Water Resource Report for the proposed expansion of the Manungu Colliery

Mpumalanga, South Africa

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CLIENT

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Report Name	**Water Resource Report for the proposed expansion of the Manungu Colliery**	
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DOCUMENT GUIDE

The table below provides the NEMA (2014) Requirements for Biodiversity Assessments, and also the relevant sections in the reports where these requirements are addressed:

GNR 326 April 2017	Description	Section in the Report
Specialist Report		
Appendix 6 (a)	A specialist report prepared in terms of these Regulations must contain— details of— i. the specialist who prepared the report; and ii. the expertise of that specialist to compile a specialist report including a curriculum vitae;	Page i.
Appendix 6 (b)	A declaration that the specialist is independent in a form as may be specified by the competent authority;	Page viii
Appendix 6 (c)	An indication of the scope of, and the purpose for which, the report was prepared;	Section 1
Appendix 6 (cA)	An indication of the quality and age of base data used for the specialist report;	Section 3.2
Appendix 6 (cB)	A description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change;	Appendix 6
Appendix 6 (d)	The duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment;	Section 1
Appendix 6 (e)	A description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used;	Section 3
Appendix 6 (f)	Details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure, inclusive of a, site plan identifying site alternatives;	Section 5
Appendix 6 (g)	An identification of any areas to be avoided, including buffers;	Section 5.8
Appendix 6 (h)	A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	Section 6
Appendix 6 (i)	A description of any assumptions made and any uncertainties or gaps in knowledge;	Section 4
Appendix 6 (j)	A description of the findings and potential implications of such findings on the impact of the proposed activity **[including identified alternatives on the environment]** or activities;	Section 5 & 6
Appendix 6 (k)	Any mitigation measures for inclusion in the EMPr;	Section 6.4
Appendix 6 (l)	Any conditions for inclusion in the environmental authorisation;	Section 6.5
Appendix 6 (m)	Any monitoring requirements for inclusion in the EMPr or environmental authorisation;	Section6.6
Appendix 6 (n)	A reasoned opinion— i. **[as to]** whether the proposed activity, activities or portions thereof should be authorised; (iA) regarding the acceptability of the proposed activity or activities; and ii. if the opinion is that the proposed activity, activities or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan;	Section 7

GNR 326 April 2017	Description	Section in the Report
Appendix 6 (o)	A description of any consultation process that was undertaken during the course of preparing the specialist report;	EIMS[1]
Appendix 6 (p)	A summary and copies of any comments received during any consultation process and where applicable all responses thereto; and	EIMS
Appendix 6 (q)	Any other information requested by the competent authority.	None

[1] EIMS has undertaken the public and stakeholder consultation process

EXECUTIVE SUMMARY

The Biodiversity Company was commissioned to conduct specialist studies to supplement the various mining related applications. This water resource assessment comprises wetland and aquatic ecology specialist components. An assessment of the wetland systems was conducted from 15-19th January 2018, which constitutes a wet season survey. The assessment of the local river systems is included in an annual biomonitoring programme, with fieldwork being completed during 12th June 2017 (high flow) and 24th October 2017 (early high flow).

According to the 2017 Manungu aquatic biomonitoring survey results, the PES assessment derived a largely modified ecological category (class D) for the Bronkhorstspruit. This PES is below the attainable ecological management class (class C).

The modified status can be attributed to a combination of flow modification, habitat and water quality related drivers and riparian areas associated with the Bronkhorstspruit and each associated tributary system. The overlying influence of low water levels in the project area with no river flow between sites has impacted aquatic macroinvertebrate and fish communities. The modification stems from a combination of agricultural and mining activities present within Bronkhorstspruit catchment and cannot be directly attributed to mining related activities at Manungu Colliery.

A total of five (5) HGM types were identified and delineated for the project. A total of 16 HGM units were identified for the project. The overall wetland health for the wetlands varied from Moderately Modified (Class C) to Largely Modified (Class D) system, with the majority of the wetlands rated a Class D. The Ecological Importance and Sensitivity of the two valley bottom wetland types was rated as high (Class B), with the remaining wetland types being rated as moderate (Class C).

All of the wetland types had overall moderately low level of service, with the exception of the unchannelled valley bottom system which had an intermediate level of service. It is evident from the study that the most benefits are associated with the indirect benefits, which includes the enhancement of water quality. The level of indirect benefits for all the systems ranged from low to moderately low. The hydrological / functional importance was rated as Moderate (Class C) for all the wetland systems. The direct human benefits were rated as low (Class D) for all the wetland systems.

The recommended buffer width is 45 m and 65 m for the construction and operational phases respectively. It is recommended that the larger buffer width of 65 m be implemented from the onset of the construction phase of the project.

The proposed project could result in the loss and modifications of water resources, notably the loss of selected pans (and associated seeps) and portions of the unchanneled valley bottom system to the east of the project area. It is permissible that the proposed opencast mining area result in the mining of the depressions within this area, but the mine plan must be amended to avoid the eastern valley bottom wetland and the associated buffer. The loss of wetlands is expected for the mining of the opencast area, and it is possible that underground mining may also result in the loss of wetland systems. 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 systems proposed to be mined by opencast methods.

The impacts associated with the proposed underground mining method are considerably less significant when compared to the proposed opencast mining methods. This compounded with the placement of new infrastructure, access routes and mining activities will have a significant impact on the local environment and ecological processes. Careful consideration must be afforded each of the recommendations provided herein. 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.

Table of Contents

Tables

Figures

Declaration

I, Dale Kindler declare that:

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

Dale Kindler

Aquatic Specialist

The Biodiversity Company

11 January 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;
- 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.

Andrew Husted

Aquatic / Wetland Ecologist

The Biodiversity Company

11 January 2018

1 Introduction

Environmental Impact Management Services (Pty) Ltd (EIMS) has been appointed to undertake relevant applications and amendment applications to existing authorisations and/or licences pertaining to the Manungu Colliery including:

- New Integrated Environmental Authorisation (Scoping and Environmental Impact Report (S&EIR));
- New Integrated Water Use Licence (IWUL);
- Amendments to existing Environmental Authorisation and Environmental Management Plan;
- Amendments to the existing IWUL; and
- Section 102 Amendment.

The Biodiversity Company was commissioned 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 wetland systems was conducted from 15-19th January 2018, which constitutes a wet season survey. The assessment of the local river systems was included in an annual biomonitoring programme, with fieldwork being completed during 12th June 2017 (low flow) and 24th October 2017 (high flow).

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 Aim and Objective

The aim of the assessment was to provide information to guide the proposed expansion of the mining operation with respect to the current ecological state 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 Manungu Colliery is located approximately 7 km south of Delmas, on farm portions Wellaagte 271 IR and Welgevonden 54 IT, in the Mpumalanga Province, South Africa. The area surrounding the project site consisted predominantly of agricultural fields and several coal mining operations. The watercourses associated with Manungu Colliery were located within the Olifants Water Management Area (WMA) within the B20A quaternary catchment. A locality map of the project area is presented in Figure 1. Two Sub Quaternary Reaches (SQR's) will be potentially affected by the proposed project. The two SQR's are part of the Bronkhorstpruit River system and were identified as the B20A-1362 (Table 1) and the B20A-1374 (Table 2) SQR's.

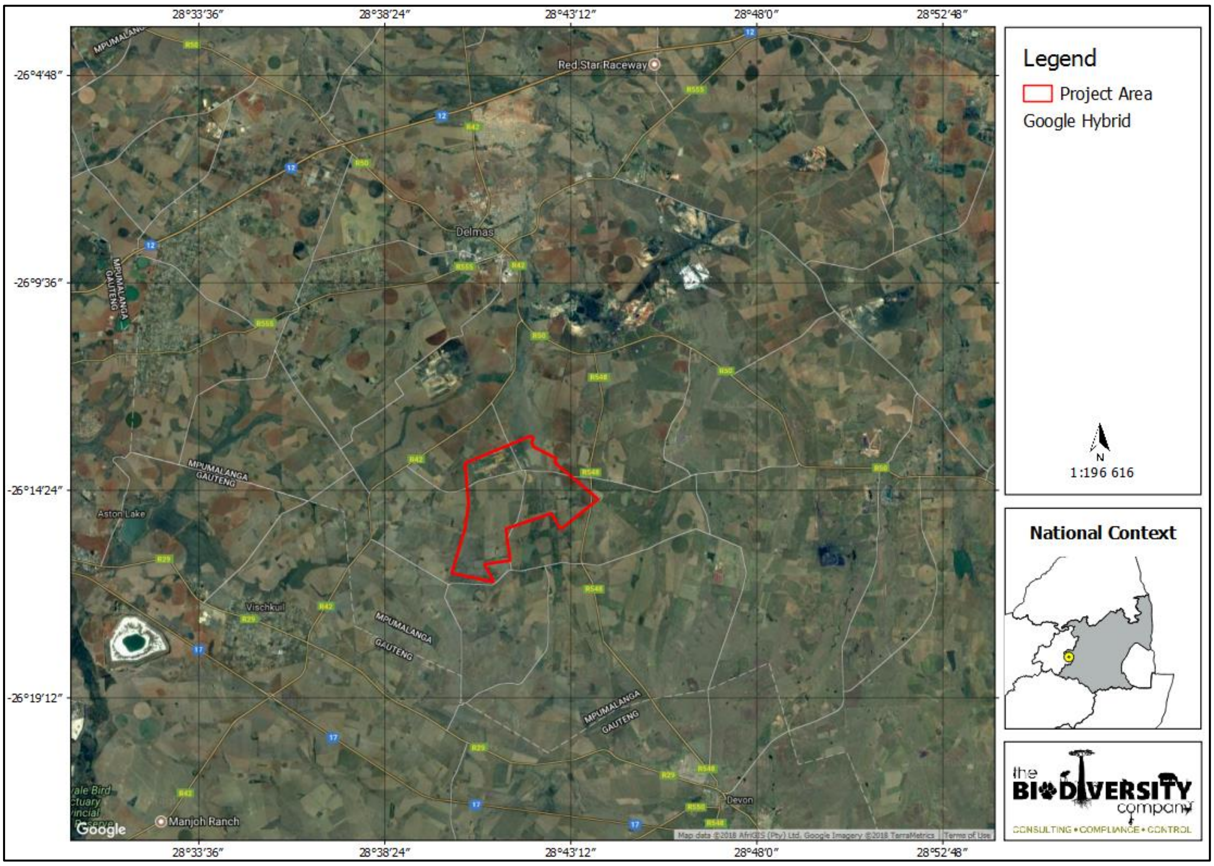


Figure 1: Location of the Manungu Colliery

Table 1: The desktop information peratining to the B20A-1362 Sub Quaternary Reach

Component/Catchment	B20A-1362
Present Ecological Status	Moderately Modified (Class C)
Ecological Importance Class	Moderate
Ecological Sensitivity	Moderate
Default Ecological Category	Moderately Modified (Class C)

Based on the above table (Table 1), the desktop PES of this reach of the Bronkhorstspruit system is a class C or moderately modified. The ecological importance and sensitivity of the river reach was rated as moderate. The defined Default Ecological Category for the river was class C or moderately modified.

Table 2: The desktop information peratining to the B20A-1374 Sub Quaternary Reach

Component/Catchment	B20A-1374
Present Ecological Status	Moderately Modified (Class C)
Ecological Importance Class	Moderate
Ecological Sensitivity	Moderate
Default Ecological Category	Moderately Modified (Class C)

Based on the above table (Table 2) the desktop PES of this reach of the Bronkhorstspruit system is a class C or moderately modified. The ecological importance and sensitivity of the river reach was rated as moderate. The defined Default Ecological Category for the river was class C or moderately modified.

Figure 2: Location of aquatic sampling points

Table 3: Location of the aquatic sampling points (Photographs: Low flow - June 2017)

	Upstream	Downstream
MAN1		
GPS	26°14'17.21"S, 28°40'36.90"E	
Site	MAN1 was located within a wetland upstream of Manungu Colliery and upstream of site MAN2. The site was characterized by a small pool below a culvert and surrounded by farmland. *In situ* water quality was conducted here. The South African Scoring System: Version 5 (SASS5) was not recommended for this site.	
	Upstream	**Downstream**

MAN2		
GPS	26°12'31.06"S, 28°41'13.41"E	
Site	MAN2 was characterised by a small pool below a culvert and surrounded by farmland. The site constitutes a wetland system and was situated downstream of Manungu Colliery. *In situ* water quality was conducted here. SASS5 was not recommended for this site.	
	Upstream	**Downstream**
MAN3		
GPS	26°13'58.12"S. 28°42'28.21"E	
Site	MAN3 was located upstream of Manungu Colliery on the Bronkhorstspruit at the inlet to a dam. The site was situated adjacent to chicken farms and agricultural lands. The site was characterized by slow flowing waters over mud substrate with abundant marginal vegetation. Isolated areas of stones were present which included concrete bedrock. *In situ* water quality and SASS5 was conducted here.	
	Upstream	**Downstream**
MAN4		
GPS	26°11'42.78"S, 28°41'52.81"E	

Site	MAN4 was characterised by very shallow still waters over mud substrate inundated with *Phragmites sp* vegetation and a moderate sized deep pool. The site was located downstream of Manungu Colliery and below a dam.

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);
- The Mpumalanga Highveld wetlands; 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 3. 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.

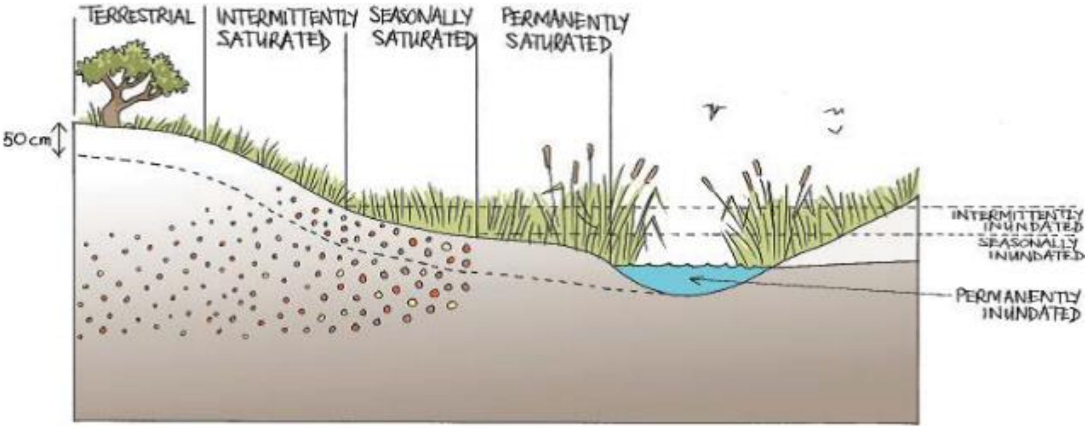


Figure 3: Cross section through a wetland, indicating how the soil wetness and vegetation indicators change (Ollis, et al. 2013).

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 4.

Table 4: The PES 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**

Impact Category	Description	Impact Score Range	Present State Category
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 5).

Table 5: 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 category as listed in Table 6..

Table 6: Description of EIS 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 Buffer Determination

The "Preliminary Guideline for the Determination of Buffer Zones for Rivers, Wetlands and Estuaries" (Macfarlane, et al., 2014) was used to determine the appropriate buffer zone for the proposed activity.

3.4 Aquatic Assessment

3.4.1 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.

3.4.2 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 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 7 and Table 8 respectively.

Table 7: 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.

Criterion	Relevance
Indigenous vegetation removal	Impairment of the buffer the vegetation forms to the movement of sediment and other catchment runoff products into the river. Refers to physical removal for farming, firewood and overgrazing.
Exotic vegetation encroachment	Excludes natural vegetation due to vigorous growth, causing bank instability and decreasing the buffering function of the riparian zone. Allochtonous organic matter input will also be changed. Riparian zone habitat diversity is also reduced.
Bank erosion	Decrease in bank stability will cause sedimentation and possible collapse of the 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 8: 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

3.4.3 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.

3.4.3.1 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 Highveld - Lower ecoregion. This method seeks to develop biological bands depicting the various ecological states and is derived from data contained within the Rivers Database and supplemented with other data not yet in the database (Table 9).

Table 9: Biological Bands / Ecological categories for interpreting SASS data (adapted from Dallas, 2007)

Class	Ecological Category	Description
A	Natural	Unimpaired. High diversity of taxa with numerous sensitive taxa.
B	Largely natural	Slightly impaired. High diversity of taxa, but with fewer sensitive taxa.
C	Moderately modified	Moderately impaired. Moderate diversity of taxa.
D	Largely modified	Considerably impaired. Mostly tolerant taxa present.
E/F	Seriously Modified	Severely impaired. Only tolerant taxa present.

** Average Score per Taxa*

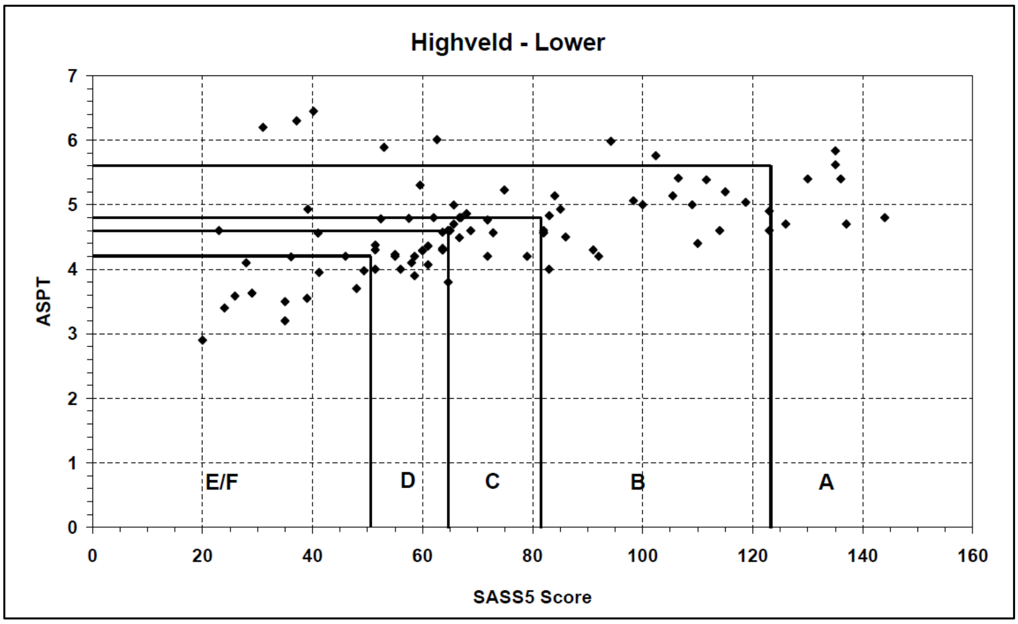


Figure 4: Guidelines used for the interpretation and classification of the SASS5 scores (Dallas, 2007)

3.4.3.2 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.

3.4.4 Fish Community Assessment

The information gained using the Fish Response Assessment Index (FRAI) gives an indication of the PES of the river based on the fish assemblage structures observed. Fish were captured through minnow traps, cast nets and electroshocking. All fish were identified in the field and released at the point of capture. Fish species were identified using the guide Freshwater Fishes of Southern Africa (Skelton, 2001). The identified fish species were compared to those expected to be present for the quaternary catchment. The expected fish species list was developed from a literature survey and included sources such as (Kleynhans *et al*., 2007) and Skelton (2001). It is noted that the FRAI Frequency of Occurrence (FROC) ratings were calculated based on the habitat present at the sites.

3.4.5 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).

3.5 Impact Assessment

The impact assessment methodology was provided by EIMS, and is guided by the requirements of the NEMA EIA Regulations (2010). The broad approach to the significance rating methodology is to determine the environmental risk (ER) by considering the consequence (C) of each impact (comprising Nature, Extent, Duration, Magnitude, and Reversibility) and relate this to the probability/likelihood (P) 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, are used to determine a prioritisation factor (PF) which is applied to the ER to determine the overall significance (S).

4 Limitations and Assumptions

- The information considered for the aquatic ecology component of the study is part of the biomonitoring programme (2017).
- 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.

5 Results and Discussion

5.1 Desktop Soils

According to the land type database (Land Type Survey Staff, 1972-2006) the Mining Right Area (MRA) is located within the Bb3, Ea15 and Ea20 land types (Figure 5). The land type is described in the table below (Table 10).

Table 10: The expected soil features for the land types present

Land Type	Expected Soil Features
Bb3	PLINTHIC CATENA: UPLAND DUPLEX AND MARGALITIC SOILS RARE; Dystrophic and/or mesotrophic; red soils not widespread
Ea15	ONE OR MORE OF: VERTIC, MELANIC, RED STRUCTURED DIAGNOSTIC HORIZONS; Undifferentiated
Ea20	ONE OR MORE OF: VERTIC, MELANIC, RED STRUCTURED DIAGNOSTIC HORIZONS; Undifferentiated

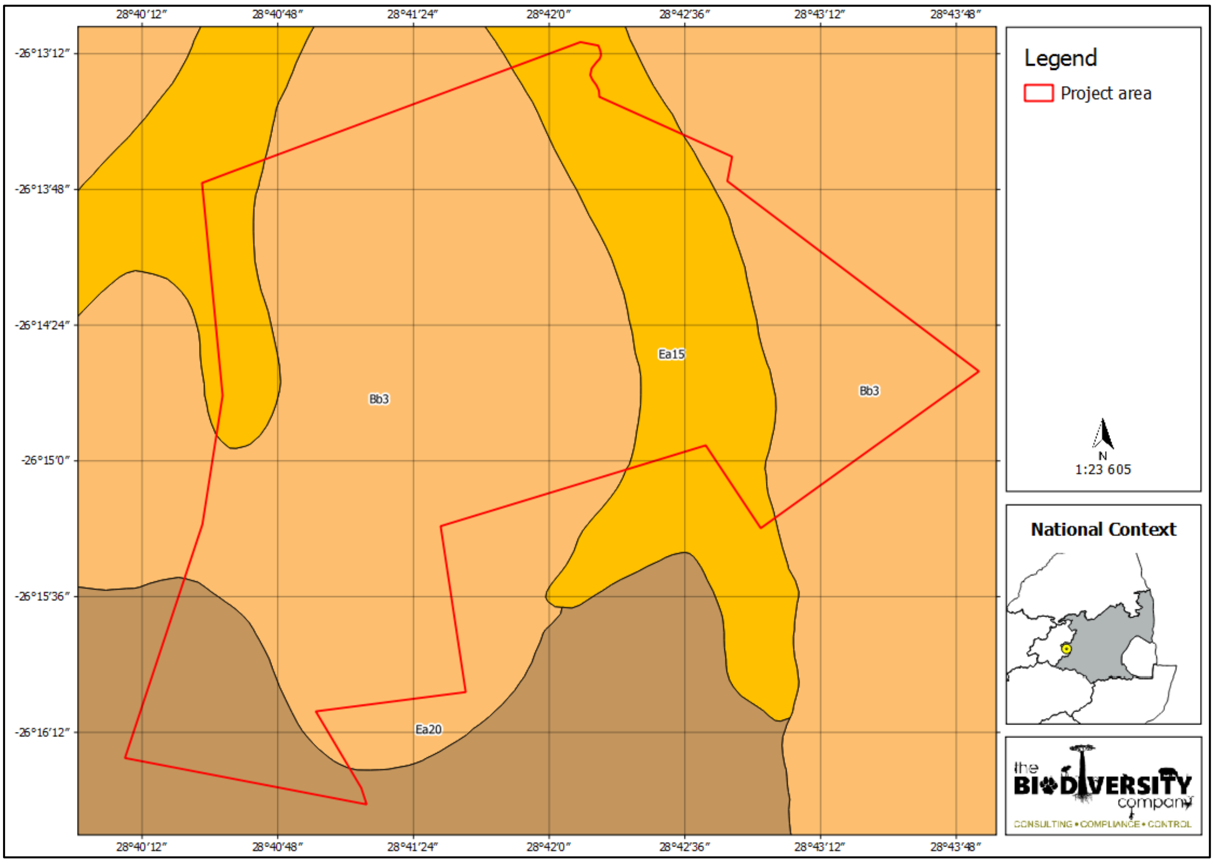


Figure 5: The land types in the project assessment area (MRA)

5.2 Desktop Vegetation

The project area is situated within the grassland biome. This biome is centrally located in southern Africa, and adjoins all except the desert, fynbos and succulent Karoo biomes

(Mucina & Rutherford, 2006). The grassland biome comprises many different vegetation types. The project area is situated across two different vegetation types; the Eastern Highveld Grassland (GM12) and the Soweto Highveld Grassland (GM8) vegetation types, according to Mucina & Rutherford (2006) (Figure 6). A third vegetation type, the Eastern Temperate Freshwater Wetlands (AZf3), occurs adjacent to the project area.

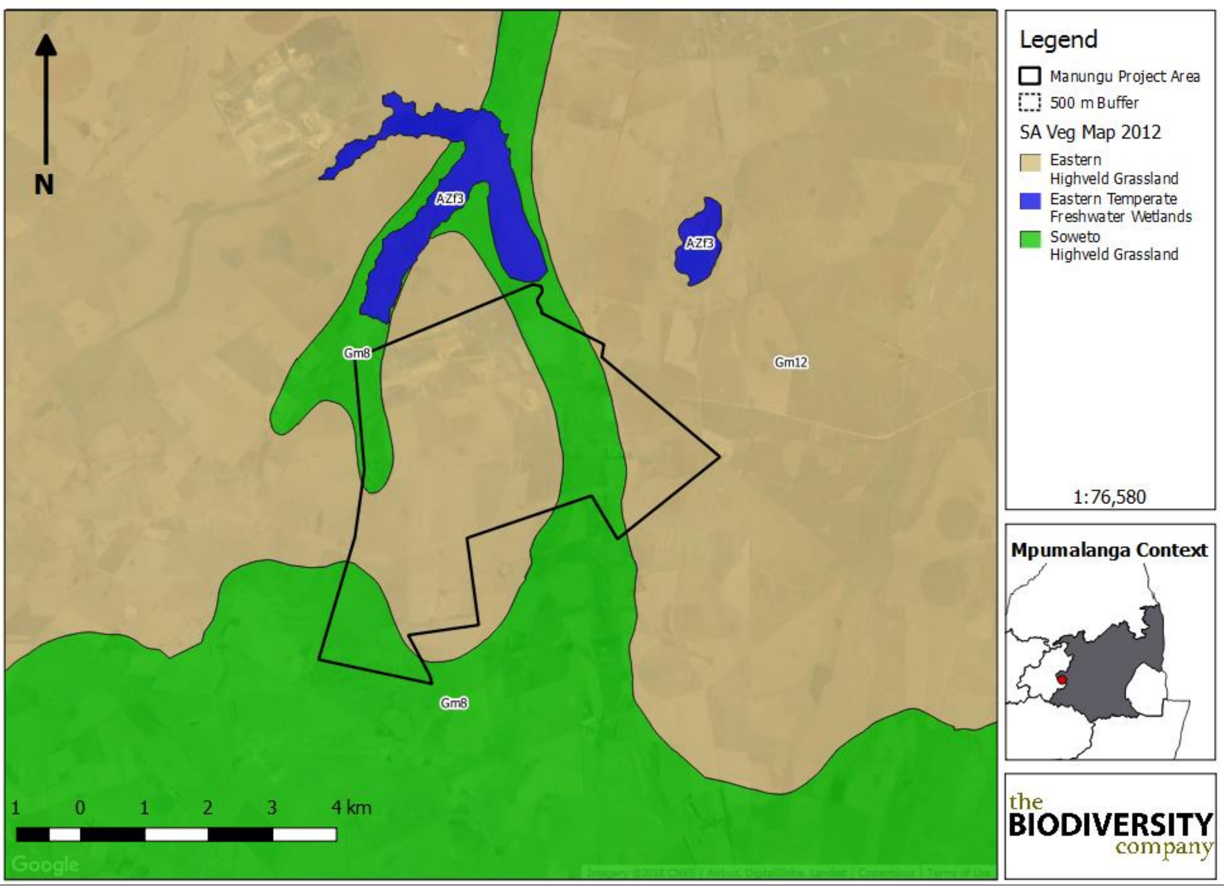


Figure 6: Project area showing the vegetation type based on the Vegetation Map of South Africa, Lesotho & Swaziland (BGIS, 2017)

5.2.1 Eastern Highveld Grassland

This vegetation type occurs on moderately undulating planes, including some low hills and pan depressions. The vegetation is a short dense grass land dominated by the usual Highveld grass composition (*Arsitida, Digitaria, Erafrostsis, Themeda, Tristachya* etc.) with small scattered rocky outcrops with, wiry sour grasses and some woody species. Some 44% transformed primarily by cultivation, plantations, mines, urbanisation and by building of dams. No serious alien invasions are reported (Mucina & Rutherford, 2006).

5.2.2 Soweto Highveld Grassland

The Soweto Highveld Grassland vegetation type is found in Mpumalanga, Gauteng and to some extent in neighbouring Free State and North-West Provinces. This vegetation type typically comprises of an undulating landscape on the Highveld plateau supporting short to medium-high, dense, tufted grassland dominated almost entirely by *Themeda triandra* and accompanied by a variety of other grasses such as *Elionurus muticus, Eragrostis racemosa,* *Heteropogon contortus* and *Tristachya leucothrix*. Scattered small wetlands, narrow stream alluvia, pans and occasional ridges or rocky outcrops interrupt the continuous grassland cover (Mucina & Rutherford, 2006).

5.3 Wetland National Freshwater Priority Areas

A total of five (5) Freshwater Ecological Priority Areas (FEPA) wetland types were identified within the assessment area of the project. The systems are either classified as natural or artificial systems. The integrity of these FEPA wetlands is considered to vary from a largely natural (AB) to critically (Z3) modified state. The rank of the systems varied from Rank 4 to Rank 6, suggesting the presence of wetlands in a largely natural or moderately modified state, or any other wetlands identified on a regional scale. The FEPA wetland system are listed in Table 11. The location of the FEPA wetlands in reference to the proposed extension are provided in Figure 7.

Table 11: NFEPA description for the FEPA sites

Classification Levels				Wetland Vegetation Class	Natural / Artificial	Wetland Condition	Wetland Rank
L1 (System)	**L2 (Ecoregion)**	**L3 Landscape Position**	**L4 HGM Classification**				
Inland System	Highveld	Slope	Flat	Mesic Highveld Grassland	Natural	AB - C	Rank 4 - 5
Inland System	Highveld	Valley Floor	Channelled	Mesic Highveld Grassland	Natural & Artificial	C – Z3	Rank 5
Inland System	Highveld	Valley Floor	Unchannelled	Mesic Highveld Grassland	Natural	C	Rank 5
Inland System	Highveld	Bench	Flat	Mesic Highveld Grassland	Natural	Z1	Rank 6
Inland System	Highveld	Bench	Depression	Mesic Highveld Grassland	Natural	Z1	Rank 6

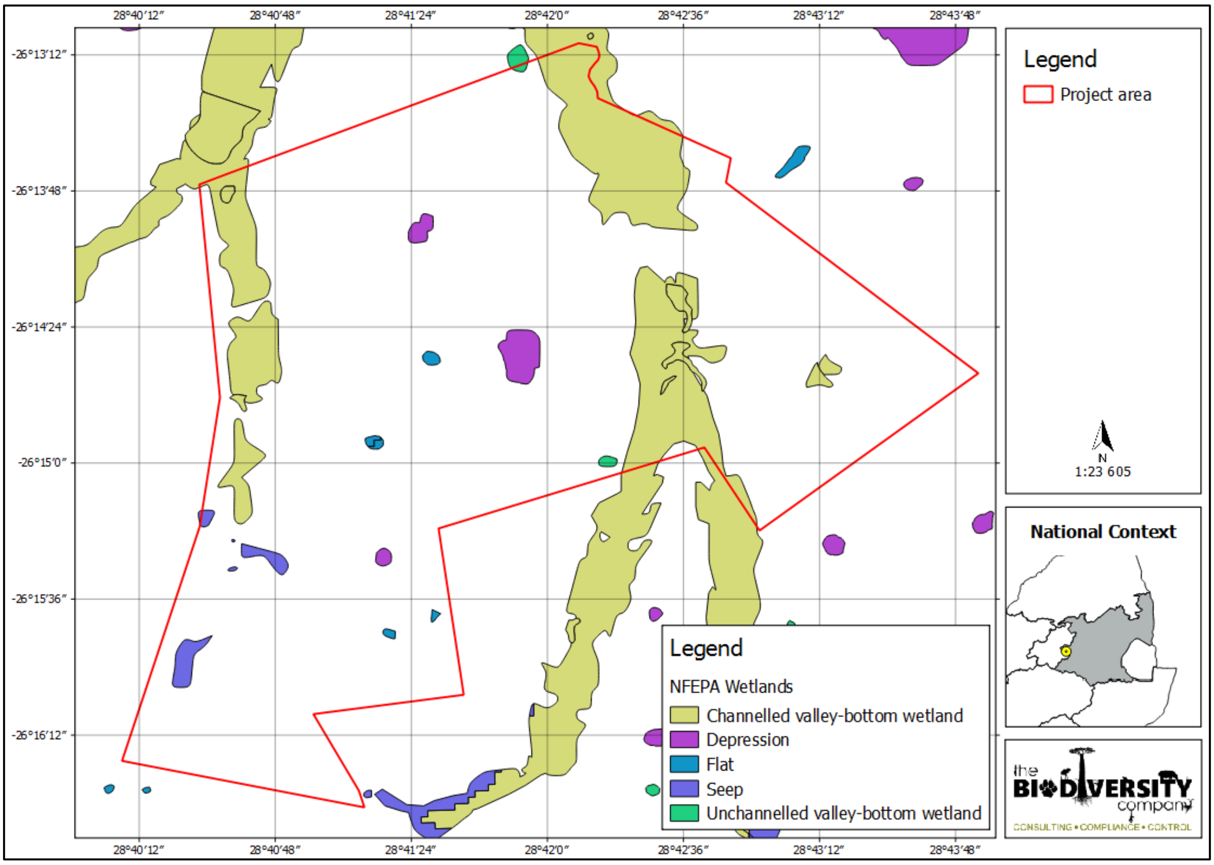


Figure 7: The FEPA wetlands in the project assessment area (Mining Right Area)

5.4 The Mpumalanga Highveld Wetlands

The Mpumalanga Highveld (MPHG) wetlands dataset was considered for the proposed expansion, with numerous HGM types located within the assessment area. The dominant wetland type within the assessment area was channelled valley bottom systems, with depression and seepage areas comprising a lower extent of the assessment area (Figure 8).

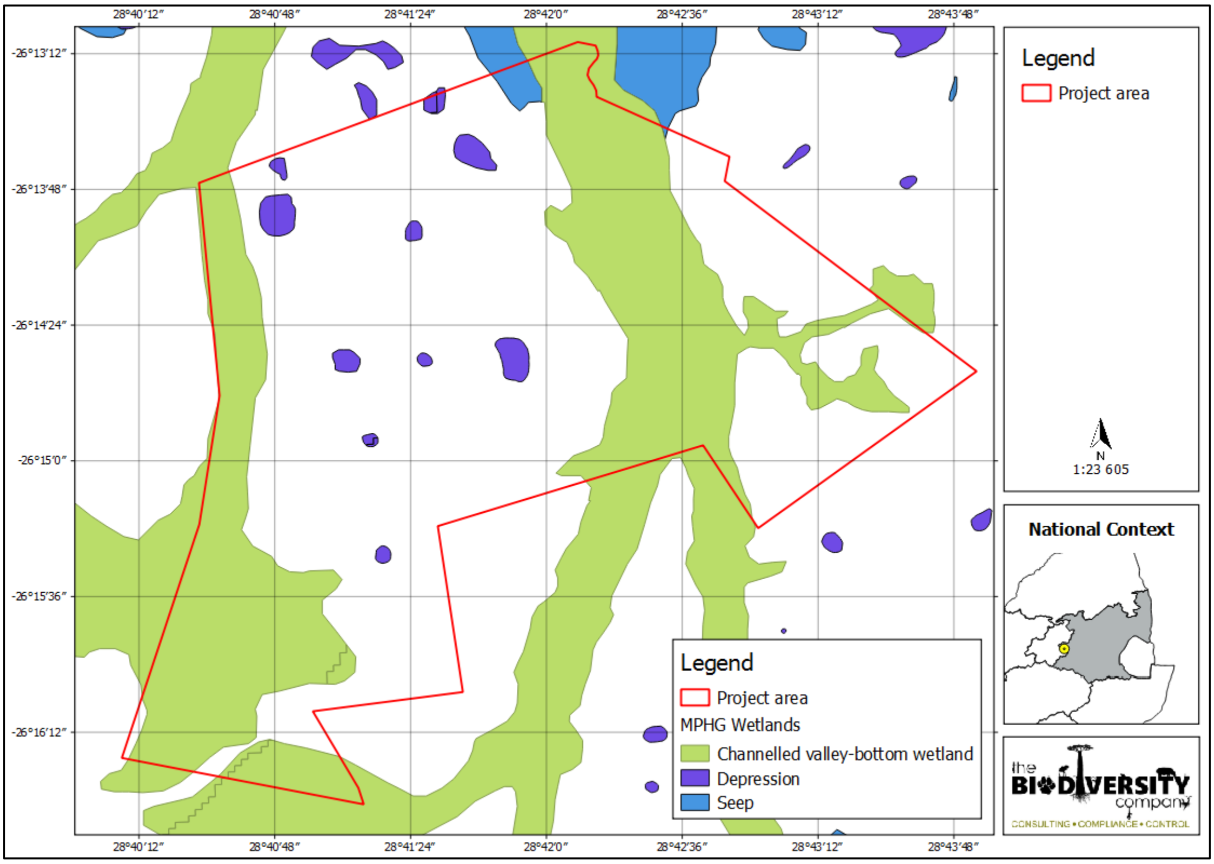


Figure 8: The MPHG wetlands in the project assessment area (Mining Right Area)

5.5 Wetland Specialist Study

Ecotone Freshwater Consultants CC (EFC) conducted a specialist wetland assessment for a portion of the project area in 2013. Information collated and generated for the study has been considered to supplement this updated wetland assessment. The extent of wetland areas identified and delineated in 2013 is presented in Figure 9.

Figure 9: The wetland areas delineated by EFC for the assessment area (2013)

5.6 Aquatic National Freshwater Priority Areas

The two sub-quaternary catchments (B20A-1362 and B20A-1374) have a total of two (2) freshwater priority areas designated to them (Table 12). Both of these priority areas are associated with SQR B20A-1374.

Table 12: NFEPA's for the two sub-quaternary catchments

Type of FEPA map category	Biodiversity features
B20A-1362	
None	
B20A-1374	
Number of wetland clusters	1 WetCluster FEPA
Wetland ecosystem type	Mesic Highveld Grassland Group 4_Fat

5.7 Wetland Assessment

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 flow accumulation plan with surface flow direction for the project area are presented in Figure 10 and Figure 11 respectively.

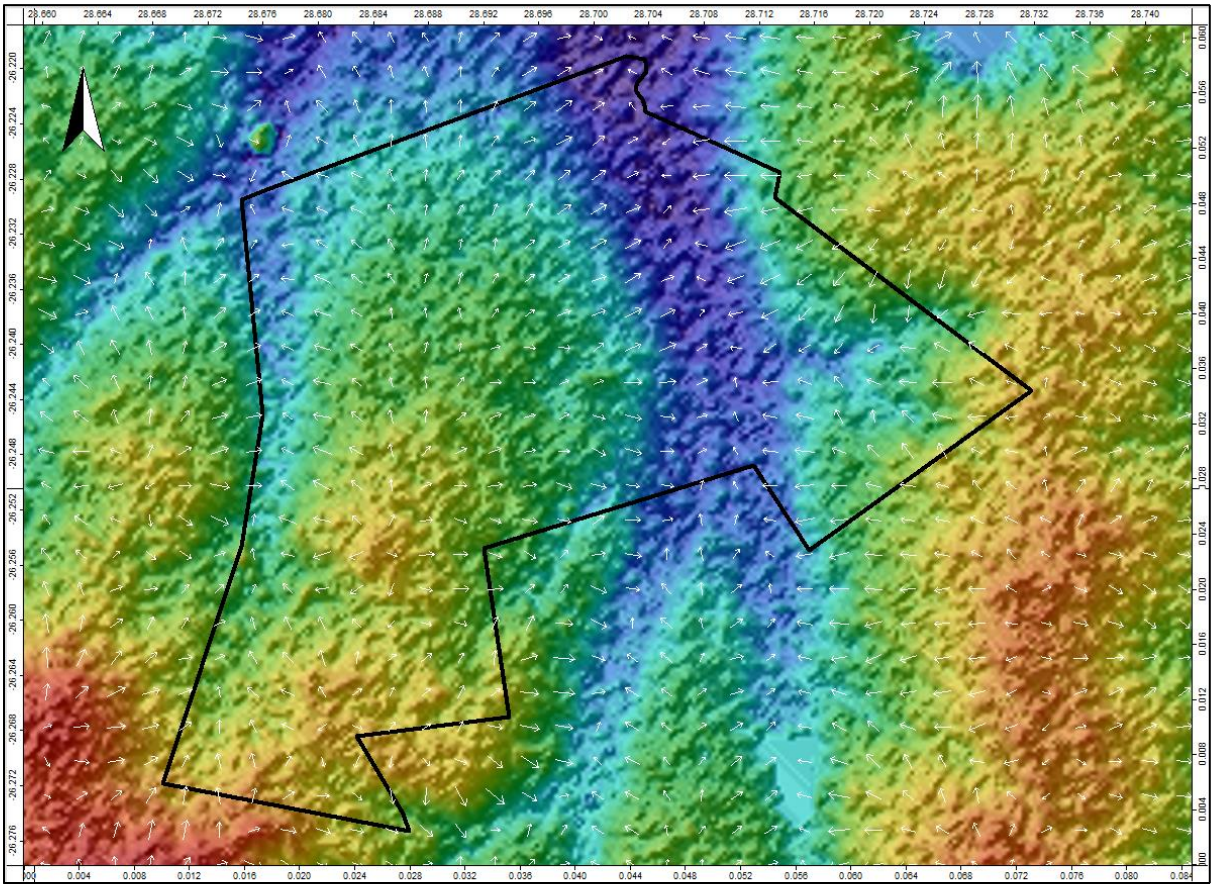


Figure 10: A 3D representation for the project area

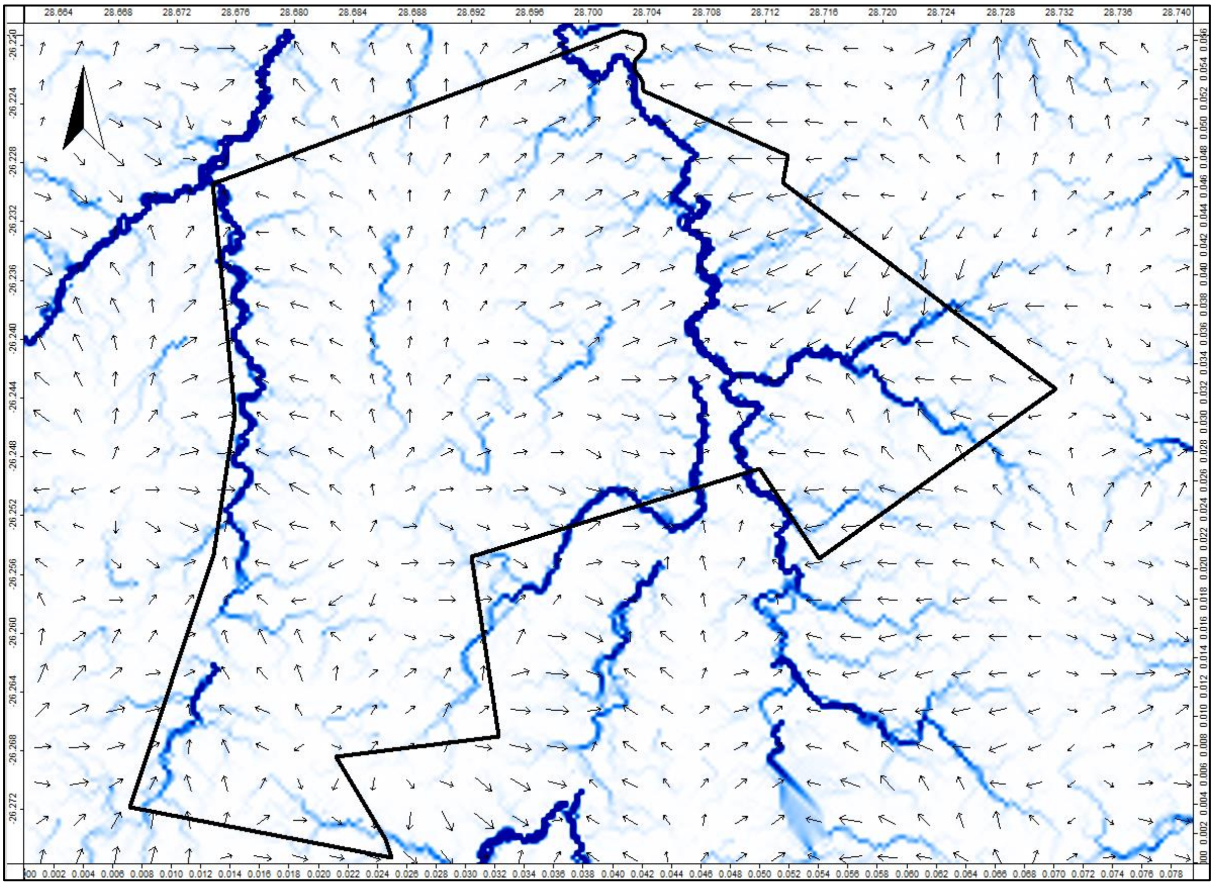


Figure 11: The flow accumulation and flow direction for the project area

The wetland delineation is shown in Figure 12. The wetland classification as per SANBI guidelines (Ollis *et al.*, 2013) is presented in Table 13. A total of 5 HGM types were identified and delineated for the project. An illustration of the HGM types in the relevant landscape, and the hydro-dynamics of the systems are presented in Figure 16.

A total of 16 HGM units were identified for the project. The two wetland systems located to the west and east of the project area have been identified as unchannelled and channelled valley bottom systems respectively, with the eastern wetland displaying channel features irregularly. The remaining HGM units comprised endorheic pans and seepage[2] areas.

The wetland areas had the greatest species composition in comparison to all the different areas. Patches of *Imperata cylindrica*, *Agrostis lachnantha var. lachnantha* as well as *Typha capensis* occurred throughout the wetland. *Crinum bulbispermum, Eucomis autumnalis* as well as *Nerine angustifolia* are flora species associated with marshy or moist areas which occurred throughout the wetland area.

The range of Soil Forms identified for the study included the Willowbrook, Oakleaf, Tukulu, Bonheim, Inhoek, Mispah and Katspruit forms. The Kastspruit form was characteristic of the valley bottom wetlands. Photographs of Soil Form and Soil Wetness encountered in the project area presented in Figure 15.

[2] For the sake of this study, seeps connected to the pans have been jointly assessed as depression systems

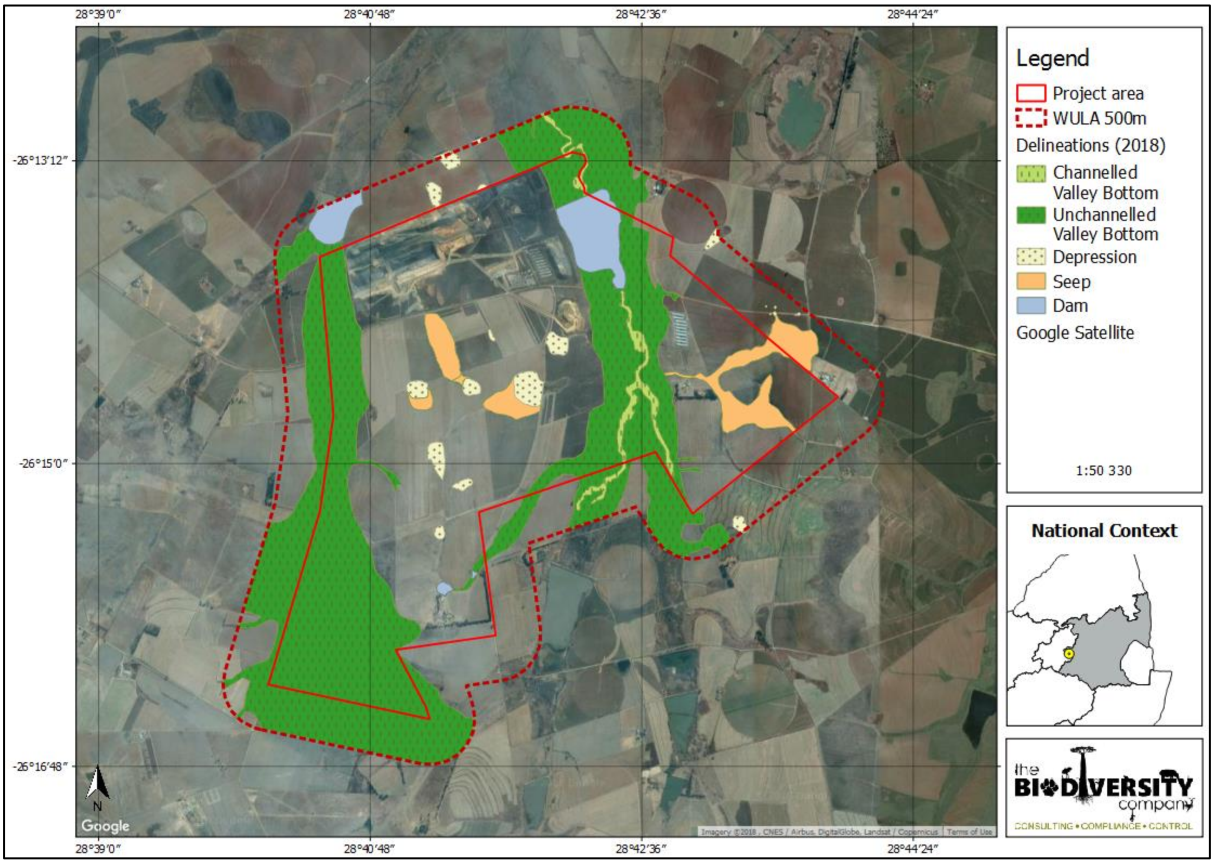


Figure 12: The delineated watercourses within 500m of the project area

Table 13: 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	Highveld	Mesic Highveld Grassland	Slope	Depression	Endorheic	Without channel inflow
Inland	Highveld	Mesic Highveld Grassland	Valley Floor	Depression	Dammed	With channel inflow
Inland	Highveld	Mesic Highveld Grassland	Slope	Seepage	Without channel outflow	N/A
Inland	Highveld	Mesic Highveld Grassland	Valley Floor	Channelled Valley Bottom	N/A	N/A
Inland	Highveld	Mesic Highveld Grassland	Valley Floor	Unchannelled Valley Bottom	N/A	N/A

Figure 13: A photo collage of some wetland systems identified for the project (January 2018)

Figure 14: Photographs of identified vegetation. A: Typha capensis. B: Agrostis lachnantha var. lachnantha. C: Cyperus congestus. D: Leersia hexandra. E: Persicaria attenuate. F: Cyperus longus var longus

Figure 15: Photographs of Soil Wetness and Soil Forms considered for the study. A: Mottling, B: Melanic topsoil, C: G horizon

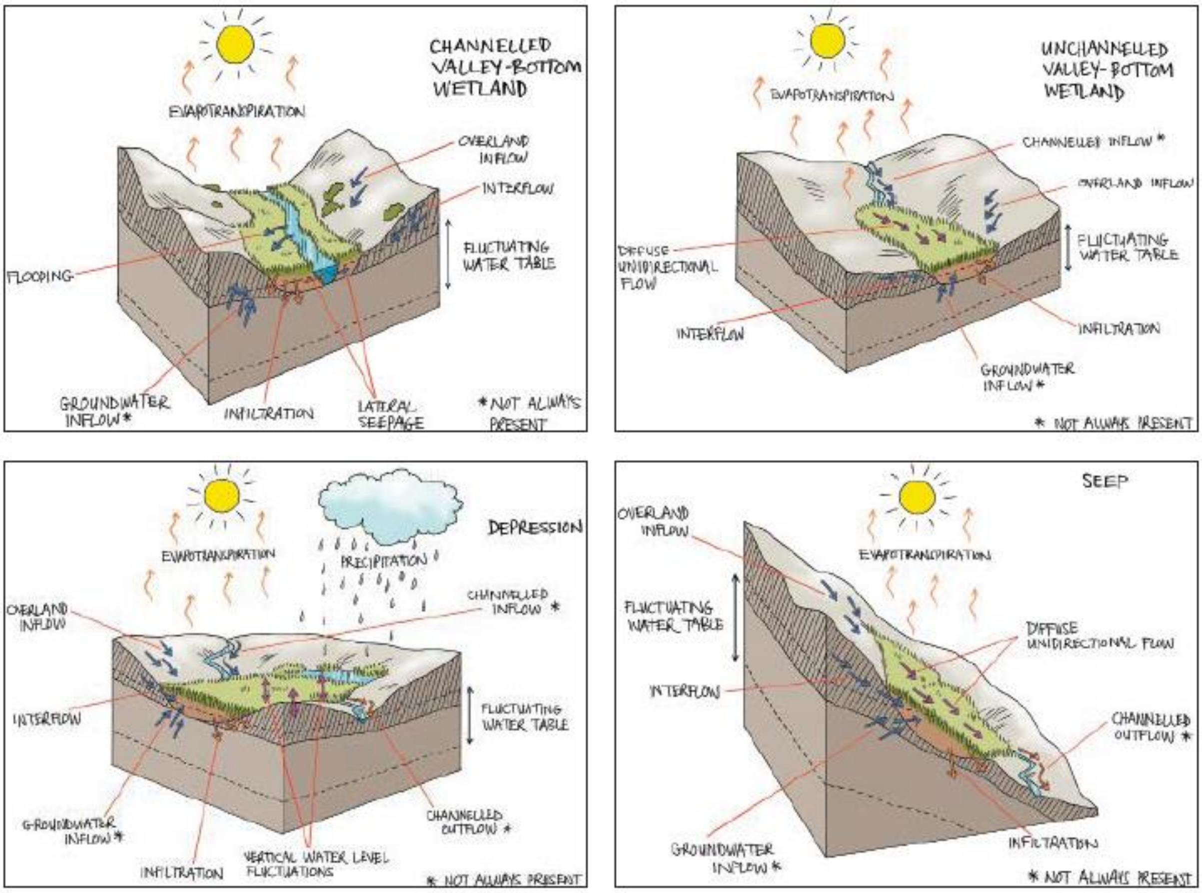


Figure 16: Conceptual illustration of wetlands, showing the typical landscape setting and the dominant inputs, throughputs and outputs of water (Ollis et al. 2013)

5.7.1 Present Ecological State

The PES for the assessed HGM units is presented in Table 15. Photographs of aspects that has contributed to the modifications of the systems are presented in Figure 17. The overall wetland health for the wetlands varied from Moderately Modified (Class C) to Largely Modified (Class D) systems, with the majority of the wetlands rated a Class D. Figure 18 depicts the PES of the wetland systems.

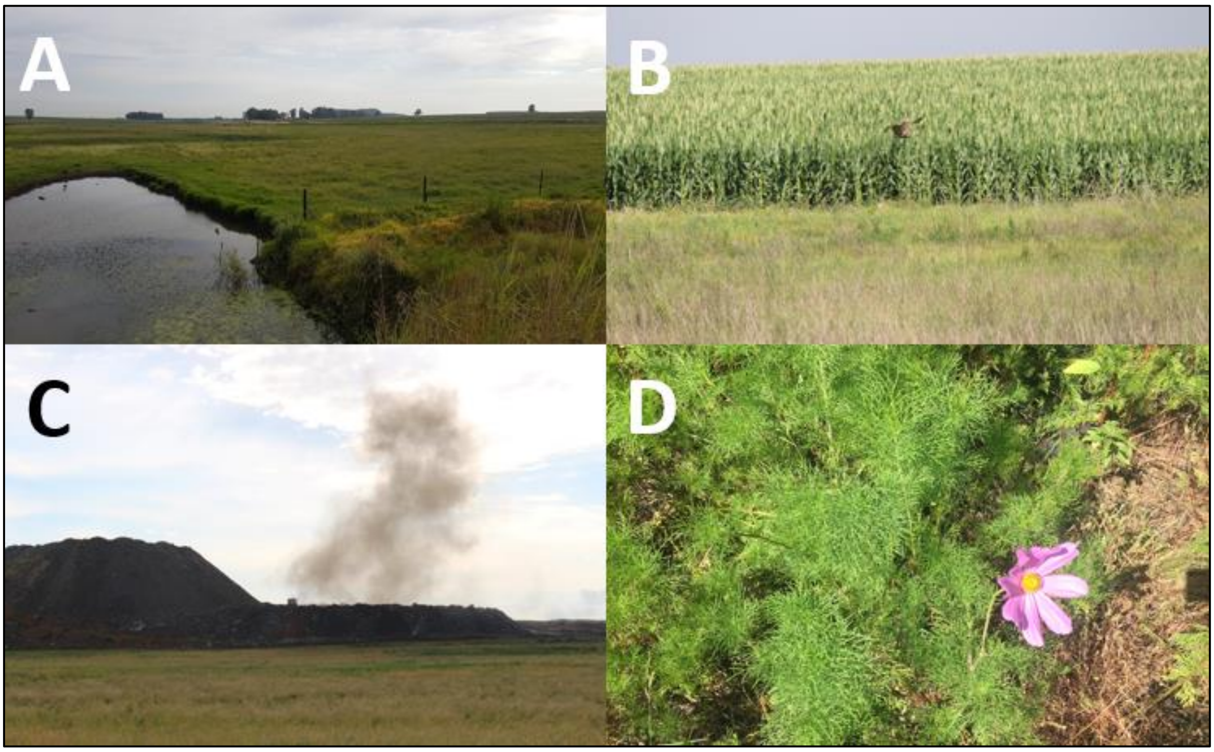


Figure 17: Photographs of aspects impacting on the wetlands. A: Impoundments. B: Commercial farming. C: Mining. D: Alien vegetation, Cosmos bippinatus

The hydrology within the catchment of the two valley bottom systems has been impacted on (or impeded) due to the placement of dams and access route crossings. The extent of commercial agriculture has caused the loss of groundcover which has resulted in increased run-off volumes and velocities across the catchment area. Run-off from the mining area has diverted and increased the volume of stormwater to the adjacent wetland systems. These increases have resulted in changes to the floodpeaks and hydrological regimes of the valley bottom wetlands. The changes in the upper catchment area, notably commercial farming and mining (to a lesser extent) have impacted on the hydrological inputs of the depression systems, due to the vulnerability of these systems to changes in water quantity.

The geomorphology of the valley bottom wetlands has also been impacted on due to the placement of dams within these systems. This has resulted in reaches of the system being inundated, and resulted in the onset or erosion, particularly within the system located to the east of the project area. The depressions are limited to the higher lying areas of the topography. These areas are flat, with poorly drained soils. The local commercial farmining and mining activities have largely avoided direct impacts to the basins of the depressions, but the supporting catchments have been encroached upon. Wetland areas were noted to be frequented by livestock which has also resulted in the trampling of these systems, notably the more permanently saturated systems.

The vegetation of the wetland systems has been impacted on by the commercial agricultural and mining operations. The agricultural and mining areas are the areas which has been degraded significantly. The agricultural areas were cultivated with Maize and Soya whereas the areas being mined had large stands of weeds and bare soil due to the disturbance to the topsoil layer. The disturbed area didn't contain a large amount of diverse indigenous vegetation mainly due to the anthropogenic influence. Weeds such as *Bidens pilosa, Conyza bonariensis* and *Tagetes minuta* occurred throughout the project area and the overall state of the area was degraded. The roads are maintained, and all the vegetation removed on a constant basis and will most likely be a monoculture of a certain grass species. The disturbed grassland area has been constantly disturbed, mainly due to grazing pressure from livestock and is a monoculture of grass species, mainly *Eragrostis curvula*.

Table 14: Summary of the scores for the wetland PES

HGM Type	Hydrology		Geomorphology		Vegetation	
	Rating	Score	Rating	Score	Rating	Score
Pans (and connected seeps)	D: Largely Modified	4.2	D: Largely Modified	4.3	D: Largely Modified	4.9
Overall PES Score	4.4		Overall PES Class		D: Largely Modified	
Seeps	D: Largely Modified	4.1	D: Largely Modified	4.1	D: Largely Modified	4.6
Overall PES Score	4.2		Overall PES Class		D: Largely Modified	
Channelled valley bottom	D: Largely Modified	4.4	D: Largely Modified	4.8	C: Moderately Modified	3.1
Overall PES Score	4.1		Overall PES Class		D: Largely Modified	
Unchannelled valley bottom	C: Moderately Modified	3.3	C: Moderately Modified	3.6	C: Moderately Modified	3.7
Overall PES Score	3.5		Overall PES Class		C: Moderately Modified	

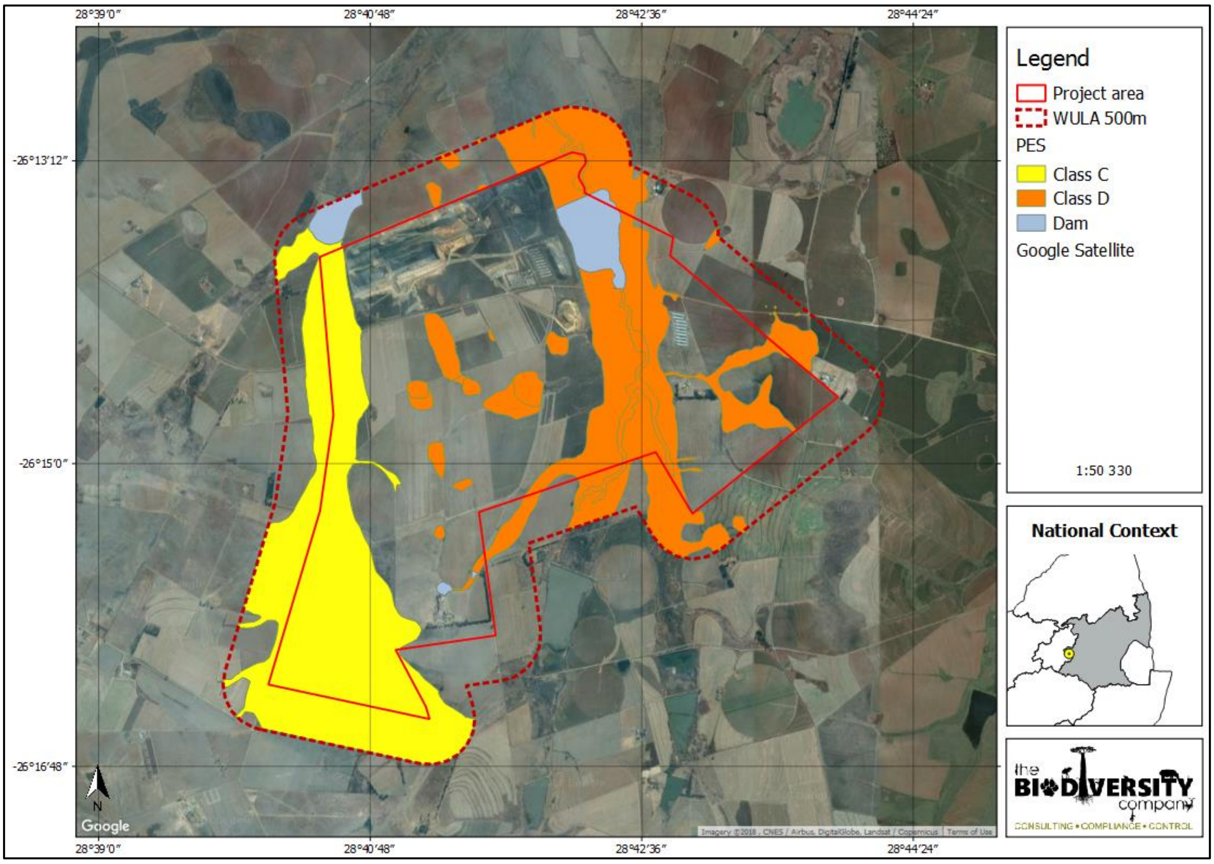


Figure 18: The depicted PES of the wetlands

5.7.2 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 15.

All of the wetland types had overall moderately low levels of service, with the exception of the unchannelled valley bottom system which had an intermediate level of service. It is evident from the study that the benefits are associated with indirect benefits, which include the enhancement of water quality. The level of indirect benefits for all the systems ranged from low to moderately low. The following factors showed services with moderately high levels or higher for identified for the study:

- Sediment trapping;
- Phosphate, nitrate and toxicant assimilation; and
- Erosion control.

The remaining services were scored as intermediate or lower.

Table 15: The Eco-Services being provided by the wetland type

Wetland Unit					Pans	Seeps	Channelled valley bottom	Unchannelled valley bottom
Ecosystem Services Supplied by Wetlands	Indirect Benefits	Regulating and supporting benefits		Flood attenuation	2.0	1.7	1.6	1.9
				Streamflow regulation	1.0	1.1	1.2	1.3
			Water Quality enhancement benefits	Sediment trapping	2.2	2.3	1.3	2.2
				Phosphate assimilation	2.2	1.1	1.4	1.4
				Nitrate assimilation	2.4	2.1	1.5	1.5
				Toxicant assimilation	2.1	2.2	1.5	1.8
				Erosion control	2.0	2.1	1.9	2.3
				Carbon storage	0.8	0.6	1.1	1.7
	Direct Benefits	Biodiversity maintenance			0.9	1.1	1.2	1.6
		Provisioning benefits		Provisioning of water for human use	0.0	0.6	1.1	1.0
				Provisioning of harvestable resources	0.0	0.3	0.0	0.5
				Provisioning of cultivated foods	0.0	0.0	0.0	0.3
		Cultural benefits		Cultural heritage	0.0	0.0	0.0	0.0
				Tourism and recreation	0.3	0.3	0.6	0.8
				Education and research	0.3	0.3	0.5	0.7
Overall					16.2	15.8	14.9	18.9
Average					1.1	1.1	1.0	1.3

5.7.3 Ecological Importance and Sensitivity

The EIS assessment was applied to the HGM type described in the previous section in order to assess the levels of sensitivity and ecological importance of the wetland. The results of the assessment are shown in Table 16. Figure 19 depicts the PES of the wetland systems. The following findings from the biodiversity assessment (The Biodiversity Company, 2018) were considered for the EIS classification:

- No plants Species of Conservation Concern (SCC) were recorded for the project area. The likelihood of occurrence of any of the Red and Orange List plant species is low to medium.
- Seventy-six (76) bird species were recorded in the project area during the January 2018 survey. No bird SCC were recorded during the survey, although based on the various wetland habitats encountered in the project area, the likelihood that bird SCC occur there is rated as high.
- Overall, mammal diversity in the project area was considered high, with eighteen (18) mammal species being recorded during the January 2018 survey based on either direct observation, camera trap photographs or the presence of visual tracks & signs.

- Three (3) mammal SCC were recorded in the project area. Serval (*Leptailurus serval*) were encountered on a number of occasions during the survey, and it appears that a healthy population of these threatened mammals occur within the project area. Similarly, there seems to be healthy populations of Cape Clawless Otters (*Aonyx capensis*) along the wetland areas and in the dams within the project area and adjacent to it.
- Six (6) reptile species were recorded in the project area during the January 2018. One near-endemic snake and one endemic snake species were recorded in the project.
- Four (4) amphibian species was recorded in the project area during the January 2018 survey based on visual observations as well as from calls made by various frog species.

The EIS of the two valley bottom wetland types was rated as high (Class B), with the remaining wetland types being rated as moderate (Class C).

The hydrological / functional importance was rated as Moderate (Class C) for all the wetland systems. The direct human benefits were rated as low (Class D) for all the wetland systems.

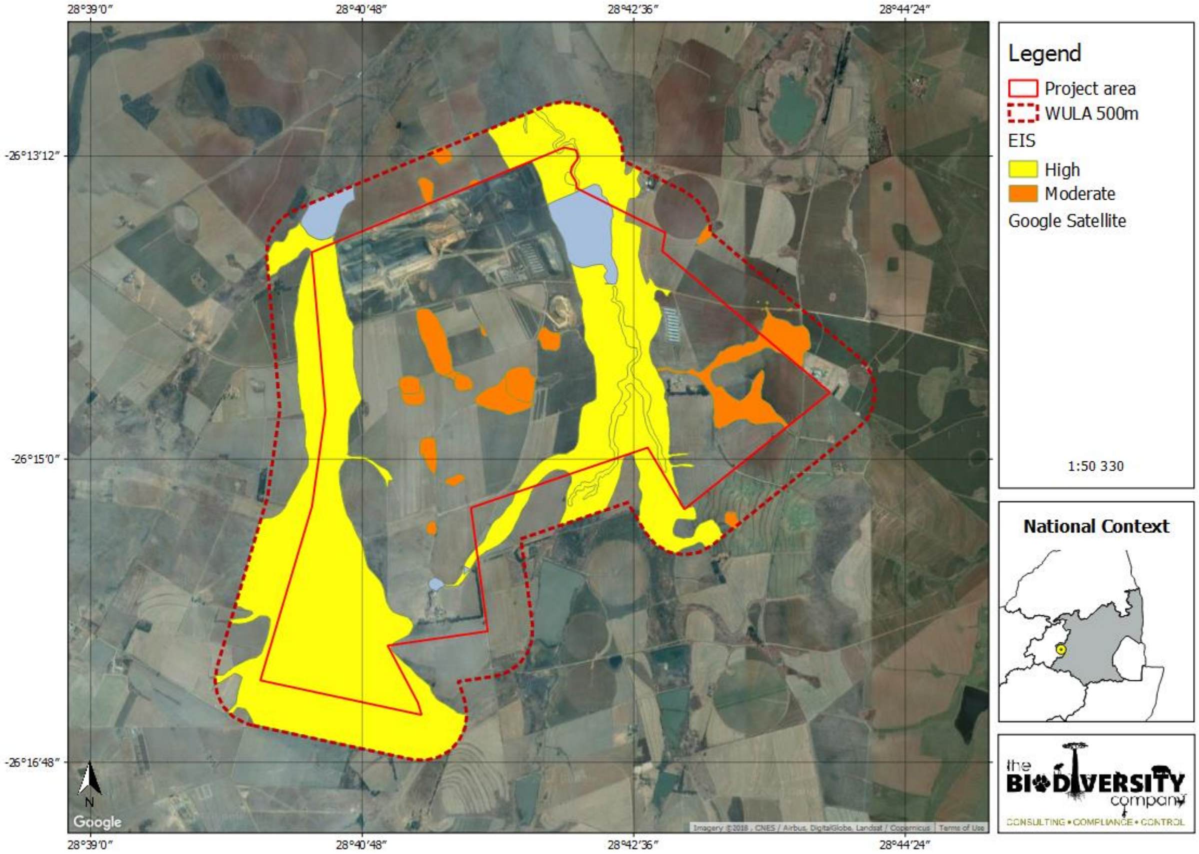


Figure 19: The depicted EIS of the wetlands

Table 16: The EIS results for the delineated wetlands

WETLAND IMPORTANCE AND SENSITIVITY	Pans	Seeps	Channelled valley bottom	Unchannelled valley bottom
Ecological Importance & Sensitivity	1.7	1.5	2.6	2.7
Hydrological / Functional Importance	1.8	1.7	1.4	1.8
Direct Human Benefits	0.1	0.3	0.4	0.6

5.8 Buffer Zones

The project is for the proposed expansion of the Manungu Colliery. The expansion of the mining area will result in the loss of the delineated wetlands. The DWS buffer tool recommends at a desktop level that the required buffer for open cast mining be 180 m.

A minimum buffer zone of 175 m is recommended for the wetlands with regards to a mining operation (Macfarlane et al. 2009). These minimum buffer widths (to protect core wetland habitat and aquatic functioning) are calculated based on a simple classification of wetland types and land use categories, broadly grouped as riverine and palustrine systems. Ecological and landscape characteristics are then assessed to establish the need to increase the buffer width, if at all.

The model shows that the largest risks (Very High) posed by the development during the construction phase is that of “increased sediment inputs and turbidity”. During the operational phase Very High risks were flagged for “alterations to flow volumes as well as patterns” and “inputs of heavy metal contaminants”. A number of High risks are also expected for the operational phase of the project” (Table 19). These risks are calculated with no prescribed mitigation and presented in Table 17.

Table 17: Pre-mitigation buffer requirement

Required buffer before mitigation measures have been applied	
Construction Phase	46 m
Operational Phase	79 m

According to the buffer guideline (Macfarlane et al. 2015) a high-risk activity would require a buffer that is 95% effective to reduce the risk of the impact to a low-level threat. However, the prescribed mitigation measures will reduce the risks for some aspects and the required buffer is then 45 m and 65 m (Table 18) for the construction and operational phases respectively. It is recommended that the larger buffer width of 65 m be implemented from the onset of the construction phase of the project.

Table 18: Post-mitigation buffer requirement

Required buffer after mitigation measures have been applied	
Construction Phase	45 m
Operational Phase	65 m

Table 19: The risk results from the wetland buffer model for the proposed project

Phase	Threat Posed by the proposed land use / activity	Specialist Threat Rating	Refined Threat Class	Specialist justification for refined threat ratings.
Construction Phase	1. Alteration to surface runoff flow volumes	Low		
	2. Alteration of patterns of flows (increased flood peaks)	Medium	Low	Avoidance of valley bottom wetland area and buffer.
	3. Increase in sediment inputs & turbidity	Very High	High	Avoidance of valley bottom wetland area and buffer. Dry season construction, limit (and demarcate) the disturbance footprint area, silt traps, stripping in a phased approach, begin vegetation clearing upslope and work downslope, managed stockpiles, storm water management
	4. Increased nutrient inputs	Low		
	5. Inputs of toxic organic contaminants	Medium		
	6. Inputs of toxic heavy metal contaminants	Medium	Low	Off-site equipment and vehicle fuelling and maintenance, storage of chemicals and fuel in bunded area, no on-site fabrication, oil spill kits, equipment & vehicle inspections.
	7. Alteration of acidity (pH)	Low		
	8. Increased inputs of salts (salinization)	Low		
	9. Change (elevation) of water temperature	Low		
	10. Pathogen inputs (i.e. disease-causing organisms)	Very Low		
Operational Phase	1. Alteration to flow volumes	Very High	High	Avoidance of valley bottom wetland area and buffer. Minimise opencast pit footprint area. Pumping of clean water back into the wetland systems. Stockpiling of soils and materials within the existing working area, and not within preferential flow paths.
	2. Alteration of patterns of flows (increased flood peaks)	Very High	High	
	3. Increase in sediment inputs & turbidity	High	Medium	Stockpiling of soils and materials within the existing working area, and not within preferential flow paths. Compile a stormwater management plan for the area. Separate clean and dirty water, intercept surface run-off and direct this around the working area.
	4. Increased nutrient inputs	High	Medium	Provide sanitation, and waste storage area. Service waste depots and facilities regularly and dispose of waste in demarcated areas.
	5. Inputs of toxic organic contaminants	High		
	6. Inputs of toxic heavy metal contaminants	Very High	High	Off-site equipment and vehicle fuelling and maintenance, storage of chemicals and fuel in bunded area, no on-site fabrication, oil spill kits, equipment & vehicle inspections.
	7. Alteration of acidity (pH)	High		
	8. Increased inputs of salts (salinization)	High		
	9. Change (elevation) of water temperature	Medium		
	10. Pathogen inputs (i.e. disease-causing organisms)	Low		.

5.9 Aquatic Ecology

5.9.1 *In situ* Water Quality

In situ water quality analysis was conducted at all monitoring sites. These results are important to assist in the interpretation of biological results due to the direct influence water quality has on aquatic life forms. The results of the low flow survey are presented in Table 20, and high flow in Table 21.

Table 20: In situ water quality results for the low flow survey (June 2017)

Site	pH	Conductivity (µS/cm)	DO (mg/l)	Temperature (°C)
TWQR*	**6.5-9.0**	**<700	**>5.00**	**5-30**
MAN1	7.65	336	5.60	8.60
MAN2	8.22	443	13.3	12.2
MAN3	9.00	349	23.2	14.0
MAN4	7.19	**785**	6.54	12.2

*TWQR: Target Water Quality Range; **Expert opinion conductivity range; Levels exceeding recommended guideline levels are indicated in red

Table 21: In situ water quality results for the high flow survey (October 2017)

Site	pH	Conductivity (µS/cm)	DO (mg/l)	Temperature (°C)
TWQR*	**6.5-9.0**	**<700	**>5.00**	**5-30**
MAN1	8.05	123	11.7	20.8
MAN2	7.35	264	5.89	19.6
MAN3	7.68	321	6.08	24.5
MAN4	7.04	356	**2.45**	19.5

*TWQR: Target Water Quality Range; **Expert opinion conductivity range; Levels exceeding recommended guideline levels are indicated in red

In situ water quality results indicate pH levels within the aquatic systems are within target water quality guidelines during the high and low flow surveys (Table 20 and Table 21). However, pH levels at site MAN3 were alkaline (9.0) during the low flow survey. Temporal trends indicate a decrease in pH levels from the 2014 study at all sites, and stabilised levels between the 2015 and 2017 studies (Figure 20).

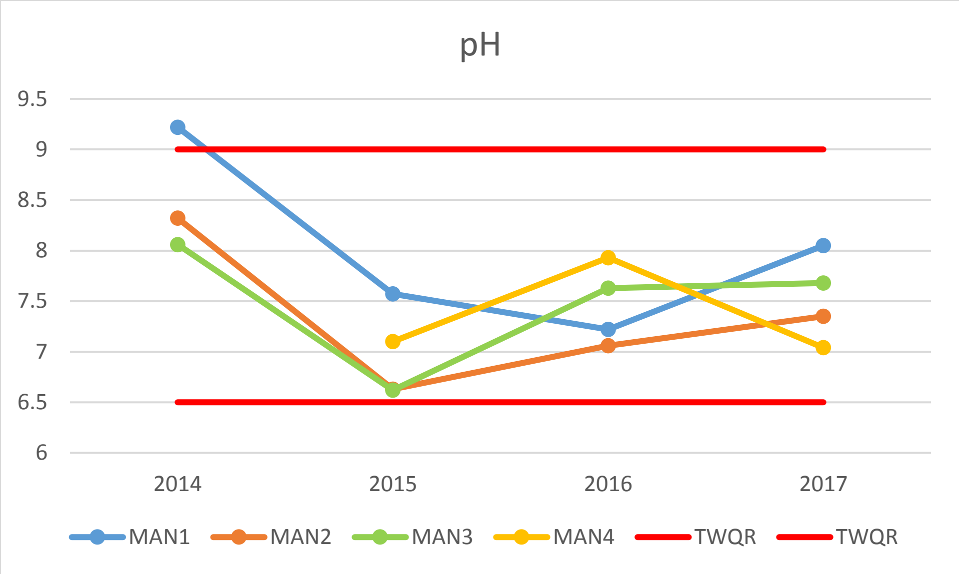


Figure 20: Spatial and Temporal trends for pH levels

Conductivity levels within the systems were elevated during the low flow survey in comparison to the high flow survey (Table 20 and Table 21). This is attributed to the concentration of dissolved solids during the dry season. Elevated conductivity levels were observed at site MAN4 during the low flow survey. All sites fell within TWQR limits during the high flow survey. Trends indicate overall decreased dissolved solid concentration levels from the 2014 to 2017 surveys, indicating improved water quality conditions. Increases in conductivity levels were observed between MAN1, MAN2 and MAN4, however, connectivity of the system was unlikely during the survey and flow was absent from all three sites. Increases in dissolved solids was observed between sites MAN2 and MAN4, and MAN3 and MAN4, indicating an influx of dissolved solids within the downstream reaches (Figure 21).

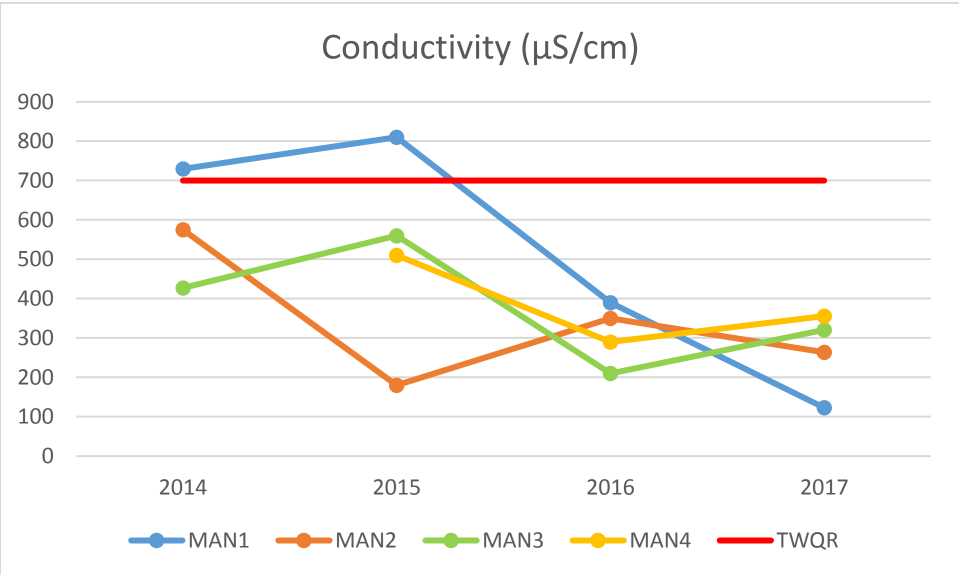


Figure 21: Spatial and Temporal trends for Conductivity levels

During the low flow survey, Dissolved Oxygen (DO) levels ranged from 5.6 mg/l to 23.0 mg/l at sites MAN1 and MAN3 respectively. Levels fell within TWQR levels, however, DO at

MAN3 was supersaturated. Extensive algae and aquatic vegetation growth was observed at the site, contributing to the elevated DO levels.

Water temperatures recorded during the low and high flow surveys fell within TWQR, and were expected for the region.

5.9.2 Intermediate Habitat Integrity Assessment

The results for the instream and riparian habitat integrity assessment for the aquatic systems associated with Manungu Colliery are presented in Table 22 and Table 23. The reach includes the 5 km section of the Bronkhorstspruit River system in which the project area falls under.

Table 22: Results for the instream habitat integrity assessment associated with Manungu Colliery

Instream	Average	Score
Water abstraction	12	6,72
Flow modification	18	9,36
Bed modification	14	7,28
Channel modification	14	7,28
Water quality	15	8,4
Inundation	18	7,2
Exotic macrophytes	0	0
Exotic fauna	10	3,2
Solid waste disposal	7	1,68
Total Instream		48.88
Category		D

Table 23: Results for the riparian habitat integrity assessment associated with Manungu Colliery

Riparian	Average	Score
Indigenous vegetation removal	20	10,4
Exotic vegetation encroachment	7	3,36
Bank erosion	10	5,6
Channel modification	13	6,24
Water abstraction	17	8,84
Inundation	18	7,92
Flow modification	14	6,72
Water quality	19	9,88
Total Riparian		**41.04**

Category	D

According to the IHIA results, instream and riparian habitat integrity in the Bronkhorstspruit reaches are rated as class D, or largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.

Impacts to the bed, channel and flow modification in the catchment are moderate to large due to the presence of dams and several river crossings which have altered the natural flows, while transforming the channel characteristics due to the absence of natural flows. The number of farm dams in the project area has collected and retained water in the catchment area, reducing the natural base flows within the project area rivers, resulting in no flow between the Manungu Colliery biomonitoring sites. The catchment activities in the assessed reaches have resulted in large amounts of abstraction from the aquatic systems as well as impacts to water quality (Figure 22). Livestock have impacted some sites within the project area through vegetation trampling which has result in erosion and sedimentation of instream aquatic areas (Figure 23).

Figure 22: Impoundments and agriculture located on the Bronkhorstspruit system (Google Earth Imagery, 2017)

Figure 23: Livestock trampling of riparian vegetation has resulted in instream sedimentation within the Bronkhorstspruit (June 2017)

5.9.3 Aquatic Macroinvertebrates

5.9.3.1 Integrated Habitat Assessment System

The IHAS index was developed by McMillan (1998) for use in conjunction with the SASS5 protocol. The IHAS results for the 2017 survey period are presented in Table 24.

Table 24: IHAS Scores at each site during the 2017 survey period

Survey	June 2017		October 2017	
Site	Score	Suitability	Score	Suitability
MAN3	28	Poor	44	Poor
MAN4	39	Poor	37	Poor

Habitat availability at MAN3 and MAN4 were rated as Poor during the low flow and high flow surveys. Habitat diversity at both sites was low, with a general absence of stones, gravel and sand. These sites comprised adequate marginal and limited aquatic vegetation with substrates dominated by mud and slow flowing (MAN3) and standing waters (MAN4) (Figure 24 and Figure 25). The low IHAS score is expected to limit macroinvertebrate assemblages.

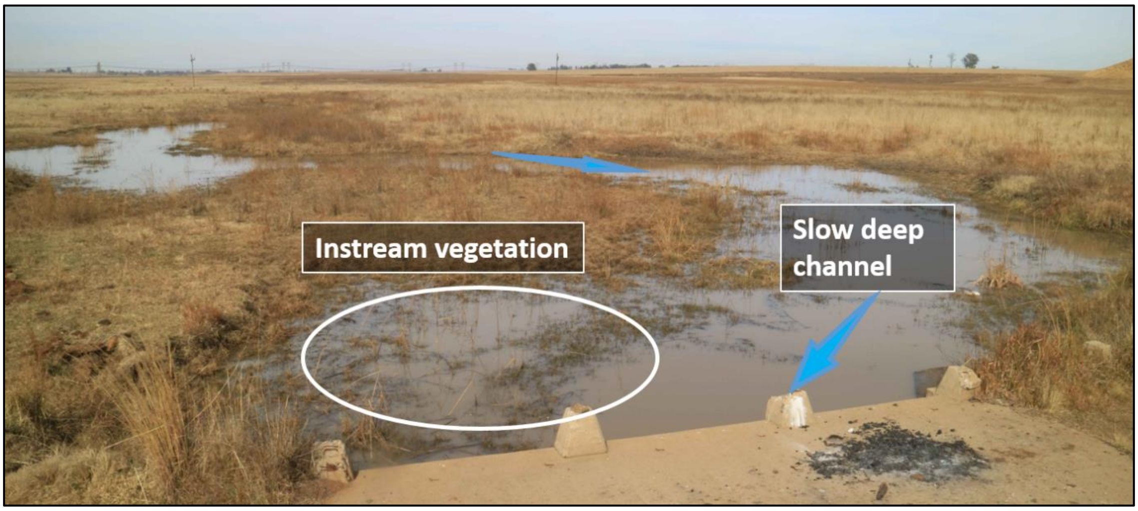


Figure 24: Image illustrating instream habitat at MAN3 (June 2017)

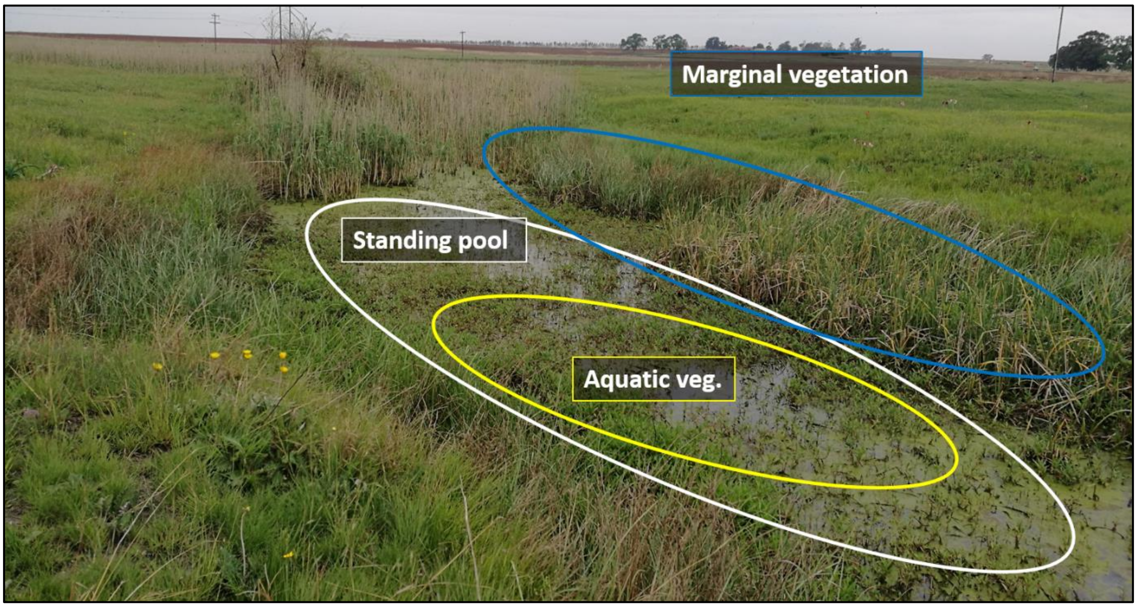


Figure 25: Image illustrating instream habitat at MAN4 (June 2017)

An indication of the available biotopes is presented in Table 25. A rating system of 0 to 5 was applied, 0 being not available. The sites assessed in this study were each assigned a biotope category of class F, indicating limited habitat availability for aquatic macroinvertebrates.

Table 25: Biotope availability at the Manungu Colliery sites (Rating 0-5)

		MAN3		MAN4	
Biotope	Weighting	Low Flow	High Flow	Low Flow	High Flow
Stones in current (SIC)	7	0	0	0	0
Stones out of current (SOOC)	7	0	1	0	0
Bedrock	3	1.5	2	0	0

Aquatic vegetation	7	2	3	0	3
Marginal vegetation in current	6	0	0	0	0
Marginal vegetation out of current	7	3	3	2	3
Gravel	4	0	0	0	0
Sand	2	0	0	0	0
Mud	2	2	3	1	2
Biotope Score (X / 45)		**8.5**	**12**	**3**	**8**
Weighted Biotope Score (%)		**19**	**27**	**7**	**20**
Biotope Category (Tate and Husted, 2015)		**F**	**F**	**F**	**F**

5.9.3.2 Aquatic Macroinvertebrate Assessment Results

Site MAN1 was considered a wetland systems and site MAN2 was an artificial pool of water. SASS5 conducted in wetland systems or dams cannot be interpreted using SASS5 methodologies whilst using the interpretation guidelines, therefore not all sites were sampled for aquatic macroinvertebrates during the 2017 survey period.

The aquatic macroinvertebrate results for the 2017 surveys are presented in Table 26 and Table 27. Based on both the low flow and high flow survey ASPT scores, the aquatic macroinvertebrate communities comprised primarily of tolerant taxa (Intolerance Rating < 5) while a low diversity of moderately tolerant taxa (Intolerance Rating 6 - 10) were sampled in low abundances.

Table 26: Macroinvertebrate assessment results recorded during the low flow (June 2017) survey

Site	SASS Score	No. of Taxa	ASPT*	Category (Dallas, 2007)**
MAN3	93	20	4.7	**B**
MAN4	34	8	4.3	**E/F**

*ASPT: Average score per taxon; **Dallas, 2007 is not applicable to wetlands or dams

Table 27: Macroinvertebrate assessment results recorded during the high flow (October 2017) survey

Site	SASS Score	No. of Taxa	ASPT*	Category (Dallas, 2007)**
MAN3	52	13	4.0	**D**
MAN4	59	15	3.9	**D**

*ASPT: Average score per taxon; **Dallas, 2007 is not applicable to wetlands or dams

The biotic integrity within the assessed reach of the Bronkhorstspruit, ranged from seriously modified at MAN4 to largely natural at MAN3 over the 2017 biomonitoring period. The biotic integrity decreased in a downstream direction during the low flow survey. The biotic integrity was largely limited by poor instream habitat availability and absence of flow. The lack of the stones in and out of current as well as gravel and sand habitats resulted in fewer aquatic macroinvertebrates species being sampled. These habitat types typically hold a diversity of moderately sensitive taxa. The ASPT and recorded taxa at site MAN4 indicates modified water quality within the sampled reaches due to the dominance of tolerant taxa. MAN3 showed good biotic integrity which can be attributed to a greater abundance of suitable instream habitat compared to MAN4 (Table 25). The macroinvertebrate assemblage indicates that the biotic integrity of the Bronkhorstspruit system has been modified to varying degrees. Both MAN3 and MAN4 sites were rated as largely modified (Dallas, 2007), and similar macroinvertebrate communities were observed at both up and downstream sites during the high flow survey. The

A gradual increase in total sensitivity scores was observed at sites MAN3 and MAN4 from the 2015 to 2017 surveys (Figure 26). The increase in total scores can be attributed to increased flows within the systems due to increased rainfall volumes. Furthermore, the stabilisation of water quality within the systems contributes to an increase in biotic integrity. However, a decrease in ASPT scores was observed during the 2017 survey from that of the 2016 survey (Figure 27). The decrease can be attributed to a combination of water quality (Table 20 and Table 21) and habitat modification (Table 25). Site MAN4 is presented as it is the most downstream site and should present the cumulative impacts in the Bronkhorstspruit associated with Manungu Colliery. Based on these trends a dry spell was present during the 2015 monitoring period. Following the dry spell, a fluctuation in SASS5 scores was noted, with scores showing a steady increase since the 2016 high flow survey. The ASPT scores were seen to reflect higher scores during the consecutive low flow assessments compared to the respective high flow assessments. The higher scores may be attributed to variances in habitat availability due to water volumes at the time of each survey.

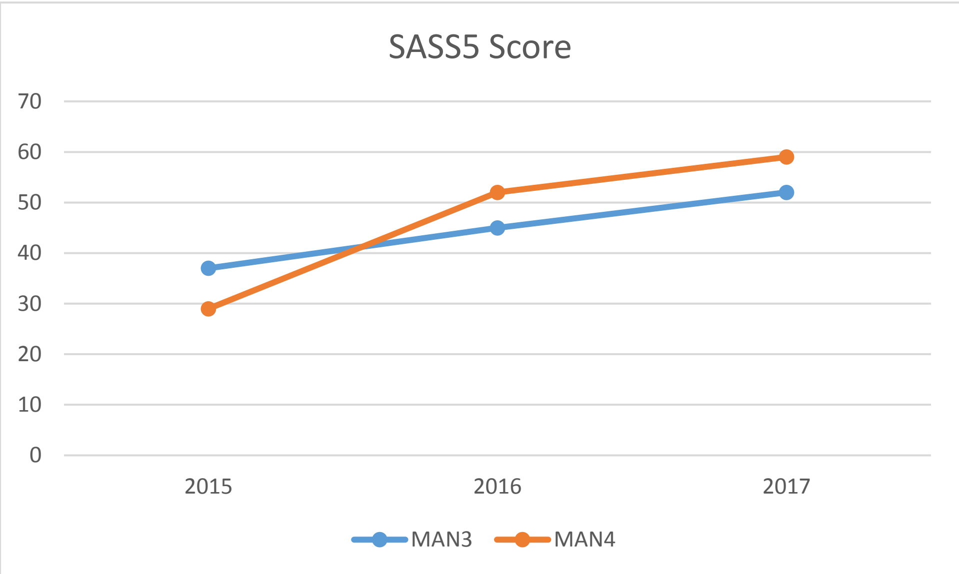


Figure 26: Spatial and temporal trends for the SASS5 scores during high flow periods in the Bronkhorstspruit associated with Manungu Colliery (2017 period)

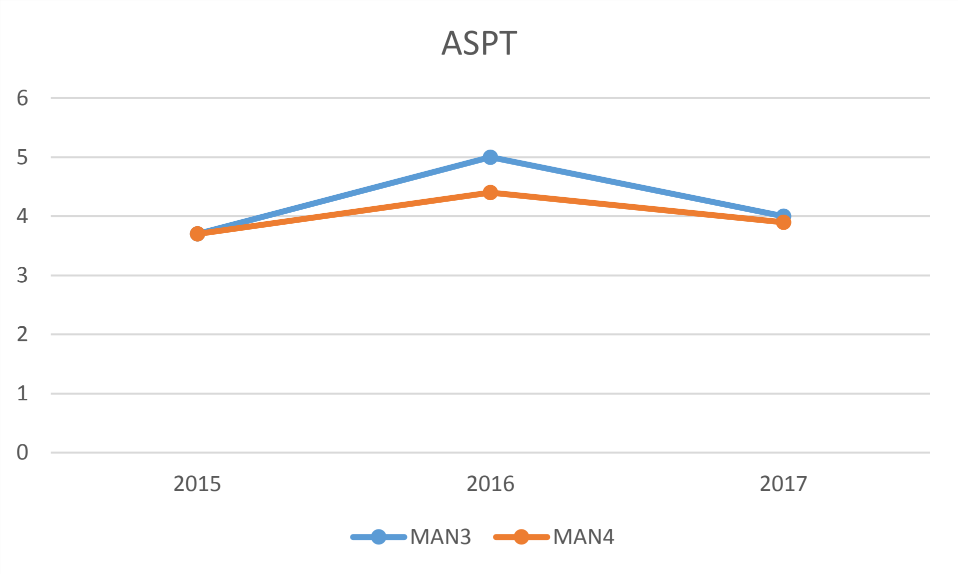


Figure 27: Temporal and spatial trends for the ASPT scores associated with Manungu Colliery during the high flow survey (2015 - 2017 period)

5.9.3.3 Macroinvertebrate Response Assessment Index

The results of the MIRAI associated with the Manungu Colliery are provided in Table 28.

Table 28: MIRAI for the Bronkhorstspruit from the June to October 2017 study period

Invertebrate Metric Group	Score Calculated
Flow modification	20.3
Habitat	39.9
Water Quality	33.3
Ecological Score	**31.5**
Invertebrate Category	**class E**

Biotic integrity according to SASS5 results (Dallas, 2007), site MAN3 was categorised as largely natural (PES class B). This decreased to seriously modified conditions (class E/F) at sites MAN4, further downstream (Table 26 and Table 27).

The results of the MIRAI derived a similar however more robust ecological category of class E or seriously modified for the Bronkhorstspruit and its tributaries, while highlighting the factors responsible for the presence/absence of taxa within the project area. Central factors resulting in a lowered ecological category were attributed to flow modification and water quality drivers. As observed in the results, flow modification factors contributed the most to the deteriorated ecological conditions as the lowest component score obtained, followed by water quality factors.

Invertebrates adapted to flow (flow sensitive taxa) were largely absent from the considered river reaches. The majority of absent taxa have a preference for fast, moderately fast and slow flowing water. taxa large component of the taxa sampled during the study have a preference for standing water, which reflects conditions present at all sites, with low water levels present across the project area. No flows were observed throughout the 2017 monitoring period. It can be derived from the results that the level of flow modification may stem from regulation by dams (Figure 22), road crossings, and the gentle slope of the system presenting wetland conditions which have cumulatively altered flows and impacted the macroinvertebrate assemblage in the Bronkhorstspruit system.

Water quality (*in situ*) in the Bronkhorstspruit during both survey periods was considered adequate, however water quality related biological responses (sensitive invertebrates) had changed from the derived reference conditions. A high number (>80%) of sensitive taxa expected for the Ecoregion under reference conditions were absent from the 2017 biomonitoring period. This included majority with a high, moderate and low requirement for unmodified water quality, confirming the poor water quality in the project area. It can be derived from the results that the level of water quality modification may stem from the presence of several mining operations and large-scale agriculture present within the Bronkhorstspruit catchment (Figure 22). Further influence on water quality can be attributed to road crossings traversing aquatic areas. Run off from vehicles and roads carry a variety of hydrocarbons (fuels, oils), solid waste, dropped coal and other cargo that flows into nearby river systems during rainfall events altering water quality. The cumulative impacts have altered the macroinvertebrate assemblage in the Bronkhorstspruit system.

Overall, the biological responses represented by the sampled macroinvertebrate assemblages within the Bronkhorstspruit shows limited impacts directly attributed to mining activities at the Manungu Colliery.

The long-term results of the MIRAI associated with the Manungu Colliery are provided in Table 29. Flow modification has remained the dominant driver in the aquatic macroinvertebrate modification due to continued low flow levels. Water quality aspects have shown deterioration since the 2015 MIRAI assessment limiting aquatic biota to a large degree while compromising ecosystem function. The habitat driver has shown minor improvement since 2015, however the limited habitat availability and diversity has been insufficient enough to maintain healthy macroinvertebrate populations.

Table 29: MIRAI trends for the Bronkhorstspruit from 2015 to 2017

Invertebrate Metric Group	2015 Score Calculated (SAS, 2016)	2016 Score Calculated (SAS, 2016)	2017 Score Calculated
Flow modification	23.1	34.7	20.3
Habitat	31.7	32.8	39.9
Water Quality	37.1	37.1	33.3
Ecological Score	**39.6**	**34.8**	**31.5**
Invertebrate Category	**class D/E**	**class E**	**class E**

5.9.4 Fish Assessment

Sampling for fish was conducted at site MAN3 within the Bronkhorstspruit using electrofishing techniques. Images of fish species collected are presented in Table 32. The high flow sampling resulted in 3 of 5 potential fish species being collected (Table 31). Two additional yet non-native species, *Cyprinus carpio* (Carp) and *Gambusia affinis* (Mosquitofish) were sampled during the October 2017 survey at site MAN3. *Cyprinus carpio* is an alien invasive fish species and known habitat modifier, while *Gambusia affinis* is also an alien invader that feeds heavily on macroinvertebrate communities. The Bronkhorstspruit presented low native fish diversity in moderate abundances with *Pseudocrenilabrus philander* (Southern Mouth Brooder) dominating, followed by *Enteromius paludinosus* (Straightfin Barb). The results from the fish assessment indicate that the community structure of the Bronkhorstspruit was in a modified condition during the 2017 monitoring period.

Fish have different sensitivities or levels of tolerance to various aspects that they are subjected to within the aquatic environment. These tolerance levels are rated with a sensitivity score as presented in Table 30. These tolerance levels are scored to show each fish species sensitivity to flow and physico-chemical modifications. The results indicate that fish collected in the project area are predominantly tolerant to flow and physicochemical modifications (Table 31 and Table 30).

Table 30: Intolerance rating and sensitivity of fish species

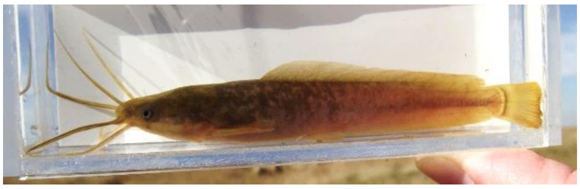
Sensitivity Score	Tolerance/Sensitivity Level
0-1	Highly tolerant = Very low sensitivity
1-2	Tolerant = Low sensitivity
2-3	Moderately tolerant = Moderate sensitivity
3-4	Moderately intolerant = High sensitivity
4-5	Intolerant = Very high sensitivity

Table 31: Fish species collected/observed during the high flow survey (October 2017)

Scientific name	IUCN status	FROC	Site	Sensitivity	
			MAN3	No-flow	Phys-chem
Clarias gariepinus	LC	3	Yes	**1.7**	**1**
Cyprinus carpio (Exotic)	Ex	N/A	Yes	**2.1**	**1.1**
Enteromius anoplus	LC	5	No	**2.3**	**2.6**
Enteromius paludinosus	LC	5	Yes	**2.3**	**1.8**
Gambusia affinis (Exotic)	Ex	N/A	Yes	**2**	**2**
Pseudocrenilabrus philander	LC	5	Yes	**1.0**	**1.4**
Tilapia sparrmanii	LC	3	No	**0.9**	**1.4**
Total native species			**3**	**1.6**	**1.6**
Total exotic species			**2**	**2**	**1.6**

FROC = Frequency of Occurrence; N/A = Not Applicable

Table 32: Photographs of fish species collected during the 2017 biomonitoring studies



Clarias gariepinus

Enteromius anoplus

Enteromius paludinosus

Pseudocrenilabrus philander

Cyprinus carpio (Exotic)

Gambusia affinis (Exotic)

Biological responses are important to consider and therefore the qualitative data obtained from the surveys was utilized in the FRAI (Kleynhans, 2007) and with the results presented below (Table 33). The Frequency of Occurrence (FROC) of the sampled fish community is calculated as follows: 0 = Absent; 1 = Present at few sites (<10%); 2 = Present at few sites (>10-25%); 3 = Present at about >25-50% of sites; 4 = Present at most sites (>50- 75%); 5 = Present at almost all sites (>75%).

Table 33: Fish Response Assessment Index for the 2017 Sampling Period

Scientific Name of Reference Species	**Reference FROC***	**2017 FROC**
		Bronkhorstspruit
Clarias gariepinus	3	3
Enteromius anoplus	5	3
Enteromius paludinosus	5	3
Pseudocrenilabrus philander	5	3
Tilapia sparrmanii	3	0
FRAI % (Automated)		**65.8**
EC FRAI		**class C**

*FROC = Frequency of Occurrence

The results of the FRAI derived a moderately modified (class C) fish community structure for the sampled Bronkhorstspruit reach. The majority of the FROC of the sampled fish community changed from the established reference FROC. The Bronkhorstspruit fish community structure was considered moderately modified due to the absence of 20% of the fish species from reference conditions, together with the presence of two alien invaders. Suitable habitat and flows are factors limiting the presence of missing species.

5.9.5 Present Ecological State

The results for the reach based PES assessment (Kleynhans and Louw, 2007) is presented in Table 34.

Table 34: PES of the Bronkhorstspruit from the 2017 biomonitoring period

Aspect assessed	Ecological Score	Ecological Category
Instream Ecological Category	48.8	D
Riparian Ecological Category	40.0	D
Aquatic Invertebrate Ecological Category	31.5	E
Fish Ecological Category	65.8	C
Ecostatus	**46.5**	**class D**

The results of the PES assessment derived a largely modified ecological category (class D) for the Bronkhorstspruit. This PES is below the attainable ecological management class (class C).

The modified status can be attributed to a combination of flow modification, habitat and water quality related drivers and riparian areas associated with the Bronkhorstspruit and each associated tributary system. The overlying influence of low water levels in the project area with no river flow between sites has impacted aquatic macroinvertebrate and fish communities. The implementation of flow releases from the farm dams in the project area will assist in restoring and improving instream and marginal habitat. An improvement of instream and marginal habitat will result in an improvement in water quality throughout the catchment stemming from restoration of biotic integrity of the Bronkhorstspruit systems

6 Impact Assessment

6.1 Existing impacts

The following existing impacts were observed in or adjacent to the proposed project area:

- Wetland areas have been lost due to the mining operation, selected wetland systems have been mined within the permitted mining area (Ecotone, 2013).
- The removal of vegetation to accommodate local agricultural activities, the existing mining operation and access routes. This has resulted in the establishment and encroachment of alien vegetation in the general area, including the water resources.
- The flow of the Bronkhorstspruit system has been modified due to the altered hydrology of these systems. The water quality of these systems has also been impaired due to the local land uses, this is reflected in the dissolved oxygen and conductivity recordings.
- The mining and agricultural activities have also contributed to wetland modifications, which include altered flows caused by compaction and drainage, and also the establishment of alien vegetation within the systems.
- The majority of wetlands falling within mining boundaries and a 500m radius, fell into a D Ecological Category and reflect a large loss in functional integrity (Ecotone, 2013).

6.2 Potential Impacts

The proposed project could result in the loss and modifications of water resources, notably the delineated wetland areas. The following list provides a framework for the anticipated major 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. Access roads and servitudes
        iii. Construction camps & laydown areas
        iv. Infrastructure development
        v. Linear trench excavation and berm creation
        vi. Soil dust precipitation
        vii. Coal dust precipitation
        viii. 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 mining 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 water courses
        i. Chemical (organic/inorganic) spills
        ii. Acid mine drainage (decanting)
        iii. Untreated runoff or effluent
        iv. Coal dust precipitation
5. Alterations in hydrological regime (flow of surface and sub-surface water)
    a. Project activities that can cause alterations in hydrological regime
        i. Excavations and infrastructure development
        ii. Road network creation
        iii. Excavations of opencast pit
        iv. Alterations to surface topography (due to voids and surface structures)
        v. Dewatering of underground mine area
    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
        vi. Loss of soil fertility and topsoil recharge through interruption of seasonal recharge and natural flow, including natural sedimentation

6.3 Assessment of Significance

Figure 28 presents the proposed project aspects which have been considered for the study, with close consideration being afforded to the opencast and underground mining areas.

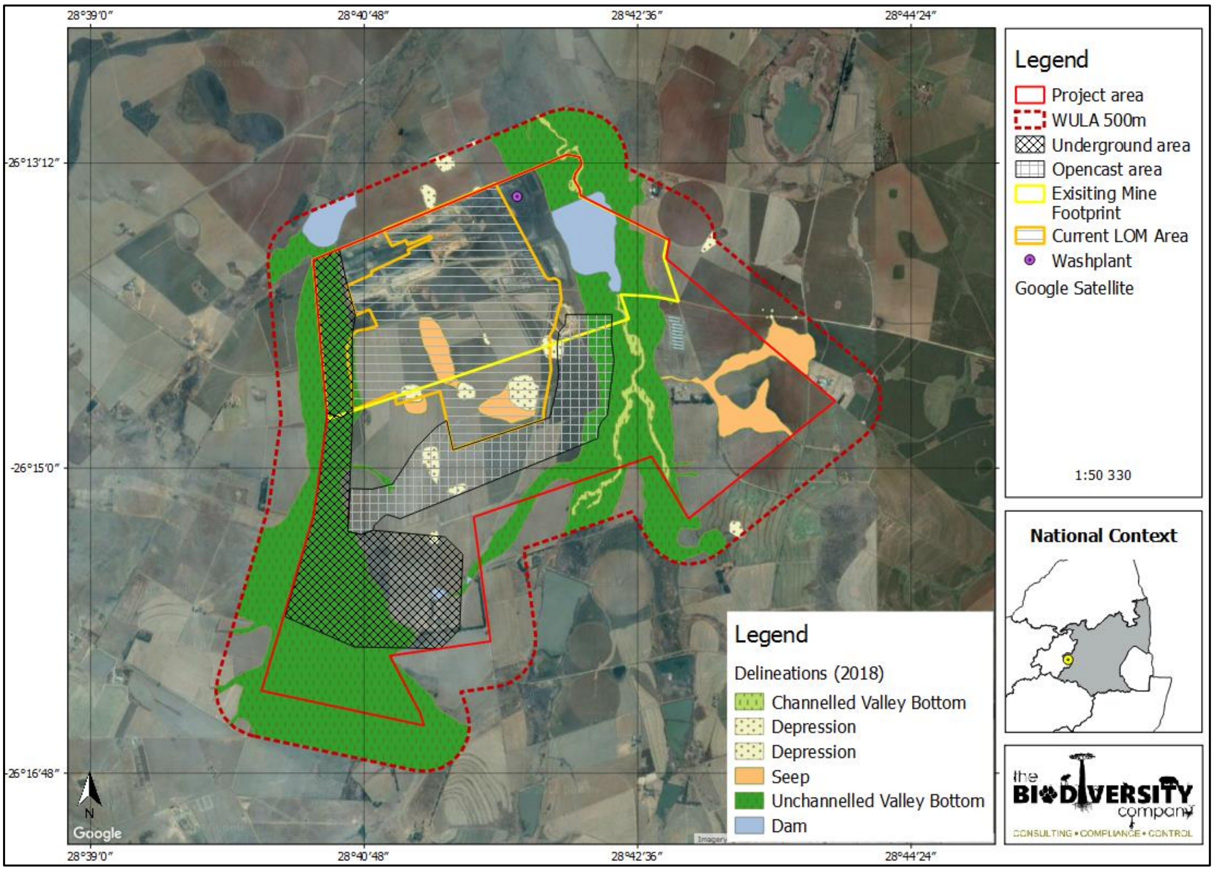


Figure 28: The proposed project aspects in relation to the wetlands

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

The most notable impact is the expectant loss some water resources, the delineated wetlands in particular. The loss of wetlands is expected for the mining of the opencast area, and it is possible that underground mining may also result in the loss of wetland systems. 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 systems proposed to be mined by opencast methods.

The DWS should be consulted in order to determine the requirements for a wetland offset strategy, which must include the wetland systems already lost as a result of the mining operation.

A. Loss /degradation of wetlands					
Impact Name	**Loss /degradation of wetlands**				
Alternative	**N/A**				
Phase	**Construction & Operation**				
Environmental Risk					
Attribute	**Pre-mitigation**	**Post-mitigation**	**Attribute**	**Pre-mitigation**	**Post-mitigation**
Nature of Impact	-1	-1	Magnitude of Impact	3	3

Extent of Impact	3	3	Reversibility of Impact	4	4
Duration of Impact	5	5	Probability	5	5
Environmental Risk (Pre-mitigation)					-18.75
Mitigation Measures					
The loss of wetland is unavoidable, and the only mitigation would be to avoid the wetland area. However, changes to the topography will likely also result in the loss of the wetland due to hydrological changes. The DWS should be consulted for an offset strategy to determine the need thereof. An artificial wetland must be considered for any possible decant post closure. Minimise footprint area of infrastructure. Avoid wetland areas and adhere to recommended buffer areas.					
Environmental Risk (Post-mitigation)					-18.75
Degree of confidence in impact prediction:					Medium
Impact Prioritisation					
Public Response					2
Issue has received a meaningful and justifiable public response					
Cumulative Impacts					2
Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is probable that the impact will result in spatial and temporal cumulative change.					
Degree of potential irreplaceable loss of resources					2
The impact may result in the irreplaceable loss (cannot be replaced or substituted) of resources but the value (services and/or functions) of these resources is limited.					
Prioritisation Factor					1.50
Final Significance					-28.13

B. Spread and/or establishment of alien and/or invasive					
Impact Name	**Spread and/or establishment of alien and/or invasive**				
Alternative	**N/A**				
Phase	**Construction & Operation**				
Environmental Risk					
Attribute	**Pre-mitigation**	**Post-mitigation**	**Attribute**	**Pre-mitigation**	**Post-mitigation**
Nature of Impact	-1	-1	Magnitude of Impact	2	3
Extent of Impact	3	3	Reversibility of Impact	2	2
Duration of Impact	3	3	Probability	3	4
Environmental Risk (Pre-mitigation)					-7.50
Mitigation Measures					
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					
Environmental Risk (Post-mitigation)					-4.50
Degree of confidence in impact prediction:					Medium
Impact Prioritisation					
Public Response					1
Low: Issue not raised in public responses					
Cumulative Impacts					1
Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is unlikely that the impact will result in spatial and temporal cumulative change.					

Degree of potential irreplaceable loss of resources	1
The impact is unlikely to result in irreplaceable loss of resources.	
Prioritisation Factor	1.00
Final Significance	-4.50

C. Environmental pollution due to increased sedimentation and erosion in watercourses

Impact Name	**Environmental pollution due to increased sedimentation and erosion in watercourses**				
Alternative	**N/A**				
Phase	**Construction & Operation**				
Environmental Risk					
Attribute	**Pre-mitigation**	**Post-mitigation**	**Attribute**	**Pre-mitigation**	**Post-mitigation**
Nature of Impact	-1	-1	Magnitude of Impact	3	2
Extent of Impact	3	3	Reversibility of Impact	4	3
Duration of Impact	3	3	Probability	3	5
Environmental Risk (Pre-mitigation)					-9.75
Mitigation Measures					
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 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.					
Environmental Risk (Post-mitigation)					-13.75
Degree of confidence in impact prediction:					Medium
Impact Prioritisation					
Public Response					2
Issue has received a meaningful and justifiable public response					
Cumulative Impacts					2
Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is probable that the impact will result in spatial and temporal cumulative change.					
Degree of potential irreplaceable loss of resources					2
The impact may result in the irreplaceable loss (cannot be replaced or substituted) of resources but the value (services and/or functions) of these resources is limited.					
Prioritisation Factor					1.50
Final Significance					-20.63

D. Impaired water quality (surface & groundwater)

Impact Name	**Impaired water quality (surface & groundwater)**				
Alternative	**N/A**				
Phase	**Construction & Operation**				
Environmental Risk					
Attribute	**Pre-mitigation**	**Post-mitigation**	**Attribute**	**Pre-mitigation**	**Post-mitigation**
Nature of Impact	-1	-1	Magnitude of Impact	4	3

Extent of Impact	3	3	Reversibility of Impact	4	4
Duration of Impact	3	3	Probability	3	3
Environmental Risk (Pre-mitigation)					-10.50
Mitigation Measures					
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. 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. Contain waste water in a PCD. 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 water hydro-dynamics. *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*					
Environmental Risk (Post-mitigation)					-9.75
Degree of confidence in impact prediction:					Medium
Impact Prioritisation					
Public Response					3
Issue has received an intense meaningful and justifiable public response					
Cumulative Impacts					2
Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is probable that the impact will result in spatial and temporal cumulative change.					
Degree of potential irreplaceable loss of resources					2
The impact may result in the irreplaceable loss (cannot be replaced or substituted) of resources but the value (services and/or functions) of these resources is limited.					
Prioritisation Factor					1.67
Final Significance					-16.25

E. Alterations in hydrological regime					
Impact Name	**Alterations in hydrological regime**				
Alternative	**0**				
Phase	**Construction & Operation**				
Environmental Risk					
Attribute	**Pre-mitigation**	**Post-mitigation**	**Attribute**	**Pre-mitigation**	**Post-mitigation**
Nature of Impact	-1	-1	Magnitude of Impact	3	2
Extent of Impact	3	3	Reversibility of Impact	3	3
Duration of Impact	3	3	Probability	3	3
Environmental Risk (Pre-mitigation)					-9.00
Mitigation Measures					
Underground workings must adhere to a safety factor that will not allow for subsidence. Rehabilitation of the opencast areas must be concurrent with the mining operation. 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. Minimise the extent of blasting.	
Environmental Risk (Post-mitigation)	-8.25
Degree of confidence in impact prediction:	Medium
Impact Prioritisation	
Public Response	1
Low: Issue not raised in public responses	
Cumulative Impacts	2
Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is probable that the impact will result in spatial and temporal cumulative change.	
Degree of potential irreplaceable loss of resources	2
The impact may result in the irreplaceable loss (cannot be replaced or substituted) of resources but the value (services and/or functions) of these resources is limited.	
Prioritisation Factor	1.33
Final Significance	-11.00

F. Loss /degradation of wetlands					
Impact Name	**Loss /degradation of wetlands**				
Alternative	**N/A**				
Phase	**Decommissioning**				
Environmental Risk					
Attribute	**Pre-mitigation**	**Post-mitigation**	**Attribute**	**Pre-mitigation**	**Post-mitigation**
Nature of Impact	-1	-1	Magnitude of Impact	3	3
Extent of Impact	3	3	Reversibility of Impact	4	4
Duration of Impact	5	5	Probability	5	4
Environmental Risk (Pre-mitigation)					-18.75
Mitigation Measures					
All voids must be backfilled, and surface infrastructure must be removed from the site. 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.					
Environmental Risk (Post-mitigation)					-15.00
Degree of confidence in impact prediction:					Medium
Impact Prioritisation					
Public Response					2
Issue has received a meaningful and justifiable public response					
Cumulative Impacts					2
Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is probable that the impact will result in spatial and temporal cumulative change.					
Degree of potential irreplaceable loss of resources					2
The impact may result in the irreplaceable loss (cannot be replaced or substituted) of resources but the value (services and/or functions) of these resources is limited.					
Prioritisation Factor					1.50
Final Significance					-22.50

P. Alterations in hydrological regime					
Impact Name	**Alterations in hydrological regime**				
Alternative	**N/A**				
Phase	**Decommissioning**				
Environmental Risk					
Attribute	**Pre-mitigation**	**Post-mitigation**	**Attribute**	**Pre-mitigation**	**Post-mitigation**
Nature of Impact	-1	-1	Magnitude of Impact	4	4
Extent of Impact	3	3	Reversibility of Impact	4	4
Duration of Impact	5	5	Probability	4	3
Environmental Risk (Pre-mitigation)					-16.00
Mitigation Measures					
All voids must be backfilled, and surface infrastructure must be removed from the site. 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 may be created in channels to retain water in the catchment.					
Environmental Risk (Post-mitigation)					-12.00
Degree of confidence in impact prediction:					Medium
Impact Prioritisation					
Public Response					2
Issue has received a meaningful and justifiable public response					
Cumulative Impacts					2
Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is probable that the impact will result in spatial and temporal cumulative change.					
Degree of potential irreplaceable loss of resources					2
The impact may result in the irreplaceable loss (cannot be replaced or substituted) of resources but the value (services and/or functions) of these resources is limited.					
Prioritisation Factor					1.50
Final Significance					-18.00

Q. Impaired water quality (surface & groundwater) -					
Impact Name	**Impaired water quality (surface & groundwater)**				
Alternative	**N/A**				
Phase	**Decommissioning**				
Environmental Risk					
Attribute	**Pre-mitigation**	**Post-mitigation**	**Attribute**	**Pre-mitigation**	**Post-mitigation**
Nature of Impact	-1	-1	Magnitude of Impact	4	4
Extent of Impact	3	3	Reversibility of Impact	4	4
Duration of Impact	5	5	Probability	4	3
Environmental Risk (Pre-mitigation)					-16.00
Mitigation Measures					

Determine the likelihood of AMD, and proactively implement measures to prevent or reduce this. Priority would be to ensure the treatment of this water to suitable standards for aquatic ecology. Rehabilitation of the area and shaping of the topography must minimise the ingress of water into the mining area. Additionally, measures must also be considered to implement constructed wetlands at likely decant areas, and the planting of tree reduce groundwater recharge. *Decommission cut-off berms and drains last. Debris must be placed in preferential flow paths. 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.*	
Environmental Risk (Post-mitigation)	-12.00
Degree of confidence in impact prediction:	Medium
Impact Prioritisation	
Public Response	3
Issue has received an intense meaningful and justifiable public response	
Cumulative Impacts	2
Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is probable that the impact will result in spatial and temporal cumulative change.	
Degree of potential irreplaceable loss of resources	2
The impact may result in the irreplaceable loss (cannot be replaced or substituted) of resources but the value (services and/or functions) of these resources is limited.	
Prioritisation Factor	1.67
Final Significance	-20.00

6.4 Mitigation measures

Table 35 presents the recommended mitigation measures and the respective timeframes, targets and performance indicators.

Table 35: Mitigation measures including requirements for timeframes, roles and responsibilities

No.	Mitigation Measures	Phase	Timeframe	Responsible Party for Implementation	Monitoring Party (Frequency)	Target	Performance Indicators (Monitoring Tool)
Water Resources							
	The loss of wetland is unavoidable, and the only mitigation would be to avoid the wetland area. However, changes to the topography will likely also result in the loss of the wetland due to hydrological changes. The DWS should be consulted for an offset strategy to determine the need thereof. An artificial wetland must be considered for any possible decant post closure. Minimise footprint area of infrastructure. Avoid wetland areas and adhere to recommended buffer areas. *All voids must be backfilled, and surface infrastructure must be removed from the site. 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.*	Construction Operation Closure	Permanent	Applicant / EAP	N/A	Compensate for loss of wetland area, target to be determined	Wetland offset: A best practice guideline (DWS / SANBI, 2013)
	Underground workings must adhere	Operation	Permanent	Applicant / Contractor	Monthly surface	Avoid or	Water quality

	to a safety factor that will not allow for subsidence. Rehabilitation of the opencast areas must be concurrent with the mining operation. 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.	Closure			and groundwater quantity and quality	minimise the loss of water input, and impaired water quality	guidelines (DWS,1996)
	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. 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. Contain waste water in a PCD. 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 water hydro-dynamics.	Construction Operation	Ongoing	Applicant / Contractor	Biomonitoring (bi-annual) Water quality monitoring, frequency to be advised by hydrology specialist	Maintain drinking water quality standards	Water quality guidelines (DWS,1996)

	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						
	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 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	Construction Operation	Ongoing	Applicant / Contractor	Biomonitoring (bi-annual) Water quality monitoring, frequency to be advised by hydrology specialist	Maintain drinking water quality standards	Water quality guidelines (DWS,1996)

	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	Ongoing	Applicant / Contractor	Biomonitoring (bi-annual) Water quality monitoring, frequency to be advised by hydrology specialist	Maintain drinking water quality standards	Water quality guidelines (DWS,1996)
	An alien invasive plant management plan needs to be compiled and implemented prior to construction to control and prevent	Construction Operation	Ongoing	Applicant / Contractor	Monthly inspections, with removal to be determined on a	Maintain drinking water quality	National Environmental Management: Biodiversity Act (Act

	the spread of invasive aliens, Clean vehicles on-site, and prioritise vehicles gaining access from surround areas	Closure			needs basis	standards	10 of 2004) (NEM:BA): Category 1a/b: Invasive species requiring compulsory control. Remove and destroy.
	All voids must be backfilled, and surface infrastructure must be removed from the site. 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 may be created in channels to retain water in the catchment.	Closure	Ongoing	Applicant	Biomonitoring (bi-annual) Wetland monitoring (bi-annual) Water quality monitoring, frequency to be advised by hydrology specialist	Maintain drinking water quality standards	Water quality guidelines (DWS,1996)
	Determine the likelihood of AMD, and proactively implement measures to prevent or reduce this. Priority would be to ensure the treatment of this water to suitable standards for aquatic ecology. Rehabilitation of the area and shaping of the topography must minimise the ingress of water into the mining area. Additionally, measures must also be considered to implement constructed wetlands at likely decant areas, and the planting of tree reduce groundwater recharge.	Closure	Ongoing	Applicant	Biomonitoring (bi-annual) Water quality monitoring, frequency to be advised by hydrology specialist	Maintain drinking water quality standards	Water quality guidelines (DWS,1996)

	Decommission cut-off berms and drains last. Debris must be placed in preferential flow paths. 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.						

6.5 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. The recommended buffer width is 45 m and 65 m for the construction and operational phases respectively. It is recommended that the larger buffer width of 65 m be implemented from the onset of the construction phase of the project
2. 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 mining or any other land use / activity within the foreseeable future.
3. A hydropedology study must be completed to assess the magnitude to which the relevant wetland systems are interlinked (or connected) and the likely dependence of these systems on the recharge of aquifers. In the event that wetland systems are determined to be connected or dependant on groundwater recharge, the extent of these wetlands must preferably be avoided.
4. The bord and pillar safety factor for the project area must be determined, and ensure that the likelihood of subsidence if not possible. Once this has been confirmed, underground mining of the wetlands may be considered.
5. It is recommended that environmental authorisation for the project only be considered on the acceptance of a comprehensive rehabilitation plan. It is further recommended that a condition of the operating licence must be to review and report on the implementation of the rehabilitation annually. If it is determined during this review period that the rehabilitation plan has not been implemented, or poorly at that, all mining must cease until rehabilitation of the area is adequate.

6.6 Monitoring programme

Aquatic biomonitoring is currently being undertaken for the Manunugu Colliery as per conditions of the Water Use Licence (WUL, No. 04/B20A/ACGIJ/2621).

It is recommended that this biomonitoring programme be continued, and consider the proposed expansion project. In addition to this, it is recommended that wetland monitoring be conducted simultaneously with the biomonitoring programme.

A monitoring programme is an essential management tool. The monitoring programme should be designed to enable the detection of potential negative impacts brought about by the proposed project. Table 36 highlights some important aspects to monitor for the duration of the programme.

Table 36: Aquatic and Wetland Ecology Monitoring Plan

Location	Monitoring objectives	Frequency of monitoring	Parameters to be monitored
Current sites used	Overall Aquatic PES	Bi-annual	Standard aquatic

Location	Monitoring objectives	Frequency of monitoring	Parameters to be monitored
in this study. Identify wetland monitoring sites	Wetland PES, functioning & EIS		ecology (Ecostatus) methods Wetland WET-Series
Current sites used in this study.	Determine if water quality deterioration is occurring.	Bi-annual	SASS5 and ASPT scores should not decrease as and be related to mining activities.
Current sites used in this study.	Determine if water/habitat quality deterioration is occurring.	Bi-annual	Monitor for presence of fish.

7 Conclusion

According to the 2017 Manungu aquatic biomonitoring survey results, the PES assessment derived a largely modified ecological category (class D) for the Bronkhorstspruit. This PES is below the attainable ecological management class (class C). The *in situ* water quality levels recorded across the project area indicated adequate conditions within the Bronkhorstspruit and its tributaries. The pH, electrical conductivity and water temperatures fell within acceptable levels and did not present adverse conditions to local aquatic biota. Low dissolved oxygen levels were however, recorded at site MAN3 during the June 2017 low flow survey. The low oxygen levels indicate high biological or chemical oxygen demand within the system, typical of wetlands.

According to MIRAI results, the aquatic macroinvertebrate assemblage indicated the Bronkhorstspruit and its tributaries to be in a class E or seriously modified. Central factors resulting in a lowered ecological category were attributed to flow modification and water quality drivers, with majority of the physico-chemical (water quality) and flow sensitive taxa absent. Habitat availability for aquatic macroinvertebrates was further considered a limiting factor to aquatic macroinvertebrates in the Bronkhorstspruit and its tributaries. It can be derived from the results that the level of flow modification from farm dams has impacted the macroinvertebrate assemblages in the project area.

The results from the fish assessment indicated that the community structure of the Bronkhorstspruit system was considered moderately modified due to the absence of 20% of the fish species from reference conditions, together with the presence of two alien invaders. Suitable habitat and flows are factors limiting the presence of missing species. Sampling resulted in 3 of 5 potential fish species being collected. The FRAI derived a moderately modified (class C) fish community structure.

The modified status can be attributed to a combination of flow modification, habitat and water quality related drivers and riparian areas associated with the Bronkhorstspruit and each associated tributary system. The overlying influence of low water levels in the project area with no river flow between sites has impacted aquatic macroinvertebrate and fish communities. The modification stems from a combination of agricultural and mining activities present within Bronkhorstspruit catchment and cannot be directly attributed to mining related activities at Manungu Colliery.

A total of five (5) HGM types were identified and delineated for the project. A total of 16 HGM units were identified for the project. The overall wetland health for the wetlands varied from Moderately Modified (Class C) to Largely Modified (Class D) system, with the majority of the wetlands rated a Class D. The EIS of the two valley bottom wetland types was rated as high (Class B), with the remaining wetland types being rated as moderate (Class C).

All of the wetland types had overall moderately low level of service, with the exception of the unchannelled valley bottom system which had an intermediate level of service. It is evident from the study that the most benefits are associated with the indirect benefits, which includes the enhancement of water quality. The level of indirect benefits for all the systems ranged from low to moderately low. The hydrological / functional importance was rated as Moderate (Class C) for all the wetland systems. The direct human benefits were rated as low (Class D) for all the wetland systems.

The recommended buffer width is 45 m and 65 m for the construction and operational phases respectively. It is recommended that the larger buffer width of 65 m be implemented from the onset of the construction phase of the project.

The proposed project could result in the loss and modifications of water resources, notably the loss of selected pans (and associated seeps) and portions of the unchanneled valley bottom system to the east of the project area. It is permissible that the proposed opencast mining area result in the mining of the depressions within this area, but the mine plan must be amended to avoid the eastern valley bottom wetland and the associated buffer. The loss of wetlands is expected for the mining of the opencast area, and it is possible that underground mining may also result in the loss of wetland systems. 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 systems proposed to be mined by opencast methods.

The impacts associated with the proposed underground mining method are considerably less significant when compared to the proposed opencast mining methods. This compounded with the placement of new infrastructure, access routes and mining activities will have a significant impact on the local environment and ecological processes. Careful consideration must be afforded each of the recommendations provided herein. 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.

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