floodplain habitat that is marked as crane habitat. The Ecosystem Threat Status is considered Critical (CR) for all the habitat within the areas. The KZN CBA considers the habitat occurring within the areas as irreplaceable. The proposed stewardship offset option would benefit the local area in terms of habitat preservation, water resources preservation and ecosystem restoration and preservation

It is therefore recommended that the KZN Ezemvelo Stewardship Programme offset option be considered as not only will wetland loss be outweighed by wetland gains be offset, the option would offer wetland conservation and protection at a catchment level and contribute to the national requirements for water resource conservation.

14 References

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15 Appendix A

15.1 Modelling methods

MaxEnt (maximum entropy species distribution modelling) is a common species distribution modelling (SDM) tool used for predicting the distribution of a species from a set of known locality records and environmental predictors.

The principle of species distribution modelling (SDM) is to relate known locations of a species with environmental characteristics such as climate and rainfall at that location in order to predict the potential range of a species. These distribution models can be used to estimate the most suitable areas for a species and infer probability of presence in areas where no systematic surveys were conducted.

SDM modelling requires two types of input datasets, i.e. species occurrence data and environmental predictors, which are combined to create a predictive model describing the suitability of any site for these species.

15.1.1 Species datasets

Species occurrence data for the target species were obtained from the following information sources:

- Frog Atlas (Mintner et al., 2004);
- The Biodiversity Database of Ezemvelo KZN Wildlife;
- Museum specimen records:
- Ditsong National Museum of Natural History, formerly the Transvaal Museum; and
- Durban Natural Science Museum.

Occurrence data is simply latitude-longitude pairs denoting sites where the species was previously observed. Occurrence data were plotted in Google Earth Pro and inspected visually to detect obvious errors. Duplicate records and records from unknown localities were removed prior to modelling to reduce bias caused by spatial autocorrelation.

15.1.2 Environmental predictors

The environmental predictors used consisted of raster data that contained 8 continuous climatic variables (Bioclim): Bio 1 (annual mean temperature), Bio 4 (temperature seasonality, determined from the standard deviation of monthly values), Bio 5 (maximum temperature of warmest month), Bio 6 (maximum temperature of coldest month), Bio 12 (annual precipitation), Bio 13 (precipitation of wettest month), Bio 14 (precipitation of driest month) and Bio 15 (precipitation seasonality, determined from the standard deviation of monthly values).

These variables were extracted from the CliMond website (https://www.climond.org; Kriticos et al. 2012). The coverages were developed at a grid resolution of 30’ (1 x 1 km for the study area).

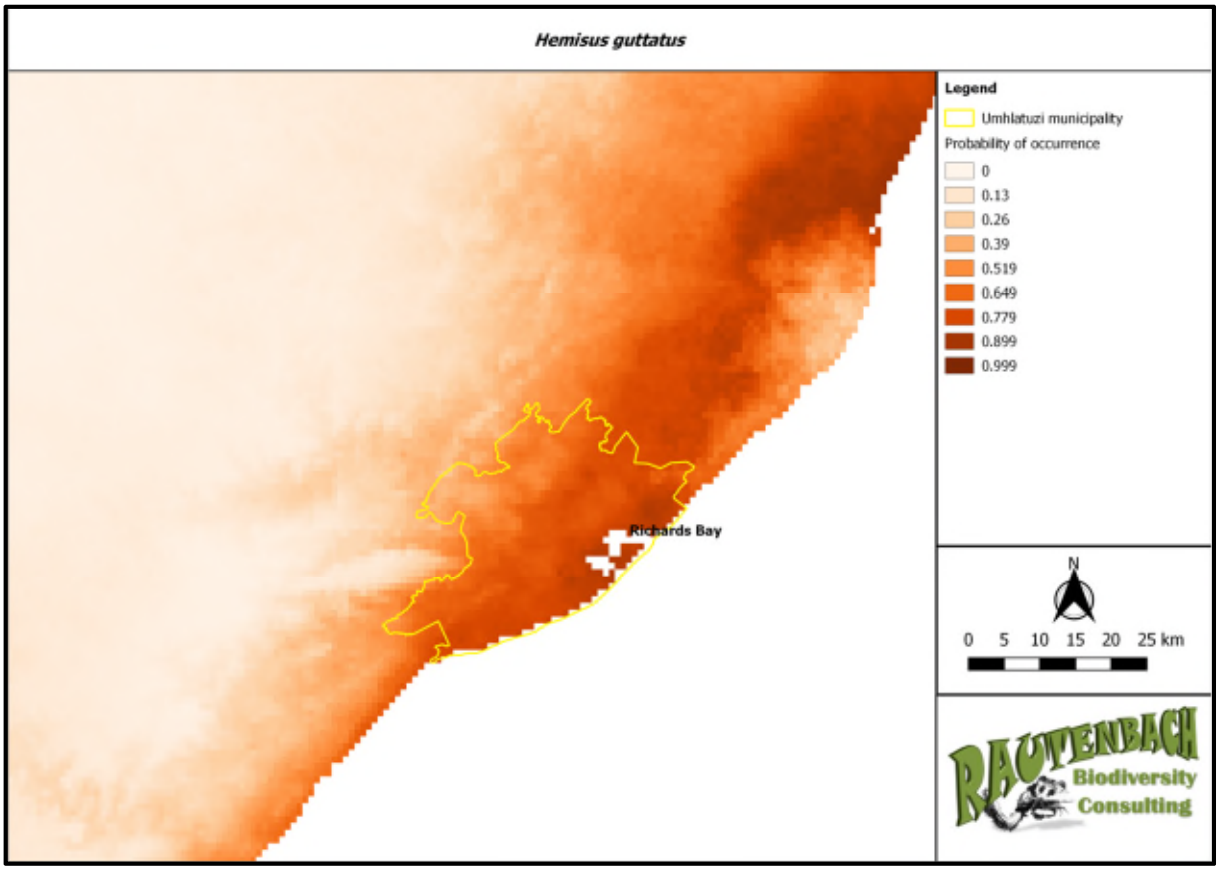

Figure 23: Habitat suitability distribution of Hemisus guttatus according to occurrence records.

QGIS version 2.18.10 was used to crop bioclimatic raster images to the required spatial extent (KZN) and re-projected to the WGS84 datum, Transvers Mercator Lo 31 central meridian.

15.1.3 Species distribution modelling

Maxent version 3.4.1 was run to develop SDM models for *C. mariquensis* and *H. guttatus* in KwaZulu-Natal province. Ten replicates were run by using the cross-validate setting. The regularization multiplier was set to 1; the maximum number of background points was set at 10 000; maximum iterations were set at 500 for *C. mariquensis*, and 1000 for *H. guttatus* to ensure algorithm convergence. Default settings were used for all other relevant parameters.

The performance of the models was evaluated by the area under the curve (AUC) statistic of the receiver operating characteristic plots.

15.2 Locality verification and final sample site selection

The resulting probability maps for C. mariquensis and H. guttatus were overlaid with the NFEPA wetlands and proposed nature reserve coverage spatial data layers for Umhlatuzi municipality in QGIS and compared with Google Earth Pro to narrow down all possible sample locations. Transformed areas were subtracted from the final probability maps.

Eight potential sample locations for C. mariquensis, and seven for H. guttatus were identified and is represented Figure 4. These areas were visited on the 8th of January 2019 to verify habitat suitability.

Many of the potential sample locations for *C. mariquensis* proved to be unsuitable due to thick and impenetrable vegetation, unsuitable microhabitat characteristics for the target species, and/or limited site access. For example, dense Cyperus papyrus swamps along most of the riparian edges along Lake Nsezi prevented access to the water's edge (Figure 3).

Figure 24: The extent of Cyperus papyrus swamps on the riparian edges of Lake Nsezi.

For sites 1-3, alternative sample locations, suited to the habitat requirements of the target species within the same 1 x 1 km grid as the potential sample locations were identified by taking the following factors into consideration:

- Distance to water – By estimating the maximum dispersal distance from water based on locality records for C. mariquensis and H. guttatus;
- Basal cover and the presence of rodent runways for C. mariquensis;
- Site accessibility – Distance from the closest access road to the potential sample location; and
- Distance between sample locations.

Due to limited habitat available to *C. mariquensis* at Mzingazi Dunes, sites 4 and 5 were located within the same 1 x 1 km grid. The georeferenced localities of the final sample locations are presented in Table 1 and Figures 4 & 5.

Table 16: Georeferenced localities of sample locations after final site selection.

Site number	**Georeferenced locality**		**General area**
	LATITUDE	**LONGITUDE**	

1	-28.73832°	31.96833°	Lake Nsezi
2	-28.74588°	31.96549°	Lake Nsezi
3	-28.74947°	31.96560°	Lake Nsezi
4	-28.77283°	31.08432°	Lake Nsezi
5	-28.77277°	32.08333°	Mzingazi Dunes
6	-28.73814°	31.97058°	Mzingazi Dunes

Figure 25: Google earth view of the potential and final sample sites for the target species.

Figure 26: Examples of habitat at selected trap sites.

15.3 Surveying methods

Trapping for the target species commenced on the 9th of January 2019 at the final selected sites. Due to low capture rates, the number of trap nights was increased from five to seven nights.

At each site, a combination of pitfall traps and PVC live-traps were used to trap target species (Figure 6). Pitfall traps consisted of four 20 L buckets that were buried in the ground with the rim of the bucket at ground level. The buckets were placed approximately 4 m apart, from rim to rim, in a Y-shaped design. A 40 cm high drift fence made from shadecloth and anchored with metal poles placed at 1 m intervals connected the pitfall traps. Pitfall traps were left unbaited but shelter in the form of soil, leaf litter and grass clippings were provided.

Figure 27: Pitfall trap arrays and PVC-live traps used at the sample locations.

No external morphological measurements were taken from captured non-target species such as rodents. These animals were however furclipped to prevent counting recaptures and subsequently released at the point of capture.

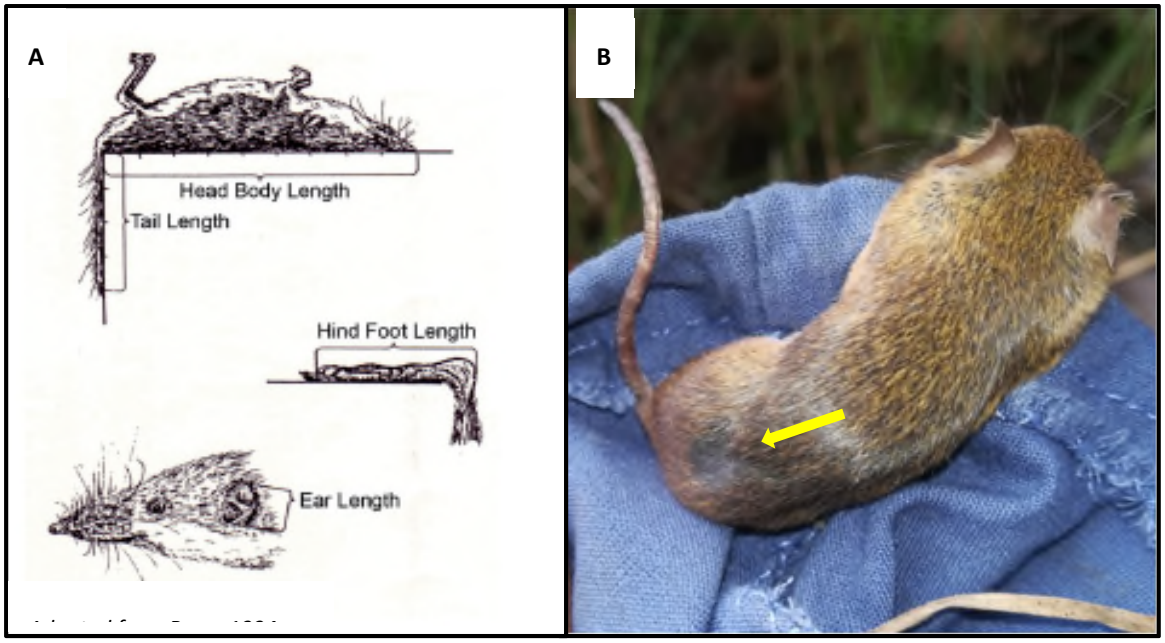

Figure 28: A -External morphological measurements taken from selected specimens captured. B - Fur clipping on the rump of Mus minutoides.

H. guttatus

Pitfall traps are also useful for documenting rare, fossorial frog species such as Hemisus guttatus that are difficult to detect using other techniques. In addition to pitfall trapping, four active night-time searches were performed and included visual searches of riparian edges and the surrounding terrestrial habitat, as well as audio recordings.